LEHIGH UNIVERSITY 1997-1998 COURSE CATALOG

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Admission
(610) 758-3100
College of Arts and Sciences
(610) 758-3300
College of Business and Economics
(610) 758-3400
College of Education
(610) 758-3225
College of Engineering and Applied Science
(610) 758-4055

Academic Calendar - inside back cover

Undergraduate Major Programs

The university offers the following undergraduate major programs. While most of these programs are offered as majors within a specific academic department, in some cases subjects transcend departmental lines or are emphases within a major program. Minors are available. Programs that are offered only as minors are described under the entries for individual colleges in Section III, Academic Programs in the Colleges, and under individual departments in Section V, Description of Courses. Graduate programs are offered in many of the subjects listed. These are described in Section IV, Graduate Study and Research.


*5 year dual degree program

Academic Departments

College of Arts and Sciences
Art and Architecture
Biological Sciences
Chemistry
Earth and Environmental Sciences
English
History
International Relations
Journalism and Communication
Mathematics
Modern Foreign Languages
Music
Philosophy
Physics
Political Science
Psychology

Religion Studies
Sociology/Anthropology
Theatre

College of Business and Economics
Business
Economics

College of Education
Education and Human Services

College of Engineering and Applied Science
Chemical Engineering
Civil and Environmental Engineering
Electrical Engineering and Computer Science
Industrial and Manufacturing Systems Engineering
Materials Science and Engineering
Mechanical Engineering and Mechanics

Lehigh University reserves the right at any time to change the rules and regulations governing admission, tuition, fees, regulations affecting its students.
LEHIGH UNIVERSITY MISSION STATEMENT

To advance learning through the integration of teaching, research, and service to others.

Excellence is the hallmark of a university of distinction. Excellence requires a total quality commitment, which must characterize every activity of Lehigh University.

Lehigh is an independent, coeducational university with programs in the arts and humanities, business, education, engineering, and the natural and social sciences, offering bachelor's degrees primarily to full-time, residential students and graduate degrees through the doctorate for both full-time and part-time students. Lehigh is small enough to be personal, yet large enough to provide stimulating diversity and to play important national and international roles.

Since Lehigh's founding in 1865, the faculty has emphasized the integration of the academic disciplines, combining the cultural with the professionals, the theoretical with the practical, and the humanistic with the technological in a modern liberal education that serves as preparation for a useful life. Lehigh is an intellectually unified community of learners, and in this sense Lehigh is an integral university.

Lehigh strives to earn international prominence as a university of special distinction through its integration of teaching, research, and service to society. The integrating element of teaching, research and service is learning, which is the principal mission of all members of the Lehigh community. Our mission of advancing learning has three aspects:

Teaching. The development of future leaders in our global society is first among Lehigh's purposes and first among our achievements. Preparation for leadership requires the best of teaching, in which both mentor and student are so deeply engaged that they become joint owners of the learning process. Research. Lehigh is deeply committed to the creative search for new understanding of nature and human society as an essential element of the learning process. The scholarly inquiry and research of Lehigh faculty and students add value to instruction on our campus, and contribute to the distinction of our university.

Service. The special commitment of the Lehigh community to experiential learning through service to others imbues the entire university with a sense of purpose and value in the larger society. Lehigh is extensively involved in developing partnerships with industry, government and others in education and human services to meet the needs of our society. In a societal sense, Lehigh is devoted to the concepts of unity, community, and cooperative achievement.

Lehigh believes that its graduates must develop critical thinking and effective communication as their habit; they must have both a broad understanding of human affairs and a domain of true competence; they are expected to live by a set of mature cultural and personal values, accept the virtue of work as a vehicle of service, and have the will to live and work with exceptional self-discipline.

Respect for human dignity is very important at Lehigh, a caring community deeply committed to harmonious cultural diversity as an essential element of the learning environment. In order that all members of the Lehigh community might develop as effective and enlightened citizens, the University encourages physical, social, ethical, and spiritual development as well as rigorous intellectual development.
I.

Information of General Interest

This section includes information related to accreditation, admission, advanced placement, transfer students, tuition and fees, financial aid, campus life and academic regulations. Similar information for graduate students may be found in Section IV. The university’s history, biographies of its presidents and descriptions of its buildings are found in Section VI.

Accreditation
Lehigh University is accredited by the Middle States Association of Colleges and Schools. Both the undergraduate general and accounting programs and the master of business administration programs are accredited by the American Assembly of Collegiate Schools of Business. The engineering curricula are accredited by the Accreditation Board for Engineering and Technology. In addition, the computer science program offered in the College of Engineering and Applied Science is accredited by the Computer Science Accreditation Board, Inc. Various College of Education programs are accredited by the National Council for Accreditation of Teacher Education, including Commonwealth of Pennsylvania approval for certification programs. Programs in chemistry are approved by the American Chemical Society.

The department of theatre was accredited by the National Association of Schools of Theatre, recognized by the US Department of Education as the accrediting body for the field of theatre.

Policy of Equality
Lehigh University provides equal opportunity on the basis of merit without discrimination because of race, color, religious creed, ancestry, national origin, age, handicap, sex, sexual orientation or union membership.

Admission Guidelines

The total undergraduate and graduate enrollment of Lehigh University is regulated by action of the board of trustees, with a resulting limitation of the number of candidates who can be admitted each year to the various divisions of the university.

Because of the limitations on enrollment, the Office of Admissions, under the leadership of the Dean of Admissions and Financial Aid, conducts a selective review of candidates for admission. Several criteria are used in an attempt to predict a student’s ability to do college level work.

The material that follows pertains to undergraduates. Graduate students should consult Admission to Graduate Standing, Section IV.

The admission policy of the university is designed to enroll students with a variety of backgrounds. The course work or units required for admission represent the equivalent of the usual four-year college preparatory curriculum with certain specific course work being required for enrollment in certain colleges within the university. Evidence of academic growth, ability to learn, and motivation are special qualities that may not be reflected in the accumulation of units. Such qualities are also considered by the admissions committee.

Minimum subject matter requirements (16 units)

- English 4 units
- Foreign languages* 2 units
- Social science 2 units
- Laboratory science 2 units
- College preparatory mathematics* * 3 units
- Elective subjects 3 units

*Only in exceptional cases, and for otherwise well-qualified candidates, will the Committee on Admission waive the foreign language requirement for admission to any one of the three undergraduate colleges.
**Waivers of the requirement in mathematics are granted to otherwise well-qualified candidates for admission who propose to major in one of the following fields offered by the College of Arts and Science: American studies, art, classics, theater, English, modern foreign languages, government, history, international relations, journalism, music, philosophy, religion studies, social relations, and urban studies.

Students planning on enrolling in the College of Engineering and Applied Sciences must have studied Chemistry and mathematics through trigonometry, and should have studied Physics and mathematics through pre-calculus. Calculus is recommended. Students planning on enrolling in the College of Business and Economics must have completed mathematics through trigonometry, but also should strongly consider taking pre-calculus or calculus. Candidates for the College of Arts and Science preparing for a bachelor of science degree must also take math through trigonometry and candidates for a bachelor of arts degree should take additional language study beyond the two required years of foreign language study.

Minimum course work requirements can be misleading since most students who gain admission to Lehigh University exceed the minimum course work. Strength of preparation can be difficult to assess since each individual comes from a different background. However, the Committee on Admissions will look for things such as: (in no particular order)

- Rank or relative rank in class
- How the student’s grades compare to those of his or her classmates at that particular school
- Evidence of improvement or deterioration in the grades during the secondary school career with particular attention paid to performance in senior year courses
- The quality of performance in courses that relate to the students anticipated area of study
- The difficulty of courses taken with special attention paid to courses which are recognized as being accelerated by national academic organizations
- Comments and recommendations from the principal, headmaster, guidance counselor, or other professional educators within the school system
- Performance on standardized testing
- Extra-curriculum/work experience with particular emphasis placed on demonstrated leadership
- Demonstrated interest in Lehigh

Entrance Examinations

SAT/ACT: Each candidate for admission to the freshman class is required to write either the Scholastic Assessment Test (SAT) or the American College Test (ACT). It is highly recommended that the student request that his or her scores be forwarded to Lehigh (CEEB code 2365) directly. It is not the responsibility of the high school guidance office to forward the results. If during the evaluation process it is discovered that the test results are missing, the student will be notified by mail or phone. Unnecessary delays in the decision making process can result if the committee does not have the scores.

The Committee on Admissions recommends that students take the exam in the junior year and again as early in the senior year as possible. In the evaluation process, the highest score in each category will be used regardless of the test date.
SAT II Tests: Candidates are not required to write any College Board SAT II tests. Students may submit them if they feel they will be helpful to the admissions process.

Test information and applications may be secured from high school guidance officials or the College Board at either of the following addresses: P.O. Box 592, Princeton, N.J. 08541, or 1947 Center St., Berkeley, Calif. 94704. Candidates writing tests outside the United States should direct their correspondence to the Princeton address.

Candidates should register for the tests early in the senior year and not later than one month prior to the test date (two months for candidates who will be tested in Europe, Asia, Africa, Central and South America, and Australia).

As with other standardized testing, the candidate has the responsibility to have the results sent to Lehigh.

Recommendations
The Office of Admissions requires, as part of a candidate’s file, a letter of recommendation from the guidance counselor, principal, or headmaster from the candidate’s school. One teacher recommendation is recommended, but is not required. Such recommendations should address the candidate’s other qualifications such as health, intellectual stability, emotional stability, intellectual motivation, social adjustment, participation in extracurricular activities, and established habits of industry and dependability.

Interviews
Prospective freshmen and their parents are highly encouraged to visit Lehigh and participate in a campus tour and to meet with an admissions officer for a personal interview. No appointment is necessary for a campus tour, but interviews should be scheduled by appointment. A call to the Office of Admissions is recommended because the schedule of tours and interviews can change several times during the year as the academic calendar changes. During the visit to our campus it is often possible to meet with faculty, coaches, or other professional staff of the university. Requests for such meetings should be made prior to the actual visit which will allow us to facilitate scheduling.

The Office of Admissions is open for interviews most weekdays from 9:00 a.m. to 4:00 p.m. Tours are conducted according to the availability of tour guides, but are usually available five days a week, except for special weekends. Specialized tours with emphasis on specific fields of interest are available by arrangement. During the fall and winter the availability of tour guides is limited, but students are encouraged to reserve a spot as soon as possible. No interviews are granted during the February 1 to April 15 period when the staff is reading files, although exceptions can be made for persons traveling great distances.

In certain cases an interview may be required if, in the opinion of the Dean of Admissions and Financial Aid, the additional information gained in an interview would be helpful in making the correct decision regarding admission. In such cases, the candidate will be notified of our request.

How to Apply
Students may secure applications by writing to the Office of Admissions, 27 Memorial Drive West, Lehigh University, Bethlehem, PA 18015, or by telephoneing (610) 758-3100. Students may also use the Common Application available from school guidance counselors. The Common Application is accepted as the equal of the Lehigh application.

Applications should be filed according to the following deadlines:

December 1-Early Decision*
December 16-year, BA/MD Program
January 1-Penn Dental 7-year Dental Program
January 15-Regular Decision

*Applications can be converted for Early Decision evaluation until January 15.

Each application must be accompanied by an application fee of $50. This fee is non-refundable and does not apply towards the tuition fees.

Waivers of application fees are accepted when forwarded on the appropriate forms from the school guidance office. Students for whom the application fee is a hardship should consult the guidance office at their school.

Early Decision
The university will act on early decision applications received by the appropriate deadlines. Our program is a binding early decision plan which means that the student, parents, and guidance counselor must sign an Early Decision Request form to confirm their understanding that if the student is accepted, and the financial aid package is appropriate, the student is expected to accept our offer and withdraw all other applications. Students applying early should have been to campus for an interview and should be sure that Lehigh is their first choice school. Students who meet the December 1 deadline will be notified by December 31 and those who convert applications by January 15, will be notified by February 1. It is understood that the student will continue a satisfactory level of academic performance throughout his or her senior year.

The early decision plan is not for everyone. It is for the student who has been early and active in their college search, and is sure that they want to attend Lehigh. When reviewing an early decision application, the committee will defer a decision on any candidate when there is insufficient information to make an early decision. It is also possible that a student may be denied admission. The Committee will give early decision applicants some slight advantage in borderline cases because of the commitment of applying early, but students must still present a strong record.

Early decision candidates who have filed the Financial Aid Profile application and prior year tax forms will be notified of their financial aid package approximately three weeks after the decisions on admission are made by the Office of Admissions. All other financial aid forms must be filed by the deadline indicated on each application.

Admission and Deposit
Notification of admissions decisions is made by mail between March 15 and April 1. Once a student has been admitted he or she may secure a place in the entering class by notifying the University that they intend to enroll at Lehigh and by forwarding the appropriate admissions deposit by May 1. This fee is applicable towards the tuition and room and board fees for the fall term. Students who fail to enroll or withdraw after depositing will forfeit their deposit.

Transfer Students
Each January and August student who has attended another college or university are admitted with advanced standing. Candidates for transfer admission must meet the high school subject matter requirements prescribed for entering freshmen, but entrance examinations are not required. The academic performance at the college level is the primary factor when giving consideration to admission.

Candidates who have been dropped for poor scholarship, or are not in good standing, or have been released for disciplinary reasons are not eligible for admission.

Each candidate must submit an official transcript from each institution attended. An admissions decision cannot be made without this information. Students wishing to enter in the spring should apply not later than November 1 and applicants for the fall semester should have their application in by April 1. Applications may be obtained by writing to the Transfer Section, Office of Admissions, 27 Memorial Dr. West, Lehigh University, Bethlehem, PA 18015 or by calling (610) 758-3100.

Students are encouraged to take an active role in seeing that the various parts of the student’s admission packet have arrived at the university. Decisions are made as soon as possible after the application is complete. Students will be notified by the Registrar as to how many credits Lehigh will grant to the student in advanced standing.

Housing: Transfer students entering with freshmen or sophomore standing are guaranteed housing. Although it is not possible to predict exactly how many housing spaces may be available at the start of any
given semester, every effort will be made to accommodate transfer students during their first year. Contact the Office of Residential Services, Rathbone Hall, Lehigh University, 63 University Drive, Bethlehem, PA 18015 or by calling (610) 758-3500. This office also can provide information about off campus housing. Fraternities and Sororities often have room for members or boarders. Information on this option may be obtained through the Dean of Students, Coordinator of Greek Affairs, University Center, 27 Trembley Drive, Lehigh University, Bethlehem, PA 18015 or by calling (610) 758-4157.

Advanced Placement

The university offers capable students who have superior preparation an opportunity for advanced placement and/or college credit. Many secondary schools, in association with the College Board, offer college-level work. Students participating in these courses should write the Advanced Placement Tests offered by the College Board.

Students who achieve advanced placement are afforded three major advantages. First, they commence study at Lehigh at a level at which they will be academically comfortable. Second, students who qualify for college credits may be graduated at an earlier time-with resulting savings in time and tuition outlay. Third, qualified students may, in the Lehigh senior year, enroll for a limited amount of work for graduate credit.

Entering freshmen who ask the College Board to send their advanced placement grades to Lehigh are considered for advanced placement.

Some departments noted below offer examinations during Freshman Orientation to students who studied college-level subjects in secondary school but did not write the advanced placement tests. Entering freshmen wishing to write an examination in any Lehigh course should notify the office of admission in writing prior to August 1. The student should specify the number and title of the course. Students who receive credit on the basis of advanced placement grades need not write Lehigh tests to confirm the credit granted.

Current practice at Lehigh is as follows:

**Art and Architecture.** Six credit hours for Art 1 and Art 2 are granted to students who earn a grade of 5. Three credit hours for Art 1 are granted to those students who earn a grade of 4. Those students who earn grades of 5 on the Advanced Placement Studio Art Examination receive three credit hours for Art 7.

**Biology.** Four credit hours for EES 31, Introduction to Environmental/Organismal Biology, are given to those who earn grades of 4 or 5.

**Chemistry.** Eight credit hours for Chem 21, Chem 22, and Chem 31 are granted to students who earn a grade of 5. Those students who earn a grade of 4, or who score 750 or higher on the chemistry achievement test, are granted five credit hours for Chem 21 and Chem 22 and may apply to the department for a special examination that, if completed successfully, will result in an additional three credit hours for Chem 31.

**Computer Science.** Students receive three semester credit hours for CSC 11 for a grade of 3. Those students who earn grades of 4 or 5 receive four credit hours for CSC 17 instead of CSC 11.

**Economics.** Students will receive four credit hours if each of the microeconomics and macroeconomics exams receive a score of 4 or better is awarded.

**English.** Advanced placement and six credit hours are given for freshman English to students who earn a grade of 5. Students who receive a grade of 4 or who have a score of 700 or higher on the verbal section of the Scholastic Assessments Test or the English Composition Subject Test receive three credit hours in freshman English; these students complete the six-hour requirement by taking an English course suggested by the department. Students who score between 650 and 699 on the SAT Verbal or English Composition examination, or who have received a grade of 3 on the advanced placement test may apply to the department for a special examination given during Freshman Orientation, which if completed successfully, will result in three hours of credit for Eng. 1.

**Government and Politics.** Three semester credit hours for Political Science 1 are given to students who earn grades of 4 or 5.

**History.** Students earning a grade of 5 in the American or European Advanced Placement examination will receive 8 credits; those who receive a grade of 4 will receive 4 credits. Students receiving advanced placement in American history may not receive credit for History 41, 42, or 43, but may register for a 100 level American history course as a freshman; students receiving advanced placement credit in European history may not receive credit for History 11 or 12, but may register for a 100 level European history course as a freshman.

Latin. Students receive three semester hours of credit for a grade of 4 or 5 in the Virgil examination; those who successfully write in more than one area (e.g. Virgil and lyric poetry) receive six hours of credit.

**Mathematics.** Four semester hours of credit for Math 21, Analytic Geometry and Calculus I, are granted to those who earn grades of 4 or higher on the Calculus AB examination. To those who earn a grade of 4 or higher on the Calculus BC examination, eight hours of credit are granted for Math 21 and Math 22, Analytic Geometry and Calculus I and II. Credit for Math 21 and 22 or both may also be earned by passing the examination offered by the Mathematics Department during Freshman Orientation. This examination may be taken by students regardless of whether they have taken the advanced placement examination or not.

**Modern foreign languages.** Students receive three semester hours of credit for grades of 4, and six hours of credit for grades of 5 on the advanced placement tests. Those who write the subject tests and score 600 and above receive three hours of credit; 700 and above receive six hours of credit. The maximum number of credits given is six and will be assigned intermediate level course credit in the appropriate language. Those students receiving grades of 4 or higher on the French or Spanish literature examinations will receive 3 credits for French or Spanish 151.

**Music.** Three semester hours of credit for Mus 20 are given to those students who earn a grade of 3 or higher on the Advanced Placement test in Music: Listening/Literature of Music: Theory.

**Physics.** Four hours of credit are given for Physics 11, Introductory Physics I, for a grade of 5 on the Physics B examination or a grade of 4 on the mechanics section of the Physics C examination. If a student receives credit for Physics II, four hours of credit will be given for Physics I, Introductory Physics II, for a grade of 4 on the electricity and magnetism section of the Physics C examination. If a student wishes to be considered for credit for Physics 12 or 22, Introductory Physics Laboratory I and II, he or she should see the chairperson of the physics department with evidence of laboratory experience. A test is offered during Freshman Orientation.

**Psychology.** Three credit hours of Psych 1 are granted to students who earn a grade of 4 or 5.

**International Baccalaureate.** Students who earn the international baccalaureate are granted credit in higher-level or advanced subjects with scores of 5 or better and will have their transcripts evaluated on an individual basis for specific course equivalency.

**Estimate of Expense for Undergraduates**

The operating expense of Lehigh University is supported principally by three areas of income: tuition and fees; endowment earnings, and gifts and grants. The university is conscious that educational costs are significant and strives to maintain a program of high quality instruction while recognizing that there are limitations on what families can afford to pay. Costs will vary somewhat from student to student depending upon the various options chosen.

**Tuition, Room, and Board**

There are three major plans that cover the major expense associated with university attendance. These are as follows:

**The tuition plan.** The university provides comprehensive academic and student services under its tuition plan. The tuition sum is inclusive of most athletic events, basic treatments in the Health Center, libraries, and laboratory services. An additional $250 fee is charged to all students enrolled in the College of Engineering and Applied Science or with a declared major in natural science. The full-time tuition rate is charged to students enrolled in twelve or more credit hours per semester. For students enrolled in less than twelve credit hours, tuition is charged on a per-credit-hour basis.
The residence halls plan. A variety of living arrangements are available. The university provides housing for 1,850 students on or near the campus in a wide selection of housing facilities. The housing arrangements are grouped within three basic categories, with rates associated with the category level. Students contracting for residence halls housing will be required to submit a $200 advance deposit. This deposit is credited toward the room charge for the respective semester. For entering freshmen, the deposit is not refundable if they make other plans. For upperclass students, the fee is either full or partially refundable based upon a published schedule.

The board plan. Eight board plans are available. Freshman residents are required to participate in one of the Category I Meal Plans. Upperclass students living in residence halls are required to participate in one of the Category I or II Meal Plans. Subscription to special program meals is required of Taylor Residential College members. Each day Centennial I sorority residents are required to participate in The Social Light Meal Plan or have the option to choose any of the Category I, II, or III Meal Plans. Students residing in campus apartments, fraternities, or any off-campus facilities have the option to choose any of the eight plans offered.

Each board plan includes South Mountain Gold Dining Dollars. This pre-paid declining balance account was designed for maximum flexibility and convenience and can be used at most dining locations on campus to further increase your purchasing options. Additional funds can be added to the South Mountain Gold account to increase the balance at any time.

Tuition and Fees
All charges and fees are due two weeks prior to the start of classes each semester. On a per-semester basis, the expenses are charged at one-half the per-year charge. Accounts not settled by the due date are subject to a late-payment fee. All figures given are for the academic year (two semesters).

Tuition, 1997-98 $21,350

Residence Halls
Category I (Dravo, Dinkler, Richards, McClintic-Marshall) $3,090
Category II (Centennial II, Warren Square) $3,480
Category III (Trembley Park, Brodhead House, Taylor College) $3,730

Board
The number of meals specified is per week. The amount included on South Mountain Gold is per semester.

Category I
The Whole Enchilada - 19 meals including $100 South Mtn. Gold $2,740
The Square Mealer - any 14 meals including $200 South Mtn. Gold $2,740
The Flexible Eater - any 12 meals including $300 South Mtn. Gold $2,740

Category II
The Deluxe Diner - any 10 meals including $100 South Mtn. Gold $2,450
The Dynamic Diner - any 8 meals including $400 South Mtn. Gold $2,450

Category III
The Value Plus - any 7 meals including $100 South Mtn. Gold $1,600
The Social Light - any 5 meals including $350 South Mtn. Gold $1,600

Category IV
The Express - any 50 meals per semester; $350 South Mtn. Gold $1,130

Other Fees (applied to prevailing circumstances)
Per credit charge for credit and audit $890
Engineering and Science Fee (for specified students) $250
Application fee (for undergraduate admission consideration) $50
Late preregistration $50
Late registration $50
Late application for degree $25
Examination make-up (after first scheduled make-up) $10
Late payment (after announced date) $50
Returned check fine $20
Key penalty (non-return), residence halls $10
Key duplicate, building door, residence halls $5
Access card duplicate, residence halls $10
Lost or non-return room key/lock change, residence halls $25
Identification card (replacement) $10

The university reserves the right at any time to amend or add charges and fees, as appropriate, to meet current requirements. Fees applicable to the 1998-99 academic year will be announced no later than January, 1998.

Other Expenses
A student should plan to meet various other expenses. These expenses include the purchase of books and supplies from the Lehigh University Bookstore located in Magillane Hall. Necessary purchases supporting one’s academic program should average approximately $500 per year. The bookstore carries basic goods for students’ needs. A student should also plan an allowance to handle personal and travel expenses.

Plan of Payments
An itemized statement of charges is mailed from the bursar’s office approximately six weeks prior to the start of each semester. Payment is expected in full by the specified due date. Payment plans are available for those desiring extended payment arrangements. Persons desiring a payment plan can elect participation in the university’s educational payment plan which provides for the payment of tuition, room, and board over ten months. You may also elect to participate in the Richard C. Knight Plans. The university also offers a plan under which enrolled undergraduate students can pre-pay more than one year of tuition at current rates. Complete information is available from the bursar’s office. Those persons desiring to use one of the plans must complete the necessary details no later than two weeks prior to the due date for payment.

Students attending the university under a provision with a state board of assistance or with financial aid from other outside agencies must provide complete information to the bursar’s office if assistance is to be recognized on the semester statement.

Refunds of Charges
Tuition refunds. A student in good standing who formally withdraws (within the first eight weeks of a semester) or reduces his or her course enrollment below twelve credit hours will be eligible for a tuition refund. The refund schedule for student withdrawals and course adjustments is as follows:

prior to the start of the semester 100%
during first calendar week 80%
during second calendar week 70%
during third calendar week 60%
during fourth calendar week 50%
during fifth calendar week 40%
during sixth calendar week 30%
during seventh calendar week 20%
during eighth calendar week 10%

The date used to calculate refunds is based on when a properly authorized withdrawal or drop/add is received by the Registrar’s Office. In the event of the death of a student, tuition will be refunded in proportion to the semester remaining.
Tuition Credit/Suspension. A student who is suspended from the university for disciplinary reasons will be eligible for a tuition credit toward the semester immediately following the period of suspension. The amount credited will be based on the regular tuition refund schedule and calculated on the tuition rate in effect during the period of suspension.

The date used to calculate the tuition credit will be the date of the incident that resulted in the suspension. Under no circumstances will a tuition refund be provided to students who are suspended for disciplinary reasons.

Summer Sessions. Students who preregister for a summer session by the end of April will receive an invoice for their tuition. Those who do not receive an invoice are expected to make payment at the time of registration. Registration will not be permitted until all charges are paid. Students in good standing who formally withdraw or reduce their course enrollment within the first four weeks of a summer term will be eligible for a tuition refund. The refund schedule for student withdrawals and course adjustments is as follows:

- Prior to first calendar week: 100%
- During first calendar week: 80%
- During second calendar week: 60%
- During third calendar week: 40%
- During fourth calendar week: 20%

The date used to calculate refunds is based on when a properly authorized withdrawal or drop/add is received by the Registrar's Office. Because of the short time involved, no refund for tuition charged in the one-week workshops will be made after the first day of class.

In the event of the death of a student, tuition will be refunded in proportion to the fraction of the summer term remaining at the time of the death.

Residence hall refunds. Residence hall rooms are rented on an annual basis only. A student who signs a room contract is expected to occupy a room for both the Fall and Spring Semesters of the specific academic year for which the contract was signed. A student who forfeits a room reservation in the Fall Semester and returns to the university in the Spring Semester is still obligated for room rental charges for the Spring Semester, if such facilities are available. An advance deposit of $200 is required to hold a room. This deposit is nonrefundable to entering freshmen and either full or partially refundable to upperclassmen students based upon specific criteria and a published refund schedule. Prior to registration, refunds are made in full in the event a student does not register because of illness, injury, or death, is dropped from the university due to academic reasons, attends a university approved study abroad or co-op program, graduates or voluntarily withdraws from the university. After registration, prorated refunds are granted based on separation from the university due to illness, injury, or death. In the event of voluntary withdrawal, a prorated refund is possible only with the provision that the lease can be transferred to another student for whom no other university accommodations exist. Prorated refunds are based upon the date the room keys are returned to the Office of Residential Services. Any student suspended or expelled from the university will not be granted any room refund.

Refunds for board plans. Board plan refunds are made in full in the event a student does not register for a specific semester and has not purchased any meals from the plan. Board Plan refunds after the start of the semester for students who register and/or purchase meals on a board plan but withdraw from the University will receive a board plan refund pro-rated on the number of unused weeks remaining on the plan. The Bursar's Office is to be notified of the withdrawal by the Dean of Students Office of Academic Support.

Board plans may be changed within the requirements of the living area up to the 10th day of class of each semester at the Bursar's Office with charges assessed per an established pro-rata schedule.

Students who wish to change outside of the required board plan or after the 10th day of class for a reason such as a medical condition must petition and receive approval from the Office of Residential Services. If such changes are approved, adjustments will be processed on a pro-rata basis as of the week following the last meal purchased.

Any student suspended or expelled from the University will not be granted a board plan refund. A student suspended may receive a prorated board plan credit based on the week following the last meal purchased which will be used toward the purchase of a board plan the semester immediately following the period of suspension. Such occurrences are to be documented by the Dean of Students Office of Academic Support and forwarded to the Bursar's Office or Office of Residential Services.

Adjustments to financial aid. The office of financial aid is responsible for determining the appropriate redistribution of charges and refunds when students are in receipt of financial assistance. These decisions are made on the basis of university, federal, and state agency regulations. Adjustment procedures, where financial assistance (including GSL and PLUS loans) is concerned, are on file in the office of financial aid.

Financial Aid

The University is deeply committed to providing need-based financial aid. Nearly 50% of our freshman classes now, and in the future, will receive financial aid awards.

Renewal of financial aid is based on continuing "need" and a minimum academic average of 2.00 (or as noted on the award notification). See below in section on Renewal of aid. Students are also expected to advance at a rate of at least 12 credits per semester.

Lehigh expects that all families of its students will make every effort to pay tuition and other educational expenses. The aid program is focused to measure the dollar difference between the cost of attendance and the amount of money the family can be expected to contribute towards that cost. That difference is called "financial need" and represents financial aid "eligibility." Most of Lehigh's funds are awarded on the basis of this "eligibility," the principal exceptions being explained below.

As noted, we currently enroll at least 50 percent of the freshman class with financial aid including university-funded scholarships ranging, according to need, from $500 to $25,500. An additional 5 percent will enroll with aid from sources other than Lehigh, including state and federal grants, ROTC scholarships, aid from private sources, and education loans.

The basic forms of financial aid are employment, repayable loans and "gift aid," which is a non-repayable form of aid that can be called either scholarship or grant. Employment provides money for books and personal expenses, and is paid through weekly paychecks as a student submits time sheets for hours worked. Loans are borrowed dollars, from one or more resources, that are repayable at low interest rates after the student ceases to be enrolled on at least a half-time basis.

Grants (or scholarships) are not repayable. Most are awarded on the basis of "need" and are renewable on the bases of both continuing "need" and some stated minimum academic advancement criteria.

Additional sources of aid are state agencies, employers, and various clubs, churches, religious and fraternal organizations, and foundations. High school guidance counselors are able to provide information on local aid programs. In addition, Lehigh provides, at no cost, access to the computer-based software called FundFinder, which operates on our Computing Center public site PCI's. (You can also access FundFinder through the world-wide web. http://www.collegeboard.org/fundfinder.) Students are expected to apply for all possible kinds of outside financial assistance, especially the Pell Grant and state grants. Students are expected to take maximum advantage of outside sources to enable Lehigh to spread its own funds further and to limit student borrowing.

Application Procedures have changed for 1998-99

The following instruction about filing for financial aid is addressed to prospective freshmen.

To be given proper consideration for financial aid, your application must be complete and ready for our review by February 15. That means you must start the application process several weeks earlier.
Start the process by registering for PROFILE. A short registration form, available in high school guidance offices, collects basic identifying information about you and asks you to list the colleges and programs from which you are seeking aid. You may also register by telephone. (In some high schools you can register via an electronic network like the College Board’s EXPAN.)

List Lehigh University #2365 on the College Scholarship Service (CSS) code list - when you register for PROFILE. That tells CSS you want to apply for aid from our institution. Complete the PROFILE registration process no later than January 5, 1998. That is the date by which we must have all financial aid applicants to have registered with CSS. (If you are applying to other colleges with even earlier deadlines than ours, give yourself at least four weeks before the earliest completion date specified by the colleges and programs on your list.)

Upon receipt of our registration CSS will send you a customized PROFILE packet. The packet contains the appropriate instructions and forms. Review the contents immediately to make sure you have everything you need. Complete the personalized PROFILE form as soon as possible and mail it so that it reaches CSS by February 1.

Within two to four weeks CSS will report to us and send an acknowledgment to you. By completing the form promptly, you ensure that your file is complete and ready to review prior to February 15. [Note: you may find you are forced to use estimates in completing your financial aid forms. Be as thorough as you can, but be sure to meet the filing deadline(s) so that your application is not considered late. Your family’s tax return(s) will be used to correct any inaccuracies in the reporting of income.]

Special note to Early Decision Candidates: Lehigh University communicates to early decision candidates within ten days of the Office of Admission’s notification. You should register for PROFILE by October 15 (or as soon thereafter as possible) if you are applying for admission under the Early Decision I calendar.

Your customized CSS/Financial Aid PROFILE Application packet may contain supplements that should be completed and returned directly to the financial aid office. If your parents are divorced or separated, and/or if your family owns a farm or business, Lehigh University needs to you to complete the appropriate supplement and mail it directly to the financial aid office. (If your packet doesn’t contain any additional supplements, that probably means you do not need them. If you have questions, call the office of financial aid.)

If you are a citizen of the United States or an eligible non-citizen, Lehigh University expects you to apply for federal student aid. To be considered for federal student aid, including Federal Pell Grants and Federal Stafford Loans, you must complete the Free Application for Federal Student Aid (FAFSA). FAFSAs are available from your high school. You may complete and submit this form any time after January 1, 1997, but we recommend that you complete it no later than February 1, 1997. The Lehigh University federal code, to be entered on the FAFSA, is 00289.

International students are being considered for university-funded financial aid beginning with the freshman class entering in the fall of 1997. Opportunities are limited. We require two forms: the Foreign Student Financial Aid Application and the Certificate of Finances. Both forms will be sent by the Office of Admission upon receipt of a completed application for admission.

Renewal of aid. It is necessary to reapply for financial aid for each year of study. Applications and filing instructions are available in mid-February in the Office of Financial Aid, or as otherwise posted.

As a returning student, you must file the Renewal FAFSA with the federal processor by April 15. (This form will be mailed to your permanent home address sometime during the month of December or January.) If you had received Lehigh-funded, need-based financial aid in 1997-98, we will register you for the CSS/PROFILE service. The customized CSS/Financial Aid PROFILE Application, together with other needed university forms, will be made available to you prior to the beginning of the spring semester. The filing deadline for all forms, including signed copies of both your parent’s and your 1997 IRS 1040, is April 15. Upperclass applications are not reviewed until the FAFSA, PROFILE, Lehigh application and income tax forms are received.

In addition, to receive any type of aid a student must make satisfactory academic progress each year. By this reference to satisfactory progress, we are referring to the policy that meets the compliance requirements of federal and state agencies providing financial aid, as well as that of Lehigh. The written university policy on satisfactory academic progress is available in the office of financial aid. Generally speaking, that includes (1) remaining in good standing, (2) advancing a minimum of 24 credits per academic year, and (3) keeping pace with your class in terms of the cumulative number of credit hours passed. This is dependent upon your academic program and means that you must progress regularly (i.e., FRI, FR2, SO1, etc.). The table governing minimum credits for advancement is available in the offices of the Registrar and Financial Aid. Recipients of Lehigh grants and scholarships are expected to achieve at least a 2.0 each semester (or, if a higher GPA is required, as noted on the financial aid notification).

Students on academic or disciplinary probation are ineligible for university scholarship aid during the period of their probation. Students not maintaining satisfactory progress, as defined by Lehigh or an appropriate governmental agency, are ineligible for all forms of federal aid, including loans and employment. Appeals based on extenuating circumstances may be submitted to the Committee on Undergraduate Financial Aid.

Eligibility for financial aid is determined by calculating the amount a family can contribute to the cost of attendance based on income, assets, family size, number in college, and other factors. The expected contribution is then subtracted from the cost of attendance to arrive at the “financial need.”

In general, a student might be expected to have some need when the family’s annual income and number of tax dependents (usually children) are as follows:

- with one child at home: $70,000
- with two children at home: $77,000
- with three children at home: $85,000
- with four children at home: $95,000

The figures above are for income before taxes and deductions, allowing for normal savings and home equity, with one child attending college. When more than one child is in college, the likelihood of financial aid is increased. Families with incomes as high as $125,000 are able to establish financial need if, for example, they have three children, all enrolled in independent universities comparable to Lehigh.

Sources of University Aid

Several forms of university-funded aid, based on need and merit, are available.

Lehigh University grants. Funds are budgeted from general income to provide awards covering the tuition charges in whole or in part.

Sponsored scholarships. Individuals, foundations, and corporations provide these funds through annual contributions to the university. Lehigh has 190 such sponsors, with awards ranging from $300 to full tuition.

Endowed scholarships. Income from invested gifts to the university makes these scholarships possible. The university has over 300 such funds, half of which are for general, unrestricted use. Most of the others are restricted by curriculum or geographic criteria.

Geographic Restrictions: Pennsylvania, New Jersey, Delaware, Maryland, Ohio, Massachusetts, Virginia, Colorado, Texas, Georgia, North Carolina, Tennessee, Missouri, Kansas, Richmond, VA, Kansas City, MO, Jackson County, MO, Johnson County, KS, Hammon, NJ, Allentown, PA, York County, PA, New York City, NY, Baltimore, MD, Western, PA.

College of Arts and sciences: Geology and Geological Science, Premedical Science, Journalism and Science Writing.

College of Business and Economics: Accounting, marketing, economics.


Miscellaneous: Musicians (brass instruments), Gryphons; employees of U.S. Steel, Milton Roy Sheen, and Alperin Co.; members of certain fraternities.
Dean's scholarships. Lehigh began, with the Class of 1999, to offer merit awards, called Dean's Scholarships. To the Class of 2002, approximately 100 scholarships will be awarded in the annual amount of $7,000. Selections are made by the Office of Admission based on academic excellence and significant extracurricular and leadership activities.

Merit scholarships. Lehigh is a collegiate sponsor of the National Merit Scholarship program. Scholarships ranging from $750 to $2,000 per year may be awarded to Merit finalists selecting Lehigh as their first-choice college, and who are not also receiving another form of National Merit scholarship.

Athletic awards. Alumni Student Grants (ASG) are awarded on the basis of financial need and exceptional athletic talent as evaluated by the department of intercollegiate athletics. Grants are supported by annual alumni contributions. ASG recipients file the PROFILE and FAFSA annually to determine the amount of their grant eligibility. In addition, there are a number of restricted endowed funds for use with intercollegiate sports participants. Alumni Student Grants replace the loan and employment portion of a financial aid package.

University tuition loans. Parental endorsement is required on the promissory note. Repayment begins three months after graduation or withdrawal from the university, until the loan principal and interest are repaid. The minimum monthly repayment rate is $50 plus interest, which is 7 percent per annum, accruing only during the repayment period. Deferment is available for students who return to school at least half-time. Other deferments are available for students who are in the military, VISTA, or Peace Corps, up to a maximum of three years; or those who are experiencing undue hardship.

Lehigh maintains these loan funds to be used to supplement or replace other types of educational loans. The guiding factor in awarding university loans is that the combination of loans (federal, state, and institutional) shall not exceed one-half the cumulative tuition to be paid through the award period. If, for example, the total tuition over four years amounted to $72,000, a university loan would not be offered if total borrowing exceeded $36,000. In reality, the average four-year debt level of Lehigh aid recipients is less than $15,000.

Loan-cancellation awards. This unique Lehigh award is used as an aid alternative for a student whose academic average is not sufficiently competitive for scholarship consideration. L-C begins as a loan, with the same terms as a regular University Tuition Loan. This award has the potential of being converted to a grant if the conditions are met: (1) achieve the required grade point average for the award period as shown on the award notification; (2) pass 12 or more credits per award term, of which no more than four (4) credits (of the first 12 credits) may be from courses for which a grade was previously received. Any additional courses (above the 12 credits) may also be repeated courses; and (3) have no outstanding X or N grades. Any X or N grades must be removed prior to the end of the next semester and is the responsibility of the student to notify the Office of Financial Aid when all courses have been completed. If not canceled, the loan is repayable according to the terms for university tuition loans.

President's Scholars Program. This program provides an opportunity to receive tuition remission for a period of up to twelve (12) months immediately following the awarding of the baccalaureate degree. A student may be declared a President's Scholar if, upon completion of 90 Lehigh credit hours, he or she has a cumulative Grade Point Average of 3.50 or higher at the end of any full-time fall or spring or full-time summer term (minimum 12 credit hours), or receives a Lehigh baccalaureate degree with High Honors or Highest Honors.

Availability of jobs

Students may receive an employment allocation as part of their aid package. Pay rates range from the federal minimum wage to $6.00 per hour. Jobs are available throughout the university, and are funded through federal and university sources.

Earnings from employment, other than work-study/work opportunity, will be included as “income” in calculating financial aid eligibility for the next year;

Aid from the government

Lehigh University is an eligible participant in the following federally-funded student aid programs.

- Federal Work-Study
- Federal Supplemental Educational Opportunity Grants
- Federal Perkins Loans
- Parent Loan for Undergraduate Students (PLUS)

Details on these programs are available through the financial aid office. Particulars on the loan programs are available from participating lenders.

ROTC scholarships. The U.S. Army awards scholarships in varying amounts, supplemented with $450 toward course-related books and a $150 per month stipend. Scholarships are also available after the freshman year. Recipients incur an obligation to serve on active duty as commissioned officers. Contact the Department of Military Science for details.

For Federal Stafford Loans, subsidized and unsubsidized, and Federal PLUS Loans, Lehigh University can provide a list of preferred lenders and arrange to have applications made available. Our preferred lender for these programs is College Credit, a part of the College Board, whose loan terms are the most competitive available.

Commercial loan programs proliferate. The Office of Financial Aid can provide a list of these programs with current interest rates and terms and conditions of repayment.

Checklist for Financial Aid

1. For prospective freshmen, the PROFILE customized packet must be received by CSS on or before February 1 to be considered on time. Use CSS college code 2365 in requesting that your information be sent to Lehigh. Returning students must file by April 15.

2. The Free Application for Federal Student Aid (federal code 003289) must be received by the federal processor on or before February 1 for freshmen to be considered on time. (Returning students file the Renewal FAFSA by April 15.)

3. For returning students, submit the Lehigh application for undergraduate financial aid. Be sure to complete all questions.

4. Submit the appropriate state grant application, especially if you are a resident of Ohio, Massachusetts, Connecticut, Rhode Island, Maryland, Delaware, Vermont, or West Virginia—states from which our students have brought scholarships. Be guided by the specific instructions for your state. The FAFSA will be the basic form for state grant consideration, but many states do require supplemental applications.

5. Submit signed copies of the 1997 IRS form 1040, including all pages, schedules and W-2s filed by you and your parent(s). Non-filer’s statements; for those not required to file a 1040, are available from the Office of Financial Aid.

6. Check to be sure your social security number is correctly listed on all forms. If you do not have a number, apply for one and notify Lehigh as soon as it is received.

7. For your records, photocopy all forms filed for financial aid purposes.

8. Transfers students: You, too, must file a FAFSA and PROFILE, together with the Lehigh Transfer Student application, to be considered
for university-funded aid. File as close to March 1 as possible. Transfer reviews are completed after decisions are made for the freshman class (normally soon after May 1). The federal government requires of all colleges, universities, and graduate schools that we verify previous federal borrowing and determine that there is not a refund due the government for an award off federal funds. To do this, we will check your Student Aid Report (SAR) for data provided through the National Student Loan Data Service (NSLDS). If that service does not have that information on file, for whatever reason, we will ask you to have your previous college(s) complete and forward the Financial Aid Transcript.

**Student Rights**

You have the right to know

- The cost of attendance
- The refund policy for students who withdraw
- The financial assistance available from federal, state and institutional sources
- Procedures and deadlines for submitting applications for financial aid
- How financial aid recipients are selected
- How your eligibility was determined, including all resources the aid office considered available to you
- How and when funds will be disbursed to you
- An explanation of each type of award you receive
- For any student loan you receive: the interest rate, total amount you must repay, when your repayments begin, the length of your repayment period, and the cancellation or deferment provisions of your loan
- For any Federal Work-Study or university-funded job: a description of the job, the hours you must work, the rate of pay, and how and when you will be paid
- The criteria used to determine satisfactory academic progress for financial aid purposes
- How to appeal a decision by the office of financial aid concerning your aid award.

**Student Responsibilities**

It is your responsibility to

- Read directions thoroughly, complete all application forms accurately, and to comply with any deadlines
- Provide any supplemental information or documentation required by the office of financial aid or other agency if applicable
- Read, understand, and keep copies of any forms you are required to sign
- Repay any student loans you may receive
- Attend an entrance interview and an exit interview if you receive federal, state or University loans while in attendance at Lehigh
- Notify the office of financial aid of any change in your enrollment status or financial status (including any scholarships or grants received from outside sources). Changes of address and enrollment status must also be reported to your lender if you have a loan
- Satisfactorily perform the work agreed upon in a Federal Work-Study or university-funded work program
- Know and comply with all requirements for continuation of financial aid, including satisfactory academic progress requirements

**Campus Life**

Approximately 70 percent of all undergraduate men and women live on campus. Campus living facilities include traditional residence halls, apartments, suites in a multi-story building, or residence in fraternity or sorority houses. Physical facilities are also described in Section VI.

**Residence Halls**

The offices of Residential Life and Residential Services at Lehigh University are committed to providing quality housing and educational services to its resident students. Lehigh firmly believes that living in a residence hall allows students to become members of a special community, offering the opportunity to live with and learn from a diverse group of people. Efforts are made to integrate academic and out-of-the-class learning in order to enable students to develop a balanced and realistic approach to life after they leave the university.

More than half of Lehigh undergraduates live in university residence halls. The university has nine principal residence halls for undergraduate men and women. Most rooms are designed for two students, but a limited number of singles, triples, and 4-person suite, and apartment units, are available. Residence halls offer a wide variety of special live-in programs including: Taylor Residential College, ROTC House, Wellness House, Creative Arts House, Umoja House (African-American/Hispanic Cultural), traditional-style living (in buildings with corridors), and suite/apartment-style living.

To help facilitate and maximize a student’s residence experience, approximately eighty staff members of the office of residence life live in the residence halls. On every hall there is a student staff member, a Gryphon, who provides assistance in personal and academic matters, refers students to other offices where appropriate, helps mediate conflicts, and develops educational, social, and recreational programs. In addition to the student staff, six professional Residence Life Coordinators live in the residence halls thus providing additional resources for students.

In every residence hall there are also House Councils that are part of the larger Residence Hall Association. Participation in the Residence Hall Council provides a chance to develop leadership, programming, human relations, and budgeting skills. It is a vital and active organization whose prime focus is to help fund residence hall programs, to assess students’ opinions on issues affecting them, and to develop many service-oriented programs to aid resident students in their stay on campus.

Currently, the demand for upperclass campus housing is competitive with all freshmen and sophomores guaranteed housing on campus. The Office of Residential Services uses a lottery to provide for fair and equitable distribution of available housing among upperclass students. The lottery is scheduled early in the spring semester. Those students who are guaranteed housing pay a $200 deposit to hold the space for the following academic year.

When a candidate accepts an offer of admission to the freshman class, the candidate is sent a Room and Board Application-Contract. Those desiring accommodation in the residence halls must return this application-contract promptly. A nonrefundable advance deposit of $200 must accompany the application and will be credited to the fall semester room charges. Priority for assignment is based on the date the candidate accepts admission. Normally, freshmen are informed of their room assignment and other information in early July by the Office of Residential Services.

**Fraternities and Sororities**

The university has one of the strongest Greek systems in the nation. The continued strength of this system is due in part to the efforts of the Interfraternity Council, Panhellenic Council, the Greek Alumni Council, the Office of Residential Services, the Office of the Dean of Students, and the Fraternity Management Association to improve the quality of fraternity and sorority life through membership, leadership, social, educational, housing, and financial management training.

Greek life is an attractive alternative among the residence options at Lehigh. Each fraternity or sorority is a relatively small, close-knit community. These groups have their own houses and business affairs with the assistance of the Office of Residential Services and the FMA, conduct their own social, philanthropic, and athletic activities, plan their own meals, and select their own membership. Because they are largely self-governing, these organizations offer numerous opportunities for student involvement and leadership.

The twenty-nine fraternities and seven sororities form a larger Greek community comprising approximately 45 percent of the undergraduate population at Lehigh. Through the Interfraternity Council (I.F.C.) and Panhellenic, they determine policies and organize social, philanthropic, and educational activities for the Greek community as a whole.
There are seven sorority chapters at Lehigh. Six are housed in the Centennial I complex on the South Mountain Campus and one is located in Sayre Park. The sororities are Alpha Chi Omega, Alpha Gamma Delta, Alpha Omicron Pi, Alpha Phi, Delta Gamma, Gamma Phi Beta, Kappa Alpha Theta. Pi Beta Phi will be joining our Greek system during the 1997-98 academic year and become our eighth sorority. Twenty-six of the fraternities are located on campus in Sayre Park. The remainder are located near the campus. The fraternities are Alpha Chi Rho, Alpha Sigma Phi, Alpha Tau Omega, Beta Theta Pi, Chi Phi, Chi Psi, Delta Chi, Delta Phi, Delta Sigma Phi, Delta Tau Delta, Delta Upsilon, Kappa Alpha, Kappa Sigma, Lambda Chi Alpha, Phi Delta Theta, Phi Gamma Delta, Phi Kappa Theta, Phi Sigma Kappa, Pi Kappa Alpha, Psi Upsilon, Sigma Alpha Mu, Sigma Chi, Sigma Nu, Sigma Phi, Sigma Phi Upsilon, Theta Chi, Theta Delta Chi, Theta Xi, and Zeta Psi.

The University Forum Steering Committee
The Lehigh University Forum Steering Committee is a unique deliberative body whose purpose is to promote the welfare of the university and attainment of a true sense of community by bringing into discourse students, faculty, and administration. A restructuring process, completed in 1996, resulted in a simplified Forum structure consisting of students (undergraduate and graduate), faculty and staff/administration. This body, University Forum Steering Committee, provides the opportunity for valuable interaction and communication among these groups. Responsibilities, such as selecting student representatives to the Board of Trustees and to certain faculty committees, previously carried out by the Forum are now the province of Student Senate or the Graduate Student Council.

Religious Activities
The Religious Program is under the general supervision of Lehigh's chaplain. The chaplain participates in the religious life of the University and conducts special university worship services throughout the year. All worship services are interdenominational, with some being inter-religious. Roman Catholic masses are held regularly. The Newman Center can be contacted for a schedule of services.
Lehigh University is non-denominational. Packer Memorial Church, dedicated in 1887 in honor of the University's founder, Asa Packer, continues to be the center for campus worship services.
The University Chaplain works with representatives of campus religious groups of all faiths and assists students in planning religious life programming. The chaplain's office sponsors an Oxfam Fast in November, organized the original Community Service Desk that helps coordinate volunteer services on campus, and creates opportunities for discussion of moral and spiritual issues through the Chaplain's Forum. In addition to providing pastoral counseling, supporting religious groups, and helping bring speakers to campus, the chaplain seeks to provide leadership to the university on religious and ethical issues.
Over fifteen religious groups on campus provide opportunities for religious fellowship. The groups include the Newman Association for Roman Catholic students under the guidance of a resident priest; the Jewish Student Center, which sponsors various activities for Jewish students; and organizations for Hindu and Moslem students. A variety of Protestant Christian organizations are available to students, including the Lehigh Christian Fellowship, Navigators, and the Fellowship of Christian Athletes.
The chaplain's office makes information about religious life available to all students in the Fall and can be contacted at any time for information about worship opportunities and religious activities either on campus or in the local Bethlehem community.

Student Organizations
Lehigh offers a wide field of extracurricular activities and student organizations. There is a campus radio station, a twice-weekly student-run newspaper, a dramatic club, musical organizations, and many other opportunities for participation. Course societies promote intellectual interest in various fields of study and develop professional spirit among students.

Interest and hobby groups include art, dance, band, chess, cultural groups, computer, language, rugby, sailing, skiing, bowling. Tae Kwan Do, crew, political clubs, fencing, and volleyball. These are described in the Lehigh Handbook which is distributed to all students.
Many students also are elected to honorary societies and others join course societies.

Lehigh University Theatre
In Spring, 1997, the department of theatre moved to the Zoellner Arts Center, Lehigh's impressive new performing arts facility. Three theatres, scene and costume shops, a dance studio, music practice rooms, classrooms and more enhance the department's curriculum and curricular activities. The department of theatre's annual production program includes four mainstage productions, now produced in the three hundred seat Diamond Theatre and four or more lab productions in the one hundred seat Black Box Theatre. The plays range from classics to world premieres and recent mainstage seasons have included The Comedy of Errors, Spunk, The Rivals, Identity Crisis, Dutchman, Black Comedy When We Dead Awaken and Jacques Brel is Alive and Well and Living in Paris.
Shows directed and produced by students as class projects or independent work occur regularly in the Black Box Theatre. Recent lab theatre productions have included The Proposal, Wine in the Wilderness, Am I Blue, Pinter's Revue Sketches, The Zoo Story, Sure Thing, The Author's Voice and readings of two student-written plays, Sylvester and Bob and Jim. Many events are sponsored by the Mustard and Cheese Drama Society, the country's second oldest drama club.
Auditions and production crews are open to all members of the university community. Production opportunities exist in performance, choreography, set and costume construction, properties management, lighting, sound, house management and publicity. Advanced students have opportunities to direct or design, under faculty supervision.
Outstanding work in the mainstage or lab theatre seasons may be recognized with Williams Prizes and Theatre Department prizes in acting, directing, design, and technical production.
Professional guest artists - directors, playwrights, designers, and actors - frequently visit the Lehigh campus to work on mainstage productions, teach classes, and conduct seminars and workshops for all interested students. The department also sponsors artists-in-residence, guest lecturers, workshops, and touring performances. Recent guests have included Roscoe Lee Brown, Anthony Zerbe, Edward Albee, Touchstone Theatre Ensemble, Jay O'Callahan and Pilobolus Dance Company.

Musical Organizations
The university sponsors both a variety of student musical organizations that give performances on and off campus and several professional concert series which bring visiting artists to the campus. The choruses, bands, orchestra, and ensembles are conducted by members of the faculty and managed by elected student leaders. Nearly all performances, except Christmas Vespers, are held in Baker Hall in the new Zoellner Arts Center. Choral Arts is comprised of three choral organizations: University Choir, Overtones and Choral Union. The University Choir tours regularly—recent trips have taken the choir to France, Canada, Germany, Puerto Rico, the Virgin Islands, Washington, D.C., California and Florida—in addition to performing several traditional concerts on campus including Christmas Vespers. The Overtones is a select small group performing jazz and popular arrangements that performs in a variety of settings each year. The Choral Union, formed in 1985, performs major works with orchestra. It is open to all students, faculty, and staff as well as members of the community.
The newly formed Lehigh University Philharmonic has already won a large following for its performances; this group also tours. A strong program of chamber music ensembles has emerged, including groups of string, brass, woodwind, percussion and mixed instruments. A variety of performing opportunities exists for these players.
Another recently formed program is the Scenes from Opera and Musical Theatre, which receives short segments to be performed in full costume with lights and some stage setting. The department plans to do a full-length musical in 97-98.
The Jazz Ensemble plays concerts on campus, at festivals, and frequently tours in the spring. The Jazz Band performs jointly with the Jazz Ensemble and on the final Concert Band concert.

The Lehigh University Very Modern Ensemble (LUVME) combines students, faculty, and professional musicians who perform the music of the 20th Century. LUVMO also sponsors concerts of music by Lehigh student composers and annually brings a composer of national reputation to campus in order to discuss and play his/her music.

The Wind Ensemble plays several concerts on campus during the spring and often tours (Florida, Montreal, New Orleans, Boston, San Francisco, Bermuda, etc.). The Concert Band, which performs on campus in the spring, is open to students, faculty, and staff as well as members of the community.

The “Spartan” marching band is widely known for its imaginative and spirited performances on the gridiron and in the stands in support of the Lehigh football team. Pregame and halftime performances are precision drills with a varied repertoire from classical music to traditional fight songs. Nine students serve in executive positions.

Private instrumental and vocal lessons with instructors approved by the music department are open to all students. The cost of lessons is in addition to tuition expense. Students have the opportunity to perform in noon recitals or in a senior recital.

Volunteer and Community Services

Lehigh’s Community Service Center, located in the Ulrich Student Center, is an information center for students, faculty, staff, student organizations and Greek letter groups who are interested in volunteering in the community. The Center is staffed by work-study students who serve as Community Service Assistants, and is overseen by Lehigh’s Community Service Coordinator, a member of the Dean of Students Office.

Typically, well over half of the student body participates each year in volunteer efforts in the Lehigh Valley area in a range of service programs. The projects include tutoring programs in local schools, Adopt-a-Grandparent, work in local hospitals, or affiliation with groups such as Big Brothers/Big Sisters, Boy’s and Girl’s Club of Bethlehem and Special Olympics. Students travel over Spring Break to work on housing projects in flood damaged and poverty stricken regions. Service learning courses are being integrated into the Lehigh curriculum.

Part of the Lehigh experience is getting involved. If you want to help in the community, contact the Community Service Center at 758-4583, the Community Service Coordinator at 758-5445, or check out the volunteer opportunities on the Lehigh network.

Guest Speakers

Students have the opportunity to hear a wide variety of notable speakers. The speeches are offered free of charge. Many of the speakers appear under the auspices of the Visiting Lecturers Committee.

Committees with access to special funds and academic departments regularly offer presentations by scholars from various disciplines. In addition to delivering a formal address, the speakers are often invited for brief residencies to provide opportunities for more informal interaction with students.

Among those to visit the campus have been attorney F. Lee Bailey, Lee Iacocca, philosopher Derek Parfit, General Colin Powell, South Africa’s Bishop Desmond Tutu, and novelist John Irving. Thomas Armstrong, director of the Whitney Museum, spoke with students during a week-long residency. An Engineering Expo with speakers representing many prominent industries featured Peter Bridenbaugh, vice president of science and technology, Alcoa. From art to engineering, the campus stays in touch with current issues, trends, and movements through its many and varied speaker series.

Athletic Opportunities

Students can participate in many intercollegiate, recreation, and intramural athletic programs.

Intercollegiate, varsity-level sports include the following: FALL: football, men’s and women’s cross-country, men’s and women’s soccer, women’s field hockey, women’s volleyball and men’s and women’s tennis. WINTER: Men’s and women’s basketball, wrestling, men’s and women’s indoor track and men’s and women’s swimming. SPRING: Baseball, tennis, golf, men’s and women’s outdoor track, men’s and women’s lacrosse and softball.

Athletic facilities are located in Taylor Gymnasium and Grace Hall and on the Murray H. Goodman campus, which is located one and one-half miles south of the main campus. The 500-acre Goodman athletic complex includes Stabler Arena, which seats 6,000 and hosts all Lehigh basketball games and several wrestling matches. The campus also includes the Philip Rasch Field House, which includes a one-eighth-mile track and indoor tennis and basketball courts. Goodman Stadium is a 16,000-seat stadium for football, soccer and lacrosse. The four-court Lewis Indoor Tennis Center was completed in 1994. Other facilities on the campus include a championship cross-country course, baseball and softball fields, indoor squash courts, outdoor tennis courts, lacrosse and field hockey fields, and a new all-weather, nine-lane, outdoor 400-meter track.

Lehigh is affiliated with the National Collegiate Athletic Association (NCAA), the Patriot League and the Eastern Intercollegiate Wrestling Association (EIWA). Lehigh frequently hosts collegiate championship events in men’s and women’s sports and is the summer training camp facility of the Philadelphia Eagles.

Intramural/Club Sports

The department of intramural sports supervises some 25 intramural sports. The aim is to ensure the health and physical development of students.

Through its program of intramural sports, the university endeavors to maintain among its students a high degree of physical fitness, to establish habits of regular and healthful exercise, to foster the development of such valuable byproducts as self-confidence, good sportsmanship, and a spirit of cooperation, and to provide each student with ample opportunity for acquiring an adequate degree of skill in sports of the type in which participation can be continued after graduation.

On a club level, there are from 24 common-interest groups ranging from equestrian to frisee and floor hockey. Several club level teams compete with other colleges on a regular basis (crew, rugby, ice hockey, bowling, volleyball, etc.) Students are encouraged to pursue their special interests.

Good Citizenship

The university exists for the transmission of knowledge, the pursuit of truth, the development of students, and the general well-being of society. Free inquiry and free expression are indispensable to the attainment of these goals. All members of the academic community are encouraged to develop the capacity for critical judgment and to engage in a sustained and independent search for truth.

Out of concern for individuality and respect for the privacy of all persons, the university does not impose a common morality on its members. Institutional existence, however, is a privilege granted by public trust, subject to the sanctions and responsibilities defined by the society of which the university is a part.

Furthermore, society generally provides legal canons, ethical mores, and conduct expectations pertaining to individual and collective behavior. Thus, the university has the obligation to establish standards of conduct appropriate and applicable to the university community.

Lehigh accepts its responsibility as an institution within the broader social community. The standards of behavior expected of its members are those that the university regards as essential to its educational objectives and to community living.

Lehigh relies primarily on general principles and statements of expectation for standards of conduct and assumes that those admitted
to the university community are capable of accepting that responsibility. Specific regulations are kept to a reasonable minimum and are published in the *Lehigh Student Handbook*. Students are responsible for knowing the procedures, rules and regulations as published in the *Handbook*.

In accordance with these purposes and objectives, disciplinary action will be taken when necessary to protect the academic integrity of the university and the welfare of its members.

All members of the university community are subject to municipal, state, and federal laws. The university is not a sanctuary for persons who violate these laws. Lehigh is concerned, however, about the rights of students as citizens and will direct them to legal counsel when necessary. Off-campus misconduct may be the basis for disciplinary action.

Further, the university as a part of the community has an obligation to report serious crimes to civil authorities.

**Policy on Dissent**

The university faculty has a policy on dissent that emphasizes the responsibility of all members of the university community. The guidelines adopted broadly set forth the following acceptable forms of dissent on campus:

1. Free inquiry and free expression, including the right to open dissent, are indispensable in achieving the goals of an academic community.

2. Coercive activities employed by individuals or groups either to repress legitimate dissent or to demonstrate dissent are a threat to the openness of the academic community and will be dealt with as an extremely serious matter.

3. Where physical coercion is employed or physical obstruction persists and the university is prevented from resolving the matter through its established disciplinary procedures, legal sanctions will be employed.

This statement provides that orderly and peaceful demonstrations on campus are not forbidden unless they interfere with legitimate university functions. The authority for making the initial judgment in determining the permissible limits of protest rests with the president and counsel of an advisory committee consisting of four faculty members and four students.

Conduct that exceeds permissible limits will be met with university sanctions ranging in severity from admonition to expulsion, or in cases of aggravated or persistent violation of defined rights, with civil arrest and prosecution under an appropriate charge. Prime authority for discipline rests with the faculty and the university committee on discipline.
II. University Resources

A student enrolled at an institution of the size and tradition of Lehigh can draw upon many resources to enhance the educational experience. These range from classrooms and laboratories with modern equipment to expert faculty members and extensive library collections. Indeed, University's 1,600 acres comprising its three Bethlehem classes are a special resource, providing a beautiful environment for learning. Following are descriptions of various resources related to academic programs.

Information Resources

The exponential growth and increasing sophistication of information technology offer new and exciting opportunities for enhanced teaching, learning, and research. At the same time these changes blur traditional boundaries between previously distinct academic functions such as library reference and computer consulting services. At Lehigh University, an organization called Information Resources (IR) delivers communications, computing, library, and media services. This new organizational structure initiated in 1996 is designed to capitalize on these new opportunities. IR services are provided by cross-functional teams organized to support each of the major disciplines and courses of study with the most advanced technology and the most appropriate scholarly resources. These teams facilitate an integrated approach to computing, information retrieval, and the use of instructional technology. Additional information about Information Resources, its mission, its organizational structure, and its staff can be found on the IR home page at http://www.lehigh.edu/~irui/irmain.html.

Libraries

Two major facilities, the Fairchild-Martindale Library and the Linderman Library, house the university collection of more than one million volumes. The Fairchild-Martindale Library, which opened in 1985, contains books, journals, newspapers, audio-visual resources, and microform collections in all branches of science, engineering, mathematics, and the social sciences, including business and education. Subscriptions to more than 7,000 journals and serials allow the university to compete successfully with many larger institutions in supporting scholarly research. A government depository since the 19th century, the Fairchild-Martindale Library also holds more than 550,000 federal, Pennsylvania, and United Nations documents, as well as a large collection of technical reports from governmental agencies.

The historic Linderman Library with its stained glass dome, spiral staircase, and gothic detailing evokes the classic collegiate atmosphere of the late nineteenth century. Appropriately, it houses books and journals in the humanities and Lehigh's impressive collection of rare books. A complete volume set of the original four volumes of James Audubon's Birds of America enhances studies in biology, botany, art, and publishing history. In the elegant Bayer Gallery of Rare Books students can examine original editions of important works in science and technology such as Darwin's Origin of Species. Other strengths of these Special Collections, numbering some 25,000 volumes, are travel and voyages, 19th century bridge construction, and English and American literature. University archives and papers of several Lehigh Valley congressmen are also among the holdings. In contrast, an up-to-date leisure reading collection located in Linderman Library invites students to enjoy a break from class work.

The "virtual electronic library" at Lehigh is just as important as the print-based one. Lehigh has available a full range of electronic indexes, reference works, full text databases, and online databases, all of which are accessible to Lehigh students from any computer on campus (including those in the residence facilities) or off campus via modem. A single Web-based interface allows the student to move seamlessly from Lehigh's own online catalog (named ASA after Lehigh founder Asa Packer) to databases of citations, abstracts, articles or book reviews to the full text of some of these resources. The Lehigh virtual library also identifies for students the most important scholarly and governmental Web sites and provides easy access to these sites and to collections in other libraries, throughout Pennsylvania and around the world. Direct borrowing from other academic libraries in the Lehigh Valley and, through interlibrary loan, use of collections throughout the country is provided.

Networking and Voice Communications

Lehigh University is a "wired" campus in every sense of the word. A high speed fiber optic backbone network ties together all major classroom and administrative buildings, the libraries and the computing center, the new Zoeller Center for the Performing Arts, and all undergraduate student residences, including fraternities and sororities. This same extensive wiring plant and associated networking hardware and software connect the university to the global resources of the World Wide Web. Electronic communication is a way of life for students, faculty, and staff at Lehigh. Student computer use in the residences is supported by the World-Wide Information Resources in Every Dorm (WIRED) program described under Residence-based Services. Many students take advantage of this program to connect their microcomputers to the campus system via the high speed backbone. A sophisticated digital telephone system managed by Information Resources supplies telephone, voice-mail, and some ancillary data services to the entire campus, including residence facilities.

Computing

Information Resources provides computing services to all university departments and research centers, serving the needs of students, faculty, and administrative users. A wide variety of computing facilities are available: a centralized site, many decentralized computing sites with workstations or microcomputers, computer classrooms, computer-equipped lecture rooms, and related printing and plotting devices. Information Resources offers the latest technology to all students and faculty across the entire campus.

The central computing facility is in the Fairchild-Martindale Computing Center and houses a network of IBM RISC System 6000 (RS/6000) high-performance computers, configured as a centralized network server cluster, a compute server cluster, and file servers. The network server cluster supports campus communications services such as electronic mail, campus-wide electronic bulletin boards, and use of the World Wide Web. The compute server cluster provides computing cycles for compute-intensive applications, including a variety of programming language, mathematical and statistical software packages, and graphics packages. The capacity represented by these machines is constantly being increased to meet the escalating demand. Qualified Lehigh computer users may also apply for access to resources at national supercomputing centers.

More than 340 microcomputers (primarily IBM-compatible personal computers) are distributed across campus for convenient use by Lehigh students at 23 computing sites. For example, there are 43 microcomputers in Linderman and Fairchild Libraries; 65 in Rauch Business Center, and 30 at Grace Hall. Local and wide area networking solutions are in place to give students and faculty access to site-licensed software applications and central file space from the campus sites or
their residence facility. The software available includes word processing, spreadsheets, database managers, presentation and graphics software, programming languages, mathematical and statistical packages, and more specialized applications for engineering, scientific publishing, and creative writing. With the assistance of the faculty, Information Resources reviews and adjusts its software licenses frequently to meet the instructional and research needs of students and faculty.

In addition to the microcomputers at distributed sites, Information Resources maintains more than 130 IBM RS/6000 workstations at campus sites. For example, there are 12 workstations in Fairchild Library, 14 in Packard Laboratory, and 21 Iacocca Hall on the Mountaintop campus. These workstations run an IBM version of the UNIX operating system (called AIX) with an X-Windows/Motif graphical user interface. They are also connected to the campus backbone and the central file space; as a result, a single user can perform high intensity computing using the resources of several workstations simultaneously. In addition to most of the software available through the PC sites, the workstation sites offer mathematical, statistical, graphics, and document authoring applications specifically designed for a workstation environment. In cooperation with the Department of Mechanical Engineering and Mechanics, Information Resources also operates the Computer-Aided Design (CAD) Laboratory.

Providing technology to support classroom teaching, laboratories, and other aspects of the academic program is a strategic priority for Lehigh University. Information Resources provides technical support for an increasing number of fully-equipped classrooms, suitable for "hands-on" computer instruction. Each computer classroom has networked microcomputers or workstations and a large-screen projection system connected to an instructor's station. Other classrooms are equipped with permanently-installed computer projection systems. In addition portable microcomputers and portable computer projectors are available through Information Resources to enable faculty or students to give computer-based presentations in any classroom.

Media Services

The Instructional Technology Support Service Team operates three facilities to provide students with access to and instruction in a wide range of traditional and high-tech media resources: the International Multimedia Resource Center or IMRC, the Media Production Center, and the Media Center.

International Multimedia Resource Center

The IMRC, located in Maginness Hall immediately adjacent to the Fairchild-Martindale Library and Computing Center, supports faculty and staff in the design and production of multimedia presentations and projects in cooperation with the College of Arts and Sciences and the Modern Foreign Language Department. Emphasis is placed on enriching student learning through the use of a variety of interactive multimedia resources. The facility also sponsors business, university, and international broadcasting and teleconferencing events through satellite and videoconferencing technologies.

The World View Room, a comfortably furnished facility accommodating about 25, features diverse cultural programs on wide screen television. These regularly scheduled domestic and international programs are derived from SCOLA (a multi-university consortium that transmits foreign news broadcasts); the International Channel; and selected cable and satellite broadcasts. Domestic and satellite dishes are mounted atop Maginness Hall. The IMRC also coordinates the programming on several Lehigh channels of the campus cable network, one of which features international news and cultural events, as well as university academic and athletic programs.

Media Production Center

The Media Production Center in Linderman Library offers students and faculty consulting assistance, instruction, and a wide range of modern and traditional technology for the creation of high quality audio, graphical, or video resources for classroom presentations, projects, and portfolios. Students can scan and edit text, photographs, and slides, and these images can be output to standard laser printers, color printers, or computer files for transfer and manipulation. Video cameras, a small video studio, and both entry-level and professional editing equipment facilitate the production of audio and video material to support the academic program. Students are introduced to the new world of digital imagery through the use of digital cameras, a photo-quality printer and image-manipulation software, and a photography studio that accommodates both traditional and digital cameras. With these facilities and instruction, Lehigh students develop the skills they need to make high quality graphical presentations required in today's business environment.

Media Center

The Media Center in Fairchild-Martindale Library offers audio, video, and electronic resources and the equipment and viewing spaces needed for their use. More than 25,000 units, including audio cassettes and CDs, videos, slides, and related materials are available. The Center also coordinates the rental of films and videos for classroom use. A limited supply of laptops for short-term rental by students, faculty or departments are housed there as well. The Media Center is also home to the Education Curriculum Library, developed in conjunction with the School of Education to afford teachers an opportunity to examine K-12 textbooks, software and auxiliary teaching materials.

Student Services

The libraries, central computing site, and most distributed computing facilities are open seven days per week and for extensive evening hours during the fall and spring semesters. For most of these hours, a help desk located at the Fairchild-Martindale Library provides general help for students and faculty on-site and for telephone inquiries relating to both library research and computing. Help desk staff refer difficult or more specialized questions to experts as needed, using a computerized tracking system designed to ensure thorough attention to each inquiry. There are also help desks located at the Linderman Library and the Computing Center. The campus telephone operators answer questions about general campus activities whenever possible.

Students may also take advantage of "virtual" help desks where they enter the questions or problems relating to library research, computing, hardware or software, or telecommunications at any hour of the day or night for response at a later time, usually within one working day. Most library and computing services are available electronically; for example, requests for books to be recalled, film rental requests, frequently asked question (FAQ) files, and seminar registrations.

Each semester Information Resources' Client Services Group offers an extensive program of seminars and course-based instructional sessions for students. Attendees learn to use software applications, the extensive print and electronic library resources, and the World Wide Web. Students learn how to create their own "home pages" as part of seminars on authoring documents for the Web. In class sessions, IR staff work closely with faculty, to integrate library, computing and media resources into the curriculum. IR computing, information retrieval, and instructional technology consultants will be instrumental in facilitating recent course projects in a wide range of disciplines using interactive Web sites created by students.

Online and printed publications to computing and library resources are provided for students. These are issued in a variety of formats: user manuals, user guides, and shorter tip sheets. Most seminars also include handouts that students can consult as needed. Through seminars and policies on use of print and electronic resources, students are taught computer ethics, recommended computing practices such as frequent backup and password changes, and an understanding and respect for state and federal laws governing copyright, privacy, and destruction or vandalism of library resources or computer systems, networks, databases or software.

Information Resources maintains a variety of facilities for printing, copying, and duplicating within the constraints of copyright legislation. In the libraries, public photocopiers and microform printers are maintained for convenience in copying print or microform resources. The Media Production Center (described under Media Services) can duplicate audio and video resources. For computer printing at central
and distributed sites, a network of PostScript laser printers is provided. In
addition, larger printing or plotting jobs can be routed electronically
to the multiple PostScript laser printers and publication-quality multi-
pen plotters at the central site.

Residence-based Services
The World-Wide Information Resources in Every Dorm or WIRED
program is designed to provide high speed network connectivity and to
assist Lehigh students with the use of computer hardware and software in
the residence facilities. Participants in the WIRED program receive
both voice mail and a data connection to the campus high speed
backbone. Software packages available through the WIRED program is
the same as the software mounted at the distributed sites. WIRED staff
communicate with students well in advance of their arrival at Lehigh to
identify for them compatible hardware and software for use on the
campus network. When students initially bring their computers to
campus, WIRED staff assist them in obtaining and installing the
necessary network interface cards and network software. Throughout
the semester the WIRED staff provide continuing assistance. The front
line WIRED consultants are well-trained students who live in the
residences and are readily available on-site assistance. The
consultants are supported by expert computing staff who supervise the
program and assist with more difficult problems.

Student Employment
Student assistants are essential for the operation of most Information
Resources services. Working for IR, students gain valuable skills and
essential work habits. At the job fair held each fall there are
opportunities to learn in-depth about the jobs available.

Art Galleries; Museum Operation
The Lehigh University Art Galleries maintain and develop the
university's permanent art collection, and present temporary exhibitions
designed to make visual literacy a result of the university learning
experience. More than twenty exhibitions a year in five campus galleries
introduce students and the community to current topics in art,
architecture, history, science, and technology. The exhibition schedule is
supplemented by lectures, films, workshops, and research
opportunities in the permanent collection. The art galleries play an
important role in the educational mission of the university through its
exhibitions and programs.

The art galleries occupy exhibition, storage, office and workshop
space in several campus locations. The Ralph L. Wilson and Hall
galleries are located in the Alumni Memorial Building; Maginnes Hall
houses the DuBois Gallery; The Siegel Gallery is in Iacocca Hall,
Mountaintop Campus. Administrative offices and workshop are in
Chandler-Ullmann Hall. The Muriel and Philip Berman Sculpture
Gardens are located in the courtyard of Mudd, Mart, Whitaker and
Sinclair Buildings; on the Mountaintop Campus and Saucon Field,
Murray H. Goodman Campus. The Study Gallery and Open Storage
facility is in Building J, mountaintop campus, available by appointment.

As of January 1997, the new Zoetliner Art Center (ZAC) will include
two additional galleries. The main level will be used for temporary
exhibits and the lower level will exclusively be for the university's work
study collection, permanent display changing approximately every 18
months.

Exhibitions
Exhibitions and gallery events are planned to supplement formal
classroom study in the visual arts, to create educational opportunities
for the entire student body, and to enrich the cultural life of the campus
and the community at large. The annual schedule includes the exhibition
of works from the permanent collection, the use of borrowed objects,
and traveling exhibitions on loan from major museums and cultural
institutions. Experts in various fields serve as guest curators of special
project exhibitions. Interdepartmental projects within the university
courage increased involvement by faculty and students.

Undergraduates may take advantage of courses in museum studies
including internship and independent study in the collection.

Collections
Lehigh University's permanent art collection is a world study collection
intended as a resource for students pursuing formal study in the visual
arts and/or museum studies; for the faculty, and for interested members
of the community. Each year, several exhibitions are prepared from the
collection and works are loaned to major museums throughout the
nation.

The permanent art collection consists of a variety of works by old
masters and contemporary artists. Important collection groups include:
the Marion B. Grace Collection of European Paintings (Gainsborough,
Reynolds, Goya, Hobbema, Hoppner, and others); the Dreyfus
Collection of French Paintings (Bonnard, Sisley, Vuillard, Courbet); the
Ralph L. Wilson Collection of American Art (paintings by Prendergast,
Sloan, Henri, Lawson, Bellows, Davies, Burchfield; prints by Whistler,
Hassam, Motherwell, Johns, Rauschenberg, Calder, Warhol); the Prasse
Collection of Prints (Delacroix, Matisse, Renoir, Kent, Kanyoshiba,
Rivera); the Philip and Muriel Berman Collection of Contemporary
Sculpture (Kadishman, Unger, Tumarkin, Bertonia, Shaw).

Also, the Fearnside Collection of European Old Master and Drawings;
the Baker Collection of Chinese Porcelain; the Langereim Collection of
Pre-Columbian Sculpture; the Mr. and Mrs. Franklin H. Williams
African Collection (gold weights of the Akam and West
African objects); the Lehigh University Photography Collection (Fox-
Talbot, Fenton, Jackson, Atget, Kasebier, Brandt, Siskind, Hahn, Clark,
Martinez-Canas, Serrano); and the Lehigh University Contemporary
Prints Collection (Bearden, Rivers, Anuszigiewicz, Soto, Roth, Chrysosa,
Ruscha, Tobey, Calder, Kitaj, Marca-Relli, Genoves, Cruz Azaceta,
Golub, Jimenez, Piper, Serrano, Simpson); and the Philatelic and
Numismatic collection.

Faculty Development and Learning Innovations Program
Faculty interest in teaching led to the establishment of this program in
1989. Faculty Development and Learning Innovations Program
connects professors with resources on teaching and learning. These
include 1) faculty-led workshops on such topics as using small groups
in the classroom, lecturing successfully, cooperative and collaborative
learning techniques, use of case studies, teaching a class on the World
Wide Web, and many more; 2) faculty-led seminars based on books
about teaching, learning, and the academic life; 3) one and two day
workshops led by nationally-known consultants on specific teaching
techniques; 4) live video conferences on teaching and learning from
several sources; 5) noon or 4:00 discussion of topics such as preparing a
Teaching Portfolio or syllabi.

The Program funds faculty trips to teaching conferences such as the
Lilly Conferences on College Teaching and annual American Association
of Higher Education conferences on such topics as case studies,
assessment and evaluation, and the quality of the academic environment.
At monthly faculty development lunches, faculty give reports from
these conferences, or discuss other aspects of teaching. For example,
one lunch group found out A How Professors Grade.

Dr. Diana Wills, Faculty Development Director, provides
confidential, voluntary consultation to faculty about their teaching,
which may include videotaping of class sessions, classroom observation
visits, with discussions about what these observations show. Informal
midsemester evaluations in classes can be done by Dr. Wills, or by
teachers of faculty who visit each other's classrooms and speak to each
other's students, using questions provided by the teacher of the class.

Both the Lehigh library and the Faculty Development and Learning
Innovations Program have books and videos on many topics related
to teaching. Policy for the Program is set and guided by a nine-member
Faculty Development Council, with representatives from all four
colleges, chaired this year by Professor Steven Krawiec, Biological
Sciences.

The Faculty Development and Learning Innovations Program is
located in room 880 of the University Center. Dr. Wills may be
contacted at 758-3638 or dw03.
Lehigh University Press

Lehigh University Press represents a clear expression of faculty and institutional commitment to the advancement of scholarship. Philip A. Metzger, Curator of Special Collections, Lehigh University Libraries, serves as director of the press, and members of the faculty of the four colleges serve on its editorial board.

The press is interested in all fine scholarship, but places special emphasis on traditional areas of strength at Lehigh: science, technology and society studies; and 18th century studies. In linking the name of the university to a list of exemplary work by scholars across the nation, the press reinforces the values of excellence in the academic environment for faculty, graduate and undergraduate students alike; and helps to maintain intellectual contact with alumni.


For more information, contact Dr. Philip A. Metzger, Lehigh University Press, 30 Library Drive, Lehigh University, Bethlehem, PA 18015-3067.

Resources for Students

Lehigh's administrators firmly believe that the interrelationship between students' classroom and non-classroom activities can be fostered to become an educational avenue through which students grow, accept responsibility, and gain maturity in ways that will contribute to productive and meaningful lives. Through various services, students are assisted in becoming informed decision makers. They are also encouraged to develop greater self-awareness and self-confidence in their ability to lead the lives they choose.

General counseling of individual students often begins in the residential setting. Staff members in the residence halls include six live-in professional hall directors, and approximately eighty undergraduate residence hall counselors, known as Gryphons. All staff members are carefully selected, extensively trained, and are available to assist resident students who may have a variety of concerns.

Students are also encouraged to seek counsel and guidance from professionals in many areas of student life. The Office of the Dean of Students serves as a central agency to help students who have questions about academic and procedural matters, personal problems, legal problems, and other general concerns, both through its staff and through referral to other student affairs and academic offices.

Students who need assistance with their physical well-being are referred to the university health center.

If a student has interests or concerns related to any personal or interpersonal issues, the office of University Counseling and Psychological Services offers a wide range of options, confidential and free of charge. Counseling Center staff, along with a group of student peer educators (TALQ), interact with students around campus in classrooms, residence halls, and other settings. In addition, traditional services such as individual and group counseling, psychological evaluation, and crisis intervention are provided by the licensed professionals in the center.

The university chaplain is available for the student with religious, moral, or personal concerns that are interfering with peace of mind and studies. A Roman Catholic chaplain also is in residence and available for counseling. A member of the faculty serves as advisor to Hillel Foundation members, who also may obtain spiritual advice from a local rabbi. The Office of Career Services offers assistance to students in identifying and developing career options that can be initiated at graduation. The office also manages an active on-campus interviewing program for graduating students.

The registrar assists students who have questions involving matters of transferred credits, graduation requirements, and allied topics.

The Office of Financial Aid consults with students who have financial concerns that are affecting their educational plans.

The Learning Center offers free individual tutoring in reading and study skills, mathematics, and writing.

Many members of the teaching faculty are also interested in students and student life. They serve as academic advisers, activity sponsors, group sponsors and advisers, and in friendly personal relationships with students.

In these and in other ways Lehigh University endeavors to maintain the close contacts with students that characterize the smaller institution. Services are available for all student concerns, and the student need only turn to his or her nearest residence hall counselor, professor, or the Lehigh Handbook to learn where help can be obtained.

Alcohol and Other Drug Programs

Alcohol and other Drug (AOD) Education Programming and Services are integrated into many aspects of Student Life with administrative coordination of much of this work provided by two offices - the Wellness Center (at 758-6484) in the University Center and the University Counseling Service (at 758-5183) in Johnson Hall. Services are offered free of charge for a wide range of issues from wellness and health to matters of substance use and misuse. Because members of the Lehigh community recognize that substance abuse and chemical dependency can significantly affect student lives, educational programs are designed to encourage students to adopt healthy lifestyles and avoid high-risk behavior. Confidential counseling and consultation services are available to students who find themselves having problems because of substance use, or related to friends and/or family members having problems with substance use. Appointments are easy to make by calling the Alcohol and other Drug Counselors at 758-5183 or by visiting during office hours (8:30 a.m. to 4:45 p.m.), Monday through Friday in room 419 Johnson Hall.

Theme weeks and sponsored outreach programs organized by the Wellness Program Coordinator and Alcohol and other Drug Counselors (Alcohol and Drug Awareness Week, and Wellness Week), provide educational programs for living groups on a variety of AOD and healthy lifestyle topics. Peer education programs sponsored by both offices are also available to students seeking ways of actively promoting healthy living environments. Intervention services include training programs for Residence Life staff Peer Educator Groups, and other members of the Lehigh community. The purpose of the training is to develop a broad safety net of interveners that can assist students with AOD problems in finding the help they need.
Individual and group counseling is provided by Lehigh University's AOD counselors housed in the office of Counseling and Psychological Services. On campus counseling may enable students to successfully enter into recovery (from alcoholism or chemical dependency) or to significantly alter previously self-destructive lifestyles without having to disrupt their university careers. If a student cannot accomplish this on campus, referrals to in-patient treatment programs can be made. Aftercare services can be provided once the student returns to campus, utilizing on campus counseling or by referral to A.A. and N.A. meetings held on campus and in the surrounding community. Referral to other treatment programs, to community service programs, and to programs associated with the court system can also be facilitated by various offices within Student Life.

Health Center
The university offers health services to all students at the Health Center in Johnson Hall. During the fall and spring semesters, doctors are available to see patients, 9:00 a.m. to 5:00 p.m. Monday, Tuesday, Wednesday, Thursday, and Friday, and 11:00 a.m. to noon Saturday. A registered nurse is present to see patients on weekends 11 a.m. to 4 p.m. with a physician available on call. During breaks, hours are Monday to Friday, 9:00 a.m. to 4:30 p.m.

The Health Center staff treats a variety of health problems, including illnesses and injuries. Gynecologic care is available by appointment. Allergy injections can be administered. Some minor surgery is performed at the Health Center. Many laboratory studies can be done at the health Center; students are referred to local facilities for X-rays. Patients are referred to local medical and surgical specialists when indicated. More seriously ill students are sent to a general hospital.

Prior to arrival on campus, each new or transfer student must submit to the Health Center a record of physical examination, a completed health history form, and updated immunization record.

Following enrollment, additional examinations are provided by the Health Center for students participating in intercollegiate athletic programs, and when required for graduate school or scholarship programs. The Health Center does not provide examinations for military, insurance or employment purposes.

There is no charge for most of the care provided to students. Some exceptions are as follows: referrals to physicians, hospitals, or other medical facilities outside the student Health Center, and medications not carried by the Health Center which require prescriptions. A low-cost university-sponsored insurance plan is available, which complements the services of the Health Center. Expenses covered include costs for several services that are not available at the Health Center, such as X-rays, laboratory studies, consultant fees, and medications not stocked by the Center. Hospital expenses are also covered. Students are urged to check with their parents regarding existing insurance coverage and to consider purchasing the university-sponsored plan if they are not adequately covered. Please consult your insurance carrier or physician if your plan is of the managed care/preferred provider type.

A health service brochure is distributed to all entering freshmen and is available through the Health Center to all other students. This brochure describes in more detail the policies and program of the health service.

Counseling Service
The University Counseling Service (at 758-3880), with most services free of charge, is located on the fourth floor of Johnson Hall. The office is open from 8:00 - 5:00, Monday through Friday. Counselors are available for 24 hour emergency consultations via campus police (758-4200).

I. PHILOSOPHY & MISSION
The University Counseling Service (UCS) is dedicated to the belief that a person's college years are a time of challenge, inquiry, experimentation, productivity and change. Services are designed to help students not only manage crises, but to thrive in meaningful ways...to grow in self-understanding in order to make more satisfying and better use of their personal and interpersonal resources. Individual contacts, group therapy, faculty and staff consultation, and numerous outreach activities are some of the primary means by which the mission is accomplished.

UCS staff members are committed to providing assistance to all registered Lehigh students interested in personal, social, and academic growth and discovery, and to the larger campus community through consultation, teaching, research, and various other types of involvement.

II. DIRECT SERVICES
To accomplish its mission, and while upholding the established APA ethical principles and code of conduct for psychologists, the UCS provides a variety of services to the Lehigh University community including:

- Crisis Intervention Services
  The UCS provides assistance to individuals and groups in crisis. Psychologists provide 24-hour coverage via pager access (call campus police dispatcher at 758-4200) during the Fall and Spring semesters.

- Group and Individual Psychotherapy
  UCS staff members provide group and individual counseling and psychotherapy services to both undergraduate and graduate students. A short term treatment model is used for individual work while much of the group work is of longer duration. Referrals for psychiatric consultation are made when requested and appropriate. All counseling and therapy services within the UCS are confidential.

- Outreach Programming
  The UCS provides programming focused on the developmental needs of college students--designed to enhance the capacity of students to maximize their personal, social, and academic potential. These presentations occur in various settings, including living residences, classrooms, athletic sites, and meeting rooms across the university. Topics may include issues related to race, eating and body image, sexuality, drinking and other drug use, study styles, athletic performance, grieving, stress, and relationships. Much of this programming is done in partnership with T.A.L.Q, a UCS sponsored student peer education group.

- Assessment and Evaluation
  Upon request and when appropriate, UCS personnel administer and use personality and career advising instruments. They also utilize a wide variety of assessment tools when assisting groups and individual students.

- Consultation Services
  The staff provide consultative services to the university community with the objective of helping students, faculty and staff identify and resolve difficulties that may be exerting a negative effect on some individual, group, or system. This may include the use of referral resources within the university or in the local community.

- Training
  One component of UCS work is to help persons such as residence life staff, peer counselors, university personnel, student leaders, and faculty more effectively advise, counsel, interact and communicate with others. A second component is to enhance the development of persons specifically interested in securing the identity and skills of a psychologist - these typically being graduate practicum students, doctoral level interns, and professional staff.

- Advocacy
  Staff of the UCS advocate for those students and groups who struggle for understanding and respect in a society sometimes blinded by traditional norms and expectations. Through dialogue, education, programming, consultation, and direct service, the staff is committed to being engaged with issues such as racism, sexism, and other practices that destroy self and group esteem.
110 Drown: The Center For Writing, Math, and Study Skills
Success at Lehigh depends in part on mastery of a number of advanced academic skills. Such skills are needed to study effectively (prepare assignments, take notes, outline, listen, recall information), to take examinations, to write well, to understand advanced mathematical concepts, and to keep up with a great deal of critical and comprehensive reading.

At Lehigh, a campus noted for its highly motivated student body and strenuous academic program, 15 percent of undergraduates, including a third of full-time freshmen, use the tutorial services of 110 Drown. Established in 1977, it provides a schedule of workshops, review sessions, and most importantly, individual tutorials in study skills, mathematics, reading and writing. Through a program of faculty and student referrals, along with periodic notices to the student body, the center helps students to improve specific communication and mathematical skills, to maintain acceptable performance levels, to raise their academic standing. Individualized assistance is emphasized.

110 Drown provides university students with a continuing opportunity for academic improvement through personalized instruction by professors and graduate teaching assistants.

Career Services
One function of a college education is to foster the growth and development of the student in preparation for a meaningful and satisfying life after college. Because developing one's career potential is an integral part of this process, Lehigh provides career planning and placement services for its students.

Career planning can best be described as an educational process through which students (1) identify and develop their abilities, aptitudes, and interests; (2) learn the relationship between their capabilities and interests, their university experiences, and professional opportunities outside the university; and (3) prepare for those opportunities.

Placement is the process of researching specific organizations that provide the types of work desired, interviewing for specific jobs through which career or professional interests can be satisfied, and then selecting from the options available the one that best meets students' needs. This part of the process also requires students to develop skills in such areas as writing effective resumes and cover letters, interviewing techniques, and individual job search strategies to enhance productive interactions with employers.

The goals of this integrated career planning and placement process are for Lehigh students to think of themselves as educated people with skills and abilities that have value to employers, and to think in terms of functional responsibilities rather than merely linking their major subjects to jobs, to acquire and develop the skills necessary to become self-reliant and informed decision-makers, to prepare for a competitive job market, and to develop their potential of becoming self-reliant managers of their own careers.

The Office of Career Services is committed to the preparation and education of Lehigh students during the transition from the academic environment to the work place. Career Services offers the following resources and services to help students prepare for professional opportunities after graduation:

Career Resources. Among the resources available in the Career Library are books and articles on career planning, current information on career opportunities, occupational information, graduate school resources, job-search directories, a library of employer literature for approximately 600 companies, and a video-tape library covering a wide range of career-related subjects, job listings for part-time, summer, internship, entry-level and experienced opportunities, and a database of alumni contacts who have volunteered to assist students with their job search strategies.

Career Counseling. Students may meet with members of the staff to discuss their career options and goals, individual job-search strategies, effective interviewing, and related interests. Self-assessment tools are available to assist students in identifying interests, skills and values.

Workshops and Special Programs. The staff conducts a variety of seminars and presentations in collaboration with academic departments, professional societies, living groups, and other interested campus organizations. Career programs like the Career Fair and many others are offered throughout the year. Workshops on resume writing, interviewing techniques, and job-search strategies are also offered.

Experiential Education. Experiential Education programs are designed so that Lehigh students can make educated decisions about career choices. Through participating in these programs, students can gain first-hand knowledge and experience about a particular career field. Experiential Education programs include opportunities in: summer employment, internships, part-time positions, externships and cooperative education.

On-Campus Interviewing. Staff members work with over 300 business, industrial, and government representatives who interview on campus each year. Seniors and graduate students typically take over 4,000 interviews.

Pre-professional Advising. The pre-professional advisor, along with a faculty advisory committee, provides information and guidance to candidates pursuing careers in medicine, dentistry, and other health professions, including individualized advising, special programs on health-related topics and field trips. In addition, information and assistance is provided for students interested in law school and legal careers.

Job Search Manual. This manual helps students learn how to use the on-campus interviewing system, prepare for interviews and plant/office visits, write resumes and letters, and develop individual strategies.

The office is open throughout the year. The main phone number is (610) 758-3710.

Special Academic Programs

Distance Education:
The distance education program at Lehigh provides educational opportunities to adults at their work sites. The program strives to maintain the same level of quality that is available to on-campus students. The university views distance students and their employers as clients of the University, desiring of the best possible effort in all areas of the operation. Programming is delivered over the Lehigh Educational Satellite Network (LESN), employs a Ku-Band earth station capable of reaching all domestic satellites. At present, the University offers master's degrees by satellite in Chemistry, Chemical Engineering, Molecular Biology, Quality Engineering, and the MBA. In addition, using two-way video teleconferencing equipment, Lehigh is now able to broadcast and receive courses from other LVAIC schools. Lehigh also provides courses to National Technological University's master's programs, and a range of non-credit short courses and seminars. For more information, call the Distance Education Office at (610) 758-5794.

Summer Studies:
There has been a summer sessions program at Lehigh for nearly a century and, through the years, it has developed into a significant portion of the University's overall academic program. Lehigh now offers over 200 courses each summer. They range from travel programs in Europe, Asia, and the Rocky Mountains to on-campus courses that service Lehigh undergraduates and graduates, adult professionals in business and education, and students at other colleges who return to their Lehigh Valley region homes during the summer. At Lehigh, summer is a time for educational experimentation. Just in the past few years, new courses have been created in such areas as creative writing, ecosystem analysis, workplace diversity, and clinical counseling. Many of these are special summer offerings and not available during the regular academic year. For more information, call the Summer Studies Office at (610) 758-3966.
Continuing Education:
Lehigh University departments, research centers, and administrative agencies offer a varied selection of non-credit continuing education programs for adults. Reflecting Lehigh's traditional educational strengths, these offerings focus on professional development, organizational problem solving, and technical skills. These programs carry no regular academic credit, but participants can earn Continuing Education Units (CEUs). In awarding CEUs, Lehigh follows the guidelines developed by the National Council on the Continuing Education Unit.

Lehigh continuing education programs are often designed to meet specific needs. Contents, schedules, and timing are adapted to effectively serve the audiences for which they have been developed. Apart from public programs presented on the Lehigh campus, a number of programs are available for "in-house" presentation to organizations on a contract basis. For more information about these programs, contact the appropriate department or research center.

Challenge For Success Program
The Challenge for Success Program (CFS) is a comprehensive academic retention program that assists students of color in attaining their goals. The primary focus of the program is to provide support through academic and cultural programs. The philosophy of the program promotes that all students are born achievers, but all students need help actualizing their talents.

Retention is enhanced by a six-week summer scholars pre-freshman program, a peer mentoring program, counseling for social and academic adjustment, monitoring of academic progress and tutorial assistance. The Lehigh University Black and Latino Alumni Council (LUBLAC) also assists in the program's retention efforts.
III.

Undergraduate Studies

Graduation Requirements

Students are expected to maintain regular progress toward the baccalaureate degree by carrying the "normal" course load—between twelve and eighteen credit hours each semester. They may, however, wish to accelerate the pace toward graduation by using advanced placement credits, summer session study, course overloads during the regular semesters, and receiving credit for courses through examination.

Students in good academic standing earn their degrees by meeting the requirements of their specific degree curriculum as well as general university requirements. Students should confer with their advisers on matters related to curriculum.

Students are expected to satisfy the credit-hour requirements of their chosen curriculum. Basic military science or aerospace studies credit hours are in addition to the credit hours specified in the curricula. A maximum of six credit hours of advanced military science and aerospace studies courses may be applied toward the baccalaureate degree.

Undergraduate Residency Requirement

To be eligible to receive a Lehigh baccalaureate degree, the candidate must have completed either a minimum of ninety credit hours in residence, or all of the last thirty credit hours at the University or in residency programs.

Five-Year, Two-Bachelor-Degree Programs

The university's five-year, two-degree programs enable a student to receive two bachelor degrees upon completion of five years of study.

The civil engineering and geological sciences program that affords two bachelor degrees, and the electrical engineering and engineering physics two-degree program are examples of programs in the College of Engineering and Applied Science.

Some five-year, two-degree programs appear in the description of courses under Arts-Engineering and Five-Year Programs in Section V. It is possible to arrange for a dual bachelor degree program even after studying at Lehigh for some time. Engineering students, for example, who decide at any stage of study that they wish to meet the requirements for both the bachelor of arts and bachelor of science degree may complete the combined requirements in five years if the decision is made before the third year.

Second degree candidates—A student entering Lehigh to obtain a second bachelor's degree, or those Lehigh students who wish to declare a second major in another college, or both a B.A. and a B.S. degree within the College of Arts and Science must have a minimum of thirty additional credit hours beyond the first degree credit-hour requirements in order to qualify for the second degree. All of the thirty additional credit hours must be taken at Lehigh or in Lehigh residency programs. All special second degree programs must be approved by the dean of the college in which the degree is to be offered and the Standing of Students' Committee.

Advisement

Every undergraduate is assigned a faculty adviser. Until the major is declared, assistance is also available through the dean's office of the college in which the student is enrolled. When the major has been chosen, a faculty member from the major department will act as the academic adviser.

This adviser is one of the most valuable resources in the educational process, not only to assist in making academic selections to match the student's particular background, interests, and future objectives, but also to identify program options, to work out an academic pace, and to develop career planning strategies. The adviser will help to identify other resources and support systems available at the university, such as The Learning Center, the counseling service, and the office of career services.

Guide to Academic Rules and Regulations

The university, like the rest of society, has adopted over the years numerous rules and regulations. Some of the principal rules and regulations are given here so that currently enrolled and potential undergraduates and graduate students will be apprised of what is expected of them, and what they can expect of the university.

This section concerns academic regulations. Additional regulations can be found in the Lehigh Handbook, and there is a comprehensive statement of all policy in the publication Rules and Procedures of the Faculty. All students are given a Handbook at the beginning of the fall semester; Rules and Procedures is available in the university libraries and in departmental and administrative offices.

Eligibility for Degree

In order to be graduated, a candidate for a baccalaureate degree must achieve a minimum cumulative average of 2.00.

To be eligible for a degree, a student must not only have completed all of the scholastic requirements for the degree, but also must have paid all university fees, and in addition all bills for the rental of rooms in the residence halls or in other university housing facilities. Payment also must have been made for damage to university property or equipment, or for any other indebtedness for scholarship loans or for loans from trust funds administered by the university.

Responsibility for meeting academic requirements. Each student is responsible for his or her progress toward meeting specific requirements for graduation. Academic advisers and department chairpersons are available to assist the student. It is strongly recommended that the students specifically consult with his or her adviser prior to the senior year to ascertain eligibility for the degree for which he or she desires to qualify and to determine that all program and honors requirements are met.

The Registrar's office will provide, at the student's request, a printout of a degree audit noting all program deficiencies. All students are requested to go through this process before registering for their senior year.

Final date for completion of requirements. For graduation, all requirements, scholastic and financial, must have been satisfied prior to the date stated in the university calendar.

Application for Degree

Candidates for graduation on University Day in May or June must file with the registrar on or before March 1 a written notice of candidacy for the degree; candidates for graduation in January file a notice of candidacy on or before December 1; candidates for graduation on Founder's Day, the second Sunday in October, file a notice of candidacy on or before September 1.

Failure to file such notice by such dates mentioned debars the candidate from receiving the degree at the ensuing graduation exercises. If a petition for late filing is granted, a fee is assessed.
Graduating Thesis

The original of the undergraduate thesis, when required, is accompanied by drawings and diagrams whenever the subject need such illustration. The original is kept by the university, as a part of the student's record, for future reference; but copies may be retained by students and may be published, provided permission has first been obtained from the faculty.

Undergraduate Credit and Grades

A "semester hour," used interchangeably with "credit hour," is a course unit normally involving three to four hours of student effort per week during one semester. This includes both in-class contact hours and out-of-class activities. The major parameters influencing the in-class/out-of-class division include the mode of instruction and the level of the course.

Latest date for registration. No registration is accepted later than the tenth day of instruction in any semester, or fifth day of a summer session.

Definitions of grades. Course grades are A, A-, B+, B, B-, C+, C, C-, D+, D, D-, F, N, and X. The meaning of each grade is as follows: A-, excellent; B+, B, and B-, good; C+ and C, competent; C-, continuation competency (the student has achieved the level of proficiency needed for the course to satisfy prerequisite requirements); D+, D, and D-, passing, but performance is not adequate to take any subsequent course which has the this course as a prerequisite. The student must petition to waive a prerequisite. Upon presentation of evidence of substantially equivalent preparation and with the approval of the instructor of the course, the teaching department chairperson and the chairperson of the major department the prerequisite will be waived; F, pass-fail grading with a grade equivalent to D- or higher; F, failing; N, incomplete; X, absent from the final examination; XN, absent from the final examination and incomplete.

Other symbols used for courses on student records are: Cr, credit allowed; W, withdrawn; WP, withdrawn with permission and with passing performance at the time of withdrawal; WF, withdrawn beyond the deadline and/or with failing performance.

Grades in the range of A through D-, and Cr may be credited toward baccalaureate degrees within the limits of program requirements. Grades of F, N, X, XN, W, WP, and WF cannot be credited toward the degree. Grades of W and WP do not count as hours attempted.

Courses in which grades of F, W, WF, N, X, or XN are recorded do not meet prerequisite requirements.

The grade N (grade) may be used to indicate that one or more course requirements (e.g., course report) have not been completed. It is the obligation of the student to explain the satisfaction of the instructor that there are extenuating circumstances (e.g., illness or emergency) that justify the use of the N grade. If the instructor feels the N grade is justified, he or she assigns a grade of N supplemented by a parenthetical letter grade, (e.g., N(C)). In such cases, the instructor calculates the parenthetical grade by assigning an F (zero score) for any incomplete work unless he or she has informed the class in writing at the beginning of the course of a substitute method for determining the parenthetical grade.

In each case in which an N grade is given, the course instructor shall provide written notification to the department chairperson stating the name of the student receiving the grade, the reason for the incomplete work, the work to be done for the removal of the N grade and the grade for the work already completed.

A student who incurs an N grade in any course is required to complete the work for the course by the fifth day of instruction in the next regular semester. The N grade will be converted into the parenthetical grade after the tenth day of instruction in the next regular semester following receipt of the N grade unless the instructor has previously changed the grade using the removal-of-incomplete procedure. The parenthetical grade will be dropped from the transcript after the assignment of the course grade.

In no case shall the grade N be used to report absence from a final examination when all other course requirements have been met.

N grades do not count as hours attempted and are not used in computations of cumulative averages.

The grade X (grade) is used to indicate absence from the final examination when all other course requirements have been met. The grade in parenthesis is determined by including in, the grade calculation an F (zero score) for the missing final exam. The X grade may be removed by a make-up examination if the absence was for good cause (e.g., illness or other emergency). To be eligible for the make-up exam, the student must file a petition and the petition must be approved by the instructor. If the student fails to petition, or if the petition is not granted, or if the student fails to appear for the scheduled make-up examination, then the X grade will be converted into the parenthetical grade after the first scheduled make-up examination following the receipt of the X grade. If the petition is granted and the final examination is taken, the X grade will be changed by the instructor using the make-up examination procedures and the parenthetical grade will be dropped from the transcript.

Where valid reasons exist for not taking the make-up examination at the scheduled time, the student may petition for a later examination with a fee.

The notation of NR (not reported) is temporarily placed in a student record when due to circumstances, no grade was reported by the instructor by the established deadline.

The grade XN (grade) is used to indicate both absence from the final examination and in completion of one or more course requirements. The instructor calculates the parenthetical grade using an F (zero score) for the final examination and either an F (zero score) or the substitute method of calculation as described above for the incomplete work.

The XN grade may be removed by the procedures presented in the previous paragraph for removing the X grade. If this results in an N grade because the course work is still incomplete, the provisions Incomplete (N grade) above shall apply, except that in no case shall the deadline for completion of the work be later than the last day of classes in the first full semester in residence (except summer) following receipt of the XN grade.

X and XN grades do not count as hours attempted and are not used in computations of cumulative averages.

Where failure to complete coursework prevents the student from taking the make-up examination at the scheduled time, the student may petition the committee on standing of students for a later examination.

An XN grade that is still outstanding after the tenth day of instruction in the next academic-year semester following receipt of the XN grade will be converted into the parenthetical grade. The parenthetical grade will be dropped from the transcript.

Withdrawal From A Course. A student dropping a course within the first ten days of the semester (five days for summer sessions) will have no record of the course on the transcript. A student dropping all courses for which he or she is registered is considered to be withdrawing from the university and the policy is noted below. A student who drops a course after the tenth day of instruction and before the end of the eleventh week of instruction will have a grade of "W" assigned to the course. A student who drops a course after the eleventh week on instruction and before the end of classes receives a "WP" or "WF" at the discretion of the instructor. A "WF" is considered to be a failing grade. An Add/Drop form signed by the student’s advisor must be submitted to the Registrar’s Office before the deadlines noted above to be official.

University Withdrawal. A student withdrawing from the University (dropping all courses during a given term) must submit the withdrawal from to the dean of students office. Withdrawal after Registration day and during the first eleven weeks of instruction will be noted on the academic transcript by assigning a grade of "W" to all courses. A withdrawal after the eleventh week of instruction and before the end of classes will have the grade of "WP" or "WF" assigned for each course at the discretion of the instructor. The date of the withdrawal will be noted on the academic transcript for a withdrawal at any time during the term.

A student who reduces his or her course load below the minimum required for standing as a full-time student, but does not withdraw from the university, becomes a part-time student for the rest of that semester. Some areas affected by part-time status are financial aid, athletic eligibility, veterans affairs, selective service, immigration status, insurance and loan deferment.
Official reports of grades are issued to advisers and students by the registrar as soon as possible following the deadline for reporting of grades. Instructors may develop their own policies for release of unofficial reports of academic progress to individual students, or to their advisers, dean of student affairs, and officers, on a need-to-know basis, including early release of unofficial final course grades. Any such policies must respect the rights of students to privacy.

A report of grades is sent to each student's home at the end of every semester.

Repeating of courses. If a course in which a "D+" or lower grade was received is repeated, the final grade received upon repetition of the course is counted in the cumulative average. The original grade and credit hours received will be dropped from the cumulative average. Courses assigned a grade of "C" or better may not be repeated. However, a student who fails a repeated course after receiving a passing grade the first time will have the original grade deleted from his or her average, but will retain credit for the course toward graduation.

A grade of "D+" or lower that was originally received in a course may not be changed by repeating the course under the pass-fail option.

For deletion of a grade from the cumulative average after repeating a course, a student must (a) file the deletion form with the Registrar's Office; and (b) repeat the identical course with a final grade at Lehigh.

**Pass-Fail Systems for Undergraduates**

Student Option System. The pass-fail grading option is intended to encourage students to take challenging courses outside the major field that otherwise might be avoided for fear of lowering grade-point averages. Students are not permitted to take courses numbered below 100 and above 400 using the optional pass/fail grading system and should avoid wasting this option on unsuitable courses, such as courses having no college-level prerequisite or corequisite. The restrictions on the use of the system are listed below.

A student may register for no more than one course pass-fail numbered above 100 and below 400 in any one semester. He or she may take a maximum of six courses per undergraduate career if the student is on a four-year program, or a maximum of eight courses per undergraduate career with a five-year, two-degree program. If a student changes a course after the first ten days of instruction from pass-fail grading to regular grading, as provided below, that course shall still count toward the maximum number of courses taken pass-fail during the student's undergraduate career.

Each college faculty shall decide under what conditions and which courses or categories of courses throughout the university may be taken for pass-fail credit by students registered in that college, except for courses designated specifically for pass-fail grading. Each college shall keep the educational policy committee advised of changes in its rules.

A student designates the course(s) to be taken pass-fail normally at preregistration but not later than the fifteenth day of instruction in a regular semester or the fifth day of instruction in any summer session. Prior to this deadline, the student may transfer from pass-fail to regular grading, or vice-versa, without penalty. The courses designated for pass-fail grading by the student require the written acknowledgment of the academic adviser.

Since the instructor giving the course is not officially notified which students are taking the course pass-fail, a regular letter grade is reported to the Registrar for the pass-fail students. The Registrar then records "P" for reported letter grades from A through D-, and "F" for a reported letter grade of F.

Under this system, the student surrenders his or her equity to letter grades of A through D-, except as specified below. A grade of P applies to the student's graduation requirements but is not used in the computation of the cumulative average; whereas an F grade is included in the cumulative grade point average.

If a student changes his or her program such that a course previously taken for pass-fail grading is not allowed for pass-fail grading in the new program, the student must submit a petition to the committee on standing of students requesting acceptance by the new program of the pass-fail grading for that course, or substitution of the original letter grade submitted by the instructor for the pass-fail grade, or the substitution of another course for the course taken pass-fail. The recommendation of the adviser must accompany the petition.

Courses at the 400 level are excluded from pass-fail grading.

**Course Auditing**

A student who is in good academic standing and has not failed any courses in the previous term may be admitted as an auditor in not more than one course, which shall be outside the curriculum requirements. Application for such admission is by petition approved by the department chairperson and the chairperson of the department concerned. In no case shall a student who has attended a course as an auditor be given an anticipatory examination for credit or register for the same course in the future. A student completing a course in this manner will have the course and the notation AU indicated on the permanent record. A student rostered on an audit basis may be withdrawn from the course with a grade of W for poor attendance.

**Review-Consultation-Study Period**

The Review-Consultation-Study (RCS) period is intended to provide a few days for informal academic work between the end of the formal instruction period and the beginning of the final examinations. It is expected that students will use this period to consolidate their command of the material in their courses. Faculty members make themselves available to their students at announced times during this period.

No quiz or exam may be given during the last five class days before final examination period begins.

**Scholastic Averages and Probation**

Scholastic requirements for undergraduate students are expressed in terms of the cumulative grade point average (GPA)—the weighted average of all grades received in residence or at institutions specifically approved for grade transfer. The cumulative GPA is computed at the end of each semester and the second summer session. Following are the cumulative GPA requirements for good standing:

- freshmen 1st semester 0 to 6 credits earned 1.60
- freshmen 2nd semester 7 to 21 1.70
- sophomores 22 to 51 1.80
- juniors and seniors more than 51 2.00

Students who do not meet the above requirements will be placed on scholastic probation. Students who, regardless of their cumulative average, have failed more than eight hours of course work in any semester are also placed on scholastic probation.

While there is no specific credit hour requirement for good standing, certain categories of students (e.g., those on financial aid and those playing intercollegiate athletics) will be expected to maintain whatever hours are required for eligibility.

**Removal from probation.** Students are removed from probation at such time as they meet the standard listed above, effective at the end of any semester or the second summer session.

**Dropped for poor scholarship.** A student who makes a 2.2 GPA or better in the probationary semester but fails to meet the standards stipulated is continued on probation for another semester. A student who makes less than a 2.2 GPA in the probationary semester and fails to meet the standards stipulated above, is dropped for poor scholarship.

If a student goes on scholastic probation for a second (although not necessarily consecutive term,) a review by the committee on standing of students will determine whether the student will continue on scholastic probation or be dropped for poor scholarship.

**Graduation Honors**

Degrees with honors are awarded by vote of the university faculty to those students who have attained an average of not less than 3.25 in a minimum of ninety credit hours in residence at Lehigh University or in programs approved by the Faculty to have grades and credit accepted toward the undergraduate degree.

Degrees with high honors are awarded by vote of the university faculty to those students who have attained an average of not less than 3.50 in a minimum of ninety credit hours in residence at Lehigh
University or in programs approved by the Faculty to have grades and credit accepted toward the undergraduate degree.

Degrees with highest honors are awarded by vote of the university faculty to those students who have attained an average of not less than 3.75 in a minimum of ninety credit hours in residence at Lehigh University or in programs approved by the Faculty to have grades and credit accepted toward the undergraduate degree.

For the purposes of graduation honors calculations, courses taken more than once at Lehigh will only have the most recent grade used in the calculation. Courses taken under the cross registration policy of the LVAIC, and those courses taken in faculty approved (for credit and grade) study abroad programs through the Lehigh Study Abroad program will be used.

Students who spend part of their career at another institution, or are transfer admits to degree programs and have fewer than ninety hours of in-residency courses, may qualify for graduation honors under the following conditions:

- The student must have at least sixty credit hours of regularly graded (not pass/fail) courses that meet the residency requirement. The graduation honors category is determined by the lower of the two averages computed as follows: (1) the average of grades received at Lehigh; (2) the average of all grades received at Lehigh and grades for courses taken elsewhere for a regular grade and that are appropriate to be considered for transfer to Lehigh, or in provisionally approved study abroad programs.

**Department Honors**

Many departments offer honors work adapted to its curriculum for students who wish to demonstrate unusual academic ability and interest in exploring a chosen field through independent study and research. The precise nature of the program for each student is determined by the academic major department, but may include: unscheduled work or independent study; participation in graduate (400-level) courses; and an honors thesis or project.

Qualified candidates should inform their academic adviser by the end of the junior year of their intention to work for departmental honors. The adviser will give the college and the registrar names of seniors working for departmental honors in particular majors. Names of those students attaining departmental honors are published in the commencement program.

Undergraduates in the College of Arts and Science may apply for acceptance into the College Scholar Program, which offers unique opportunities for those qualified to develop their critical faculties and intellectual interests.

**Honor Societies**

There are at least eighteen honor and course societies. The three best-known are:

- **Phi Beta Kappa.** The desired profile for this Arts and Science honor society consists of:
  - A minimum cumulative GPA of 3.5
  - In addition to a student's major, which might encompass one of the distribution requirements noted below, a student should present a minimum of:
    - Two natural science courses, with at least one lab as part of that instruction.
  - Two social science courses
  - Two humanities courses, especially reading/critique of literature beyond basic freshman English Inclusion of the study of calculus, or advanced mathematics Study of foreign language roughly equivalent to 2nd-year college level
  - No academic violations sufficient to warrant suspension

- **Beta Gamma Sigma.** Election to membership in Beta Gamma Sigma is the highest scholastic honor that a student in business administration can achieve. Beta Gamma Sigma is the only national honorary scholarship society in the field of business administration recognized by the American Assembly of Collegiate Schools of Business.

**Tau Beta Pi.** Tau Beta Pi recognizes high achievement in all engineering curricula. The national Tau Beta Pi was founded at Lehigh in 1885. A bronze marker in front of Williams Hall commemorates this event.

Among course societies are the following: Alpha Pi Mu, for those in industrial engineering; Beta Alpha Psi, accounting; Chi Epsilon, civil engineering; Eta Kappa Nu, electrical engineering; Lambda Mu Sigma, marketing; Omicron Delta Epsilon, Economics; Omicron Delta Kappa, leadership; Order of the Omega leadership in Greek activities; Phi Alpha Theta, history; Phi Beta Delta, international; Phi Eta Sigma, freshman scholastic excellence; Pi Tau Sigma, mechanical engineering; Psi Chi, psychology; Sigma Tau Delta, English; and Sigma Xi, research.

**College of Arts and Sciences**

Bobb Carson, dean; Gary G. DeLeo, associate dean; Kenneth P. Kodama, associate dean

The College of Arts and Sciences offers several curricular options:

- A four-year curriculum in arts and science, leading to the degree of bachelor of arts; or bachelor of science in designated fields; and
- A five-year curriculum in arts-engineering leading to a bachelor's degree from the College of Arts and Sciences and bachelor of science degree in a specific field from the College of Engineering and Applied Science.

- Double degree programs within the college and in conjunction with the other two undergraduate colleges are possible.

Specific requirements for many of the degree programs described in this section may be found in Section V.

**Major Programs in the College**

The college offers the following major programs:

**Bachelor of Arts Degree**

- Humanities: architecture, art, classics, classics and classical civilization, Asian studies, English, modern foreign languages-French, German and Spanish, music, philosophy, religion studies, Russian studies, theatre.

- Social Sciences: American studies, anthropology, cognitive science, economics, history, international studies, international relations, journalism, journalism/science writing, political science, psychology, science, technology and society, social relations, sociology, social psychology, and urban studies.

- Mathematics and Natural Science: behavioral neuroscience, biology, chemistry, computer science, earth and environmental sciences, mathematics, molecular biology, natural science, physics, premedical science, premedical science, and preoptometry science.

**Bachelor of Science Degree**

Behavioral neuroscience, biochemistry, biology, chemistry, computer science, earth and environmental sciences, mathematics, molecular biology, physics, statistics.

**Major Field of Concentration**

By the end of the sophomore year, each student in the curriculum of arts and sciences usually selects some sequence of studies as a major field of concentration. A major consists of at least fifteen hours of advanced work in the field chosen. Including preliminary college work, the minimum number of hours constituting a major is 30.

The major field of concentration is designed to enable a student to master an area of knowledge so far as is possible during the undergraduate years. Each field prescribes certain courses, and a student must achieve a minimum 2.0 average in major courses.

**Standard major sequences.** The student may choose one of the standard major sequences. When a student selects one of these standard majors, a faculty member from the department or program offering the
major becomes a student's major adviser and assists the student in constructing a program of study. The final responsibility for meeting both major and nonmajor requirements, however, rests with the student.

Special interdisciplinary majors. In addition to the standard major programs, specially structured interdisciplinary major sequences between majors are possible.

For example, a student interested in a professional school of urban or regional planning might wish to structure a special major consisting primarily of courses in political science and economics, or in economics and social relations.

Any student may, with the aid of faculty members chosen from the disciplines involved, work out an interdisciplinary major program to include not less than thirty hours of related course work, of which at least fifteen hours shall consist of advanced courses. The program must be approved by the major advisers and the dean of the college.

Multiple majors/Double degrees. Students who wish to fulfill the requirements for more than one major sequence may initiate this process by having separate major programs constructed by the corresponding advisors. The college distinguishes between programs leading to multiple majors and multiple degrees. Multiple majors may be constructed from two or more B.A. degree programs, with double majors often completed in four years. Double-degree candidates have chosen to pursue a second degree in another college, or receive two B.S. degrees or a B.A. and a B.S. degree from within this college. These students must petition the standing of students committee, satisfy both sets of major and distribution requirements, and receive a minimum of thirty additional credit hours beyond those required for the first degree.

Because successful completion of only one major program is required for a baccalaureate degree, a student with more than one program is asked to designate one as the primary major for administrative purposes but is expected to maintain normal progress in fulfilling the requirements in both.

Junior-Year Writing Certification
The faculty of the College of Arts and Sciences is committed to the concept that writing is a valuable tool for learning and views the ability to write well as an essential professional skill. Students are encouraged to take courses that require writing throughout their years in the college.

Each student in the college must complete at least one “writing-intensive” course and receive writing certification from the instructor. Students normally take this course during the junior year. Students must follow the guidelines for this requirement set up by their major departments. Some departments specify that the “writing-intensive” course must be in the major field; some departments require “writing-intensive” courses in specified disciplines other than the major; and, other departments allow their majors to choose freely from “writing-intensive” courses across the college. Courses that satisfy the junior-year writing requirement may also satisfy major or distribution requirements.

Bachelor of Arts and Bachelor of Science Degrees
The curriculum in arts and science emphasizes a liberal education. It asks the student, in collaboration with the adviser, to select courses to satisfy three general categories, namely, distribution to ensure breadth of education, a major field of concentration to provide depth, and free electives to provide breadth and depth to meet the student’s needs.

A student electing to work for the bachelor of science (B.S.) degree may have a strong preprofessional orientation and will take more courses in the major field of concentration than will another in the bachelor of arts (B.A.) program. In all other respects the student in a bachelor of science curriculum meets the same requirements as the student in the bachelor of arts program.

The bachelor of arts and bachelor of science degrees require the completion of a minimum of 121 credit hours of collegiate work, apportioned to cover distribution and concentration requirements. A cumulative average of 2.0 or better in courses required in the student’s major program and the completion of all general requirements apply to all candidates for baccalaureate degrees. A maximum of six credit hours of advanced military science or aerospace studies courses, and a maximum of eight credit hours of music courses numbered 21-79 may be applied toward the degree.

Distribution Requirements for the B.A. and the B.S.
Distribution requirements are intended to ensure a breadth of learning without imposing undue restrictions on a student’s course of study. Each distribution requirement may be fulfilled with a variety of courses, which can be chosen to complement the student's interests. No course applied to distribution may be taken pass-fail.

A College Seminar must be taken in the freshman year. This unique course allows students to study a subject of personal academic interest with an established faculty member who is an expert in the field. Seminars are usually limited to 20 students and encourage close interpersonal relationships with faculty and peers, heightened intellectual engagement, and freedom to explore and discuss ideas as they arise.

A. A&S 1, Choices and Decisions
   (first semester at Lehigh) 1 hour
B. College Seminar
   (one course during the first year) 3 hours
C. English Composition
   (two courses during the first year) 6 hours

Students and advisors should monitor closely the progress toward completion of these requirements. Courses taken within a major department to satisfy a major may be used to satisfy distribution requirements in only one distribution area; i.e., these courses must have the same distribution designation (natural science, social science, or arts and humanities - no mixtures).

D. Mathematical Sciences 3 hours
   Chosen from mathematics or designated courses from philosophy or computer science
E. Sciences 8 hours
   Chosen from those designated in: astronomy, biological anthropology, biosciences, chemistry, earth and environmental sciences, physics, and neuroscience.
   At least one science course must also include the associated laboratory.
F. Social Sciences 8 hours
   Chosen from those designated in: anthropology, classics, economics, political science, history, international relations, journalism, psychology, social psychology, social relations, sociology, STS, and urban studies.
G. Humanities 8 hours
   Chosen from those designated in: architecture, art, classics, history, modern foreign languages, English, music, philosophy, religion studies, and theatre.

Total required for graduation: 121 hours

A student's program, including the choice of distribution requirements, is not official until approved by the adviser.

Foreign Language Study
Students who are planning on graduate study toward a doctoral degree are reminded that most graduate schools require doctoral candidates to demonstrate a reading knowledge of one or two foreign languages.

Ability to use foreign languages is beneficial in many careers, such as law, journalism, commerce, industry, and government.

Centers and Institutes
The college participates in research and scholarship in a number of centers and institutes, where graduate and undergraduate students work closely with faculty members. These include: Center for Advanced Technology for Large Structural Systems, Center for International Studies, Center for Molecular Bioscience and Biotechnology, Health
Sciences Institute, Center for Innovation Management Studies, Center for Social Research, Emulsion Polymers Institute, Energy Research Center, Institute for Bioengineering and Mathematical Biology, Lawrence Henry Gipson Institute for Eighteenth-Century Studies, Materials Research Center, Philip and Muriel Berman Center for Jewish Studies, Center for Polymer Science & Engineering, Sherman Fairchild Center for Solid-state Studies, Technology Studies Resource Center, Zettelmeyer Center for Surface Studies.

Minor Programs in the College

Certain departments, divisions, and programs in the College of Arts and Sciences afford an opportunity to minor in an additional field of concentration other than the major field.

A minor consists of at least fifteen credit hours; the specific content is determined by the department, division, or program concerned. A minor is optional and, if successfully completed, will be shown on the university transcript in the same manner as the major field of concentration. A 2.0 minimum grade-point average is required for courses in the minor. Because of this requirement, no course in the minor program may be taken with Pass/Fail grading. No more than one course may be double-counted toward a major and a minor.

It is the responsibility of students desiring a minor to initiate it no later than the beginning of the junior year by filing a minor program with the department, division, or program where it is offered. The student’s minor adviser maintains appropriate records.

Minors in the College of Arts and Sciences departments and programs are available for degree candidates in other colleges within the university, with approval of their college adviser.

The following are established minors in the College of Arts & Sciences. Program descriptions may be found in the alphabetical listing of Sec. V. Some minor-program descriptions are collected within departmental descriptions, or located elsewhere, as indicated by parentheses.

- Actuarial Science (Mathematics)
- African American Studies
- American Literature (English)
- Anthropology (Sociology and Anthropology)
- Architecture (Art and Architecture)
- Art (Art and Architecture)
- Art/Architecture History (Art and Architecture)
- Asian Studies
- Astronomy
- Biology ( Biological Sciences)
- British Literature (English)
- Chemistry
- Chinese (Modern Foreign Languages)
- Classical Civilization (Classical Studies)
- Classics (Classical Studies)
- Cognitive Science
- Communication (Journalism and Communication)
- Computer Science (Electrical Engineering and Computer Science)
- Earth and Environmental Sciences
- Economics
- Education (Education Minor/Teacher Certification, this section)
- English
- Environment and Society
- French (Modern Foreign Languages)
- German (Modern Foreign Languages)
- Graphic Communication (Art and Architecture)
- Health and Human Development (Health Professions Programs, this section)
- History
- International Relations
- Interpersonal Behavior (contact Sociology and Anthropology Department)
- Jewish Studies
- Journalism (Journalism and Communication)
- Latin American Studies
- Mathematics, Applied (Mathematics)
- Mathematics, Pure (Mathematics)
- Molecular Biology (Biological Sciences)
- Museum Studies (Art and Architecture)
- Music
- Philosophy
- Physics
- Political Science
- Probability and Statistics (Mathematics)
- Psychology
- Public Administration (Political Science)
- Public Relations (Journalism and Communication)
- Religion Studies
- Russian (Modern Foreign Languages)
- Russian Studies
- Science, Technology and Society
- Science Writing (Journalism and Communication)
- Social Relations (Sociology and Anthropology)
- Sociology (Sociology and Anthropology)
- Social Psychology (Sociology and Anthropology)
- Spanish (Modern Foreign Languages)
- Studio Art (Art and Architecture)
- Theatre
- Urban Studies
- Women's Studies
- Writing (English)

College Scholar Program

The Roy Eckardt College Scholar Program is intended for students who show outstanding academic promise or unusual creativity and whose interests transcend traditional programs. It is a highly selective program, restricted to a small number of especially qualified students, some of whom are enrolled at the time of admission to the university and the rest in the following two years. Applications from entering freshmen are evaluated by the Admissions Office and the College Scholar Advisory Council on the basis of their written statements of educational goals, high school records, college board test scores, and teachers’ recommendations. Applications from freshmen and sophomores are evaluated by the Advisory Council on the basis of their academic records and written statements of educational goals, and recommendations from two faculty members.

The program allows students to devise individualized courses of study and to engage in scholarly work of an advanced nature. Participants are obliged to obtain 121 credits, including A&S1 and the junior writing requirement, take at least one college scholar seminar, and pursue departmental or interdisciplinary majors. With the approval of the program director, they design their own academic programs. They are released from distribution requirements and, if necessary, modifications may be made in major requirements. Responsibility for the student’s overall program lies with the director who cooperates closely with the major adviser. In each of the final two semesters, the student receives up to six credits for work with a faculty member, leading to a senior project of substantial dimensions. This can take whatever form is appropriate to the nature of the subject. Students present accounts of their projects at the annual college scholar graduation dinner. The award of the College Scholar graduation honors is subject to the recommendation of the program director (Prof. Ian Duffy, 340 Maginnes Hall) and the chairperson in the major field.

In addition to the academic privileges of the program, college scholars are offered a variety of extracurricular opportunities. These include invitations to meet visiting speakers, informal meetings with faculty members, dinners, lectures, plays, musical events, and other cultural activities in the Lehigh Valley and nearby cities. For a listing of courses and Advisory Council members, see Roy Eckardt College Scholar Program entry, section V.
College Seminar Program
During the fall or spring semester of the freshman year, every freshman student in the College of Arts and Sciences is required to enroll in a college seminar taught by a member of the faculty. With ten to twenty students per class, these seminars provide an intimate and supportive environment that facilitates the transition to university life. Students begin to develop many of the skills that serve as a framework for their future scholarly work—how to read closely, think critically, write clearly, learn cooperatively, speak persuasively, and solve problems creatively.

College seminars are an excellent way to explore a subject that may be new, or to enter more deeply into an area of previous interest. Many of the topics are non-traditional or interdisciplinary subjects of special interest to the professor. Recent offerings have included: “The Jazz Age,” “The Death of Western Civilization,” “Cosmic Physics,” “The Soviet Collapse and Russia's Future,” “Fate and Character,” “AIDS and Society,” “Acting,” “In Search of Big Foot.”

Whatever the topic, seminars involve considerable effort on the part of students. Some classes emphasize reading assignments, papers, and oral presentations; others include tests, laboratory work, or fieldwork. Each 3-credit seminar fulfills the College Seminar requirement but does not fulfill any distributional requirements.

Pre-Law Programs
The university has a strong pre-law tradition. In keeping with the policy of the Association of American Law Schools, the university does not have a prescribed pre-law program.

Lehigh students have been successful in attaining entrance into law schools from diverse curricula in all three of the undergraduate colleges. Law-related courses, some of which rely on the case method, are provided by both the College of Arts and Sciences and the College of Business and Economics. These courses are open to all students, including those in the College of Engineering and Applied Science. Illustrative courses in Arts and Sciences include Constitutional Law, Civil Rights, Administrative Law, Media Ethics and Law, and American Constitutional and Legal History. Correspondingly, there are courses such as Introduction to Law and Legal Environment of Business in the College of Business and Economics. That college also offers basic accounting courses that are often recommended as part of an undergraduate’s pre-law preparation. Students interested in pursuing a postgraduate legal education should contact one or more of the professors in these courses.

In addition to formal academic instruction, Lehigh provides other opportunities for learning about law and careers in law. The annual Tresolini Lecture series brings nationally recognized speakers to campus for extended interactions with faculty and students. Tresolini lecturers have included present and past U.S. and state Supreme Court Justices and renowned legal scholars and practitioners. Lehigh also provides opportunities for gaining academic credit in several off-campus programs which provide practical experience in law and public affairs.

Counseling is available to prospective pre-law students on a continuous basis from freshman orientation through the law school application process in the senior year. An advisory committee, composed of faculty members and the pre-professional advisor in Career Services, coordinates these pre-law counseling services. Students are urged to consult members of this committee as early as possible in their academic careers.

Health Professions Programs
Schools of medicine, dentistry, optometry, podiatry, and veterinary medicine stress the importance of a strong liberal arts education as well as prescribed studies in the sciences. Although most pre-health students will choose a major in a pure or applied science, as long as candidates have the essential courses in biology, chemistry, physics, and mathematics, they may major in any of the three undergraduate colleges.

A health professions advisory committee, which includes a pre-professional advisor and faculty members from biology, chemistry, and physics, provides career and academic counseling and works closely with students from freshman orientation through the entire process of applying to professional schools. Students are urged to consult with the pre-professional advisor as early as possible in their academic career. Students interested in other allied health fields may also obtain information to aid them in planning their courses with their academic advisers.

Combined-Degree Program in Medicine
In cooperation with Allegheny University of the Health Sciences the university offers an accelerated program that enables selected students to earn both the bachelor of arts degree in premedical science and the M.D. degree after a minimum of six or seven years of study at the two institutions. The program was initiated in 1974, and approximately ten students are admitted each year.

The program includes two or three academic years at Lehigh, during which time ninety-one credit hours are earned toward the 121 credits required for the baccalaureate degree. The next four years are spent in the regular program of medical education in Philadelphia. After successfully completing the first two years at the medical school, students will have acquired the necessary additional credit hours for the baccalaureate degree.

During the pre-professional years at Lehigh, students are expected to make satisfactory progress in academic areas as well as in the more subtle task of personal growth in those attributes ultimately needed as a physician. AUHS receives student grades and monitors student progress through feedback from Lehigh staff. Students are expected to maintain an overall grade point average of 3.45 or better (A=4.0) and no grade(s) less than a “C". Credentials again will be processed through the medical school’s Admissions Committee prior to extending a final definitive acceptance. This program also requires that students take the Medical College Admissions Test. The results will be evaluated by the Committee prior to final acceptances. It is expected that the three numbered scores be “9” or better on the 1-15 scale.

The medical college reserves the right to withdraw an offer of acceptance if academic or personal criteria cause the college to question a student’s academic or personal maturation.

Application for admission to the program is made through the Lehigh Office of Admissions. Criteria for admission include SAT scores (minimum combined score of 1360 recntered scale), scholastic achievement, maturity, and motivation for medicine. SAT II scores are not required but are recommended (i.e. Mathematics, English Composition, and Chemistry).

Completed applications are reviewed by the Office of Admissions, and a pool of students are chosen for interview by the AUHS.

Interviews are not required at Lehigh, but students are encouraged to make arrangements to come to campus to have an interview and to become better acquainted with Lehigh and the special features of this program. Application deadline is December 1. Course work for a two year format follows.

**Year 1:**

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<th>Course</th>
<th>Credits</th>
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<tr>
<td>Arts 1 (1)</td>
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<td>Engl 1 (3)</td>
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<tr>
<td>Chm 21, 22 (5)</td>
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<tr>
<td>Math 21 or 51(4)</td>
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<tr>
<td>Humanities 3</td>
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**Year 2:**

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<th>Course</th>
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<tr>
<td>Phy 11, 12 (5)</td>
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<tr>
<td>BioS 31, 32 (4)</td>
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<tr>
<td>Math 23 or Math elective (3-4)</td>
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<tr>
<td>Humanities 3</td>
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<tr>
<td>Elective (free) (3)</td>
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**Summer 1:**

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<th>Course</th>
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<td>Chm 51, 53 (4)</td>
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<tr>
<td>Chm 52, 58 (4)</td>
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<td>Elective (free) (3)</td>
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**Year 3:**

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<th>Course</th>
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<tr>
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<tr>
<td>Chm 31 (3)</td>
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<tr>
<td>BioS 101, 102(4)</td>
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<tr>
<td>Social Science (3)</td>
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<td>Elective (free) (3)</td>
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**Year 4:**

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<th>Course</th>
<th>Credits</th>
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<tbody>
<tr>
<td>Writing Intensive (3)</td>
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</table>
Summer 2:
- Humanities (3)
- Social Science (3)
- Elective (free) (3)

Combined-Degree Program in Dentistry
The university, in cooperation with the School of Dental Medicine at the University of Pennsylvania, offers an accelerated program that enables selected students to earn a combined baccalaureate and doctor of dental medicine degree after a minimum of seven years of study at the two institutions.

The program includes three academic years during which time ninety-two credit hours are earned toward the baccalaureate degree. The next four years are spent in the regular program of dental education in Philadelphia.

During the first three years at Lehigh, students are expected to make satisfactory progress in the academic areas as well as in the areas of personal growth, developing those attributes ultimately needed to become a dentist. Students must maintain a minimum 3.0 grade-point average throughout their three years at Lehigh and are required to take the Dental Admissions Test.

The dental school reserves the right to withdraw an acceptance if academic or personal concerns cause the college to question a student's ability to function as a dentist. The dental school also reserves the right to require that students spend additional time at Lehigh if the school feels that this is necessary to insure the student's academic or personal maturation.

Application to the program occurs when a student applies to Lehigh University. The dental school takes action on the applicant in the spring of an academic year. Final decisions are forwarded to Lehigh University about March 20. The applicant is notified of joint acceptance by Lehigh University. Admission is based on SAT scores (a minimum combined score of 1270 recentered scale), scholastic achievement, maturity, and motivation for dental school. Application deadline is January 1.

Year 1, fall
- Arts 1 (1)
- Engl 1 (3)
- Math 51 (4)
- Chm 21, 22 (5)
- Humanities (3)

Year 1, spring
- Arts 1 (1)
- Engl 2 (3)
- Math 52 (3)
- EES 31 (4)
- Freshman Seminar (3)

Year 2, fall
- Chm 51, 53 (4)
- Bios 31, 32 (4)
- Humanities (3)
- Elective (free) (3)

Year 2, spring
- Chm 52, 58 (4)
- Bios 101, 102, (4)
- Social Science (3)
- Elective (free) (3)

Joint Degree Program in Optometry
In cooperation with the State University of New York, State College of Optometry located in New York City, Lehigh offers a seven year Bachelor of Arts in Behavioral Neuroscience and Doctor of Optometry (O.D.) Program. Students accepted into the Joint Degree Program are admitted into the Behavioral Neuroscience major at Lehigh and are simultaneously admitted to candidacy to the SUNY College of Optometry's professional program of study.

Application to the program occurs when a student applies to Lehigh or while enrolled at Lehigh. Criteria for selection is based upon maturity and motivation; an interest in the basic understanding of the optometric profession; a minimum of 1180 SAT recentered score, 92 high school grade average, and ranked in the top 10% of the high school graduating class. Or, if a first or second year Lehigh student, a minimum overall 3.2 grade point average in undergraduate coursework and in all prerequisite math and science courses completed at the time of application with no grade below a C. A committee comprised of representatives from both institutions selects the students for admission into the program.

Students will matriculate at Lehigh for three years during which time ninety-eight credit hours are earned toward the baccalaureate degree. Upon maintaining a minimum 3.2 grade point average in the required math and science prerequisites, attending total science courses of 320 or above on the Optometry Admissions Test (OAT), and passing reasonable personal interview standards, these students will be admitted to the SUNY College of Optometry at the completion of their third year at Lehigh. All science and math prerequisite courses must be satisfied with a C or higher. Students must submit a formal application, transcripts, and recommendations at this time. After successfully completing all first-year coursework at the college of optometry, a BA degree in Behavioral Neuroscience will be granted by Lehigh.

The optometry school reserves the right to withdraw an acceptance if academic or personal concerns cause the school to question a student's ability to function as an optometrist.

Application for admission to the program for incoming students is made through the Lehigh Office of Admissions. Applications deadline is January 1.

Year 1, fall
- Arts 1 (1)
- Engl 1 (3)
- Math 21 or 51 (4)
- Psy 1 (4)

Year 2, fall
- Bios 177 (3)
- Chem 51, 52 (4)
- Humanities elective (3)
- Social Science elective (3)
- Approved Bios elective (3)

Year 3, fall
- Approved Writing Intensive (3)
- Chem 31 (3)
- Phy 11, 12 (5)
- Social Science elective (3)
- Approved Bios elective (3)

Health and Human Development Minor
The minor in health and human development, located primarily within the College of Arts and Sciences, is an interdisciplinary program designed to provide insight into the social scientific aspects of health issues through the human life cycle. While this minor program is open to anyone in the three undergraduate colleges, it may be of particular interest to students preparing for careers in any aspect of health care, social work, and child or adult development.

The program is administered through the Program in Health and Human Development, an interdisciplinary group of faculty members who have research interests in this area. Current research studies cover all aspects of the life cycle, including the health dimensions of both normal and abnormal child development, reproductive health issues, adult life crises such as illness and loss, and dimensions of aging.

Students are able to serve as research assistants in some of these studies.

The minor consists of a minimum of fifteen credit hours chosen in consultation with the program director, Donna Kosteva, in the office of Career Services.
College of Business and Economics

Patti T. Ota, vice provost and dean of the CBE.
Therese A. Massukka, associate dean, director of undergraduate programs; Kathleen A. Teaves, assistant dean, director of MBA program; James A. Greenleaf, Chairperson, department of business; Vincent G. Manley, chairperson, department of economics, Michael G. Kolchin, director, graduate and professional education, James A. Dearden, director, Ph.D. program.

The College of Business and Economics offers the bachelor of science degree in business and economics, which couples a liberal educational background with an understanding of the complexities and processes of management. It can serve as the basis for a career in business or for professional studies in fields such as law, business, or related fields.

The undergraduate business program, undergraduate accounting program, and MBA program are accredited by the American Assembly of Collegiate Schools of Business (AACSB), of which the College of Business and Economics is a member. The college offers an undergraduate education designed to provide an understanding of the complexities of the managerial process in society, both within and outside the business firm.

The College of Business and Economics consists of two departments: the Department of Business and the Department of Economics. The Department of Business offers undergraduate majors in finance, information systems, management and marketing, as well as a program in accounting, and courses in law. The Department of Economics offers a major in the College of Business and Economics as well as a major in the College of Arts and Science.

Many of the most difficult societal problems today involve decision-making, conflict resolution, and the efficient and effective management of human, financial and physical resources. The study of business and economics provides a basis for understanding and developing solutions to these problems.

Thus the college’s undergraduate business programs stress analytical and communication skills, and problem-solving techniques. Educational breadth equivalent to many liberal arts programs is accompanied by in-depth study of business processes such as accounting information systems, financial flows and markets, management processes, and the impact of economic forces upon business and social issues.

Goals of the College

The mission of Lehigh University’s College of Business and Economics is to provide educational programs at the undergraduate and graduate levels that prepare students for the increasingly complex and globally competitive environment of the 21st century. This environment will be characterized by rapid and continuous changes in both technology and in the structures of organizations that employ our graduates. These graduates may find themselves repeatedly changing employers and even careers; they will work and live with colleagues from diverse cultural backgrounds. Hence our educational programs must provide them not only with basic entry-level technical knowledge and professional skills, but also broader intellectual capacities that will enable them to thrive during a lifetime of dramatic change.

The objectives of the undergraduate education we provide are as follows:

- To stimulate student interest in basic business and economic principles of resource allocation, financial management, management of human and physical resources, information systems, financial and managerial accounting, and pricing and distribution through a common body of knowledge;
- To provide breadth of appreciation of the scientific, technological, social, and human features of the global environment of business;
- To develop intellectual tools which permit rigorous analysis of business problems and foster a capacity for continuing lifelong learning;
- To offer advanced courses for upperclass students as a prelude to a professional career or to graduate study;

Education Minor and Teacher Certification

The education minor helps undergraduates explore career options in school teaching or other professional careers with elementary, secondary, or special-education students. The minor may accelerate entry into a teaching career because appropriate credits from the minor may be applied toward completion of teacher-certification credits for those admitted to Lehigh’s graduate-level Teacher Intern Program.

The minor offers a systematic background of professional education experiences, coordinating practicum activities with theory courses designed to provide a foundation for future educational studies. Its focus is exploratory. No career decision is required but the minor is provided for those with a serious interest in considering the teaching profession.

The experiences of the minor are intended to enrich an individual’s understanding of education as a central intellectual activity of our culture and to provide self-understanding of one’s own potential as an educator.

An undergraduate may take one or all of these courses during the junior and senior years with the approval of the adviser and minimum GPA of 2.75. Completion of the minor does not assure admission to the Teacher Intern Program to become a certified professional. However, if the student passes the screening process on the basis of previous work and interviews, he or she may enter the intern program with advanced standing toward certification.

The program coordinator is Lynn Columbia, Mountaintop Campus, 111 Research Drive.

Fifteen credit hours are chosen from among the following courses for those in the education minor:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Educ 312</td>
<td>Classroom Practice (1)</td>
<td></td>
</tr>
<tr>
<td>Educ 314</td>
<td>Intern Seminar (2)</td>
<td></td>
</tr>
<tr>
<td>Educ 394</td>
<td>Special Topics in Instruction and Curriculum (3)</td>
<td></td>
</tr>
<tr>
<td>Educ 429</td>
<td>Child Development (3)</td>
<td></td>
</tr>
<tr>
<td>Educ 441</td>
<td>Youth in Society (3)</td>
<td></td>
</tr>
<tr>
<td>Elective</td>
<td>Education course (appropriate to student’s objective (3)</td>
<td></td>
</tr>
</tbody>
</table>
• To provide each student through his or her major an in-depth learning experience in at least one area of business or economics, such as accounting, economics, finance, management, or marketing;  
• To enhance written and oral communication and critical thinking skills.

**Breadth of Study**

The integrated undergraduate programs in the College of Business and Economics are designed to provide—through outstanding teaching, innovative curriculum, and opportunities for all students to have personal interaction with practitioners—educational experiences that clearly demonstrate the comparative advantage of Lehigh's academic programs for students majoring in accounting, economics, finance, information systems, management, and marketing.

This education in fundamental principles, and problem-solving techniques provides graduates with various options. Some of the students choosing this curriculum have already settled upon business careers. Others will use it as a base for further professional studies in law, graduate business schools, or specialized graduate training in economics, operations research, or other related fields. Still others go into administrative careers in government or nonprofit institutions such as hospitals and universities. Others apply their talents to professional accounting, financial investment, or management consulting careers. Business today cannot be approached without new, superficial vocational training. Everywhere, organizations are affected by local, national and international economic trends as evidenced by the complex cultural, social and ethical issues today's global marketplace presents.

Thus a strong basis in the social sciences is essential to understanding the nature of business organizations. Students must also be familiar with physical sciences and technology and with the ways in which mathematics and computer systems are essential elements of modern decision-making processes. The undergraduate program in business and economics provides an introduction to all of these academic areas.

**Variety of Options**

Students preparing for careers in the 21st century must be provided with options to sample the insights and wisdom of a wide variety of academic disciplines outside of business. Lehigh's undergraduate program is designed to provide breadth of study and exposure to science, language, and the arts and humanities is accomplished by distribution requirements, within each of which the student has wide choice. In addition, students have 33 credits of free electives, 24 of which must be taken outside the College of Business and Economics.

The degree of bachelor of science in business and economics may also lead to achievement of the bachelor of business administration degree at Lehigh or another institution. In addition to the master of business administration, the college also offers the following graduate degrees: doctor of philosophy, master of science in economics, master of science in business and economics, master of science in management science, and master of science in management of technology. These are described in Section IV.

**Centers and Institutes**

The college also oversees research and scholarship in a number of centers and institutes, where graduate and undergraduate students work closely with faculty members. These include: Diamond Center for Economic Education, Center for Innovation Management Studies, Martin Center for the Study of Private Enterprise, Institute for the Study of Commodities, Philip Rausch Center for Business Communications, Goodman Center for Real Estate Studies, and Mueller Center for Entrepreneurship. The college is also associated with the Center for International Studies, and the Iaccocca Institute.

**Bachelor of Science in Business and Economics**

To obtain the bachelor of science degree in business and economics, 120 credit hours are required. A writing requirement, which is included within the required 120 credit hours, is also a part of the college curriculum.

**College Core Requirements (56 credits)**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engl 1</td>
<td>Composition and Literature</td>
<td>3</td>
</tr>
<tr>
<td>Engl 2</td>
<td>Composition and Literature: Fiction, Drama, Poetry</td>
<td>3</td>
</tr>
<tr>
<td>Math 51</td>
<td>BMSS Calculus I</td>
<td>4</td>
</tr>
<tr>
<td>Math 61</td>
<td>Linear Algebra</td>
<td>2</td>
</tr>
</tbody>
</table>

**Business and Economics Core (44 credits)**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eco 1</td>
<td>Economics</td>
<td>4</td>
</tr>
<tr>
<td>Mgt 1</td>
<td>Introduction to Business Computing</td>
<td>3</td>
</tr>
<tr>
<td>Mgt 107</td>
<td>Introduction to Business Communication</td>
<td>2</td>
</tr>
<tr>
<td>Eco 115</td>
<td>Applied Microeconomics</td>
<td>3</td>
</tr>
<tr>
<td>Eco 145</td>
<td>Statistical Methods</td>
<td>4</td>
</tr>
<tr>
<td>Eco 129</td>
<td>Money and Banking</td>
<td>3</td>
</tr>
<tr>
<td>Acct 151</td>
<td>Introduction to Financial Accounting</td>
<td>3</td>
</tr>
<tr>
<td>Acct 152</td>
<td>Introduction to Managerial Accounting</td>
<td>3</td>
</tr>
<tr>
<td>Acct 211 or</td>
<td>Management Information Systems in Business</td>
<td>3</td>
</tr>
<tr>
<td>Acct 311</td>
<td>Accounting Information Systems</td>
<td>3</td>
</tr>
<tr>
<td>Law 201</td>
<td>Legal Environment of Business</td>
<td>3</td>
</tr>
<tr>
<td>Mkt 211</td>
<td>Contemporary Marketing</td>
<td>3</td>
</tr>
<tr>
<td>Fin 225</td>
<td>Business Finance</td>
<td>3</td>
</tr>
<tr>
<td>Mgt 269</td>
<td>Management of Operations in Organizations</td>
<td>3</td>
</tr>
<tr>
<td>Mgt 270</td>
<td>Organization Theory and Behavior</td>
<td>3</td>
</tr>
<tr>
<td>Mgt 301 or</td>
<td>Business Management Policies</td>
<td>3</td>
</tr>
<tr>
<td>Mgt 306</td>
<td>Entrepreneurship and Business Policy</td>
<td>3</td>
</tr>
</tbody>
</table>

**Major Program (15 credits)**

Before the end of the first semester of the junior year, students select a major consisting of sequential or related courses in one of the five major programs: accounting, economics, finance, management, and marketing. A grade point average of 2.0 or higher in the major program is required for graduation.

**Distribution Requirements (15 credits)**

Students are required to take six (6) credits of humanities, six (6) credits of social science, and three (3) credits of science for a total of 15 credits of distribution requirements. Students should refer to the catalog to determine which course offerings may be taken to satisfy this requirement.

**Electives (34 credits)**

Students will earn 34 credits of “free” electives; a maximum of nine credits may be taken from other course work in the College of Business and Economics. The remaining 25 credits are to be taken outside the College of Business and Economics. Of these 25 credits, six credits may be approved 300-level economics courses.

**Planning Courses of Study**

In addition to freshman English and mathematics requirements, one half of the freshman class will be assigned Eco 1 during the fall semester, while the other half will be assigned Eco 1 during the spring semester. Students are encouraged to consider substituting Math 21 and 22 for the Math 51 and 61 requirement because Math 21 and 22 are prerequisites for many courses in engineering and science. Acct 151 is taken in the first semester of the sophomore year.

**Freshman Year - 1997**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
<th>Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>first semester</td>
<td>second semester</td>
<td></td>
</tr>
<tr>
<td>Engl 1</td>
<td>3 cr hrs</td>
<td>Engl 2</td>
</tr>
<tr>
<td>Math 51</td>
<td>4</td>
<td>Math 61</td>
</tr>
<tr>
<td>Eco 1</td>
<td>4 or elective</td>
<td>Eco 1</td>
</tr>
<tr>
<td>**Mgt 95</td>
<td>1</td>
<td>elective</td>
</tr>
<tr>
<td>elective</td>
<td>(3)</td>
<td>elective</td>
</tr>
</tbody>
</table>
The pass-fail option is available for students in the college for elective courses only. Students desiring to obtain Lehigh credit for courses taken at other institutions must obtain a petition form from the registrar's office and obtain the approval of appropriate Lehigh academic departments in advance.

** Class of 2001 students

MGT 1, Introduction to Business Computing, will not be offered during Fall 1997 or Spring 1998. The College of Business and Economics Class of 2001, entering Lehigh in Fall 1997 as freshman, will take instead MGT 95, Introduction to Business (1) credit and a series of computer proficiency exams (2) credits.

Members of the Class of 2001 will be required to take MGT 95, Introduction to Business, for one credit during Fall 1997 on a pass-fail basis. MGT 95 will be offered only in the fall and is open only to College of Business and Economics freshmen. These students are also required to pass a series of proficiency exams dealing with various computer topics, such as spreadsheets, databases, operating systems, presentation software, programming and the Internet. Students will have the option of self-study or enrolling in computer tutorials offered by the College beginning in Spring 1998. Upon successfully passing all of the proficiency exams, students will receive two credits.

College of Education

The university's College of Education offers opportunities for advanced study in the field of education. For information, see Graduate Study in Education, Section IV or College of Education, Section V.

College of Engineering and Applied Science

Harvey G. Stenger, dean
Richard N. Weisman, associate dean
Carol S. Smith-Nichols, assistant dean

The College of Engineering and Applied Science offers the bachelor of science degree in thirteen programs, combining a strong background in sciences and mathematics with requirements in humanities and social sciences. Students in college programs learn principles they can apply immediately in professional work; those who plan on further academic experience can design a curriculum centering on interests they will pursue in graduate school.

Major Subjects

The College of Engineering and Applied Science includes six departments and offers undergraduate and graduate degree programs at the bachelor, master, and doctor of philosophy levels. The undergraduate degree programs leading to the bachelor of science degree are:

- biochemistry
- chemical engineering*
- chemistry
- civil engineering*
- computer engineering*
- computer science**
- electrical engineering*
- engineering mechanics
- engineering physics
- fundamental sciences
- industrial engineering*
- materials science and engineering*
- mechanical engineering*

*Accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology.
**Accredited by the Computing Science Accreditation Board, Inc.

Programs in chemistry and physics have been approved by the faculty program review committee in these disciplines.

Information about each of these programs may be found under alphabetical listings in Section V.

Each of the curricula includes course requirements in the physical sciences, mathematics, engineering, and the advanced engineering or science course work essential for the particular degree. In addition, each curriculum requires study in humanities and social sciences (HSS).

Declaration and Change of Curriculum

In the second semester of the freshman year, at preregistration for the sophomore year, students usually indicate their choice of curriculum. However, since the sophomore year programs for several curricula are very much alike, it is possible to transfer from one curriculum to another as late as the end of the sophomore year. This is done by means of a petition following consultation with curriculum advisors. There are instances where such a transfer may require one or two courses to be taken during a summer session at Lehigh or elsewhere.

Undergraduates with interests in such topical areas as environmental biotechnology, or aerospace engineering may pursue their interests through electives provided in each of the curricula. Effective preparation for graduate study in such specialties consists of basic programs in engineering and science, along with electives especially chosen for the field of interest. Such electives are chosen from among all the offerings of the university and are usually taken during the senior year.

Free Electives

The college, through its advisers, is prepared to help students to use the credit hours of "free electives" that, along with other electives in the curriculum, may be used to develop a program of personal interest. Free electives may be satisfied by taking regular course offerings or up to six credit hours from Mus 21-79, or up to six credit hours from Jour 1-8, or up to six credit hours of advanced ROTC courses.

Qualified juniors in the college planning to continue their formal education in graduate school are urged to take advantage of the flexibility in their programs and design their senior-year "free elective" opportunities in a manner that provides an effective foundation for a graduate program. Students who plan their programs in this manner can, upon recommendation of the department, receive credit toward their degree for up to six hours of graduate-level courses.

Technical Minors

Minors are offered in technical or scientific specialties that are not normally included within the standard curricula. Each minor program contains at least fifteen credit hours of technical and/or scientific courses. Often these courses can be chosen as approved electives in the student's major curriculum; others are chosen as free electives.

The student interested in a technical minor should contact the Associate Chair of the Department in which the minor is desired for specific degree requirements.

Recommended Freshman Year In Engineering and Applied Science

A recommended outline of courses for the freshman year, which satisfies requirements for all students in the college, is shown below. For schedules of the courses required in the following three years, refer to Section V.

Freshman year, first semester (15-16 credits)

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engl 1</td>
<td>Composition and Literature (3)</td>
</tr>
<tr>
<td>Chm 21,22</td>
<td>Introductory Chemical Principles and Laboratory (5) or</td>
</tr>
<tr>
<td>Phy 11, 12</td>
<td>Introductory Physics I and Laboratory (5)</td>
</tr>
<tr>
<td>Math 21</td>
<td>Analytic Geometry and Calculus I(4)</td>
</tr>
</tbody>
</table>
Engr 1 Elective  Engineering Computations (3) or 
Humanities/Social Sciences or free 
elective (3-4) and Engineering 2, 
Introduction to Engineering (1)

Freshman year, second semester (15-16 credits)
Engl 2  Composition and Literature: Fiction, 
Drama, Poetry (3)
Phy 11, 12  Introductory Physics I and 
Laboratory (5) or
Chm 21, 22  Introductory Chemical Principles and 
Laboratory (5)
Math 22  Analytic Geometry and Calculus II (4)
Engr 1/Elective  Engineering Computations (3) or 
Humanities/Social Sciences or free 
elective (3-4) and Engineering 2, 
Introduction to Engineering (1)

Humanities/Social Sciences (HSS)
Requirement for all Accredited Engineering Majors

Basic Requirement: English and Economics (3 courses totaling a 
minimum of 10 credit hours):
Students must complete English 1 or 3, English 2,4,5,6,8 or 10, and 
Economics 1.

Advanced Requirement: Breadth and Depth  A minimum of 5 
courses whose total credit hours plus the total credit hours in the basic 
requirement equals a minimum of 25 credit hours. These courses must 
be selected from the departments/programs listed in Table 2, excluding 
those courses in Table 1.

Depth: A minimum of 3 courses totaling at least 9 credit hours must 
be in one discipline, of which at least one course must be at the 100 level 
or above. This course sequence establishes HSS depth.

Breadth: A minimum of 2 courses totaling at least 6 credit hours.
These courses must be taken in disciplines different from the 
courses which establish depth. These courses must not be cross listed with 
the department/program chosen for depth. These courses, plus the courses 
which established depth and the courses in the basic requirement, 
establish HSS breadth.

TABLE 1
Courses which cannot be used to satisfy the HSS requirement.

Anthropology 12
Architecture 147, 351, 352
Communications 60, 130, 144, 331
Economics 101, 145, 351, 352, 357
English, all freshman composition courses, 171, 173
Government 313, 314
Journals through 12, 111, 123, 128, 129, 141, 212, 214, 215, 220, 
Music 11 through 79
Philosophy 114
Psychology 110, 160-162, 176, 210, 335, 373, 375, 382
Social Relations 41, 111, 112
Theater 61, 111, 161, 181

TABLE 2
Course Designations for HSS Courses

African American Studies (AAS)
Ancient Greek (GRK)
Anthropology (ANTHI)
Architecture (ARCH)
Art (ART)
Arts and Science (AS)
Asian Studies (ASIA)
Chinese (CHIN)

Education (EDUC)
Classical Civilization (CLSS)
Communications (COMM)
Economics (ECO)
Education (EDUC)
English (ENG)
French (FREN)
German (GERM)
Hebrew (HEBR)
History (HIST)
International Relations (IR)
Japanese (JPNS)
Journalism (JOUR)
Latin (LAT)
Law (LAW)
Modern Foreign Language (MFL)
Music (MUS)
Philosophy (PHIL)
Political Science (POLS)
Psychology (PSYC)
Religion Studies (REL)
Russian (RUSS)
Science Technology and Science (STS)
Social Relations (SR)
Sociology/Social Psychology (SSP)
Spanish (SPAN)
Special Education (SPED)
Theater (THTR)
Urban Studies (US)
Women's Studies (WS)

Minors in Humanities/Social Sciences
For greater emphasis in a particular area, a student may choose to 
complete a minor in Humanities and Social Sciences (HSS). Specific 
requirements may be found under the heading Minor Programs in the 
College. Because students must fulfill the HSS requirements, this will 
result in taking as many as seven HSS courses. Therefore, a student 
electing a minor must use personal (free) electives. Each curriculum in 
the College contains a minimum of two such unrestricted electives.

Written permission to pursue a minor in HSS must be obtained from 
the sponsoring department, and the student's academic advisor, and 
filed with the Registrar. A student successfully completing a HSS minor 
will receive a certificate in recognition of this accomplishment.

Other issues and constraints:
1. None of the courses taken to satisfy the HSS requirement can be 
taken pass/fail
2. The introductory level course in any language can only be used to 
meet the HSS requirement if a second course in the same language is 
successfully completed. Completing 3 courses in a language will satisfy 
the depth requirement even if none of the courses are at the 100 level or 
above.

Centers and Institutes
Faculty and students in the college also have research and scholarship 
activities in a number of centers and institutes, where graduate and 
undergraduate students work closely with faculty members. These 
include: Center for Advanced Technology for Large Structural Systems, 
Biopharmaceutical Technology Institute, Chemical Process Modeling 
and Control Center, Emulsion Polymers Institute, Energy Research 
Center, Fritz Laboratory,

Iacocca Institute, Institute for Biomedical Engineering and Mathematical 
Biology, Institute of Thermo- Fluid Engineering and Science, Materials 
Research Center, Sherman Fairchild Center for Solid-state Studies, 
Zettlemyer Center for Surface Studies.
Special Undergraduate Academic Opportunities

The academic programs in the colleges are supplemented by five-year, two-degree programs as well as opportunities for advanced, foreign, and experiential study.

Arts-Engineering Option
The curriculum in Arts-Engineering is designed for students wanting a professional education in a field of engineering and also the opportunity to study a second field.

Arts-engineers fulfill all requirements for the professional engineering degree for which they are working. However, the first three years of science and engineering courses are scheduled over four years for the arts-engineer. During this period the arts-engineer is a student in the College of Arts and Science pursuing a bachelor of arts or bachelor of science major program.

In many instances it may be advisable to take the two degrees at the end of the fifth year. Arts-engineers working towards the bachelor of science in biology, computer science, environmental science, geological sciences, geophysics, molecular biology, and statistics are advised to pay special attention to the engineering Humanities and Social Science requirements, which must be met in time for the student to qualify for the B.S. in engineering.

Arts-engineers have the same opportunities for multiple majors and special interdisciplinary majors as are available to students working for the baccalaureate (B.S. or B.A. degree only) in the College of Arts and Sciences. Additional information may be obtained by contacting Prof. Daniel Zeroka, 496 Seeley Mudd Building.

Bachelor/Master Degree Programs
Of increasing interest to undergraduates are the two-degree programs that may lead to both a bachelor and a master’s degree in five years. Because Lehigh’s well-established graduate programs are closely integrated with the undergraduate programs, it is possible to consider programs leading to the arts/master of business administration degree and the engineering/master of science in Material Science, among others. The fifth-year program in the School of Education enables those receiving a B.A. degree to accomplish professional teacher training and serve as salaried interns in public schools. After the completion of one year of full-time teaching, secondary teachers can receive the master of arts and elementary teachers can receive master of education degrees.

Many other five-year, graduate-level combination programs exist, and students are advised to consult with their adviser in planning such programs.

Arts/M.B.A. Program
Students in the College of Arts and Science may enroll in a special arts/master of business administration program by completing the 43 credit hours of courses listed below in the suggested sequence, while completing their major in one of the B.A. programs in the college during their first four years. At the end of this period, if they are admitted to the Graduate School, they may be granted their M.B.A. degree upon completion of an additional 36 hours of course work. This can usually be accomplished in two regular semesters and two summer sessions.

All courses listed below under “other required courses” must have a grade of B minus or better in order to be credited toward the M.B.A. program.

The following comprise the required courses during the four years in the college:

required background courses
* Eco 11 Principles of Microeconomics (3) or
  * Math 41 BMSS Calculus (3) and
  * Math 21 Principles of Macroeconomics (3)
  * Math 22 Analytical Geometry & Calculus (4)
  * Mgt 1 Analytical Geometry and Calculus II (4)

courses to be used as waivers for M.B.A. courses
** Eco 145 Intro to Business Computing (3)
  ** IE 121 Statistical Methods (3) or
  ** Math 231 Applied Engineering Statistics (3)
  ** Acct 151 Probability and Statistics (3)
  ** Acct 152 Essentials of Accounting (3)
  ** Eco 119 Essentials of Accounting (3)
  ** Acct 324 Macroeconomic Analysis (3)
  ** Mgt 302 Cost Accounting (3)
  ** IE 222 Quantitative Models-Conceptual (3)
  ** Law 201 Operations Research-Deterministic (3)
  ** Eco 229 Legal Environment of Business (3)
  ** Eco 229 Money and Banking (3)

* recommended in the freshman year
** recommended in the sophomore year
*** junior standing required for this course

Note: Students must take both Acct 152 and Acct 324 to waive Acct 413; and students must take both Eco 119 and Eco 229 to waive Eco 409.

Engineering-M.B.A. Program
The bachelor in engineering-master of business administration two-degree program is designed to meet the needs of especially competent students in any engineering curriculum who want to add to their engineering studies training in business management at an advanced level.

The time involved will vary depending on the student’s background. One or more summer sessions in addition to two or more regular semesters of study may be necessary after completion of the bachelor’s degree in engineering to attain the M.B.A. an M.S. in management of technology or the M.S. in economics. All candidates must take the Graduate Management Admission Test and must meet the standards for admission into The Graduate School.

For background courses required for the master of business administration program, engineering students should read Section IVY Graduate Study in Business and Economics, and consult with Kathleen Trexler, Assistant Dean and MBA Director, College of Business and Economics as early as possible.

Interdisciplinary Programs
The university’s interdisciplinary programs are designed to cross the boundaries between colleges to accommodate new and developing fields as well as the interests of students. They include such programs as the following:

AfroAmerican Studies. A program offering a minor is available to students interested in exploring various aspects of the African American experience. Courses covering African American art, history, literature, music, and society are offered. The program is complemented with a lecture, film, and arts series that highlights the richness and diversity of black culture.

Science, Technology and Society Program (STS). Faculty from all three colleges explore the interrelationships between science and technological advancement and the quality of human life in the popular STS program.

International Programs at Lehigh
“The University emphasizes the development of future leaders in our global society as first among Lehigh’s purposes...”

The International Mission Statement, Lehigh University
Office of International Education

Anne H. Thomas, Director, 318 Whitaker, 5 E. Packer Ave., Bethlehem, PA, 18015; (610) 758-4859. Fax(610) 758-5156. E-mail: AHTO@lehigh.edu. WWW: http://www.lehigh.edu/intl/intl.html

Lehigh fosters an environment that welcomes and encourages the international exchange of students and scholars, and that integrates their global experience into the academic and cultural community. The Office of International Education is a university-wide resource for students and scholars from abroad, for U.S. students studying abroad, for U.S. students and faculty who are interested in the global focus, and for international alumni. Its mission is to advance, promote and serve the Lehigh community through the internationalization of the University by: maintaining the office as a University-wide international and Lehigh Abroad resource; providing services and advising specific to the needs of international students and scholars, and to students, faculty and staff going abroad; integrating international students and scholars and Lehigh Abroad returns into the international dimension of the University; maintaining the Lehigh Global Network of alumni and friends.

International Students and Scholars

Gisela M. Manstedt, Immigration Specialist, 318 Whitaker, 5 E. Packer Ave., Bethlehem, PA, 18015; (610) 758-4859. Fax(610) 758-5156. E-mail: GMN0@lehigh.edu. WWW: http://www.lehigh.edu/intl/intl.html

The Office of International Education (OIE) serves the unique needs of foreign nationals who come to Lehigh as students, scholars, faculty and staff members, and their families. More than 700 people from over 62 nations currently live, work and study on our campus. OIE offers advising on immigration, visa, and personal matters. The office acts as a liaison with other offices and departments on campus, and with national and international agencies.

Services

A variety of cross-cultural programs are initiated by the OIE, including a combined undergraduate and graduate orientation, an International Advisory Committee, spouse conversation groups, seminars on immigration matters, international tax advising, the Halloween Party, Thanksgiving Dinner, and the International Bazaar. The office also sponsors the Cultural Exchange Committee; the International Club; the Lehigh International Lyceum; an undergraduate symposium for all students to present their academic, scholarly, and creative achievements.

The year for international students and scholars at Lehigh begins with the International Orientation. Orientation takes place in conjunction with other programs offered by the undergraduate admissions office and graduate departments, starting immediately before the university-wide orientation at the beginning of each semester. Orientation for international undergraduates, LIFT - Lehigh International Freshman and Transfer, strongly recommended for all new international undergraduates. Issues discussed include filing for a social security number, opening a banking account in the United States, health insurance, and adjustment to university life at Lehigh and to the United States. International Orientation is a time to become accustomed to life in America, and to meet other foreign students. Orientation closes with a picnic in honor of the entire international population at Lehigh hosted by the University President.

Throughout the year, special events are held to promote the international community at Lehigh. These culminate in the International Bazaar in April. Sponsored by the OIE, the bazaar is the international students’ opportunity to entertain the University. Student organizations offer their favorite home country foods, dances, art work, culture and a fashion show in an event which is unrivaled for international flavor.

An electronic bulletin board (INTERNAT) features information of interest to the international community including news about cultural events, immigration matters, tax help, etc. OIE also maintains an electronic mailing list which contains the names of all of the foreign students and scholars on campus. Regular updates are sent through e-mail which keep the international population abreast of current events.

A Handbook for International Students and Scholars is available for all. Lehigh University is committed to providing an international experience which is rivaled by none. To this end, an International Administration Team consisting of administrators across campus has been assembled to actively support and promote the international dimension of the campus. Its membership represents a cross section of the University, including Lehigh Abroad, the offices of student affairs, admissions, development, alumni, and ESL. The team works to enhance the Lehigh experience for foreign nationals by providing quality services to students, scholars, alumni, parents and families.

Additional Special Services for International Students

Career Services: Advising and special workshops for careers for international students are provided.

Food Service: For undergraduate students on the meal plan, menus meet the dietary needs of the students. There is a stir fry bar and balanced meals for vegetarian diets.

Global Union: The Union brings together all the international and various U.S. student clubs and provides social and cultural experiences.

Health Center: Fully staffed medical personnel meet both the physical and personal needs of all students. The Counseling Center has special services for international students.

Housing: Some residence halls are open over vacation time periods.

Immigration/Visa Advising: Complete service.

International Club: An undergraduate campus-wide club for all international and U.S. students which plans social activities and helps with orientation.

International Partners Program: International students are paired with volunteer students and staff to get together regularly for social and learning activities.

Learning Center: Tutors are provided in writing, math and science.

Lehigh Global Network: An alumni outreach program is dedicated to establishing alumni organizations worldwide.

National Clubs: Several home country clubs from all regions of the world are established on campus. They form an important part of the cross-cultural dimension of the campus, providing social events, films, and international dialogue.

Phi Beta Delta, International Honor Society: The Beta Pi chapter of this national organization is at Lehigh, see below.

Religious Services: Services for all the major religions are on campus or nearby, including Muslim, Christian, Jewish, Hindu and Buddhist.

"Lehigh University recognizes that in the future, every aspect of life will involve a greater diversity of people and cultures. A learning experience outside the U.S. at a quality institution of higher education is an important component of a Lehigh education ..."

Lehigh Abroad Mission Statement

Lehimer Abroad

Casimir Sowa, Associate Director, 343 Whitaker, 5 E. Packer Ave., Bethlehem, PA 18015; (610) 758-3351; Fax (610) 758-5156. E-mail CMS2@lehigh.edu. WWW: http://www.lehigh.edu/intl/intl.html

The Lehigh Abroad office maintains a list of more than 45 approved semester and year programs around the world where Lehigh students can study and receive Lehigh credit. The programs are regularly evaluated and monitored by faculty in order to ensure high academic quality.

The Lehigh Abroad office advises students and refers them to the appropriate faculty or staff member. Students can take advantage of a resource room and an electronic bulletin board (ABROAD) for the Lehigh community interested in going abroad. Group and individual advising sessions take place every week. Lehigh Abroad also provides a series of required pre-departure orientation meetings for all students going abroad and continuous registration at Lehigh.

Additionally, Lehigh University maintains formal exchange agreements
with universities in Australia, Belgium, Mexico, The United Kingdom, France, Hong Kong and Japan. Students are selected through faculty interviews for these programs.

Architecture and Urban Studies students who qualify can earn credits with grades on the Columbia University program, “The Shape of Two Cities: New York and Paris,” which offers a semester of study in each location.

The Philip and Muriel Berman Center for Jewish Studies sponsors semester and year programs in Israel in cooperation with Tel Aviv University and Hebrew University in Jerusalem. Contact: Center for Jewish Studies, 324 Maginnes, 9 W. Packer Ave., Bethlehem, PA, 18015; (610) 758-4869.

Fullbright Scholarships: The Lehigh Abroad office promotes and advises students who wish to apply for the Fullbright Scholarship. Fullbright provides a year of post graduate study/research abroad for students with a bachelor degree.

Foreign Language: Students are encouraged to study in the language of their program country. Most programs in non-English speaking areas require four or five college semesters of language study. The Department of Modern Foreign Languages and Literature offers limited merit scholarships. Contact MFL, Maginnes Hall, 9 W. Packer Ave., Bethlehem, PA 18015; (610) 758-2090.

Requirements: A minimum GPA of 2.7 and good judicial standing are required to study abroad for a semester or year. A student with a GPA below 2.7 may petition for a waiver through the Lehigh Abroad Office to the Committee on the Standing of Students.

Applications: Students who receive Lehigh academic credit for a study abroad program must submit an application through Lehigh Abroad. Applicants are required to consult with academic advisors, have courses approved by departments, and in some cases request recommendations by faculty.

Academic Credit: Academic credit is given for approved inter-institutional agreement programs approved by Lehigh faculty.

Fees: Lehigh endeavors to make study abroad available to all students. Financial aid, as determined by the financial aid office, goes with the student. In addition, Lehigh usually provides partial travel grants to the study abroad sites. Lehigh requires the payment of Lehigh’s tuition, minus the financial aid, for all students going abroad who receive Lehigh credit. Lehigh Abroad then pays the student tuition fees to the program abroad. In some cases, room and board are handled in the same way.

Deadlines:
- Fall or Year programs: February 1
- Spring programs: September 15

Note: Programs in Australia have a rolling admission process. For some sites, students may need to submit applications eight (8) months in advance.

Summer Programs:
Lehigh offers several faculty-led summer programs each year. The number of programs and academic offerings can vary from year to year. Past destinations included Belgium, England, Czech Republic, Italy and China. Contact the Lehigh Abroad Office for program details.

Lehigh Abroad also maintains a list of approved summer study abroad programs offered through various institutions. The office advises students on programs appropriate for their field of study and procedures for summer programs and credit transfer. Study abroad programs are approved through the Lehigh Abroad Faculty Policy Board.

Deadlines:
- Preliminary Application: March 1

Lehigh University sponsors through the Lehigh Valley Association of Independent Colleges (LVASIC), several six-week summer language programs in Europe and Mexico. Credits and grades transfer to Lehigh and are counted in the student’s GPA.

The Philip and Muriel Berman Center for Jewish Studies sponsors summer programs in Israel in cooperation with Tel Aviv University and Hebrew University in Jerusalem. Contact: Center for Jewish Studies, 324 Maginnes, 9 W. Packer Ave., Bethlehem, PA, 18015; (610) 758-4869.

Phi Beta Delta: Honor Society for International Scholars
Anne H. Thomas, Advisor, 318 Whitaker, SE Packer Ave., Bethlehem, PA, 18015; (610) 758-4859. Fax: (610) 758-5156. E-mail: AHTho@lehigh. edu. WWW: http://www. lehigh.edu/intl/intnl.html

Lehigh’s Beta Pi chapter of Phi Beta Delta, the international honorary with chapters across the U.S., is an important international organization on campus. The purpose of the society is to honor those involved in high academic achievement and service in the international dimension, and to foster international exchange on campus. The honor society has three categories of membership: international students who have demonstrated high scholastic achievement at Lehigh; U.S. students who have demonstrated high scholastic achievement in the pursuit of international studies including study abroad; faculty and staff distinguished in international endeavors.

International Advancement
Christine D. Smith, Director, 342 Whitaker, 5 E. Packer Ave., Bethlehem, PA, 18015; (610) 758-4859. Fax: (610) 758-6454. E-mail: CDSS @lehigh.edu. WWW: http://www. lehigh.edu/intl/intnl.html

The International Advancement Office was created July 1, 1996 as part of the International Education Office. Activities include fund-raising for all international alumni, friends, and parents, assisting the admissions office and colleges with the recruitment of undergraduate and graduate students from outside of the United States, and assisting the Alumni Association with international alumni clubs and activities. The office coordinates the Lehigh Global network, an electronically linked group of alumni, parents, and friends worldwide, the travel of faculty and staff who meet with alumni around the world, the Global Advancement Council, the university’s international group of advisors and the securing of resources from international constituents to advance the interests of the university in conjunction with the development office.

English as a Second Language
Judith Rance-Roney, Director, 33 Copper Drive, Bethlehem, PA, 18015, (610) 758-6099.

The English as a Second Language Program (ESL) offers academic semester and summer courses for undergraduate and graduate students and their families. In addition, academic support is provided for ESL students through conversation groups and low-cost language enrichment courses.

English Department Courses. After reviewing placement test results, undergraduates accepted by the ESL Program and may take English 3 and English 5 (ESL) in substitution for English 1 and 2. (Refer to the English Department course listings.)

ESL Credit Courses. Both undergraduate and graduate students may select from a variety of supplemental ESL credit courses in conversation, accent reduction, reading, and writing offered throughout the year. (Refer to the English as a Second Language course offerings.)

Intensive ESL Summer Program. The STEP/UP Program provides an intensive academic ESL experience for both enrolled Lehigh students and for other students preparing to enter a U.S. university or who need professional English skills. STEP/UP enhances English skill in academic reading and writing, formal academic language, and an orientation to academic culture. Students entering STEP/UP should be at a high intermediate or advanced English level.

Non-credit ESL. The TLC (The Lehigh Community) Program offers non-credit enrichment ESL classes at a low cost to enrolled students and members of their families and to members of the surrounding community. Contact the ESL Office for a schedule.

International Multimedia Resource Center
Neil Toporski, Director, IMRC, 535 Maginnes, Johanna Bruns, Coordinator, 473 Maginnes; (610) 758-6067.

The International Multimedia Resource Center, located in Maginnes Hall, provides a diversity of services ranging from multimedia to
telecommunications. Through collaboration with the College of Arts and Sciences, the Modern Foreign Language Department, Lehigh University Computer Center, and Distance Education, the center maintains a multimedia computing center (470 Maginnis Hall) equipped with state-of-the-art multimedia computers and the World View Room (490 Maginnis Hall) where we broadcast international, historical, and cultural events on our wide screen television. As a resource center, the IMRC supports the efforts of faculty and staff in the design and construction of multimedia presentations and projects. Our facility sponsors business, university, and international broadcasting and teleconferencing events through satellite and videoconferencing technologies.

As a Window to the World, the World View Room (490 Maginnis Hall) shows regularly scheduled international and cultural programs. The International Multimedia Resource Center offers a full range of programming from cable, SCOLA, The International Channel, and special downlinks from our domestic and international satellite dishes. International broadcasts from around the world are scheduled throughout the day. A daily schedule is posted and is updated monthly. Comfortably furnished, the World View Room accommodates about 25 people. A 47 inch large screen television allows easy viewing by all. Recently, the IMRC started broadcasting on two cable stations (21 and 22) through the campus-wide cable network.

**Experiential Learning**

The accommodation of student interest extends beyond regular departmental offerings. Hands-on experiences in learning enrich classroom instruction. Each of the three colleges offers a number of such experiences to undergraduates. Among them:

**The Philadelphia Urban Semester.** Undergraduates in all fields of study can earn 16 Lehigh credit hours by spending a semester studying in the nation’s fourth-largest metropolis. They live, work, and study with other students from two dozen other institutions, supervised by faculty of the Great Lakes Colleges Association. This consortium of schools leading Midwestern institutions as DePauw, Kenyon, Oberlin, and Wooster is a recognized leader in providing extra-mural academic programs both here and abroad.

The curriculum consists of four-credit seminars and an eight-credit internship. All students are enrolled in a core “Seminars on the City” which introduces them to the field of urban affairs and to Philadelphia. The second seminar is elected from a half-dozen more specialized urban topics; recent choices available have included “Folklore in Philadelphia,” “Art in the City” (which met each week at a different site), and “Justice.” Internships involve working four days weekly in a public or private placement which tests the student’s aptitude in a variety of practical ways while enhancing appreciation of city life.

**The Washington Semester.** Opportunity is available each year for six juniors or seniors to spend a term studying in Washington, D.C., in cooperation with American University. Lehigh University is a member with 180 other colleges and universities.

Students enroll at Lehigh but spend the semester in residence at American University with the students from other participating colleges.

The curriculum consists of national-government seminars, an internship, and a written research project. Besides the national government program, the student may choose other program offerings such as economic policy, humanities, public administration, foreign policy seminar, and justice seminar.

Inspection tours. The location of the university in the center of industrial activities of various types affords unusual opportunities for visits to manufacturing plants. Inspection trips to individual plants are a required part of specific courses in various engineering curricula. Written reports may be required. These trips are generally held during the senior year and involve an average expense of $25 to $50.

**Credit by Examination**

Upon petition and presentation of evidence that he or she has qualified for it, a student already enrolled at Lehigh may be permitted by the Standing of Students Committee to take a special examination for credit towards graduation. Special Examinations are granted only for extraordinary reasons and upon petition. There must be adequate supporting evidence of sufficient cause accompanying each petition. There is a fee for all special examinations.

Students taking a special exam after matriculation at Lehigh will have the grade and credits assigned to their permanent Lehigh record. Special exam credit will be counted as in residence credit and the grade will be used in all grade point average calculations. No special exam will be granted in a course that the student has already taken (except Senior reexaminations), or in a course in which the student has already completed more advanced work at Lehigh.

**Preparation for Graduate Work**

Students planning to continue in graduate programs should take advantage of the flexibility in many undergraduate programs to design an upper-division curriculum that meets requirements in the anticipated graduate program.

The policy of the Graduate School provides as much flexibility as possible for students who wish to change to new but related fields of study after the baccalaureate degree. Students should consult with their previous program adviser and the department representative of the new field to establish an academic program that will remedy any deficiencies in background.

**Apprentice Teaching**

The apprentice teaching program is designed to benefit juniors and seniors who wish to learn about teaching under the guidance of an experienced teacher. Apprentices often do a limited amount of supervised lecturing or leading of discussions, assist in making up and evaluating written assignments, and are available for individual consultation with students.

To participate in the apprentice teaching program a student must:
1. Have an over-all cumulative grade point average of 2.80 or better;
2. Have a cumulative grade point average of at least 3.3 and have completed at least two courses in the major field in which apprentice teaching is done and;
3. Have previously taken for credit the course or its equivalent in which the apprentice teaching will be done.

A student may register for apprentice teaching only once each semester, only once in a given course, and only twice during a college career.

To register for apprentice teaching each student-teacher partnership will submit an apprentice teaching agreement, indicating the duties and obligations for approval to the department chair and the dean of the student’s college in which the course is taken. This form must be submitted to the Registrar before the first day of classes in the semester. To complete the course, the apprentice teachers must submit a written report of their experience to the supervising teacher, who will forward it to the Office of the Provost.

**Curricular Flexibility**

Choice is a regular part of university life, and encompasses the determination of a college and major, the selection of courses each term, and the development of life goals and career options.

Many of these choices are academic in nature. The undergraduate curricula are flexible, designed to accommodate the changing interests and needs of students. Boundaries between colleges are as fluid as possible to provide many options in an educational program. For instance, students may take a bachelor of science (B.S.) degree in the College of Business and Economics or the College of Engineering and Applied Science with a minor in journalism in the College of Arts and Science. There are five-year programs for which degrees are awarded in two colleges.

Transfers between undergraduate colleges is permitted but only after the freshman year. Students considering such a transfer must confer with their advisers to begin the process.

Academic offerings of the various departments are described in Section V. To provide additional flexibility and encourage student
initiative and depth of investigation, the university has developed academic alternatives including the following:

**Provisional Courses.** Departments may introduce Provisional Courses temporarily within a semester, either experimentally or as a response to a contemporary social or scientific issue. If successful, a course may become part of the regular curriculum. Such courses, identified with a 95, 96, 97 or 98 number (preceded by a 1, 2, or 3 indicating level) may sometimes take provisional courses numbered above 100 on a pass/fail basis.

**Independent Study.** Juniors and seniors of ability who wish to concentrate in their chosen field can substitute no more than four or six credit hours of independent, unscheduled work each semester for an equal number of credit hours of elective work required for graduation. Students, in collaboration with the major adviser, with the advice of the departmental chairperson and consent of the college dean, may structure such a project for study in any curriculum and most major study sequences.

**Pass/Fail Option.** Students have the opportunity to study in areas without concern for possible poor grades by electing a pass/fail option. Intended to encourage exploration at the upper division level outside the major field, this option is open to those who are sophomores and above, in good standing, who have declared a major. Courses numbered below 100 will not be eligible for pass/fail. The pass/fail option may not be used for major or minor subject credit toward graduation or for distribution requirements. Consultation with the adviser is required.

**Graduate Courses.** Qualified undergraduates may petition the Graduate Committee to register for 400-level courses if they are certified by the course instructor and the department chairperson concerned.

**LVAIC Cross Registration**
Currently enrolled full time degree seeking students in good academic standing who have achieved sophomore status may register for up to two courses per term that cannot be scheduled at the home institution at any one of the member institutions (Allentown College of St. Francis de Sales, Cedar Crest College, Lafayette College, Moravian College, and Muhlenberg College). The student must obtain the appropriate approvals of his or her own adviser and the host institution registrar. The courses must be in the normal academic load and not produce an overload.

All grades of courses taken through the LVAIC cross registration process will be accepted by the home institution and entered on the permanent record, and such grades will be used in computing the grade point average. Credits taken through the cross-registration process will be calculated as in residence. The number of credit hours assigned to a course is the responsibility of the home institution Registrar.

Students may not repeat a course at another LVAIC institution in which they expect to have a Lehigh cumulative grade point average adjustment.

Lehigh University students are not permitted to cross register for courses in ALL JANUARY INTERSESSION PROGRAMS, the EVENING PROGRAM AT MUIHLENBERG COLLEGE, all WEEKEND COURSES AT CEDAR CREST COLLEGE, or the ACCESS PROGRAM AT ALLENTOWN COLLEGE. All independent study and correspondence courses are prohibited from cross registration without prior approval of the Lehigh University Standing of Students Committee.

SUMMER SESSION-Lehigh Students must have been registered full time in the prior Spring semester to be eligible to cross register for a summer term. A maximum of two courses per session, and 12 credit hours over the course of the entire summer may be rostered. Students may not cross-register for a course being offered at Lehigh during the Summer term.

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**The General College Division**

The General College Division supplements the mission of the established undergraduate curricula by providing: an opportunity for persons not planning to qualify for a degree to pursue work, either of a general or specialized nature, which their preparation and interests make desirable; a trial period for those who wish to become candidates for baccalaureate or graduate degrees, but whose preparation does not satisfy the entrance requirements for the established curricula; and an opportunity for qualified students to continue their education without being committed to a restricted or specialized program of studies.

Courses taken in the General College Division may not be submitted to meet the requirements for a graduate degree.

For admission to the General College Division the student must submit an application, at least one month prior to the start of the semester in which they hope to enroll, to the undergraduate admissions office. The applicant must show maturity, seriousness of purpose, and evidence of ability to pursue with profit the program of studies he or she desires. The student must have the established prerequisites for courses in which he or she wishes to enroll, and may register for courses up to and including the 300-level. There is no established curriculum for the General College Division. Each student works on a program outlined to meet his or her special needs. Each program must be approved by the Registrar, director of the division. Students in the division are not permitted to take courses using their optional Pass/Fail grading system, or cross register for courses in the L.V.A.I.C.

Students in the division, as non-degree candidates, do not meet the eligibility criteria for federal student aid, under Title IV, including Federal Pell Grants and Federal Stafford Student Loans. Similarly, institutional financial aid is also limited to degree candidates.

Students in the division are not candidates for degrees. A student may transfer to regular matriculated undergraduate status in any of the colleges only upon petition to, and with the approval of, the committee on standing of students. Transfer to the graduate school is possible only through the normal graduate admission process.

With the exception above, students in the General College Division are subject to the same rules and regulations as students of the university. They pay the tuition and fees established for regularly matriculated students.
IV.

Graduate Study and Research

Graduate Study

Lehigh began awarding graduate degrees in 1882. The first recipient, T.H. Hardesty, of the Class of 1880, wrote his thesis on Alexander Pope, entitled it The Rights of Man, and read it aloud at commencement in June 1882.

The first Ph.D. was granted in 1885 to Joseph W. Richards, Class of 1886. Richards, Class of 1886. Richards, who had a background in metallurgy and electrochemistry, taught at Lehigh until his death in 1921.

Women were admitted to the graduate program in 1918 when the faculty and the board of trustees agreed to grant the degrees of M.A. and M.S. to women, provided they attended classes in the late afternoon and on Saturdays "so that the general character of campus life shall not be affected." Three women received graduate degrees in 1921, the first women to complete graduate work at Lehigh. In 1929, the rule was changed, and women were admitted on much the same basis as men.

In 1936, the Graduate School was established to administer the graduate program. The Ph.D., which was temporarily discontinued in 1894, was reinstated in nine departments: chemistry, chemical engineering, civil engineering, geology, history, mathematics, mechanical engineering, metallurgical engineering, and physics. Tomlinson, professor of mathematics, was selected in 1938 as the first dean of the Graduate School.

In 1961, the university officially resolved to strengthen and expand graduate programs university-wide. Since then, graduate work has assumed increased importance and prominence, and facilities and funding have increased tremendously.

In 1995, graduate programs were decentralized and are now administered the four colleges of the university, as described below.

College of Business and Economics
Patti T. Ota, dean

The College of Business and Economics offers the master of science degree in economics, master of business administration with concentrations in finance management, marketing, international business and management of technology, master of science in management of technology and the doctor of philosophy degree in business and economics.

There are two departments in the college: business and economics. Course descriptions can be found listed under accounting, business, economics, finance, information systems, law, management, and marketing in Section V; more information about the various degree programs appears below. The college publishes a packet describing its graduate programs, which may be obtained by writing to the College of Business, Graduate Programs Office, Rauch Business Center, 621 Taylor Street, Bethlehem, Pa. 18015.

College of Education
Roland K. Yoshida, dean

The College of Education offers the master of arts in education, the master of education, the master of science in education, the educational specialist, the doctor of education, and the doctor of philosophy. More information about these degrees appears below.

The College was established as the School of Education in 1966, elevating it from its former departmental status under the College of Arts and Science. In 1985 the school was given its present status as a college, headed by a dean. The College is engaged in the preparation of elementary and secondary teachers in both school and non-school settings, school and community counselors, counseling psychologists, school psychologists, school administrators, curriculum specialists and supervisors, specialists and supervisors in the education of mentally and emotionally disturbed children, teachers of preschool children (especially children with handicaps), and specialists in educational technology.

The College of Education is interested in potential and established leaders in all aspects of educational endeavor. A total of 466 students are involved in advanced study at the master's and doctoral levels during the 1996-97 academic year.

Through its working relationship with other colleges and universities in eastern Pennsylvania, Lehigh has undertaken to complement existing undergraduate preparation programs by emphasizing study at the graduate level. Off-campus course work and in-service projects are integral parts of many programs.

An internship teaching program is specifically designed for qualified persons who hold bachelor of arts degrees and who desire to enter the field of teaching. Those admitted to this program have the opportunity to accomplish their professional training and serve as interns in the public schools. After two semesters of directed full-time study, students may begin the teaching internship. Upon completion of the fifth-year program and the required semesters of intern teaching, these students ordinarily will have completed requirements for the M.A. (secondary teachers) or the M.Ed. (elementary teachers), as well as state certification.

Organization. The College of Education consists of one department, Education and Human Services, and one school, Centennial School. Within the department there are six program areas, each with its own coordinator: counseling psychology, educational leadership, educational technology, school psychology, special education, and teacher education.

College of Arts and Sciences
Bob Carson, dean

Within the College of Arts and Sciences, professionally oriented students may pursue advanced degrees in chemistry (M.S., Ph.D., D.A.), English (M.A., Ph.D.), earth and environmental sciences (M.S., Ph.D.), history (M.A., Ph.D.), mathematics (M.S., Ph.D.), physics (M.S., Ph.D.), political science (M.A.), psychology (M.S., Ph.D.), social relations (M.A.), and applied social research (Ph.D.).

Although degree requirements vary from department to department, most departments require a combination of formal coursework and independent research. Students work closely with a faculty adviser both in formulating and carrying out their research programs. Given the nature of the liberal arts, these programs commonly involve faculty and/or coursework from more than one department or a department and research center/institute. Students interested in such an interdisciplinary approach are admitted to a single department but formulate a program of study and research that draws on faculty and facilities in other areas of the university. Superior candidates may qualify for financial support in the form of teaching assistantships, graduate assistantships, research assistantships, scholarships, or dean's fellowships.
Centennial School. The College of Education operates the Centennial School, a laboratory facility for exceptional children that has both an elementary and a secondary component. Centennial School provides research opportunities as well as practical experience for advanced students in counseling, school psychology, and special education.

Undergraduate minor in education. Upper-level undergraduates are given an opportunity to take a minor in education that combines practical activities with theoretical work and is designed to provide a foundation for further educational studies at the graduate level.

College of Engineering and Applied Science
Harvey G. Stenger, dean
Carol S. Smith-Nichols, assistant dean of graduate studies

The College of Engineering and Applied Science offers the master of science and doctor of philosophy degrees in each of its six academic departments and in interdisciplinary programs as well. The departments in the college are chemical engineering, civil and environmental engineering, electrical engineering and computer science, industrial and manufacturing systems engineering, materials science and engineering, and mechanical engineering and applied mechanics. In addition, a student may earn the master of engineering degree in chemical engineering, civil and environmental engineering, electrical engineering, industrial engineering, and materials science. A master of science degree is offered in computer engineering, quality engineering, and management science.

The Center for Interdisciplinary Research and Graduate Studies is closely related to the college's extensive research activity, and graduate students are expected to engage in analytical or experimental research as part of their programs of study. This activity involves students in the process of creation of new knowledge under the direction of the college's distinguished faculty and brings them into contact with some of the most modern and advanced experimental techniques. Many college research programs are supported by contracts, fellowships, and grants from industry and from federal, state, and local governments. This funding not only provides financial support for outstanding students but also allows them to deal with more complex and pressing problems facing our society.

Many faculty members and graduate students in the College of Engineering and Applied Science are associated with interdisciplinary research centers and institutes as well as with their own departments. The opportunity for interdisciplinary study allows them to cross departmental lines in specific technological areas and to work with faculty and graduate students from other departments. Centers and institutes currently carry on research in the areas of biotechnology, health sciences, thermofluids, materials, energy, and environmental sciences, surfaces and coatings, solid-state studies, structural and geotechnical studies, high-rise habitats, emulsion polymers, fracture and solid mechanics, metal forming, robotics, computer-integrated manufacturing, and design and management innovation. Extensive research in many of these areas is also conducted with academic departments.

Admission to Graduate Study
A graduate of an accredited college or university may be considered for admission to graduate study. The decision to admit a student rests with the applicant's major department and stands for one year following the first semester for which admission was offered. If more than one year elapses, the prospective student's department reserves the right to reconsider the original offer. Students wishing to pursue the master's degree in Manufacturing Systems Engineering should apply to that interdisciplinary program directly.

Applications for admission may be obtained by writing to the department to which admission is sought or to the office of the dean of one of the colleges.

An applicant may enter the graduate program as a student in one of two categories: regular or associate. Except for qualified Lehigh undergraduates, only those who have been admitted officially by the graduate program office of an appropriate college or by a department either as regular or associate graduate students may register for graduate courses or take them for credit.

Regular graduate students. Only regular graduate students are candidates for graduate degrees. Application for admission as a regular graduate student must be filed by July 15 for the following fall semester or by Dec. 1 for the spring semester. Regular applications for the first and second summer sessions are accepted until April 30 and May 30, respectively. Certain departments or programs have earlier deadlines. Applicants should consult their respective departments or the dean's office. In order to be considered for admission as a regular graduate student, the applicant must satisfy at least one of the following conditions: have a graduate G.P.A. of at least 2.75 out of 4.00; have an average of at least 3.00 for the last two semesters of undergraduate study; have scores at or above the 75th percentile on the Graduate Record Examination or other recognized test (all foreign graduate students are required to take the Test of English as a Foreign Language and achieve a minimum score of 550); have a graduate grade-point average of at least 3.00 for a minimum of twelve credit hours of graduate work completed at other institutions; or have successfully satisfied the probationary conditions as an associate graduate student discussed below. Satisfying one of these conditions is a necessary but not sufficient condition for admission as a regular graduate student.

Individual departments may evaluate their candidates for admission according to higher standards and additional criteria. Departments should be consulted for information regarding required examinations for admission. For example, candidates for the M.B.A. program are required to take the Graduate Management Admission Test (GMAT).

Admission of a student to graduate standing is executed through the Office of Graduate Studies in each college or the respective dean's office. Credentials for admission to Counseling Psychology and School Psychology Programs and to the Doctoral Programs in Special Education are acted upon only once a year. Completed applications and requests for financial aid must be submitted by January 15 for admission in the following Fall semester. Applications received for these programs after this deadline will be dealt with on a space-available basis.

Associate graduate students. Associate graduate student status may be offered to applicants who apply but fail to qualify for regular graduate student status. Only associate student applications will be considered during the late admissions period between the end of the regular admissions period and the first day of classes. Applicants for associate status may submit unofficial rather than official transcripts; letters of recommendation are not required at that time. The Registrar will require an official final transcript, however, before grades are released. Certain departments or programs have earlier deadlines and more stringent requirements. Applicants should consult their respective departments.

Associate graduate students who are admitted during the late admissions period and who clearly qualify for admission as regular graduate students may petition for regular status after classes begin if all credentials are in order. There is no late application fee.

Other associate graduate students must meet the following condition before they may petition for regular status: completion of the first nine credit hours of courses numbered 300 or higher with at least one grade of C or better; all other grades must be B or better. Students receiving a grade of B or lower will be dropped from the program. Students should note that individual departments may impose more rigorous probationary standards.

When the probationary period of nine credit hours is completed successfully, associate graduate students must petition for regular student status in order to continue. This requires the submission of regular admission documents not already on file. Courses completed during a successful probationary period may count toward a graduate degree if they are part of an approved program.

Lehigh University undergraduates. A Lehigh undergraduate may take any 400-level course for which he or she is qualified. The
qualifications are defined by the department, and are certified by the course instructor and department chairperson through petition to the graduate committee. Undergraduates at Lehigh who are within a few hours of meeting the requirements for a baccalaureate degree may, with the special approval of the graduate and research committee, enroll for a limited amount of study for graduate credit. Lehigh undergraduates may apply course credits taken in the undergraduate program toward a graduate degree under the following conditions: (a) the course credits are not submitted as part of the requirement for an undergraduate degree; and (b) courses for possible graduate credit are approved in advance by the course instructor, department chairperson, and the dean of the college. The student must receive a grade of B- or better.

Readmission. A student who has not been registered in a Lehigh graduate program for five years must petition for readmission. Petitions approved by the student’s major department must be forwarded to the registrar’s office.

International Students and Scholars. International applicants must hold an American Bachelor’s degree or an equivalent foreign degree requiring at least 16 years of primary, secondary, and university education. International applicants must submit all documents required for regular graduate student status, as explained above. Brochures for international applicants may be requested from individual departments.

Registration
Requirements. All graduate students using Lehigh University resources must be registered. No graduate student may register for more than 15 credits per semester. University employees may register for at most, two courses per semester with appropriate approval. The maximum registration in a summer session is six credits.

Full-time status. In order to maintain full-time enrollment status, a graduate student must ordinarily register for a minimum of nine credits each semester. Identification as a full-time student is important for three purposes: (1) eligibility for financial aid, (2) compliance with visa requirements for international students, and (3) for university and national graduate enrollment data.

After fulfillment of degree credit-hour requirements and in some other circumstances, full-time status may be maintained with fewer than nine credits of registration, provided that the student is, in fact, continuing a program of full-time study and research. In such cases, the status must be certified on the Graduate Registration form, first by the department and then by the dean of his or her college.

Registration procedure. Pre-registration is scheduled for a two-week period at a time designated on the university calendar. Graduate registration is held during the week preceding the start of classes. Students should check with their departments for registration and semester class schedules. To register, graduate students must complete registration forms available in their departments. A course adviser will discuss course selections with students and sign registration forms upon approval.

Late registration penalties. Registration between the second and tenth day of class during the fall and spring semesters, and the second and fifth day of class during the summer session will require a late registration fee. Students who have not completed the registration process by the fifth day of the regular semester or by the fifth day of the summer session will not be permitted to attend class.

Services provided by the registrar. In addition to maintaining student academic files, the office of the registrar fills transcript orders. The registrar honors written and over-the-counter requests to have transcripts mailed to schools and prospective employers.

The office also forwards final grades to students after each final exam period, provided student credentials are in order.

Graduate Credit and Grades
Course grades are defined as for undergraduates except that no grade lower than C may be counted toward a graduate degree and pass/fail registration is not allowed for graduate students. No student who receives more than four grades below a B- in courses numbered 200 or higher is allowed to continue registration as a graduate student.

The N grade is defined as for undergraduates except that graduate students have a calendar year to remove course incomplete grades unless an earlier deadline is specified by the instructor. Graduate student incomplete course grades that are not removed remain as N grades on the student’s record. Thesis or research project N grades may remain beyond one year until the work is completed.

The X grade is defined as for undergraduates except that to be eligible for a make-up examination a graduate student must file a petition and the petition must be approved by the graduate and research committee.

The XN grade is defined as for undergraduates except that graduate students have a calendar year to complete coursework following an XN grade unless an earlier completion deadline is specified by the instructor. The X portion of the grade is removed as described for undergraduates. XN grades which are not removed remain on the record of graduate students. All petitions for exceptions are sent to the graduate and research committee.

Withdrawal From A Course. A student dropping a course within the first ten days of the semester (five days for summer sessions) will have no record of the course on the transcript. A student dropping all courses for which he or she is registered is considered to be withdrawing from the university and the policy is noted below. A student who drops a course after the tenth day of instruction and before the end of the eleventh week of instruction will have a grade of “W” assigned to the course. A student who drops a course after the eleventh week of instruction and before the end of classes receives a “WP” or “WF” at the discretion of the instructor. A “WF” is considered to be a failing grade. An Add/ Drop form signed by the student’s advisor must be submitted to the registrar’s office before the deadlines noted to be official.

University Withdrawal. A student withdrawing from the University (dropping all courses during a given term) must submit the Drop/Add form signed by the advisor to the registrar’s office. Withdrawal after registration and during the first eleven weeks of instruction will be noted on the academic transcript by assigning a grade of “Wy” to all courses. A withdrawal after the eleventh week of instruction and before the end of classes will have the grade of “WP” or “WF” assigned for each course at the discretion of the instructor. The date of the withdrawal will be noted on the academic transcript for a withdrawal at any time during the term.

Graduation
Degree registration. A student must be registered in the semester in which the degree is conferred. A spring or summer registration will satisfy the registration requirement for the following Founder’s Day degree, provided all work is completed before the first day of fall classes.

Application for degree. Candidates for degrees to be conferred on University Day in May or June must file an application for degree with the registrar by March 1. Candidates for degrees to be conferred on Founder’s Day in October must file this form by September 1. Candidates for degrees to be conferred in January must file by December 1. Late application for a degree will incur a penalty fee of $25.

Clearance. Graduate students must receive clearance from the university prior to the awarding of the degree. The following obligations must be satisfied:
- Students must be certain that they have completed all coursework for incompletes they may have received.
- Theses and dissertations must be cleared by the appropriate dean’s office.
- All financial obligations must be cleared with the bursar. Tuition fees, bookstore charges, library fines, and motor vehicle fines must be paid before graduation.
- All library books on loan must be returned.
- Students must turn in their student identification cards at I.D. card office.
- The interdepartmental clearance sheet must be completed. This form requires the signature of the student’s department chairperson (except for the College of Education), and the Facilities Services office before it is submitted to the registrar at least three days prior to graduation.
Tuition

Tuition payment. Graduate students must register for courses and pay tuition bills at the bursar’s office during the registration period held the week before classes begin. Students who mail their registration forms, personal data sheets, and tuition payments to the bursar’s office must be certain that their forms are postmarked two business days prior to the final day of the registration period.

Tuition refunds. A student in good standing who formally withdraws from a course during the first eight weeks of the semester is eligible for a tuition refund. The refund schedule for student withdrawals and course adjustments is as follows:
- prior to the start of the semester: 100%
- during first calendar week: 100%
- during second calendar week: 60%
- during third calendar week: 50%
- during fourth calendar week: 40%
- during fifth calendar week: 30%
- during sixth calendar week: 20%
- during seventh calendar week: 10%
- during eighth calendar week: 0%

Students should note that the first calendar week begins with the first day of classes at the university.

Tuition and Fees for 1997-98

<table>
<thead>
<tr>
<th></th>
<th>Per credit hour</th>
<th>Per semester</th>
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</thead>
<tbody>
<tr>
<td>College of Arts &amp; Sciences</td>
<td>$800</td>
<td></td>
</tr>
<tr>
<td>College of Business &amp; Economics</td>
<td>$590</td>
<td></td>
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<tr>
<td>College of Engineering &amp; Applied Science</td>
<td>$800</td>
<td></td>
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<tr>
<td>College of Education, and for full-time elementary and secondary teachers and administrators enrolled in the other three college</td>
<td>$450</td>
<td></td>
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<tr>
<td>Maintenance of candidacy</td>
<td>$800</td>
<td></td>
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<tr>
<td>Master’s candidate registration fee</td>
<td>$800</td>
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</table>

Living accommodations. The university maintains a graduate student housing complex in the Saucon Valley Apartments that has 112 living units. This complex, Saucon Village Apartments, provides units generally on a yearly lease basis. For the 1997-98 period beginning in September, the following are the monthly rents exclusive of utilities:

- Efficiency apartment: $375
- One-bedroom apartment: $440
- Two-bedroom apartment: $500
- Three-bedroom apartment: $510

Other Fees

- Application fee (for graduate admission consideration): $40
- Graduate activities fee, per semester:
  - Full-time students: $12
  - Part-time students: $6
- Late registration (for completing registration after announced day): $50
- Late application fee: $25
- Late payment (after announced date): $50
- Return check fee: $20
- Identification card (replacement): $10
- Thesis, microfilming: $25
- Dissertation, microfilming: $50
- Placement fee, College of Education: $25
- Supervision fee, College of Education (per 3 credits) | $100
- Counselor intern: $100
- Counselor and school psychology clinic: $100
- Social restoration intern: $225

Financial Aid

Financial aid is ordinarily available only for regular, full-time graduate students. Teaching assistantships, research assistantships, graduate assistantships, fellowships, and scholarships are academic awards made by individual academic departments or by the Graduate School. Several graduate assistantships unrelated to a particular area of study can be obtained by applying to administrative offices. In general, students are also encouraged to apply for funding to outside sponsoring agencies and/or government agencies. Finally, loans and work-study employment are available through the Office of Financial Aid.

Academic awards. Requests for fellowships, scholarships, research assistantships, teaching assistantships, and graduate assistantships must begin in the fall semester. The recipients of these awards based on merit, students are not required to submit a financial statement.

In addition to their stipends, graduate students holding half-time teaching appointments generally receive tuition remission. Fellowship holders also receive a stipend and tuition award. Scholarship recipients are awarded tuition. Research assistants receive a stipend for research services, but their tuition is commonly paid directly by research projects.

Teaching assistants and graduate assistants. Teaching assistant and graduate assistant (TA/GA) are technical terms used to describe specific types of Lehigh University student employees. The duties of TAs and GAS are generally set by the departments or offices that employ them, but certain conditions must be satisfied before a student can be classified as a teaching assistant or a graduate assistant. These conditions include:
- Each TA/GA must be a regular full-time resident Lehigh graduate student, which normally requires registration for at least nine credit hours per semester.
- A TA/GA is a half-time position and each TA/GA provides services to Lehigh University in a full-time capacity.
- TA/GA appointments are possible for full-time resident graduate students, with stipends and tuition remission appropriately reduced.
- Each TA/GA must be paid a specific stipend, which is set for the academic year by the dean of graduate studies after consultation with the director of budget.
- Qualified TAs/GAS receive tuition remission for at most ten credit hours in a regular semester. No TA/GA may register for more than ten credit hours. A student who is a TA/GA during the preceding academic year is entitled to at most three hours of thesis, research, or dissertation registration (not course credit) in the following summer without payment of tuition.
- Each TA/GA is appointed by a process which begins with a formal letter of appointment issued by the appropriate department chairperson. The appointment letter specifies standard university conditions including stipend level, time of arrival, length of service, and the requirement of satisfactory academic progress and performance of duties. Each department chairperson submits written notification of TA/ GA appointments to the appropriate college dean or vice president.

The graduate committee endorses academic guidelines for new teaching assistants which exceed minimum admission requirements. Each TA should satisfy one of the following: have a G.P.A. of 3.0 or better in the undergraduate major field of study; have a G.P.A. of 3.5 in the senior year major field; rank in the 85th percentile or higher on the Graduate Record Exam or other standardized test; or have a G.P.A. of 3.5 in at least twelve hours of graduate work in the major field. Exceptions to these guidelines shall be made only with the approval of the dean of graduate studies.

In addition, each teaching assistant must make normal progress toward a graduate degree. The definition of normal progress may vary among departments, but the criteria for satisfactory progress are
established by the department faculty and the graduate committee. Teaching assistants who fail to satisfy these criteria are ineligible for reappointment.

Teaching assistants whose native language is other than English must have on record with the ESL Program in addition to a minimum total score of 550, a comprehensibility score of 230 or higher on the SPEAK (Speaking Proficiency English Assessment Kit) or the TSE (Test of Spoken English) in order to work with Lehigh undergraduates in academic settings (i.e., classrooms, recitations, labs, office hours, etc.). Those whose comprehensibility score is 220-229 may also be appointed as TAs, but they are required to attend ESL courses until their comprehensibility score is at least 230 or until they no longer have a TA position. A comprehensibility score of 200 or below eliminates an international graduate student from being appointed as a TA.

The SPEAK is given at announced times during the academic year, usually at the beginning and end of each semester. Contact the ESL Program (302 Copper Hall, ext. 86099) for details and for information concerning ESL courses. The TSE is given by ETS several times each year throughout the world.

Tuition remission for qualified TAs/GAs is authorized by the appropriate dean or vice president as part of the registration process. Each college dean or appropriate vice president will be provided tuition remission accounts against which TA/GA remissions will be charged. The accounts will be budgeted at an amount equal to the ten-hour TA/GA tuition rate times the approved number of TA/GA positions included in the annual operating budget. The budgets shall not be exceeded. If additional TA/GA positions are desired on a temporary basis, the account executive must provide for the transfer of budget support to the remission account. These budgets are to be used exclusively for tuition remission for authorized TA/GA positions.

There are a limited number of summer TA/GA appointments. These TA/GA employees must receive the same monthly stipend as academic year TA/GA and provide services of up to twenty hours per week to the university. A summer TA/GA registers for a maximum of three credit hours in each summer session of employment and receives tuition remission for that registration.

Other graduate assistantships. Graduate students may apply directly to administrative offices for graduate assistantships unrelated to their areas of study. The availability of these assistantships is based upon the needs of the individual departments. GAS are employed regularly by the graduate school office, the office of the vice president of student affairs, the dean of students office, the university counseling service, and by career services.

Loans and work-study awards. Students may apply for the federally-funded Stafford and Perkins loans, Lehigh University Tuition Loans (ULT), and Federal Work-Study through the Office of Financial Aid at 218 W. Packer Avenue. These funds are awarded on the basis of demonstrated need using the Free Application for Federal Student Aid, the university application, and a copy of the most recent (1997) IRS 1040. We are also required to obtain information on all previous federal student loan borrowing from any other college(s) attended, as well as an indication that there is no prior default or refund due the government for overpayment of federal aid. To do this, Lehigh will depend upon the information that will be displayed on the Student Aid Report (SAR), which will be obtained from the National Student Loan Data System after you file the FAFSA. If that doesn’t provide the necessary certification, we will need to have you have college send us a Financial Aid Transcript. We’re hoping the NSLDS will provide the necessary certification so that the transcript will not be necessary. Funds cannot be disbursed without a SAR and the NSLDS information or a FAFSA file. This is a federal requirement. Students not able to demonstrate "need" may borrow from the Federal Unsubsidized Loan Program. Because the Stafford loans are financed through commercial lenders, their availability is virtually assured if you qualify. There is only limited availability of Federal Perkins and Work-Study, and University Tuition Loans.

Literature on federal student aid programs is available through the financial aid office. Particulars on the Federal Stafford Loan (with and without subsidy) are also available at participating lenders. A listing of student “rights and responsibilities” is printed in the section on undergraduate financial aid. The Office of Financial Aid can provide a list of preferred lenders and applications for Federal Stafford Loans, as well as a listing of commercial educational loans together with current interest rates and terms and conditions of repayment.

Degree Information

The following degrees are offered by the university: the master’s degree, the doctor of philosophy, the doctor of education, and the doctor of arts.

Master’s Degree

Candidates for the master’s degree have six years in which to complete their programs. Students should confer with their advisers to be certain that specific department and program course requirements are met. The following requirements must be satisfied by master’s candidates in all departments.

Program for the master’s degree. A student’s program must include: not less than 30 credit hours of graduate work; not less than 18 credits of 400-level coursework (research or thesis registration counts as part of the 400-level coursework requirement); not less than 18 credits of coursework in the major of which 15 credits must be at the 400 level. All coursework for the master’s degree must be taken under at least two instructors and must be approved by Lehigh University. With the approval of the appropriate dean, a maximum of six credits may be transferred to a Lehigh Master’s program. A petition is submitted, with course descriptions and transcript, as well as departmental recommendation. Course grades of B or better are required.

A student must complete the form, “Program for Master’s Degree,” setting forth the courses proposed to satisfy the degree requirements. This form should be approved by the department and then submitted to the registrar as soon as possible after 15 credit hours toward the degree have been completed. Approval of the program by the registrar signifies that the student has formally been admitted to candidacy for the master’s degree.

Thesis and comprehensive exam. Candidates are required to submit a thesis or a report based on a research course of at least three credit hours, or to pass a comprehensive examination given by the major department. The department will specify which of these requirements applies and may require both. If required, the thesis or report shall not count for more than six credit hours, and thesis registration is limited to a maximum of six credit hours. University procedures must be followed if the thesis or research project involves human subjects. One unbound copy of the thesis, approved by the thesis adviser and the department, must be delivered to the registrar at least three weeks before the degree is conferred. A binding and microfiling fee of $25 must be paid to the bursar, and the bursar’s receipt presented with the completed thesis. Guidelines stipulating the form of the thesis are available in the registrar’s office. A non-thesis option exists in certain departments in the College of Engineering. Students should check with their departments regarding that option.

Doctor of Philosophy

Time and Registration requirements. A candidate for the doctor of philosophy degree ordinarily is expected to devote at least three academic years to graduate work. In no case is the degree awarded to someone who has spent less than two full academic years of graduate work. All post-baccalaureate work toward the doctorate must be completed within ten years. A student beginning doctoral coursework after an elapsed period of at least one semester after the master’s degree has been conferred is granted seven years in which to complete the doctoral program.

Doctoral students whose graduate study is carried out entirely at Lehigh University must register for a minimum of 72 credits beyond the Bachelor’s degree. However, resident students who during their entire doctoral program, including the semester of graduation, have paid full tuition continuously (normally a minimum of 9 credits per academic semester) will have satisfied the tuition requirements for the doctoral degree upon completion of all other requirements. Students who have earned a Master’s degree at another university must register for a minimum of 48 credits. These requirements include registration for research or dissertation credits.
Full-time students working toward the doctorate normally register for a minimum of nine credits each semester. If the minimum degree registration requirement of 72 or 48 credits is attained prior to formal admission to doctoral candidacy, continued registration of at least three credits per semester is necessary. Full-time student status must be certified on the graduate registration form.

After admission to doctoral candidacy, a student must maintain candidacy by registering at least two times each calendar year (in each academic semester or in one academic semester and one summer session). After completion of the minimum registration requirement plus any additional requirements of the student’s department or program, registration is permitted for Maintenance of Candidacy. The tuition charge is for one credit-hour. Full-time status again must be certified on the graduate registration form.

Residence. Each Ph.D. candidate must satisfy Lehigh’s residence requirement. The residence requirement is intended to ensure that doctoral students spend a period of concentrated study and intellectual association with other scholars. Either two semesters of full-time graduate study or 18 credit hours of graduate study within a twelve-month period must be completed.

Individual departments may impose additional stipulations. Candidates should check with their advisers to be certain that they have satisfied their residence requirements.

Language requirements. Language requirements for the Ph.D. are the option of and in the jurisdiction of the candidate’s department. Since proficiency in a language is not a university requirement, each department decides which languages, if any, constitute part of the doctoral program.

Qualifiers. Many departments require students who wish to enroll in doctoral programs to pass qualifying examinations. Since these examinations vary among departments, students should ask their advisers or department chairpersons for more detailed information. If a qualifying examination is not used, students should find out how and when eligibility to pursue doctoral studies is determined.

Admission to candidacy. With the help of an academic adviser, the student names the faculty members of the doctoral committee, a special committee formed to guide the student through the doctoral program. The committee is responsible for assisting the student in formulating a course of study, satisfying specific departmental requirements, submitting a suitable dissertation proposal, over seeing progress in research, and evaluating the completed dissertation. At least four faculty are appointed to the committee; one must be a member of an outside department. Committee membership must be approved by the university’s graduate and research committee.

A doctoral student should apply for candidacy no later than one year after completion of the master’s degree or its equivalent and after passing qualifying examinations if they are required by the major department. The prospective Ph.D. candidate must submit to the doctoral committee a written program proposal that includes a discussion of proposed dissertation research. Upon receiving approval of the proposal, the candidate submits the proposal, signed by the committee members, to the appropriate dean for action by the graduate and research committee. The dean will advise the student of the committee’s decision.

If the dissertation research involves human subjects, university procedures must be followed.

General examinations. Examinations composed and administered by the members of the student’s doctoral committee are designed to test the candidate’s proficiency in a particular field of study. These examinations, which may be both written and oral, should be passed at least seven months before the degree is to be conferred. If a student fails the general examination, a second examination will be scheduled not earlier than five months after the first. If the results of the second examination are unsatisfactory, no additional examination is scheduled.

Dissertation and defense. The Ph.D. candidate is required to write a dissertation prepared under the direction of a Lehigh University professor. The dissertation must treat a topic related to the candidate’s specialty in the major subject, show the results of original research, provide evidence of high scholarship, and make a significant contribution to knowledge in the field.

Upon approval of the dissertation and, if required by the department, secondary readers, the dissertation is submitted to the appropriate dean for inspection at least six weeks before the degree is to be conferred. Upon its return, the student should distribute copies of the draft to the members of the doctoral committee for review and for suggestions for revision. The candidate then schedules a dissertation defense before the doctoral committee, additional faculty members the department may add to the examining committee, and the general public. After the dissertation has been defended and revised accordingly, the student must submit the finished dissertation to the appropriate dean for review by the university’s graduate and research committee no later than two weeks before the degree is to be conferred. Two bound copies must be delivered to the dean’s office. One copy must bear the original signatures of the special committee members. In addition, the candidate must pay a microfilm fee of $50 and present a bursar’s receipt for the payment. Guidelines stipulating the standard form of the dissertation are available in the dean’s office.

Doctor of Arts (D.A.)
The doctor of arts degree (D.A.) is offered to students preparing for careers in college teaching in the field of chemistry. The program requirements are similar to those for the Ph.D. with the following exceptions: (1) a broader distribution of graduate courses in the field, (2) a minor area of study for students interested in interdisciplinary preparation for two-year college teaching, (3) coursework and training in interpersonal awareness, (4) a supervised internship in college teaching, (5) and a research project appropriate to college teaching in the student’s field of specialization.

Graduate Degrees in Business Administration and Economics
Candidates for admission to graduate study in the College of Business and Economics must provide the results obtained in either the Graduate Management Admission Test (GMAT) for degrees in business administration, or the Graduate Record Examination general test (GRE) and the subject test in economics for degrees in economics.

Master of Business Administration
The Master of Business Administration (MBA) degree program is designed to provide candidates with conceptual, analytical, and operational skills that are involved in the decision-making processes connected with managing human, physical, and financial resources. The MBA curriculum provides a blend of strong theoretical foundation together with practical application in the areas of accounting, organizational, behavioral, economics, finance, the legal environment, management, marketing, and quantitative methods.

Education in the business professions requires an understanding of the various organizational functions and integrating these with internal and external aspects of the enterprise into the managerial process. The program encompasses generalized managerial competence, while permitting advanced study in such fields of specialization as finance, management, marketing, international business and management of technology.

All candidates for entry into the MBA program are required to take the Graduate Management Admission Test (GMAT). Information concerning this test may be obtained at college and university counseling centers, or by contacting GMAT, Educational Testing Service, P.O. Box 6103, Princeton, N.J. 08541-6103.

Program prerequisites. Students entering the MBA program should have completed college-level coursework in principles of economics, calculus, and computer literacy. Although failure to complete these prerequisites will not necessarily result in denial of admission to the program, a student without them will be expected to complete the three prerequisites at Lehigh or elsewhere by the end of the first semester following matriculation into the program. If a student demonstrates proficiency in a high-level programming language without formal coursework, he or she may petition to have the computer programming prerequisite waived.

The MBA curriculum. The minimum number of credit hours required for the MBA degree is thirty, normally consisting of ten
courses. This minimum assumes that the prerequisites and foundation courses in the various functional fields were completed prior to entry into the program. If you have a bachelor's degree in business administration from an institution accredited by the American Assembly of Collegiate Schools of Business, you may reasonably expect to have fulfilled many of the foundation course requirements.

The maximum number of credit hours required for graduation is 48. Full-time students can fulfill that requirement in 15 months. Most part-time students require three to four years. Students with little or no undergraduate exposure to business administration and economics other than the prerequisites of calculus, computer literacy and principles of economics usually require the full 48 hours of coursework to earn the MBA. The average student can expect to take 39 to 42 credit hours (13 or 14 courses) to complete the program.

Waiver Policy. Many core courses (listed below) may be waived if you possess the sufficient knowledge to make a course redundant. You may waive any core course if you have completed that course or its equivalent at an AACSB-accredited school with a grade of at least B minus not more than eight years prior to entering the MBA program. You may also petition to waive a foundation course via a proficiency examination.

For each waiver granted, one credit hour of elective work is added to the minimum requirement of three elective courses. The number of credit hours to be added because of waivers is rounded up or down to the nearest multiple of three to determine the number of additional three-credit-hour courses you must take as a result of waiving core courses.

Core Courses

Foundation Courses
GECO 401 Basic Statistics for Business and Economics
GBUS 401 Financial Flows and Accounting Measures
GBUS 402 Legal Environment of Management
GBUS 403 Quantitative Methods in Business and Economics
GBUS 404 Information Systems for Managers ***

Advanced Integrative Courses
GECO 403 Money, Banking and Macroeconomic Analysis *
GBUS 405 Organizational Behavior and Management *
GBUS 406 Financial Management *
GBUS 407 Managerial Accounting and Decision Making *
GBUS 408 Marketing Management*

Interdisciplinary Courses
GECO 402 Managerial Economics **
GBUS 409 Strategic Information Systems***
GBUS 410 Operations Management **
GBUS 411 Managerial Policy and Decision Making **

* Waiver of any of these courses requires a B- or better in two undergraduate courses in the discipline.
** These courses are required of all candidates and cannot be waived.
*** Students must complete either GBUS 404, Information Systems for Managers or GBUS 409, Strategic Information Systems. Only one of the two courses is required.

Elective Courses. You must take three to six elective courses, depending on the number of core courses you are able to waive. These electives may include a maximum of two courses per discipline and up to six credit hours outside the College of Business and Economics (but within Lehigh University). All elective courses must be at the 400 level.

Class Scheduling. For the convenience of full-time and part-time students, most classes are scheduled in late afternoons and evenings. Part-time students may complete the entire program during late afternoons and evenings. To help you accelerate your completion of the program, many courses are offered during the two six-week summer sessions.

Master of Science

Degree in Business and Economics

The master of science degree is offered to students interested in pursuing graduate work in economics or in economics and business. A minimum of thirty semester hours of coursework is required. At least eighteen of these hours must be taken in the College of Business and Economics. In addition, the student will be expected to pass comprehensive examinations in general economic theory and in one other field in the college.

To qualify for the master of science degree, the student must take the following courses in Economics, as part of his or her thirty semester hours of coursework:

GECO 415 Econometrics I
GECO 420 Advanced Macroeconomic Analysis
GECO 421 Managerial Economics
GECO 432 Advanced Microeconomic Analysis
GECO 456 Mathematical Economics

Master of Science in Management of Technology

Lehigh's Master of Science program in Management of Technology (M.S. in MOT) equips scientists and engineers for general management responsibilities in technology-intensive firms and industries, and prepares them for such managerial responsibilities as:

- Creating or acquiring technical knowledge that can become the basis for new and improved products, processes, and services
- Commercializing innovative products, processes, and services that embody new technical knowledge
- Generating profits from technical and commercial developments

Graduates will be equipped to participate in strategic and tactical decisions that are affected by technology, and be effective agents of change for improving the technology-management process.

Applicants must submit a complete application, including data sheet, official transcripts from all undergraduate and graduate institutions, two letters of recommendation, a personal essay, and test scores from the Graduate Record Examination (GRE) or the Graduate Management Aptitude Test (GMAT). Complete applications must be received by June 15 to be considered for the Fall semester. A brochure describing the MOT program, an application for admission, and any additional information may be obtained by contacting either Alden S. Bean (director, Center for Innovation Management Studies, 610-758-3427), or Kathleen A. Trexler (Assistant Dean, College of Business and Economics, 610-758-3418) at Lehigh University, 621 Taylor Street, Rauch Business Center, Bethlehem, PA 18015.

Doctor of Philosophy

The Ph.D. degree in business and economics is designed to provide advanced knowledge and the capacity to carry on independent research in various areas of business and economics. Holders of the Ph.D. are normally employed in academic positions in departments of economics or in schools of business administration, or in policy analysis and research positions in banks, business, government, and research organizations. Employment opportunities are excellent for holders of this degree.

The Ph.D. program requires a minimum of 48 semester hours of study (including dissertation) beyond the master's degree or 72 hours of study beyond the bachelor's degree. Each student is expected to choose three major fields of specialized study. Economic theory must be included as one of the major fields. Each student must take a research core of twelve hours and prepare for written and oral comprehensive examinations in the major fields. The chairperson of the doctoral committee will help to arrange a plan of study suitable for each student's program and to prepare the student to pass the examinations.

Major fields of specialization that are normally available include economic theory, international economics, labor economics, managerial economics, money and banking, and public finance.

Under the guidance of a dissertation chairperson and committee formed after passing of the examinations, the candidate takes
research culminating in an acceptable dissertation. The Ph.D. is awarded upon the successful completion of the doctoral dissertation and its oral defense.

Graduate Degrees in Education
Lehigh's College of Education offers only graduate degree programs. Students enrolled in the College of Education should check with their adviser for a list of regulations and requirements governing their degree programs.

Financial assistance. The College of Education, because it does not offer many undergraduate courses, cannot usually provide teaching assistantships for graduate students. Graduate assistantships and research assistantships are available in the College and in various administrative offices on campus. In addition, graduate students may be recommended for a limited number of fellowships and scholarships, which are awarded by the College.

Lehigh's Centennial School, a laboratory school for socially and emotionally disturbed children, provides employment for some Lehigh education students. Graduate students may apply for teaching internships, which pay tuition plus salaries.

Master of Education (M.Ed.)
This degree is offered in the following professional specializations: elementary education, secondary education, special education, educational leadership, counseling and human services, and elementary and secondary school counseling. Degree requirements vary from program to program.

Master of Arts (M.A.)
The master of arts degree offered in the field of secondary education provides a major in education with an academic specialty. The student must take eighteen credits of graduate work in education plus twelve credits of graduate work in an academic field. The academic fields that cooperate with the College of Education in offering this program include: classical languages, modern foreign languages, English, mathematics, economics, government, social relations, history, international relations, or physical and natural sciences.

Master of Science (M.S.)
The master of science degree is awarded in educational technology.

Educational Specialist (Ed.S.)
Specialized post-master's degree programs for practitioners are available in school psychology and special education.

Certification and Concentration Programs
In addition to offering master's degrees, the College offers state certifications in various professional specialties. The College of Education also offers special twelve to fifteen credit programs that provide concentration in gifted education and education of the severely/multiply handicapped.

Doctor of Education (Ed.D.)
The doctor of education degree program provides specialized study in elementary education, special education, educational leadership, curriculum and instruction, and educational technology. Successful professional experience is required for admission to candidacy for this degree in most programs.

The requirements for the Ed.D. degree parallel those already stated for the Ph.D. degree with the following exceptions: language examinations are not required and a statistics competency examination is required. The residence requirement for the Ed.D. is the same as that for the Ph.D.

Doctor of Philosophy (Ph.D.)
The College of Education also offers the Ph.D. degree to students enrolled in the fields of school psychology, special education, and counseling psychology. The requirements for this degree are the same as those for the Ph.D. in the other colleges and as described in previous sections.

Graduate Studies Organizations

The Graduate and Research Committee
The graduate and research committee consists of twelve members representing the faculties of Lehigh's colleges: four from the College of Arts and Science; two from the College of Business and Economics; four from the College of Engineering and Applied Science; and two from the College of Education, plus the college deans, the registrar, the director of the office of research and sponsored programs, and two non-voting graduate student members.

The committee formulates policies and regulations on graduate education, and it recommends policies and procedures for research-related activities. The committee interprets and applies faculty rules governing graduate students and degrees, including questions concerning student petitions and appeals.

Graduate Alumni Committee
The Lehigh University Alumni Association has established a graduate alumni committee. The committee is composed of distinguished Lehigh graduate alumni and is chaired by Mary Comfort, Ph.D. '85. The committee will provide leadership deepening the involvement of graduate alumni in Lehigh affairs.

Graduate Student Council
The graduate student council, comprised of one graduate student from each academic department, represents the graduate student community regarding graduate programs and graduate student life at Lehigh. It provides a forum for discussion with university officials and committees. Graduate students selected by the graduate student council are non-voting members of the graduate and research committee and the educational policy committee.

Besides functioning as a forum for discussion, the graduate student council maintains a graduate student center. The council plans social events and disseminates information in order to facilitate communication among graduate students.

Interdisciplinary Graduate Study and Research

In addition to offering graduate degrees within academic departments, Lehigh University offers interdisciplinary graduate degrees in the fields of applied mathematics, biology, clinical chemistry, manufacturing systems engineering, physiological chemistry, and polymer science and engineering.

In addition, Lehigh's interdisciplinary research centers and institutes address the research needs of government, industry, and society. Organized to recognize research efforts in interdisciplinary problem areas, they supplement the university's academic departments.

Graduate students pursuing M.S. and Ph.D. degrees in academic departments as well as students enrolled in interdisciplinary degree programs may pursue research opportunities in the various centers.

A complete listing of research centers, institutes, and other research organizations appears following the section on interdisciplinary graduate programs.

Financial assistance. Teaching assistantships and fellowships are provided by individual academic departments, while research assistantships are available through both academic departments and research centers. Students interested in research are encouraged to seek appointments with members of the faculty working in their area of special interest, with department chairpersons, or with center or institute directors.

Interdisciplinary Graduate Programs
Several interdisciplinary programs are offered to the Lehigh graduate student.
Applied Mathematics

Lehigh University offers interdisciplinary programs leading to the degrees of Master of Science and Doctor of Philosophy in Applied Mathematics.

Students may participate in the program either through the Division of Engineering Mathematics within the Department of Mechanical Engineering and Mechanics or through the Division of Applied Mathematics and Statistics within the Department of Mathematics.

The Ph.D. program is aimed at students with a background in mathematics, the sciences, or engineering who wish to obtain a thorough training and to develop their research ability in applied mathematics including its possible utilization in the physical sciences.” Students will be admitted to one of the two divisions according to background and interests.

Seminar series in engineering science and applied mathematics in which visitors, faculty and students discuss current research, are available.

Admission Procedure. Applications are invited from students with backgrounds in engineering, mathematics or the sciences.

A complete application should include undergraduate and graduate transcripts, the aptitude part of the GREY and at least two letters of recommendation. Foreign students must submit evidence of proficiency in English.

All applications are reviewed by the Department of Mathematics and Department of Mechanical Engineering and Mechanics. Students whose area of specialization is Applied Mathematics must register in one of the two departments and specify on their application the department of their choice.

For application forms and information, write:

Prof. Philip A. Blythe, Head
Division of Engineering Mathematics
Packard Laboratory # 19
Lehigh University
Bethlehem, PA 18015 Tel. (610) 758-3782

Prof. Gregory T. McAllister, Head
Division of Applied Mathematics & Statistics
Christmas-Saucon Hall # 14
Lehigh University
Bethlehem, PA 18015 Tel. (610) 758-3730

Send completed applications to:
Chairman of Coordinating Committee
Prof. D. Gary Harlow
Applied Mathematics Program
Department of Mechanical Engineering and Mechanics
Packard Laboratory # 19
Lehigh University
Bethlehem, PA 18015 Tel. (610)758-4127

Financial Aid. Teaching assistantships are offered by both departments, and university fellowships and scholarships are offered by the Graduate School. Research assistantships are sponsored by governmental agencies and industry.

M.S. Program. A master’s program must include at least thirty semester hours of courses.

Students in the Mathematics Department must pass comprehensive examination. They may replace up to six course credits of course work with a thesis. Research credits are obtained by registering in MATH 490 Mathematics Thesis.

Students registered in the ME/Mechanics Department must submit a thesis which may replace up to six hours of course work. No comprehensive examination is required. Research credits are obtained by registering in EMA 490 Engineering Mathematics Thesis.

Ph.D. Program. The master’s degree is not a requirement for the Ph.D.

A candidate entering at the bachelor’s level must satisfy only the course requirements of the master’s degree in the division in which he/she is enrolled. The candidate’s advisor will recommend courses that help in preparing for the qualifying exams. Any additional course requirements will be determined by the student’s dissertation committee. Students registered in the ME/MECH department obtain research credits by registering in EMA 499 Engineering Mathematics Dissertation.

Students registered in the Mathematics Department must satisfy the foreign language requirement. They may obtain research credits by registering in MATH 499 Mathematics Dissertation.

It is recommended that the qualifying examination be taken at the beginning of the fourth semester for students entering at the bachelor’s level and at the beginning of the second semester for students entering with a master’s degree.

The examination consists of three written tests. One is in analytical methods, one is on numerical methods or discrete mathematics, and one is on a topic from the physical or mathematical sciences as approved by the candidate’s division.

Clinical Chemistry

The M.S. program in clinical chemistry is offered by the department of chemistry in cooperation with local hospitals. It is directed toward training clinical laboratory scientists to be active in hospital-based and industrial laboratories in both patient sample service and new product development. The program requires fulfillment of a clinical laboratory practicum as well as a research project at the M.S. level. The core requirements for the degree are:

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<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>Chm 371</td>
<td>Elements of Biochemistry I (3)</td>
<td></td>
</tr>
<tr>
<td>Chm 372</td>
<td>Elements of Biochemistry II (3)</td>
<td></td>
</tr>
<tr>
<td>Chm 332</td>
<td>Analytical Chemistry (3)</td>
<td></td>
</tr>
<tr>
<td>Chm 336</td>
<td>Clinical Chemistry (3)</td>
<td></td>
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<tr>
<td>Chm 358</td>
<td>Advanced Organic Chemistry (3)</td>
<td></td>
</tr>
<tr>
<td>Chm 437</td>
<td>Pathophysiological Chemistry (3)</td>
<td></td>
</tr>
<tr>
<td>Chm 421</td>
<td>Chemistry Research (1-4)</td>
<td></td>
</tr>
</tbody>
</table>

Electives or courses that may be substituted, upon an approved petition, for core requirements in clinical chemistry can be drawn from those listed in the Ph.D. programs in molecular biology or physiological chemistry (see below).

Students may be admitted into this program from undergraduate majors in chemistry, biology, medical technology, or other areas of the biochemical life sciences. One semester of undergraduate physical chemistry is required for the M.S. in clinical chemistry although in some cases this course may be taken while enrolled as a graduate student but for no graduate credit. Graduates of the program are encouraged to continue their education toward the doctorate in any one of the several biological chemistry programs offered at Lehigh.

Design

The Master of Science in Design Program is built upon an undergraduate engineering degree. It is anticipated that with time similar programs will develop for students with degrees from undergraduate arts or business programs. The curriculum is technological in nature, emphasizing design practice, design history, and design communication. It also focuses on issues related to aesthetics, business communication, management of people and technology, mathematics and modeling, manufacturing and manufacturing methods. A key component of the Design program is the Design Studio.

The studio (6 credit hours) affords students and faculty the opportunity to collaborate on design related problems. The studio experience, which is the equivalent of a six-credit thesis, is modeled after the design studio concepts used by the Department of Art and Architecture. Students in this program are expected to provide designs in response to problem/need statements and to defend the solutions both in writing and orally. Faculty feedback is provided to students
relative to the design and the effectiveness of the written and oral presentation. The critiques are offered by the “Design Faculty” from the Colleges of Engineering & Applied Science, Business and Economics, and Arts and Sciences. As part of this process, faculty discuss the pros and cons of the specific design, as well as the design process or processes used for producing the designs. These discussions are an ongoing part of the design studio and afford students the opportunity to reflect on the design process and how is should be executed in real world situations. As appropriate and as needed, personal from industry and government are asked to participate in the review/critique process. Regular design meetings and seminars are used to provide input to this process and to provide continuity for the students over the course of their studio experience.

Additional Courses which make up the 30 credit hours curriculum include:

- **MSE 423 Product Design & Analysis 3** Provides modeling and math skills
- **MSE 431 Marketing and the Invention to Innovation Process 3** Provides marketing business skills
- **MSE 427 Production Systems 3** Provides manufacturing skills
- **MAT 458 Design 3** Provides materials Application and materials processing skills
- **ART 395 3** Provides rendering/industrial design skills
- **Electives 9** To be selected in Consultations with an advisory committee

For further information, contact Professor Richard Roberts, program director, 200 West Packer Avenue, Bethlehem, PA 18015, (610) 758-3848, fax (610) 758-6527.

**Management of Technology**

Lehigh’s Master of Science Program in Management of Technology (M.S. in MoT) is designed to prepare students to deal with the full range of functional and general management issues in technology driven firms and industries.

The program prepares students with a firm knowledge base to analyze issues, formulate options and implement solutions in the areas of:
- creating, acquiring, commercializing and implementing technology;
- formulating and implementing strategy to achieve competitive advantage; interacting effectively with senior management;
- managing cross-functional teams involving engineers, scientists, financial managers, cost management specialists, and marketing/sales executives;
- external sourcing of technology; managing strategic alliances; forming effective customer and vendor relationships; participating in regulatory and public policy decision process.

Students of the MoT program have career ambitions to become managers and executives in technology intensive companies - companies whose competitive advantage depends on the generation and implementation of technologically advanced products, processes and services.

The MS in MoT is a 37 credit program, including an MS Thesis. The MoT curriculum is specifically designed to achieve the above objectives and offers application to real world situations through case studies and the thesis. The program is comprised of nine required and three elective courses which may be completed full time in one year or part time in two years.

**Curriculum.** Foundation courses establish a solid base of knowledge about the economic and historical importance of technology to industry and society and build competence in the use of financial and accounting tools to support technology-management decision-making. These courses give special attention to the issues and problems encountered by technology managers and to the distinctive challenges of leading technical professionals.

- **Technology and Economic Analysis**
- **History of Industrial Technology**
- **Cost Management and Accounting**
- **Managerial Finance**

**Functional Core courses** prepare students to manage and lead cross-functional technical projects by developing project-management skills and by studying the management responsibilities associated with other major functions encountered in most technology intensive industrial firms. These courses emphasize both the strategic aspects and the operational skills associated with technology management in each functional area.

- **RD&E Project Management**
- **R&D Management**

**Integrative courses** emphasize the formulation and implementation of overall technology strategies for companies ranging from individual businesses to large, complex firms. Integrative courses also provide an understanding of the roles played by scientific and technical institutions outside the firm, including government regulatory and standard-setting organizations, in the technological innovation process.

- **Science and Technology Policies and Institutions**
- **Science, Technology, and Competitive Strategy**

**Elective courses** allow students to pursue special interests. In addition to a menu of elective courses within the MoT program, selected technical courses offered by other Lehigh departments may also be taken as electives, with the approval of the Program Director.

- **Total Quality Management**
- **Science, Technology and International Business**
- **New Product Planning and Development**
- **Diffusion and Implementation of Technology**

**Admission**

The MoT program is intended for students with undergraduate degrees in science or engineering and several years of industrial experience. Students with undergraduate degrees in other fields will be considered based on employers’ recommendations and other qualifications.

Applicants must hold a bachelor’s degree from a U.S. institution or an equivalent degree from a foreign institution requiring at least 16 years of primary, secondary and university education (including at least 4 years at the university level).

Applicants should have an adequate knowledge of calculus, probability and statistics, and economics to feel comfortable in taking required courses. Deficiencies may be satisfied before taking certain courses. See the MoT Program Advisors if there are concerns in this regard.

Applicants must submit a completed application, including data sheet, official transcripts from all undergraduate and graduate institutions, two letters of recommendation, a personal essay and test scores from the Graduate Record Exam (GRE) or the Graduate Management Aptitude Test (GMAT). Completed applications must be received by July 15 to be considered for the Fall semester.

For further information, please contact: Center for Innovation Management Studies, Management of Technology Program, College of Business and Economics, Lehigh University, Rauch Business Center, 621 Taylor Street, Bethlehem, PA 18015-3117. Phone (610) 758-6740; fax (610) 758-3655; E-mail: inmot@lehigh.edu
Center for Innovation Management Studies

The M.S. in MOT program is affiliated with Lehigh's Center for Innovation Management Studies (CIMS), a National Science Foundation-supported industry/university cooperative research center for the study of technological innovation and its management. CIMS is the hub of a national network of industrial corporate sponsors and academic research associates. The MOT program will draw upon this network of industrial, government, and academic colleagues for guest lecturers and seminar speakers throughout the program.

Manufacturing Systems Engineering

Lehigh's award-winning graduate program leading to the master of science degree in manufacturing systems engineering (MSE) is sponsored by all the departments in the College of Engineering and Applied Science and is administrated by the Center for Manufacturing Systems Engineering. In addition, the College of Business and Economics participates in teaching accounting, business, finances, management, and marketing aspects of manufacturing systems.

This graduate curriculum aims to develop engineers who can design, develop, implement, and modify manufacturing systems involving materials, processes, equipment, facilities, logistics, and people, with leading edge technologies. It integrates systems perspectives with interdisciplinary course offerings.

The 30-credit hour curriculum may be structured as a one-year full-time program, beginning in January (some industrial experience is a requirement), or a two-year part-time program for working engineers within commuting distance of campus. Courses in this flex-time program are scheduled on Tuesday evenings and all-day Friday, in the spring and fall semesters. The core programs are structured as follows:

FULL-TIME OPTION

Spring semester
MSE 421 Managing the Manufacturing Life Cycle (3)
MSE 423 Product Design/Analysis (3)
MSE 427 Production Systems (3)
+ one or two electives

Summer session (ten weeks)

One week study tour of industry visits selected manufacturing plants, design centers and research facilities. Students and faculty analyze the manufacturing strategies, systems and technologies used in these facilities.

The summer also provides opportunities for meeting elective requirements and completion of thesis/project research.

MSE students are required to pursue a three credit project or six credit thesis to complete their Master's degree.

MSE 451. Manufacturing Systems Engineering Project (3) OR

MSE 490. Manufacturing Systems Engineering Thesis (6)

In depth study of a problem in the area of manufacturing systems engineering. The study should lead to specific conclusions embodied in a written report, suitable for publication.

Fall semester

Required courses:
MSE 425 Production Planning and Resource Allocation (3)
MSE 431 Marketing & the Invention to Innovation Process
MSE 433 Technology and the Factory of the Future (3)
+ one or two electives

PART-TIME OPTION

First Spring semester (odd years)
MSE 421 Managing the Manufacturing Life Cycle (3)
MSE 423 Product Design/Analysis (3)

First Fall semester
MSE 425 Production Planning & Resource Allocation (3)
Elective Course

Second Spring semester
MSE 427 Production Systems (3)
Elective Course

Second Fall semester (even years)
MSE 431 Marketing & the Invention to Innovation Process
MSE 433 Technology and the Factory of the Future (3)

Summer sessions

Elective courses, thesis/project registration and research, and summer study tour are done during the summer sessions.

Additional Requirements. There are weekly seminars, specially designed tutorials on simulation, injection molding, and current topics etc., industry tours, and meetings with executives from industry at which attendance is expected.

Elective courses (6 or 9 credit hours): In order to complete their thirty credit hour minimum, students are required to take three approved elective courses unless they register for a thesis (6 credit hours) in this case they are required to take only two elective courses.

Elective courses should be selected, in consultation with the MSE academic adviser and faculty, from the five technical and business areas related to manufacturing systems engineering. These areas include:
- design
- materials, processes and quality control
- automation, control systems, and computer integration
- computer and information systems
- business, management, organization and operations research

In addition to the regular classroom work, this program includes extensive use of Lehigh’s computing and engineering laboratories. There is heavy emphasis on ability to communicate and work in teams, as well as a team approach to projects which foster learning.

Admission

- A bachelor’s degree in engineering or in an appropriate science is required.
- Candidates enroll in the program through one of the university’s engineering departments, depending on their individual backgrounds and interests.
- All candidates must follow admission procedures and standards established by Lehigh University.

Financial aid. A limited number of graduate fellowships are available on a highly competitive basis for MSE applicants.

Special Activities Fee. In addition to the applicable Lehigh University tuition, the MSE Program requires a special activities fee of $2,500 for 1998. Tuition and fees are expected to increase on a yearly basis.

Inquiries. For a brochure describing the MSE program, an application for admission (which includes an application for financial aid), or any additional information, please contact: Jeannette MacDonald, MSE Program Coordinator, H.S. Mohler Lab, 200 West Packer Avenue, Bethlehem, PA 18015 (610) 758-4667, FAX (610) 758-6527, Email JIM1 @ Lehigh.edu, or visit our web site at www.lehigh.edu/~inmsgad/gradprog

Molecular Bioscience and Biotechnology

This interdisciplinary program leads to the degree of Master of Science in Molecular Bioscience and Biotechnology. The program is designed as a broad-based introduction to advanced study in the fundamental bioscience and engineering that is the foundation of modern biotechnology. Students are enrolled through the departments of Biological Sciences, Chemistry, or Chemical Engineering and take a core set of courses in molecular biology, biochemistry, and biochemical engineering, supplemented with advanced level courses in these three
areas. Full-time registrants conduct research under the direction of faculty members of these research areas. Students wishing to continue beyond the M.S. degree can enter this program into Ph.D. programs in Molecular Biology, Biochemistry, or Chemical Engineering.

The degree requires completion of thirty credits, eighteen of which must be at the 400 level. The required core courses, representing eighteen of the thirty credits, are:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
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<tbody>
<tr>
<td>Bios 371</td>
<td>Elements of Biochemistry I (3)</td>
</tr>
<tr>
<td>Bios 372</td>
<td>Elements of Biochemistry II (3)</td>
</tr>
<tr>
<td>ChE 341</td>
<td>Biotechnology I (3)</td>
</tr>
<tr>
<td>ChE 342</td>
<td>Biotechnology II (3)</td>
</tr>
<tr>
<td>Bios 345</td>
<td>Molecular Genetics (3)</td>
</tr>
<tr>
<td>Bios 411</td>
<td>Cell Biology (3)</td>
</tr>
</tbody>
</table>

With the consent of the M.S. program coordinator, students may petition for substitution of courses equivalent to the core courses. The substitutions must receive the approval of the department responsible for the course.

With the guidance of the student's advisor and the M.S. program coordinator, the remaining twelve credits must be drawn from the following approved 400 level courses:

<table>
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<th>Course</th>
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<tr>
<td>Bios 415</td>
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<tr>
<td>Bios 450</td>
<td>Biochemistry (3)</td>
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<tr>
<td>Bios 461</td>
<td>Biochemistry (3)</td>
</tr>
<tr>
<td>Bios 462</td>
<td>Biochemistry (3)</td>
</tr>
<tr>
<td>ChE 444</td>
<td>Biochemistry (3)</td>
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<tr>
<td>ChE 445</td>
<td>Biochemistry (3)</td>
</tr>
<tr>
<td>ChE 450</td>
<td>Biochemistry (3)</td>
</tr>
<tr>
<td>Chm 423</td>
<td>Biochemistry (3)</td>
</tr>
<tr>
<td>Chm 424</td>
<td>Biochemistry (3)</td>
</tr>
<tr>
<td>Chm 427</td>
<td>Biochemistry (3)</td>
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<tr>
<td>Chm 428</td>
<td>Biochemistry (3)</td>
</tr>
<tr>
<td>Chm 469</td>
<td>Biochemistry (3)</td>
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<tr>
<td>Chm 470</td>
<td>Biochemistry (3)</td>
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<td>Chm 471</td>
<td>Biochemistry (3)</td>
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<td>Chm 472</td>
<td>Biochemistry (3)</td>
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<tr>
<td>Chm 473</td>
<td>Biochemistry (3)</td>
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<tr>
<td>Chm 476</td>
<td>Biochemistry (3)</td>
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</tbody>
</table>

no more than 6 credits from the following 400 level approved lab courses:

<table>
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<tr>
<th>Course</th>
<th>Title</th>
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<tbody>
<tr>
<td>Bios 463</td>
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<tr>
<td>Bios 464</td>
<td>$\ldots$</td>
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<tr>
<td>ChE 446</td>
<td>$\ldots$</td>
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<tr>
<td>Bios 479</td>
<td>$\ldots$</td>
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<tr>
<td>Chm 480</td>
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</tbody>
</table>

no more than 6 credits from the following 400 level approved seminar courses:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
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</thead>
<tbody>
<tr>
<td>Bios 466</td>
<td>$\ldots$</td>
</tr>
<tr>
<td>ChE 448</td>
<td>$\ldots$</td>
</tr>
<tr>
<td>Chm 435</td>
<td>$\ldots$</td>
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<tr>
<td>Chm 477</td>
<td>$\ldots$</td>
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</tbody>
</table>

a minimum of 3 credits of the following:

<table>
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<tr>
<th>Course</th>
<th>Title</th>
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<tbody>
<tr>
<td>Bios 407</td>
<td>$\ldots$</td>
</tr>
<tr>
<td>ChE 480</td>
<td>$\ldots$</td>
</tr>
<tr>
<td>Chm 421</td>
<td>$\ldots$</td>
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</tbody>
</table>

All students must (a) register for 6 credits of research, successfully complete a research project under the direction of a faculty member in one of these areas, and submit a written report that is approved by the research advisor, the admitting department, and the M.S. program coordinator or (b) complete 6 credits of advanced level course work approved by the M.S. program coordinator and pass a Comprehensive Examination administered by the faculty from the program.

For further information, contact Neal Simon, Chair of the Department of Biological Sciences, Science Hall, 111 Research Dr., Lehigh University, Bethlehem, PA 18015.

**Physiological Chemistry**

The graduate program in physiological chemistry leads to the M.S. and Ph.D. degrees. This curriculum prepares individuals who want to pursue careers in biomedical research, teaching, or administration, or in some aspect of public health.

Individuals may elect to specialize in one of the following areas: nuclear medicine, medicinal chemistry, chemical and experimental parasitology, invertebrate pathobiology, comparative immunology, and chemical physiology. The core course distribution and selection of electives may be altered to reflect the area of specialization.

**Core Courses**

Students select at least six of the following core courses:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
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<tbody>
<tr>
<td>Chm 336</td>
<td>Clinical Chemistry (3)</td>
</tr>
<tr>
<td>Chm 371</td>
<td>Elements of Biochemistry I (3)</td>
</tr>
<tr>
<td>Chm 423</td>
<td>Bio-organic Chemistry (3)</td>
</tr>
<tr>
<td>Chm 424</td>
<td>Medicinal and Pharmaceutical Chemistry (3)</td>
</tr>
<tr>
<td>Chm 435</td>
<td>Advanced Topics in Clinical Chemistry (3)</td>
</tr>
<tr>
<td>Chm 437</td>
<td>Pathophysiological Chemistry (3)</td>
</tr>
<tr>
<td>Chm 456</td>
<td>Spectral Analysis (3)</td>
</tr>
<tr>
<td>Chm 477</td>
<td>Topics in Biochemistry (1-3)</td>
</tr>
<tr>
<td>Chm 479</td>
<td>Biochemical Techniques (3)</td>
</tr>
<tr>
<td>Bios 421</td>
<td>Molecular Cell Biology I (3)</td>
</tr>
<tr>
<td>Bios 422</td>
<td>Molecular Cell Biology II (3)</td>
</tr>
</tbody>
</table>

Students, with the consent of their graduate committee members, may petition to substitute equivalent courses for some of the required ones. The substitution must be approved for the student's area of research concentration. In addition, each student selects, with the guidance of the committee, sufficient courses from the following to satisfy the requirements of the Graduate School.

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
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</thead>
<tbody>
<tr>
<td>Chm 358</td>
<td>Advanced Organic Chemistry (3)</td>
</tr>
<tr>
<td>Chm 372</td>
<td>Elements of Biochemistry (3)</td>
</tr>
<tr>
<td>Chm 421</td>
<td>Chemistry Research (1-4)</td>
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<tr>
<td>Chm 423</td>
<td>Bio-organic Chemistry (3)</td>
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<td>Chm 424</td>
<td>Medicinal and Pharmaceutical Chemistry (3)</td>
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<td>Chm 441</td>
<td>Chemical Kinetics (3)</td>
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<td>Chm 445</td>
<td>Elements of Physical Chemistry (4)</td>
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<td>Chm 458</td>
<td>Topics in Organic Chemistry (3)</td>
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<td>Chm 476</td>
<td>Microbial Biochemistry (3)</td>
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<td>Chm 480</td>
<td>Advanced Biochemical Preparations (1-3)</td>
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<td>Chm 481</td>
<td>Chemistry Seminar (1-6)</td>
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<td>Bios 133</td>
<td>Invertebrate Zoology (3)</td>
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<td>Bios 353</td>
<td>Virology (3)</td>
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<td>Bios 405</td>
<td>Special Topics in Molecular Biology (1-3)</td>
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<td>Bios 415</td>
<td>Neuropharmacology (3)</td>
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<tr>
<td>Bios 464</td>
<td>Molecular Biology of Eukaryotic Organisms (3)</td>
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Students admitted into this program may have majored in biology, chemistry, animal science, entomology, veterinary science, pharmacy, or some other areas of the life sciences.

All students in the doctor of philosophy program are required to satisfy one foreign language requirement and pass a qualifying examination. The completion of a research project is required of M.S. students. A dissertation is required of Ph.D. candidates.

For further information, contact Ned D. Heindel, Chemistry Department, Lehigh University, 6 E. Packer Avenue, Bethlehem, PA 18015-3172.

**Polymer Science and Engineering**

Lehigh has a diverse group of faculty members with strong, primary interest in polymer science and engineering. In order to provide better opportunities for courses and research in this interdisciplinary field, activities are coordinated through the Center for Polymer Science and Engineering (CPSE), and its academic Polymer Education Committee. Polymer faculty from traditional departments of chemical engineering, chemistry, and materials science and engineering, physics, and mechanical engineering and mechanics, are participants of the CPSE.

There are two ways in which qualified graduate students, with degrees in the above or related fields, may participate. They may pursue graduate studies within an appropriate department. Departmental procedures must be followed for the degree sought. The student's advisor may be in that department, or in another department, or research center. In this case, the student receives a normal departmental degree, with emphasis in polymer courses and research.

Alternatively, students may elect to pursue studies toward an interdisciplinary M.S. or Ph.D. degree in polymer science and engineering. The procedures for this latter case are summarized as follows.

M.S. in polymer science and engineering.

For the M.S., the student's program must include: not less than thirty credits of graduate work; not less than eighteen credits of 400 level course work, and not less than eighteen credits of course work in the major, of which fifteen must be at the 400 level. The program must include six course credits in the student's admitting department, six research credits, and a research report or thesis to the satisfaction of the faculty advisor, to be filed with the polymer education committee.
Required courses:

Chem 388 Synthesis and Characterization Lab (3)
Chem (Mat) 393 Physical Polymer Science (3)
Chem (Chem) 394 Organic Polymer Science (3)
Research (6)

Three 400 level polymer courses to be selected from the following list (list may vary slightly from year to year):

Chem 428 Rheology (3)
Phys 472 Polymer Physics (3)
Chem (Chem) 483 Emulsion Polymers (3)
Chem (Mat) 482 Engineering Behavior of Polymers (3)
Chem (Mat) 485 Polymer Blends and Composites (3)
Chem 486 Processing (3)
Chem 489 Organic Polymer Science II (3)
Chem 491 Physical Chemistry of Organic Polymer Coatings (3)
Chem 492 Topics in Polymer Science (3)
Chem 493 Organic Chemistry of Radiation-Induced Polymer Coatings (3)
Chem (Mat) 487 Polymer Interfaces (3)

Courses in the admitting department must include one of the following:

Chem (Chem) 400 Chemical Engineering Thermodynamics (3)
Chem (Chem) 445 Elements of Physical Chemistry (4)
Mat 401 Thermodynamics and Kinetics I (3)
Mat 420 Advanced Thermodynamics
Phys 442 Statistical Mechanics

plus one other 300 or 400 level non-polymer related course from their admitting department.

Ph.D. in polymer science and engineering. For the Ph.D., the student must satisfactorily complete a qualifying examination administered by the Polymer Education Committee, satisfactorily complete graduate course work determined in consultation with the doctoral committee, pass a general examination administered by the Polymer Education Committee, and defend the dissertation to the satisfaction of the doctoral committee, a dissertation in the field of polymer science and engineering. Students deficient in polymer science or related topics may be required by their committee to take remedial course work.

The doctoral committee consists of the research advisor, at least two other members of the center for polymer science and engineering, and at least one outside person. The committee's composition is subject to approval by the Polymer Education Committee and the graduate and research committee of the university.

For more information, write to Dr. M.S. El-Aasser, director, Center for Polymer Science and Engineering, Iacocca Hall, Lehigh University, Bethlehem, PA 18015, or Dr. L.H. Sperling, chairman, Polymer Education Committee, Whitaker Laboratory, Lehigh University, 3 E. Packer Avenue, Bethlehem, PA 18015.

Research Centers and Institutes

Lehigh has developed a number of centers and institutes to provide greater research and academic opportunities for primarily graduate students and faculty. Centers and institutes are generally interdisciplinary and complement the scholarly activities of academic departments and represent scholarship and research based on the expertise and capabilities of a group of faculty members. Frequently, centers relate to the broad-based research needs of government, industry, and the social community.

Biopharmaceutical Technology Institute

The Biopharmaceutical Technology Institute coordinates the educational and research activity in the biopharmaceutical area of the Chemistry and Chemical Engineering Departments at Lehigh University. The main focus of this institute is to contribute to the creation and to the dissemination of engineering and scientific knowledge required to develop, to improve and to regulate biotechnology and pharmaceutical industry processes and products.

Research activities: The research program of this institute is devoted specifically to the engineering and scientific fundamentals related to the development, design, validation, cGMP (current Good Manufacturing Practice) operation, safety, monitoring and control of fermentation, purification, product modification and formulation.

The research thrusts of the institute include: immunochemistry applied to clinical diagnostics; modification and use of monoclonal antibodies in radiosensitization and NMR imaging; structural analysis of glycoprotein pharmaceuticals; tumor image enhancement; medicinal chemistry; chemistry of biologically potent molecules; fundamental kinetics of microbial, mammalian and plant cell and enzyme systems; design and scale-up of bioreactor and bioseparation systems; development of instrumentation for the on-line monitoring of biological unit operations; development of novel separation and purification schemes for recovery of biologically active macromolecules, antibodies, and antibodies; development of cGMP validation procedure for biopharmaceutical processes and products; and biopharmaceutical drugs research, design and delivery systems.

Specific examples of projects recently carried out within the institute include: development of Fourier transform infrared spectroscopy for the on-line monitoring of substrate, product and cell concentrations; kinetics of recombinant microbial and cell culture systems analysis of nutritional limitations and medium formulation for mammalian cell systems; use of cell cycle for enhancing mammalian cell culture productivity; fundamental studies of separation systems such as continuous chromatography, and aqueous two-phase extraction; plasmid DNA and recombinant protein purification; fundamental studies of protein conformation in bioprocessing by 2D FT HNMR; pressurized effects in chromatographic separations; effect of cross-linking on biological activity of biopharmaceuticals; kinetics and enzyme production by cellulytic fungi actionomycetes; bioprocessing equipments cleaning and validation.

The research is conducted in Iacocca Hall, Mountaintop Campus, where the laboratories for the Department of Biological Sciences research group, the Department of Chemical Engineering, the Emulsion Polymers Institute, and the Chemical Process Modeling and Control Center are located. Because of the interdisciplinary nature of the research, projects typically involve joint supervision by faculty from Chemical Engineering, Molecular Biology, and Chemistry/Biochemistry.

The Biopharmaceutical Technology Institute presently occupies 3600 square feet of laboratory and 2250 square feet of pilot plant space in the C wing of Iacocca Hall of the Mountaintop Campus. The institute is equipped with 30/250 of pilot-scale computer-controlled bioreactors, monitored and controlled by Leeds & Northrup MAX 1 Distributed Digital Control Unit. In addition, numerous small-scale reactors are available for batch and continuous culture work. Key emerging monitoring systems used on the pilot-scale fermentation equipment include a UTI Quadropole Mass Spectrometer, BioChem Technology Fluoromassure System, and an ASRI Reactor 1000 FTIR Spectrophotometer with steam sterilizable DiComp™ probe. Pilot scale separations capability is being developed and currently includes a Millipore Pellicon Unit, Sharples centrifuges and large-scale chromatography.

The fermentation and separations facilities are supported by analytical equipment and facilities including UV/visible spectrometer, isocratic and gradient HPLC’s with refractive index and variable wavelength UV/visible detectors, gas chromatographs with FID and TCD detectors, YSI analyzer, Branson cell sonifier, incubator/shakers, laminar flow hood, microscopes, centrifuges and ultracentrifuges, scintillation and gamma counters, liquid and gas liquid chromatographs, high-field NMR, etc.

Mammalian cell cultivation is conducted in a recently constructed class 1000 laboratory equipped with CO2 incubators, vertical laminar flow hoods, a Bellco roller bottle apparatus, Millipore Milli-Q purification system, inverted microscope, etc.
Educational opportunities: As listed in the course descriptions for the Department of Chemistry and Department of Chemical Engineering, the faculty of the Biopharmaceutical Technology Institute conduct a variety of courses as part of the graduate education curriculum in biochemical engineering and chemistry. The typical graduate level biochemical engineering curriculum would also include core courses in chemical engineering and basic science courses in microbiology, biochemistry, and molecular biology offered through the departments of biological sciences and chemistry.

For more information, write to Dr. James T. Hsu, Director, Biopharmaceutical Technology Institute, Lehigh University, 111 Research Drive, Bethlehem, PA 18015.

Building and Architectural Technology Institute

BATTI is concerned with the entire scope of the built urban environment, the social, and the cultural aspects of building technology. BATTI researchers and faculty carry out border-crossing studies aimed at the development of enhanced livability of the urban environment and its structures, their suitability to the environment for which they are planned, mutations in urban function and conditions, and the concurrent architectural, urban planning, and design problems.

The institute provides a center for interdisciplinary study, research activity, information dissemination, and stimulation for the use of new information in design. BATTI has as its goal both the enhancement of academic knowledge through academic research and the practical solution of current physical problems through applied research.

BATTI provides a forum for faculty discussion, not only from the different disciplines on the campus as they relate to the built environment (architecture, history, sociology, psychology, business, and economics), but also for visitors and professors. It also provides a contact between the academic and the business worlds.

Research. The institute provides the opportunity to identify research problems, develop proposals, and seek mechanisms for their solution. This can include the traditional single-discipline approach, but typically it involves work across the disciplines within the university and with other academic and commercial entities.

Study opportunities. The resources of the institute, the Council on Tall Buildings and Urban Habitat, and other related centers at Lehigh University are available to interested scholars.

For more information write to Dr. Tom F. Peters, Director, Building and Architectural Technology Institute, Lehigh University, 17 Memorial Drive East, Bethlehem, PA 18015-3007.

Center for Innovation Management Studies

The Center for Innovation Management Studies (CIMS) was established in 1984, in response to the needs of industrial executives and government officials for a university-based center to study the management of research and development and technological innovation.

The center's research program is interdisciplinary and involves research as well as continuing education. The center supports studies of the industrial innovation process, encourages publication in the professional literature, and trains students and business executives for technology management responsibilities through regular course offerings and continuing education programs.

The goal of this research is to enhance the contribution of technology to corporate performance and national productivity through an improved understanding of the technological innovation process and its management.

Under the direction of Alden S. Bean, Kenan Professor of Management and Technology and former director of the division of policy research and analysis at the National Science Foundation, the center is sponsored by 12 corporations, and NSF.

For more information, write to Alden S. Bean, Director, Center for Innovation Management Studies, Rauch Business Center, Lehigh University, 621 Taylor Street, Bethlehem, Pa. 18015, or call (610) 758-3427.

International Center for Democracy and Social Change

The International Center for Democracy and Social Change was established at Lehigh University in 1994. A key purpose of the Center is to develop an innovative learning and research program in "democracy and social change" in international affairs, broadly defined to include both national (including the USA) and systemic dimensions.

This interdisciplinary program will educate students and faculty in understanding and managing critical changes in the global society within the parameters of political democracy. Thus, the program is centrally involved in Lehigh's traditional educational mission of preparing future leaders both at home and abroad.

In addition, the Center will focus on other aspects of international studies at the University, with the following responsibilities:

- To coordinate and strengthen existing area studies programs, i.e., Asian Studies, Latin American Studies, and Russian Studies.
- To promote awareness of other global areas of interest such as African Studies and European Studies.
- To develop new multicultural programs, such as Asian American Studies and Latino Studies, in order to reflect the increasing cultural diversity on campus.
- To promote the internationalization of the curriculum throughout the College of Arts and Sciences. This will be implemented through faculty development programs, curriculum revision and enhancement, technological applications in teaching, and innovations in student research and experiential learning.
- To cooperate with the departments, centers, and programs to enhance the overall international dimension at the University.
- To strengthen the Lehigh Abroad program by developing innovative study and internship opportunities for students and faculty alike, e.g., Lehigh in China Program.

In all of its activities, the Center focuses on educating our students to understand the complexities of social change in our rapidly evolving "global village," and preparing them to play a leadership role in managing future global challenges through democratic political institutions and processes.

Further information on the Center's programs can be obtained from the Resource Room, 539 Maginnes Hall, 758-4745. This room houses informative material on the Center's activities as well as other international studies programs and support services throughout the university.

Director: Raymond F. Wyile, 537 Maginnes Hall, 758-4745 (RFW1).

Center for Manufacturing Systems Engineering

The Center for Manufacturing Systems Engineering aims to catalyze, coordinate, develop and focus university activities associated with manufacturing. The Center is a focal point for manufacturing-related activities involving graduate education and research. It facilitates the development of knowledge of manufacturing sciences, systems and technologies and promotes the transfer of this knowledge to industry for practical application. The Center uses close ties with industry to ensure that classroom instruction is current, and that research goals are compatible with the long-range needs of industry. It is essential to maintain free flow of ideas and technology transfer both from research laboratories into industry, and from industry into the classroom. The Center works with an Industrial Advisory Board comprised of member firms in order to accomplish these goals.

The Center has four major thrusts:

1. A Graduate Program which offers a tightly focused one year curriculum leading to the Master of Science degree in MSE, with a "part-time" two year option.
2. Research directed at solving problems of manufacturing; this also serves to maintain faculty currency and provides a vehicle for student project or thesis studies.
3. Technology transfer to sustain the free flows of knowledge from the research laboratories out to industrial applications, and in the reverse direction from leading-edge member industries back into the classrooms.
4. The provision of services by offering conferences, clinics, workshops and other means for communicating and disseminating the advantages of sound manufacturing systems engineering practice.

Representatives appointed by subscribing member firms attend twice
yearly meetings of the Industrial Advisory Board (IAB), and enjoy opportunities to serve on committees advising on research priorities, funding allocations, curriculum development, technology transfer (Conferences, clinics, seminars, plant visits and workshops), student recruiting and hiring.

Research activity. It is a basic thesis that “manufacturing” consists of any activity whereby materials and information are transformed into goods or services for the satisfaction of human needs; furthermore, it is the purpose of manufacturing systems to generate wealth. The components of a manufacturing system can be enumerated simply as consisting of materials, processes, equipment, facilities, logistics and people. A manufacturing system is viewed as a complete system which embraces all the activities involved in developing an idea from concept to the realization of a product (or service) which generates customer satisfaction and revenues, through to end-of-life. Manufacturing systems engineering involves the study, research and development of knowledge of the interactions between the various components as they are combined to generate products with revenues for the sponsoring enterprises and prosperity for the associated communities and stakeholders.

The Center supports research in manufacturing systems engineering by means of grants to faculty, and support of research assistants; students in the MS in MSE Program are also encouraged to undertake research of interest either to their employers, or to industry in general. Selection of appropriate research topics is done in consultation with the members of an Industrial Advisory Board. A current focus of activities is Microelectronics Manufacturing and especially Packaging, Design Systems, Thin Film Hybrid, the characterization of coatings and package interfaces, and the use of lead free solders. Thin film hybrid manufacturing and other processes are being set up in the Microelectronics Manufacturing Laboratory assisted by grants from the AT&T Foundation and equipment from the IBM Corporation. The purpose of the laboratory is to provide research capability and hands-on experience. Other topics of interest range from studying the manufacturing systems aspects of designing and delivering electronic functionality in a variety of forms out to theoretical modeling and simulation work. There are investigations into activity based costing, design management, application of financial information systems, injection molding, together with research in various labs on the Lehigh campus. Investigations were completed recently on applications of 3-D Lithography in rapid prototyping. There are additional activities examining impacts of Total Quality and ISO 9000. There is particular interest in the development of intelligent process diagnostic techniques and their application to small and medium sized enterprises (SME’s).

The center supports activities of various university laboratories engaged in the studies relating to manufacturing systems, however, the Center does not operate its own laboratories. There is collaboration with other Centers, Departments and Laboratories in the preparation and planning of research proposals and programs which aim to improve the understanding of manufacturing.

Educational opportunities. A predominant CMSE activity is a cross-disciplinary graduate program leading to an MS in MSE degree in the College of Engineering and Applied Sciences. This program includes courses delivered by faculty from the College of Business and Economics, it commenced in 1984 as result of a major initiation grant from the IBM Corporation. Since inception over 320 students have passed through this integrated offering which comprises several notable features including teasing activities and courses taught by members of several different departments.

The Center also administers and is closely associated with the interdisciplinary graduate degree program in design. A partial release program utilizing the same “manuscript” curriculum is available for employees of Lehigh Valley and neighboring industries, there are separate classes requiring four semesters of one evening and one day per week attendance plus an industrial research project.

Admission to educational programs administered in association with the Center is achieved by application through the Program and the department of the appropriate engineering discipline. The Center is NOT a department and graduate students come under the department of whichever discipline happens to be appropriate, and must meet the standards required by that department. Candidates who wish to pursue a doctorate focused on aspects of MSE must apply for entry to the Ph.D. program of the department of their choice. The Center may, or may not, choose to be associated with the support of the research goals of such doctoral candidates.

For more information, write to: Keith M. Gardiner, kg03@lehigh.edu, Director, Center for Manufacturing Systems Engineering, H. S. Mohler Laboratory, Lehigh University, 200 W. Packer Avenue, Bethlehem, Pa. 18015, or call (610) 758-5157 or visit our website at www.lehigh.edu/~imnse/center/

Center for Polymer Science and Engineering
The Center for Polymer Science and Engineering (CPSE) was formally established at Lehigh University in July 1988. The Center provides a unique opportunity for faculty and students from the traditional departments of chemistry, chemical engineering, materials science and engineering, mechanical engineering and mechanics, and physics to perform interdisciplinary research in polymers. The Center is an umbrella organization encompassing polymers research and graduate studies at Lehigh University. The Center’s primary missions are preparation of first rate scientists and engineers with proficiency in polymers; fostering cross-disciplinary polymer research; and organizing and teaching continuing education short courses in areas of interest to the polymer industry; and organizing campus wide seminars.

The Center’s Polymer Education Committee graduate studies through the academic departments leads to the Master of Science and Doctor of Philosophy in Polymer Science and Engineering. Students may also elect to pursue studies towards a classical degree in their respective departments with an emphasis in polymer courses and research. Both advanced undergraduate and graduate courses in polymer science and engineering are offered through the participating departments. Current course offerings include polymer synthesis and characterization laboratory, physical polymer science and organic polymer science, engineering behavior of polymers, rheology, polymer processing, emulsion polymers, biopolymers, polymer blends and composites, fatigue and fracture of engineering materials, colloidal science, and polymer interfaces.

Research activities. The center has a wide range of research activities covering the field of polymers. The following are the major research themes: Surface/interfacial aspects of polymer colloids, adhesion, and polymer blends and composites; polymerization mechanisms and kinetics; polymerization reactors modeling and control; structure/property relationships of interpenetrating polymer networks; macromolecular chemistry of biopolymers and coal; polymer coatings for corrosion protection, microelectronic packaging.

Research facilities. The following research instrumentation are available for the Center for Polymer Science and Engineering: X-Ray Photoelectric Spectroscopy (ESCA), Scanning Auger Electron Spectroscopy, Laser Ramon Spectroscopy, Mossbauer Spectroscopy, Nuclear Magnetic Resonance Spectroscopy of both solids and solutions (NMRS) (3 instruments; 90 MHz, 300 MHz and 500 MHz), Fourier Transform Infrared Spectroscopy (FTIR) (both conventional and photo-acoustic), a variety of advanced transmission and scanning electron microscopes, modulated differential scanning calorimetry and high-resolution addition analysis, instruments for rheological studies (including a Rheometrics RDA2 and Bohlin Rheometer), particle sizing instruments (Coulter N4M, Joyce-Loebl Disc Centrifuge, Capillary Hydrodynamic Fractionation, and Hydrodynamic Chromatography), Gel Permeation and Gas Chromatography units, Electrographic Mobility apparatus, mechanical testing devices such as the Rheovibron Dynamic Mechanical Spectroscopy, Instron Tensile Test equipment, several computer-controlled servohydraulic fatigue test machines, and Polymerization Reactors, including Bottle Polymerizer, Tubular Reactor, Stirred Tank Reactors with on-line sample analysis for residual monomer and interfaced with computer for control operations.

Educational opportunities. Programs of study for individual students are designed to meet the student’s interests, the requirements of the academic department, and the student’s dissertation committee. Considerable flexibility is permitted in the selection of courses and a
research topic. Lehigh University has been awarding interdisciplinary M.S. and Ph.D. degrees in Polymer Science and Engineering since 1975. Graduate students conducting polymer research may also earn the M.S. and Ph.D. degrees in the classical fields of chemistry, chemical engineering, materials science and engineering, physics, or mechanical engineering and mechanics. For further information please refer to the Polymer Science and Engineering Program in the section:
Interdisciplinary Graduate Programs.

For more information about the center activities, admission to graduate school, or financial aid, contact: Dr. Mohamed S. El-Aasser, Director; Center for Polymer Science and Engineering, Iacocca Hall, Room D330, Lehigh University, 111 Research Drive, Bethlehem, PA 18015; (610) 758-3590 or Dr. L. H. Spurling, Chairman, Polymer Education Committee, Lehigh University, 5 East Packer Avenue, Bethlehem, PA 18015; (610) 758-3845.

Center for Social Research
The Center for Social Research is a multidisciplinary organization designed to stimulate and conduct research involving the social and behavioral sciences.

Several disciplines are involved in the activities of the center: psychology, sociology, anthropology, marketing, and political science. The center also cooperates with the university’s other research centers and with several science and engineering departments.

Founded in 1965 as the Center for Business and Economics, the focus of the center was later broadened, and the name changed to the Center for Business, Economics and Urban Studies. The center’s early activities included research on economics and business forecasting, and on transportation problems. The change to include urban studies broadened the center’s scope to encompass the disciplines of political science, sociology, and history. In 1972, the center’s scope was further broadened to include behavioral science and international affairs, and the present name was selected to more accurately reflect this broadened focus.

Interdisciplinary research. The social research of the Center is interdisciplinary in nature and is relevant to the community outside the university-local, regional, national, and international. Many research activities are based on a cooperative university-community relationship through which the research goals of the center are achieved and community needs met. Interdisciplinary research activities of the center are currently being conducted in the following areas:

Health and Human Development. Members of the departments of psychology, sociology/anthropology, and education participate in research on health and human development. The program focuses on life from early childhood to maturity. Research interests include the effect of perinatal loss on families and family members; the influence of family and community on health; management aspects of organizations that serve elderly individuals; psychological aspects of aging; design of housing for the older adult, and psychological aspects of late life physical disabilities such as stroke and amputation.

Families and Children. Members of the departments of psychology, sociology/anthropology, and education participate in studies pertaining to families and children. Research interests include family dynamics and child rearing practices and the emphasis on families included under the health and human development program. Current research focuses on the effect of child rearing practices on children’s development of competence.

Program evaluation. Members of the departments of psychology, sociology/anthropology, and economics, participate in research to evaluate the effects of a variety of programs. Particular emphasis is on improving program evaluation methodology. Current research interests include evaluation of several business, science and engineering programs in the university. Research has recently been conducted on the effect of compensatory education and social service programs.

Educational opportunities. Master’s and doctoral-level degrees are offered through the departments with which CSR cooperates.

For more information, write to Diane Hyland, Director, Center for Social Research, Lehigh University, 516-526 Brohead Ave., Bethlehem, Pa. 18015.

Chemical Process Modeling and Control Research Center
Mission: The mission of the Chemical Process Modeling and Control Research Center is the development and application of advanced process modeling and control techniques to improve chemical process productivity, enhance product quality, and assure compliance with government regulation while continuing to educate engineers in the techniques that the Center has and continues to develop.

Background: The Chemical Process Modeling and Control Research Center was established in January, 1985 through the efforts of faculty members of the Chemical Engineering Department at Lehigh University, leading industrial processing companies, the Ben Franklin Partnership Program of the Commonwealth of Pennsylvania, coupled with the organizational and financial support of the National Science Foundation (NSF). Many of the original industrial member companies have been continuous supporters of the Center as has the National Science Foundation. The involvement of the National Science Foundation has and continues to be an important element in the success of the Center’s efforts since the National Science Foundation provides critical annual evaluations of the Center to ensure both leadership and relevance in the technological developments that the Center initiates and supports.

The Center provides a unique atmosphere for fundamental research, development of specific techniques, application to real industrial processes, and opportunities for advanced education in chemical process modeling and control for academics and industrial practitioners. Facilities are available for real-time testing of new algorithms in experimental process units, development of dynamic simulations of real processes, and the close collaboration with researchers in several other fields of chemical processing.

Interdisciplinary collaboration is encouraged with other research groups, centers or institutes engaged in biotechnology, polymer processing, environmental science, applied statistics, signal processing, chemical reaction engineering, and process design.

Direct industrial benefit is realized by participation in the Center by a number of companies through an industrial consortium and its advisory committee. This committee actively participates in setting the research areas; collaborates with the Center faculty, students, and staff in program assessment and implementation and provides a portion of the funding for the operation of the Center.

Education: An integral part of the Center is the commitment to continuing an outstanding program dedicated to the education of undergraduate and graduate students. The Center has and continues to attract top quality students from a large group of well-recognized international universities. In addition to these gifted students, each year several industrial companies send employees to receive advanced training and engage in research efforts for particular company technical requirements. Because of the recognition of the value of the program and the quality of the students, the Center has established a worldwide reputation as an outstanding educational and research unit in this critical area of technology development and implementation. More than a dozen graduate students are engaged in the Center’s research efforts and are candidates for Ph.D and Masters degrees in this area of specialization.

Faculty: The Center brings together more than a dozen faculty members and research staff from different engineering disciplines in the University engaged in the research and educational efforts of the Center. Visiting faculty from other well-recognized universities supplement these researchers and provide opportunities for diversity of thinking and innovative research. All of the associated faculty members are recognized around the world as leaders in their respective fields of specialization. They are invited very frequently to present plenary lectures in international conferences, industrial company meetings and various universities. They organize and chair national and international conferences and symposia. They also serve as consultants to a variety of industries seeking their advice on leading technological developments in process modeling and control.

Facilities: The Center is located at the Iacocca Hall of the Mountain Top Campus of Lehigh University. This building represents a unique facility available to the Center as well as the Chemical Engineering Department
and the Emulsion Polymers and Bioprocessing Institutes. The Center has the use of several dedicated computer facilities with more than 50 PC or workstation computers continuously available to the students, faculty and staff. In addition to the local computing network, the Center’s researchers have access to the Lehigh University central computing facilities and its outside links to other worldwide computing systems and data networks. The Center has several laboratories with sophisticated equipment dedicated to process control research work.

Areas of Research: The Research activities of the Center are grouped in the following four focus areas that are briefly described in the following: I) Tendency Modeling, Optimization and Control of Batch Processes, II) Statistical Engineering Process Control, III) Nonlinear Identification and Model Predictive Control, and IV) Engineering Interface Between Process Design and Control.

I. Tendency Modeling, Optimization and Control of Batch Processes: Instead of either working with very detailed models that are not easily developed or with approximate input-output models that do not incorporate all existing knowledge of the process, a novel methodology, called Tendency Modeling, has been developed for batch reactors. This approach aims to use a model based on all the fundamental knowledge of the process as well as the available pilot or plant data. Model adaptation between batches has resulted in substantial process improvements within two or three adaptation cycles. Techniques for the quantification of the Tendency Model’s accuracy and the on-line model adaptation are the subject of present research. Besides batch procedure optimization, the Tendency Model can be used for the on-line estimation of important unmeasured process variables, such as compositions. Furthermore, they can be used in the implementation of model-based control strategies aiming to calculate the optimal batch time and to minimize the variability in the product quality. Important process applications in polymerization reactors, bioreactors, and organic synthesis reactors for specialty chemicals and pharmaceuticals aim to provide important process-related results of value to industry as well as to enrich the generic methodology.

II. Statistical Engineering Process Control: In meeting the goal of the continuous improvement of chemical processes, a key strategy is the systematic identification and elimination of special causes of variation. This focus area is devoted to developing statistical methods that can work in harmony with existing process control methods toward the goal of process improvement. By exploiting the nature of as well as the data available from continuous processes, we have developed methods that advance statistical process control far beyond the state of the art as it exists in more traditional applications in manufacturing. Current Center expertise in modeling, inferential measurements, principal component analysis, and model-based control is drawn upon and enhanced through the research activities of this focus area. The basic approach pursued is to develop both knowledge-driven (i.e., fundamental) or data-driven (i.e., empirical) models for the monitoring of the process operation. Of specific interest is the identification of the on-coming of a disturbance and the possible isolation of its character and its point of origin. Most of the application so far have been in the operation of continuous chemical processes, including the Tennessee Eastman process and the air separation plants of Praxair and BOC member companies. Furthermore and in combination with the techniques of focus area A on Tendency Modeling of Batch processes, these multivariate Statistical Process Control tools can be effectively applied to the operation of batch processes.

Parallel statistical tools are presently considered for the monitoring of the effectiveness of the control structure active in a plant. This aims to provide an early detection for the need to re-tune the controller and possibly re-identify the process model use in model-based control strategies and model-based inferential measurements.

III. Process Identification and Model-based Control: Recent efforts to increase process productivity and product quality of petroleum, chemical and pharmaceutical processes have increased the importance of process nonlinearities and process constraints as well as the interactions between several variables and units in the controller design. The traditional unconstrained univariate linear controller, like the PID type, is not well suited to handle these challenges. This realization has led to the development of various multivariable linear and nonlinear model-based control designs in the past decade. The general aims of the present research efforts include the development of process models and model-based control strategies that handle complex industrial problems. One of the specific objectives is to develop an effective Multivariable Nonlinear Model-based Predictive Control (MN MPC) technology. The controller design utilizes a nonlinear model derived from either a detailed first principles’ model (knowledge driven) or based on input-output data obtained from the actual process (data driven) or preferably a model driven by both process knowledge and data (hybrid model). In order to be able to develop process models from existing plant data obtained under closed-loop conditions, a parallel objective has been recently established in closed-loop identification. This type of identification results in a control-relevant process model yielding a high performance model-based controller. The aim of the effort is to adapt and further develop closed-loop identification methods applied to challenging chemical process examples (e.g., hoco FCCU, Tennessee Eastman plant simulation) and obtain process models suitable for the design of linear or nonlinear model predictive controllers.

IV. Engineering Interface Between Process Design and Control: Several research projects explore two important aspects of process design and process control: (1) trade-offs between steady-state economics and dynamic controllability, and (2) plant-wide control. One completed project studied a number of coupled reactor/column processes, outlining design procedures and developing effective control structures. The processes varied from a simple rectifier/reactor binary system to a four-component reactor-stripper, two-column process with recycle. The use of steady-state sensitivity analysis to screen plant-wide control structures was demonstrated. Another project explores the effects of design parameters on controllability. The goal is to develop methods and heuristics that can aid in selecting a more controllable plant. For example, large reactors and impure recycle streams have inherent dynamic advantages.

A methodology has been developed to quantitatively incorporate dynamic controllability into the economics of steady-state design. It is simple and rapid enough to permit screening of a large number of alternative flowsheets and design parameters at the conceptual design stage. Product quality variability is explicitly incorporated into the procedure by determining the time periods in which off-specification product is produced. Other projects include (1) design and control of chemical plants that must undergo frequent transitions from one product to another, and (2) design and control of plants with recycle streams in which purging of inert components is required to prevent buildup.

Diamond Center for Economic Education
The Center for Economic Education was established in 1976. It is part of a nationwide network of more than 270 such centers under the guidance of the Economic America-National Council on Economic Education. It is also one of 12 Centers in the statewide network affiliated with the EconomicsAmerica-Pennsylvania Council on Economic Education.

For more than a quarter of a century, the Joint Council has been involved in programs to reduce the level of economic illiteracy in the United States. The purpose of Lehigh’s center is to increase the quantity and improve the quality of economic education.

Located in the Rauch Business Center, the center is part of the College of Business and Economics. But it takes on an interdepartmental role as it coordinates programs aimed at heightening understanding of the American business and economic system. The center also serves as a clearing house for educational ideas. It also houses an expanding resource library including books, videos, curriculum material, testing packets, and simulation games for use by faculty and area educators.
Educational opportunities. The center sponsors workshops, seminars and guest lectures designed to meet the educational needs of faculty and students. activities and projects, such as the Stock Market Game simulation, allow teachers and students the opportunity to experience the workings of the market and the free enterprise system.

For more information, write to Jon T. Innes, Director, Diamond Center for Economic Education, Rauch Business Center, Lehigh University, 621 Taylor Street, Bethlehem, PA 18015.

The Discovery Center of Science and Technology
The Discovery Center of Science and Technology (formerly The SMART Discovery Center) was established in 1992 to contribute to national efforts to achieve science and mathematics literacy for all Americans. Achievement of this goal requires innovative reforms in the areas of science, mathematics and technology education, including an increasing emphasis on informal science education. In April 1995, the Center opened to the public as the SMART Discovery Center, a hands-on exhibit center for informal science, mathematics and technology education in a relaxed, non-traditional setting. In April 1997, the Center relocated to its permanent home on a former Bethlehem Steel site on the South Side and was renamed the Discovery Center of Science and Technology.

The mission of the Discovery Center is to advance formal and informal learning in science, mathematics, and technology through participatory exhibits, interactive workshops, and research. Programs are designed for students, families, and the community with particular attention to the historically underserved and underrepresented.

The center serves as a resource for the promotion of mathematics, science, and technology education throughout the Lehigh Valley and Pennsylvania. Hands-on exhibits attract individuals, families, and school groups. For Lehigh students and faculty, the Center provides opportunity to actively participate in research and program development. Through collaboration with Penn State, Lehigh, and other academic resources, the Center offers a rich menu of educational resources to enhance students' understanding of the importance of science, mathematics, and technology in their everyday lives.

Training/Educational opportunities. The Center sponsors workshops and enrichment programs for elementary and secondary students and teachers. Interactive programs with an interdisciplinary emphasis focus on creative thinking and problem solving, increase participants' understanding of multiple points of view and advance students' breadth and depth of knowledge about science, society, and technology. In addition to annually presenting the JASON Project to over 10,000 Lehigh Valley residents and students, thousands more visit the Center's hands-on science exhibits. The Center also offers professional development workshops for educators, linking students' experience at the Center with school science and mathematics curricula.

Research and Development activities. The Center serves as an umbrella for a wide variety of education and training programs for both teachers and students of mathematics, science, and technology and a laboratory for research and evaluation of innovative teaching techniques. Lehigh students and faculty from numerous disciplines and all four colleges actively participate in the development of Center exhibits and programs and serve as teachers and mentors for elementary and secondary students and teachers. A major focus of Center activities is the evaluation of informal and formal science instruction on student learning and attitudes about science and technology careers.

For more information, write to Lin Erickson, Executive Director and CEO, Discovery Center of Science and Technology, 511 East Third Street, Bethlehem, PA 18015.

Emulsion Polymers Institute
The Emulsion Polymers Institute, established in 1975, provides a focus for graduate education and research in polymer colloids. Formation of the institute constituted formal recognition of an activity that had grown steadily since the late 1960s. The institute has close ties with polymer and surface scientists in the Center for Polymer Science and Engineering, Polymer Interfaces Center, Zetllemeyer Center for Surface Studies, Materials Research Center, Center for Chemical Process Modeling and Control, and the departments of chemical engineering, chemistry, physics, and material science and engineering.

Polymer colloids or polymer latexes, as they are more commonly called, are finely divided polymer particles that are usually dispersed in an aqueous medium. Important products produced and utilized in latex form include synthetic rubber, latex paint, adhesives and paper coatings. The small particle size of typical latexes make their colloidal properties as important as the polymer properties in a number of applications. Hence, the study of emulsion polymers is an interdisciplinary activity.

Research activities. Emulsion polymers research includes a broad range of problems in the areas of preparation, modification, characterization, and application of polymer latexes. Most commercial polymer latexes contain a number of important ingredients, some in only small quantities.

Research programs at Lehigh are aimed at understanding the function of recipe components during preparation and application of the latexes. The research projects are a blend of fundamental and applied efforts as well as a mixture of theoretical and experimental problems: emulsion polymerization kinetics, mechanisms, and morphology of core/shell latexes; colloidal, surface, and bulk properties of polymer colloids; dispersion polymerization; miniemulsion polymerization; film formation and properties; NMR studies of polymer colloids; and particle size characterization via capillary chromatography.

Significant research support for institute activities is obtained from industrial organizations through their membership in the Emulsion Polymers Liaison Program. Hence some considerable effort is made to relate the research results to industrial needs. Consequently, graduates can find excellent opportunities for employment.

Educational opportunities. Graduate students in the institute undertake dissertation research leading to the master of science or doctor of philosophy degree in existing science and engineering curricula or in the Center for Polymer Science and Engineering.

Programs of study for individual students are designed to meet the student's interests, the requirements of the appropriate academic department, and the student's dissertation committee. Considerable flexibility is permitted in the selection of courses and a research topic.

Faculty members of the institute are involved in teaching normal university courses and continuing education courses for industrial personnel. The annual one-week short course, Advances in Emulsion Polymerization and Latex Technology, typically attracts about 100 industrial participants and 20 Lehigh students. This course is an important mechanism for developing meaningful interactions between institute staff and students and industrial scientists and engineers.

Educational and research opportunities exist for postdoctoral scholars and visiting scientists as well as resident graduate students.

For more information, write to Mohamed S. El-Assar, laocoeca Hall, Lehigh University, 111 Research Drive, Bethlehem, PA 18015.

Energy Research Center
Energy research at Lehigh is a multidisciplinary activity, involving faculty and students from engineering, the physical sciences, life sciences, business and economics, and the social sciences. The Energy Research Center provides a structure within which faculty and students from different backgrounds can explore their specific research interests.

The center coordinates the university's energy research, helping the faculty respond to research opportunities and developments in energy. It is also the major contact between the university and industry and government for matters dealing with energy research. Originally founded in 1972 as the Task Force for Energy Research, the center was organized into its present form in 1978.

The research within the center involves a wide range of topics related to the supply and use of energy. Work in progress-supported by contracts and grants from government, industry, and private foundations-deals with fuels and energy resources, energy conversion systems, energy conservation and the environment.

The Energy Research Center has particularly close ties with industry. A number of joint research projects involve Lehigh faculty and students and research staff from industry. The center also operates the Energy Liaison Program, through which participating companies and
government facilities have access to faculty consultants, make use of laboratory facilities and library services, and receive assistance on research problems, feasibility studies and other projects related to energy. Through the center’s Energy Intern Program, opportunities also exist for students to receive part of their training in industry. Through this program, a graduate student involved in energy can do a research internship in industry under the joint supervision of company research staff and the student’s faculty adviser.

Experimental support for energy research is provided in a number of specialized laboratories maintained by the university. These laboratories, furnished with the latest instrumentation and equipment, include the following: boiling and two-phase flow, fluidized bed, fluid mechanics, surface chemistry, chemical kinetics, GC/mass spectrometer, atomic absorption spectrometer, electron optical, mechanical testing, structural testing, welding, metal forming, fracture mechanics, ceramics, polymer, hydraulics and water resources, van de Graaff accelerator, biotechnology, aquatic biology, and microprocessor development.

All faculty members who participate in Energy Research Center activities belong to academic departments. In addition, a number of faculty and staff members affiliated with the center have close ties with other on-campus research centers and institutes, assuring broad interactions between center personnel and experts from many research specialties, including economics, social science, materials and metallurgy, marine biology, fracture and solid mechanics, metal forming, structural design, sanitary and water resources engineering, thermal science, fluid mechanics, surface chemistry, and biotechnology.

Energy research. Research within the center falls within five major categories. Projects of interest include:

- **Fossil fuels.** Fluidized bed combustion of coal; heat transfer in fluidized beds; pulverized coal combustion; catalytic combustion; cyclonic combustion; coal slugging; freezing of coal; coal chemistry; microbial desulfurization of coal; kinetics of coal gasification; fluidized bed gasification; dynamic simulation of coal conversion systems; kinetics of coal liquefaction; hydrogen-enhanced crack growth in high-strength steels; organic coatings for flue gas desulfurization service; weld repair of steam turbine rotors; mechanical properties of cryogenic steels for LNG applications; toughness of pipeline steels; fracture analysis of pipelines; mechanisms of tertiary oil recovery.

- **Nuclear technology.** Instrumentation for reactor safety studies; boiling heat transfer in water-cooled reactors; fracture toughness of reactor steels; static and dynamic fracture toughness of steel welds; microstructural characterization of pressure vessel welds; pressure vessel design; radioactive waste disposal; high-energy particle physics; nuclear physics.

- **Environmental impact of energy systems.** Oil pollution studies in the coastal and wetlands environment; effects of power plant operations on biological life in the New Jersey estuarine region; acid rain; trace metal contamination of aquatic ecosystems; hazardous waste disposal and control.

- **Conservation and renewable resources.** Biological conversion of cellulose to chemicals and fuels; catalysis for alcohols from biomass; energy recovery from municipal solid waste; fuel derived from waste water treatment; energy conservation in the metal-forming industries; instrumentation and analysis of industrial processes; use of computers for process control; development of microprocessors for residential load control; cooling of electric utility generators and high-capacity electric motors; design of cryogenic turbines; instrumentation for HVAC applications; siting of wind-power applications.

- **Energy economics.** Dynamic analysis of energy supply-demand systems; model of an investor-owned electrical utility; peak-load pricing of electricity and natural gas.

**Educational Opportunities.** The extensive involvement of faculty in energy research has created a wide range of opportunities for graduate studies in energy. Most of the departments in the College of Engineering and Applied Sciences, as well as several departments within the College of Arts and Science and the College of Business and Economics, are active in energy research and offer both masters and doctoral degree programs for studies of energy-related topics.

All degrees are granted by the academic departments and graduate students interested in energy enroll in traditional graduate degree programs in departments of their choice. These students specialize in energy by complementing their programs with a selection of special energy-related courses. They pursue their graduate research in energy areas under the supervision of faculty from the Energy Research Center or from other research centers or academic departments.

Opportunities also exist for students to receive part of their training in industry through a program in which a graduate student involved in energy can do a research internship in industry under the joint supervision of company research staff and the student’s faculty adviser. The Energy Intern Program is individualized: each internship is designed to meet the specific needs and interests of the student, the faculty adviser and the company.

Financial support for graduate students is available through the Energy Research Center by means of fellowships and research assistantships related to sponsored research. Each year Lehigh faculty members offer a number of special energy-related courses at the undergraduate and graduate levels; many of them are outgrowths of current faculty research. Recent examples include courses dealing with energy economics, the international politics of oil, nuclear reactor engineering, public policy and nuclear power, air pollution, coal catalysis, coal technology, materials for modern energy systems and solar energy.

The Energy Research Center also sponsors an annual seminar series, bringing some of the outstanding people in the energy fields to the campus to speak. Covering a range of topics from economics to energy policy to science and engineering, these seminars provide an opportunity for faculty and students to learn of new developments in energy.

For more information, write to Edward K. Levy, Director, Energy Research Center, Lehigh University, 117ATLSS Drive, Bethlehem, PA 18015.

**Engineering Research Center For Advanced Technology For Large Structural Systems (ATLSS)**

The ATLSS Engineering Research Center was established in May 1986 with a grant from the National Science Foundation (NSF) to serve as a national focal point for research and technology aiding structures-related industries. Structural research and materials research are being conducted for the basic infrastructure of bridge, building, offshore-platform, and ship structures. Currently, about 90 persons, including graduate and undergraduate students, research associates, faculty and staff members representing the disciplines important to large structural systems are active at the Center.

ATLSS research is broad in scope. Research topics include Innovative Structural Systems and Materials, Condition Assessment and Life Prediction, Renewal Engineering, Life-Cycle Engineering and Information Systems, and Seismic Behavior. Projects within these research areas follow the structural systems life-cycle processes of experimentation, design, fabrication and construction, operation, and renewal and retrofit. The studies are conducted in close association with advisory committees of engineers and scientists from industry, government, design and professional groups and other universities.

ATLSS has excellent research facilities and equipment, including two world-class structural testing facilities: the Fritz Engineering Laboratory and the major newer (1989) ATLSS Laboratory, in which researchers study large-scale complex connections, assemblages and structures under static, dynamic, and/or cyclic multidirectional loading with complete computer-controlled experimentation. ATLSS also has outstanding resources for computing, mechanical testing, welding, metallography, and non-destructive evaluation.

**Research Activities:**

- **High-Performance Materials Research** is conducted on innovative structural forms and structural systems to promote competitive use of high performance materials, including high-performance steel, aluminum, concrete, fiber-composites, and mixed systems. Bridge, building, offshore platform, and advanced ship-hull applications are emphasized.

- **Connection Design Methodologies**—An integrated effort to advance connection technology in construction and to establish a
connection design methodology. Connections for seismic resistance are emphasized. A new patented system of ATLSS connectors has been developed to facilitate fabricability and erection automation.

Techniques for improving structural assemblies are being studied.

**Condition Assessment of Structures** - Smart monitoring systems, with new intelligent sensors and with new applications for traditional sensors, are being utilized for life prediction and condition assessment. The studies have resulted in improved design specifications, new sensor systems for corrosion and fatigue diagnosis, and a hypermedia bridge fatigue investigator system for bridge inspection and fatigue and fracture damage assessment.

**Renewal and Retrofit Techniques** - To restore or increase structure durability and strength, renewal and retrofit technologies are being studied for bridge, building and offshore-platorm structures.

**Educational Opportunities.**

The ATLSS Center facilitates programs of study and research that cross the traditional boundaries of engineering curricula, providing a fundamental, broad approach to the field of structures. Graduate students participating in the Center’s programs receive master of science, master of engineering, or doctor of philosophy degrees in the academic discipline of their choice, i.e., civil engineering, material science and engineering, computer science, industrial engineering, mechanical engineering, etc. However, they are expected to pursue course work related to a broader understanding of structures and to conduct research on a cross-disciplinary basis in the Center.

Financial support for graduate students is available through the ATLSS Center by means of fellowships and research assistantships related to sponsored research programs.

Undergraduates also participate in the Center’s research and educational program. Opportunities for summer internships and for academic-year special projects are available which enable direct involvement in the Center’s research effort.

For more information, write to Dr. John W. Fisher, Director, ATLSS, Lehigh University, 117 ATLSS Drive, Bethlehem, PA 18015-4729.

**Iacocca Institute**

Over the years, Lehigh University has developed an impressive ability to forge university-industry-government partnerships. These partnerships are critical not only to the future of universities, but also to improving U.S. competitiveness. It is primarily through partnerships with companies, schools, government agencies and other universities that the Iacocca Institute pursues its mission of advancing the global competitiveness of U.S. industry. The program units under the umbrella of the Iacocca Institute include: the Agility Forum, the Northeast Tier Ben Franklin Technology Center (NET/BFTC), the Manufacturers Resource Center (MRC), and The Discovery Center for Science &Technology.

The institute also partners activities in educational competitiveness include development of a new executive education program called the Iacocca Program in Enterprise Leadership; the Global Fellows Program, which will bring to Lehigh’s campus students from around the world; and the Iacocca Workforce Development Initiative. The institute also partners with Cities In Schools, Inc., (Alexandria, VA.), and Lehigh’s College of Education in the National Center for Partnership Development to help stem the dropout crisis in America and improve basic, intermediate and secondary education throughout the United States. Through the NCPD, training sessions are held at Lehigh to replicate the successful Cities In Schools model across the nation.

The Iacocca Institute was established in 1987 with the support of Lee A. Iacocca, former chairman and chief executive officer, Chrysler Corporation, and a member of Lehigh’s Class of 1945. Mr. Iacocca chairs a distinguished advisory board which provides close ties with industry. Its other members are Curtis H. Barnette, chairman and CEO, Bethlehem Steel Corporation; Bob L. Benninger, president - Northeastern PA Market, CoreState Bank; George M.C. Fisher, chairman and CEO & COO, Eastman Kodak Company; Douglas A. Fraser, former president, United Auto Workers, University Professor of labor studies, Wayne State University; William F. Hecht, chairman, president and CEO of P&L; William C. Hittiger, ’44, former executive vice president, research and engineering, RCA Corporation; Russell Leslie, account executive, EDS; Peter Likins, president, Lehigh University; Ari Melissaratos, vice president of science, technology, and quality, Westinghouse Electric Corp.; Thomas J. Murrin, former deputy secretary of Commerce, Dean, A. J. Palmero School of Business, Duquesne University; John Wells Put ’52, J. W. Puth Associates; David M. Roderick, former chairman and CEO, USX Corporation; Robert L. Woodson, president, National Center for Neighborhood Enterprise; and Jerome B. York, vice chairman, Tracinda Corp.

In 1993 the Iacocca Institute launched a special honors program, The Iacocca Scholars. About 12 students are chosen each autumn on the basis of their potential for leadership in areas that enhance national competitiveness such as manufacturing, public policy, and other aspects of both the public and private sectors. Students entering their junior year or Seniors involved in a five-year program are invited to submit an application for this two-year affiliation that includes special projects with faculty mentors, interaction with distinguished national leaders, summer internships and other individual and group activities.

For more information, write to Dr. Roger N. Nagel, CEO & Executive Director, Iacocca Institute, Iacocca Hall, Lehigh University, 117 Research Drive, Bethlehem, PA 18015.

**Institute for Biomedical Engineering and Mathematical Biology**

The Institute for Biomedical Engineering and Mathematical Biology was established July 1, 1989 to foster interdisciplinary research and support graduate study in the application of engineering and mathematics to medicine and biology. Faculty from several engineering departments and from mathematics and biology actively participate in the Institute.

Current research includes the mathematical analysis of transport and exchange in microraycularly physiology, theoretical and experimental biomechanics, experimental biofluidmechanics, fracture and failure in skeletal units and in protheses, shock propagation through the human body, and design for the handicapped.

The Institute has established an extensive network of interaction and generated significant research collaboration with a number of major medical centers. An effective liaison program fosters interaction between the University and industry in the biomedical field.

Graduate students interested in studying biomedical engineering or mathematical biology at Lehigh enroll in one of the engineering departments or in the applied mathematics program, and satisfy the corresponding degree requirements. The Institute provides the opportunity for interdisciplinary research for both the master’s thesis and the Ph.D. dissertation.

For more information, write to Eric P. Salathe, Director, Institute for Biomedical Engineering and Mathematical Biology, Chandler-Ullmann Hall, Lehigh University, 17 Memorial Drive East, Bethlehem, PA 18015.

**Institute for Metal Forming**

The Institute for Metal Forming, sponsored by the department of materials science and engineering, was established in 1970 to teach the principles and applications of metal-forming technology to graduate and undergraduate students; to provide instruction and equipment for graduate research in metal-forming processes; and to assist industry with solutions to problems in metal forming.

Metal-working processes are analyzed mathematically, usually involving the computer. The results of the analyses are checked and refined by comparison with experimental data obtained in the fully instrumented metal-forming laboratories that are part of the institute's facilities.

In addition, an important part of the effort of the institute is the preparation of educational programs using the latest audio-visual techniques in integrating expert systems provided as software for personal-computer users. These programs are used in the classroom and in institute-sponsored seminars on campus and at industrial facilities.

**Research activities.** Current research areas include: hydrostatic strussion; pressure-induced ductility; flow through converging conical dies; effect of holes, inclusions and pressure on tensile properties;
friction modeling and measurement; cladding and forming of composite materials; forming of polymers; deep drawing, impact extrusion and iron rolling; and powder consolidation. Special emphasis is currently being given to fabrication of high-temperature ceramic, super-conducting wire, and to computer simulation of metal forming processes.

Educational opportunities. Students interested in metal forming should refer to course descriptions for metallurgy and materials engineering and mechanics.

For more information, write to the Institute for Metal Forming, Whitaker Laboratory, Lehigh University, 5 E. Packer Avenue, Bethlehem, Pa. 18015.

Institute of Fracture and Solid Mechanics
The Institute of Fracture and Solid Mechanics was established in the fall of 1970 to enable faculty members and students within the university to participate in research relevant to fracture and solid mechanics on an interdisciplinary basis. A branch of this Institute was established in the Republic of China in 1987 to carry out cooperative research activities.

An area of special interest to the institute has been in fracture mechanics, which deals with the study of structural and material sensitivity to flaws. Such flaws can seriously affect the design and strength of ships, aircraft, automobiles, bridges and buildings. In the design of nuclear power plants, the incorporation of the fracture mechanics concept of safety in the presence of flaws is required. In addition, fracture mechanics is finding application in such areas as bone fracture, environmentally accelerated cracking of pavements and structural members, the fracture of rocks, and erosion of materials by solid or water particle impingement.

The activities of the institute include: expansion of research capabilities to include the application of concepts of fracture mechanics to geology (rocks), medicine (bones), and composite materials; editing books on timely subjects in fracture and solid mechanics; compilation and collection of written materials to establish and maintain a special library of fracture mechanics; planning of conferences on fracture and solid mechanics; offering short courses and seminars on special topics; and conducting liaison programs with industry and government agencies.

Research activities. There are several research programs being conducted in solid and fracture mechanics, sponsored by industry and government agencies. They include:

Fracture mechanics. Analytical; stress analysis of engineering structures weakened by flaws.

Experimental: static and dynamic fracture toughness testing of metallic, nonmetallic and composite materials.

Solid mechanics. Analytical and numerical methods of analysis.

Plates and shells.

Educational Opportunities. Students interested in fracture and solid mechanics should refer to course offerings in the departments of mechanical engineering and mechanics, metallurgy and materials engineering, civil engineering, chemistry and biology.

For more information, write to George C.M. Sih, Director, Institute of Fracture and Solid Mechanics, Packard Laboratory, Lehigh University, 19 Memorial Drive West, Bethlehem, Pa. 18015.

Institute of Thermo-Fluid Engineering and Science
The Institute of Thermo-Fluid Engineering and Science, established in 1978, provides a focus for research and educational activities in fluid mechanics, thermodynamics, and heat transfer.

This institute seeks to consolidate the substantial ongoing research effort in these fields, to aid in the further development of such research, and to facilitate utilization of this interdisciplinary strength in the university’s educational programs.

Currently 28 full-time faculty and staff from the departments of chemical engineering, mechanical engineering and mechanics, mathematics, and physics are among the institute members. Graduate students and undergraduates as well as part-time and visiting staff members, join in the institute’s activities.

Research facilities for thermo-fluids programs are based in the College of Engineering and Physical Sciences. Among the facilities available are laboratories for experimental investigations of fluid mechanics, gas dynamics, turbulent structure, solid-gas fluidization, boiling heat transfer and two-phase flow, refrigeration and heat pump systems, internal combustion engines, radiation and optical measurements, unit operations, thermodynamic properties, and reaction engineering. The university’s Computing Center as well as various minicomputers are available for use in analytical computations.

The institute also conducts the Thermo-Fluids Liaison Program, to promote the interchange of knowledge between the researchers at Lehigh and the engineers and scientists in industry and government. In cooperation with companies participating in the liaison program, the institute’s staff members seek to apply their specialized capabilities in thermo-fluids to current industrial and governmental engineering and scientific problems.

Research activities. The institute’s staff members are involved in three interrelated areas: fluid mechanics, heat transfer and thermal science, and applied thermodynamics and modeling.

Combining experimental investigations with theoretical analyses, the researchers seek to understand and quantify the phenomenological mechanisms governing thermo-fluid processes. This knowledge is then brought to bear on relevant engineering problems of current concern in such applications as energy conservation, power production, coal conversion, aerodynamics, weather modeling, and nuclear energy.

The institute’s current research program includes more than twenty grants sponsored by industry and various governmental organizations. A wide spectrum of subjects are under investigation, including research on flow-induced vibrations, unsteady turbulent flows, coherent turbulent boundary layer structures, blade flutter in compressors and fans, stochastic optimal control, colloid size distributions by hydrodynamic chromatography, fluidized combustion of coal, heat transfer in fluidized beds, heat pump systems, two-phase flow instrumentation, boiling heat transfer and two-phase flows, and nuclear reactor thermal safety.

Educational opportunities. Formal courses in fluid mechanics, heat transfer, and thermodynamics are offered in the College of Engineering and Physical Sciences. Institute staff members regularly teach both undergraduate and graduate courses in the departments of mechanical engineering and mechanics, chemical engineering, and physics.

Undergraduates can select a program of study in consultation with their advisor, with emphasis on thermo-fluid sciences by elective choices among the departmental offerings. A formal minor program in fluid mechanics is available. Graduate studies leading to the M.S. or Ph.D. with concentration in thermo-fluids are available in the three departments.

Participation by both undergraduate and graduate students in the thermo-fluids research activities is encouraged. Many undergraduates participate as individuals or as groups in term projects under the supervision of institute faculty members. This provides an opportunity for interested students to obtain first-hand experience in pioneering thermo-fluids research. The research programs directed by institute staff members also provide support for graduate research assistantships, enabling selected graduate students to pursue their education and research in thermo-fluids on either a part-time or full-time basis.

In cooperation with various academic departments, the institute sponsors seminars by both staff specialists and by invited speakers from other institutions. These seminars are open to the university community, liaison program participants, and to engineers and scientists from neighboring industries. The institute anticipates organizing topical meetings, workshops, and short courses on specialized subtopics within the over-all discipline. Meeting topics will be selected to reflect ongoing research activities of the staff members and contemporary engineering concerns.

For more information, write to John C. Chen, Director, Institute of Thermo-Fluid Engineering and Science, Iacocca Hall, Lehigh University, 111 Research Drive, Bethlehem, Pa. 18015.

Lawrence Henry Gipsom Institute for Eighteenth-Century Studies
The Lawrence Henry Gipsom Institute for Eighteenth-Century Studies was established in 1971, to honor one of America’s most distinguished scholars, who served as a long-time member of the faculty at Lehigh.
Gipson's monumental life work, *The British Empire Before the American Revolution* (15 volumes) was written between 1936 and 1970. Gipson received the Pulitzer Prize in History in 1962 for Volume 10, subtitled, *The Great War For Empire*. When he died in 1971, Professor Gipson left his entire estate to Lehigh and provided the original endowment for the Institute.

**Research activities.** The income from the endowment of the Institute is used to encourage faculty and student research in the eighteenth century by providing small grants to defray travel cost, copying and other expenses to permit scholars to visit necessary libraries and depositories, to help support deserving students in their dissertation year, and to encourage interdisciplinary research activities at Lehigh. The Institute also helps provide additional resources to build the university library's research collections in eighteenth century studies.

**Educational opportunities.** The Institute invites leading scholars to give occasional lectures and supports relevant programs such as interdisciplinary seminars and visiting scholars interested in the eighteenth century. Annual symposia honor Professor Gipson by bringing to the campus distinguished scholars in eighteenth-century studies to lecture and discuss various topics. The essays generated at the symposia have been published and the Institute maintains a continuing close relationship with Lehigh Press that also publishes original manuscripts on the eighteenth century.

For more information, write to either of the co-directors, Jean R. Soderlund, department of History, Maginnis Hall, 9 W. Packer Ave, or Jan Fergus, department of English, Drown Hall, Lehigh University, 35 Sayre Drive, Bethlehem, PA 18015.

**Philip and Muriel Berman Center for Jewish Studies**

The Philip and Muriel Berman Center for Jewish Studies established in 1984, develops, administers and coordinates a comprehensive program in Jewish studies at Lehigh University that also serves other member institutions of the Lehigh Valley Association of Independent Colleges (LVAIC) (Lehigh University, Muhlenberg College, Lafayette College, Moravian College, Cedar Crest College, and Allentown College of St. Francis de Sales). The Center for Jewish Studies is directed by Laurence J. Silberstein, Philip and Muriel Berman professor of Jewish Studies. The center supports and encourages shared course offerings as well as the exchange of faculty among LVAIC institutions. Faculty in Jewish Studies, housed at Lafayette College and Lehigh University, are associated with the center. In addition to teaching on their home campuses, these faculty offer Jewish studies courses on other LVAIC campuses each semester. A visiting scholar from Israel is in residence at the center annually and teaches courses at Lehigh and other LVAIC schools.

Activities of the center include designing and implementing new courses and seminars, establishing research grants for undergraduate students, sponsoring study programs abroad for undergraduates, organizing an annual lecture series, and sponsoring colloquia, conferences, and a publication series in Jewish studies. The Center coordinates year-long, semester, and summer study programs in Israel at the Hebrew University and Tel Aviv University. For further information on Israel study programs, contact Shirley Ratnousky, (610)758-3352. Philip and Muriel Berman of Allentown, Pa., in consultation with Judaic scholars from the United States and Israel, conceived of and provided for the center. Their goal was to establish in the Lehigh Valley a first-class academic program for the study of all aspects of Jewish civilization. The center customarily opens its programs to the public.

For more information, write to Dr. Laurence J. Silberstein, Director, Philip and Muriel Berman Center for Jewish Studies, Lehigh University, 9 W. Packer Avenue, Bethlehem, PA 18015, or call (610)758-4869.

**Martindale Center for the Study of Private Enterprise**

The Martindale Center for the Study of Private Enterprise was established in 1980 by a gift from Harry and Elizabeth Martindale. The primary purpose of the center is to contribute through scholarship to the advancement of public understanding of the structure and performance of our economic system.

Attention is focused on the private sector of the economy and on public policies as they influence the private sector. To achieve this end, the center activities include the sponsorship of lectures and conferences, support of faculty research and case studies, administration of the visiting scholar and executive-in-residence programs. The center sponsors and administers the Martindale Students Association Program (for undergraduates) and the publication of their journal *Perspectives on Business and Economics*. The center has established the Canadian Studies Institute which encourages scholarship dealing with the business and economic environment of Canada and with U.S./Canadian business and economic relations; and the Kalmbach Institute for the Study of Regional Political Economy which focuses attention on the business and economic environment of the Lehigh Valley and other regions throughout the U.S.

For more information, write to J. Richard Aronson, Director, Martindale Center for the Study of Private Enterprise, Rauch Business Center, Lehigh University, 621 Taylor Street, Bethlehem, PA 18015.

**Materials Research Center**

The Materials Research Center was established in 1962. Currently, approximately 140 persons, including graduate students, research associates, and faculty members representing science and engineering departments, are engaged in research pertaining to materials science and engineering.

The fundamental objectives of the Materials Research Center are to encourage interaction among the science and engineering disciplines with an interest in materials and to promote interdisciplinary research activity and interdepartmental educational opportunities. To achieve these objectives, the center seeks to establish a climate in which faculty members, research scientists, postdoctoral associates, and graduate assistants develop an awareness of materials, arrange for facilities and space required to conduct interdisciplinary research; guide the search for new materials by encouraging fundamental research and new approaches to materials problems; and assist in developing educational opportunities in materials-in particular, interdisciplinary graduate programs devoted to training for research in materials.

The center also conducts the Materials Liaison Program. Founded in 1963, this program promotes the interchange of knowledge between the materials community at Lehigh and engineers and scientists in industry and government. The program conducts seminars on materials research, special lectures and workshops on topics of current interest; consults on materials problems and research; distributes master of science and doctor of philosophy theses and abstracts of materials research; and sponsors seminars with outstanding invited speakers.

The staff consists of members of the departments of chemistry, chemical engineering, materials science and engineering, mechanical engineering, and physics. Members of other departments and centers frequently are involved in cooperative programs.

**Research Activities.** The present organization of the Materials Research Center includes six laboratories: the ceramics, electron microscopy and microanalysis, engineering polymers, mechanical behavior, microelectronic packaging materials and thin films and coatings laboratories, located in Whitaker Laboratory. Current interdisciplinary research activities include:

- **Ceramics.** Microstructural and solid-state chemistry of electronic and optical oxides including both polycrystalline and single-crystal materials; degradation mechanisms in ceramic devices; deformation mechanisms, including creep and hot pressing, contact damage and indentation behavior; sintering studies and additive effects; microstructural characterization of ceramic materials; microstructure design of multi-phase structural ceramics for optimum mechanical behavior.

- Defect structure and impurity interactions in insulating, semiconducting, and superconducting oxides in both bulk and thin-film form; interfacial segregation and phase formation in metal-oxide systems.

- **Electron Microscopy and Microanalysis.** Characterization of fracture surfaces in polymers, ceramics, and steels by scanning electron microscopy, ferrous alloys, geological materials and ceramics using the
electron probe microanalyzer; transmission and scanning transmission electron microscopy studies of grain boundaries in oxides; and metals, domain structures in ferroelectrics; low-temperature phase transformations in iron alloys; reactions in thin films; interfacial reactions in composites, and chemistry of nanometer-size catalyst particles.

Engineering Polymers. Structure, morphology and mechanical behavior of interpenetrating polymer networks; thermosetting resins; vinyl polymers; polymers based on renewable resources; permeability and mechanical behavior of membranes, coatings, and filled polymers. Mechanical Behavior. Effect of polymer chemistry and molecular structure on fatigue crack propagation (FCP); test frequency sensitivity and fatigue fracture micromechanisms in polymer solids; metallurgical aspects of FCP in ferrous and nonferrous alloys; fracture mechanics of functionally gradient materials, fracture mechanism studies by transmission and scanning electron microscopy.

Microelectronic Packaging Materials. Characterization of materials used for the packaging of microelectronic circuits with an emphasis on reliability; application of fracture mechanics to organic passivation coatings, organic die attach adhesives and liquid encapsulants; finite element modeling of dual-in-line packages, plastic quad flat packs, and C4 packages; surface characterization to predict adhesion; application of fluorescence to study diffusion of water in polymeric materials and at interfaces.

Thin Films and Coatings. Thin films of conducting, superconducting, magnetic and insulating materials; coatings for corrosion and wear resistance; processing facilities such as sputtering, plasma enhanced and electrodeposition; characterization by electron and optical microscopy, differential calorimetry and x-ray diffraction.

Educational opportunities. This center facilitates programs of study and research that cross the traditional boundaries of science and engineering curricula, providing a fundamental, broad approach to the field of materials science and technology.

Graduate students participating in the center’s program usually receive master of science or doctor of philosophy degrees in the academic discipline of their choice, i.e., chemistry, physics, materials science and engineering, electrical engineering and computer science, etc.; or in an interdisciplinary program such as polymer science and engineering. However, they are expected to pursue coursework related to a broader understanding of materials and to conduct research on an interdisciplinary materials problem in one of the center’s six laboratories.

Financial support for graduate students is available through the Materials Research Center by means of research assistantships related to sponsored research programs.

For more information, write to Martin P. Harmer, Director, Materials Research Center, Lehigh University, 5 E. Packer Avenue, Bethlehem, Pa. 18015-3194.

The Murray H. Goodman Center for Real Estate Studies

The Murray H. Goodman Center for Real Estate Studies was established in 1988 through a major gift from Murray H. Goodman, '48. The center is a self-supporting, interdisciplinary unit of the College of Business and Economics. The center provides financial support and other assistance for undergraduate courses in real estate and real estate finance, supports scholarly research in real estate, and sponsors joint activities with practitioners in the real estate field.

Educational opportunities. The center provides resources for teaching undergraduate courses in real estate and real estate finance. Sponsored courses include FIN 240 - Introduction to Real Estate and FIN 336 - Real Estate Finance. In addition, the center sponsors a continuing series of seminars and presentations by real estate executives and practitioners. The center also serves as a clearinghouse for students seeking internships with real estate firms and related companies.

Research activities. Consistent with the university’s encouragement of scholarly research, the center provides funding for faculty research in the real estate area. Funding possibilities include: summer faculty research grants; travel, telephone and administrative support; and grants for part-time graduate assistants. The center also maintains a file of sponsored research opportunities available through private foundations, government agencies and practitioner organizations and provides administrative support to faculty applying for such funding.

Practitioner Interaction. The third aspect of the center’s activities is its interaction with practitioners in the real estate field. The increased emphasis on continuing education and research among real estate practitioner organizations, as well as Lehigh’s proximity to major real estate markets, enable the center to engage the practitioner community in a variety of joint projects. These joint projects include: 1. sponsored research projects; 2. continuing education programs and short courses; 3. special conferences and events of national and/or regional interest; and, 4. center-sponsored databases and continuing activities of interest to the practitioner community.

For more information, write to Stephen F. Thode, Director, Murray H. Goodman Center for Real Estate Studies, Raubus Business Center, Lehigh University, 621 Taylor Street, Bethlehem, PA 18015, or call (610) 758-4557.

Musser Center for Entrepreneurship

The Warren V. Musser Center for Entrepreneurship was established through a generous grant from “Pete” Musser, Lehigh class of 1949, for the promotion of entrepreneurship among the students and friends of Lehigh University. Mr. Musser, chairman and CEO of Safeguard Sciences, Inc., is a highly successful entrepreneur in his own right and an active supporter of entrepreneurial ventures by others. Creation of the Musser Center at Lehigh caps more than a decade of university activities dedicated to encouraging and recognizing the role of entrepreneurship in the American business system. The center enables Lehigh to provide new levels of support for the entrepreneurial spirit.

SBDC. Associated with the Musser Center for Entrepreneurship is the Small Business Development Center. Established in 1978, the SBDC provides general management assistance to over 1,500 entrepreneurs and small businesses per year in the Lehigh Valley and surrounding areas. Primary funding for this program comes from a major grant from the U.S. Small Business Administration and the Commonwealth of Pennsylvania. The Musser Center provides supplemental support for the efforts of the SBDC and contributes money to enhance its mission and broaden its scope.

Specialized programs. The Management Assistance Program delivers general management consulting to existing small firms and startup ventures. Services are offered to retail, service, wholesale, construction and manufacturing firms. Support is offered through electronic data base research. Seminars are offered on many topics of interest to growing firms. The International Trade Development Program is a specialized outreach effort of the Small Business Development Center. The ITDP helps companies with exportable products to develop export marketing plans and establish direct contacts with international markets. Seminars, trade missions and research projects support the efforts of this program.

The Government Marketing Assistance Program assists potential suppliers to government in identifying and developing government related to government procedures are handled on a one-to-one basis. Trade fairs and seminars are also offered.

The Financing Assistance Program provides assistance in loan packaging and financial planning and helps clients identify appropriate financing sources. The program administers the Lehigh Valley Small Business Loan Pool. Contracts with the Lehigh/Northampton Revolving Loan Fund, the Bethlehem Economic Development Corporation and other funding agencies provide resources for this assistance.

LUMAC. The Lehigh University Management Assistance Counseling program (a graded three-credit course) was established in 1972 on the initiative of undergraduate students. Through support from the SBDC, approximately one hundred, fifty students per year gain practical experience by providing counseling to sixty businesses.

ACE. The enrichment of entrepreneurship programs at Lehigh is accomplished in part by the Association of Collegiate Entrepreneurs. Through ACE, students meet entrepreneurs and promote new ventures.

SCORE. The Service Corps of Retired Executives is another affiliate of the Musser Center. SCORE, which works most closely with the
SBDC, is chartered by the U.S. Small Business Administration and provides business expertise to current or potential business owners.

Liaison. Funding from the Masser Center assists other Lehigh University entrepreneurial activities. The Martindale Center for the Study of Private Enterprise uses funding to support student publications. The Center for Economic Education develops curricular materials for secondary school instruction on entrepreneurship. The Masser Center also conducts studies on the problems of business formation and operation and the characteristics of entrepreneurs.

For more information, write to John W. Bunge, Director, Masser Center for Entrepreneurship, Rauch Business Center, 621 Taylor Street, Bethlehem, PA 18015.

The Philip Rauch Center for Business Communications

The Philip Rauch Center for Business Communications was established in 1981 in Lehigh’s College of Business and Economics in response to a growing need for more effective communication in business. The Center was established with a gift from Philip Rauch ’33, who is a retired chairman of the board of Parker Hannifin Corporation.

The Center’s mission is to help students develop the skills needed to write effective professional memos, letters and reports, and make successful oral presentations.

In support of the Undergraduate Writing Requirement Program in the College of Business and Economics, the Center’s staff collaborates with CBE faculty from all academic areas to reinforce and improve student writing skills. The Center also operates a Business Writing Clinic which invites students to drop by any time during business hours for counseling on writing projects. The Center’s HOMEPAGE on the Internet offers a “Virtual Clinic”, offering advice on writing projects and the design and delivery of oral presentations. Students taking business communication courses receive training in the use of presentation software, LCD panels and laptop computer technology in their class presentations.

The Center sponsors workshops for faculty and students on the use of communication technology.

Research Activities. The Center’s HOMEPAGE offers faculty and student access to INTERNET research tools and resources dealing with the theory and practice of written and oral communications.

Undergraduate and graduate students can explore the results of student research projects. Students will also be able to review student PowerPoint presentations.

Supported by a grant from AT&T, the Center has created an Internet link to relevant resources dealing with doing business with and in Asia. A multimedia computer located in the Center serves as a permanent site for displaying this information and members of the Lehigh Valley community are welcome to use this resource.

The Center is in the process of developing multimedia business cases which will support our business curriculum and integrate writing across the curriculum.

For more information, write Peter M. Saunders, Director, Center for Business Communications, Rauch Business Center, Lehigh University, 621 Taylor Street, Bethlehem, PA 18015.

Polymer Interfaces Center

The Polymer Interfaces Center (PIC) is an Industry/University Cooperative Research Center that was established at Lehigh University in 1991. It is sponsored by the National Science Foundation (NSF) and is one of approximately fifty centers that have been established at universities throughout the U.S. in an effort to leverage industrial development with university science. In this arrangement, university professors, research scientists and graduate students conduct industrially relevant fundamental research while member companies and the NSF provide operating funds and guidance on the kinds of model polymers, model substrates and goals that are of interest to them.

PIC is developing a molecular-level understanding of the structural, dynamic, kinetic and energetic characteristics of the interface region between polymers and substrates while also developing versatile methodologies to characterize the interface region. Center research addresses such topics as adsorption, desorption, dynamic wetting, adhesion, charge transfer, transport, miscibility, compatibility and mechanical behavior. The Center’s ultimate goal is to generate a scientific database to assist in designing advanced polymers for such diverse applications as lubricants, water treatment, secondary oil recovery, coatings, inks, adhesives, and engineering plastics.

Research activities. The Center is interdisciplinary and includes faculty from five academic departments: chemical engineering, chemistry, materials science and engineering, mechanical engineering and mechanics, and physics. The Center also has six research scientists and engineers who help guide the research program. The current research effort is divided into three theme areas:

* Polymer adsorption/characterization. Investigators are elucidating the processes of water soluble polymer adsorption and desorption from water onto colloidal and planar surfaces such as polystyrene, TiO₂, and silica.

* Adhesion. Using industrially important metal and plastic surfaces, researchers in this area investigate the fundamentals of wetting and adhesion and the means of varying these processes by altering the molecular structure at the interface.

* Mechanical behavior of polymer systems. PIC researchers examine the mechanical behavior of polymer systems that intrinsically contain interphase regions or are purposely modified to incorporate interphases. Selected projects include investigations of film formation, role of mechanical interlocking on adhesions, and “toughening” mechanisms and fatigue resistance in plastics that are modified with rubber and/or glass fiber inclusions.


Educational opportunities. PIC supports graduate-level research for M.S. and Ph.D. degree students in subjects related to the Center’s goals. Students receive degrees from their respective academic departments, but they also take special courses on polymer interfaces offered by the Center faculty and participate in the multidisciplinary activities of the Center. There are a few opportunities for research by undergraduates who have achieved senior standing in a science or engineering major.

For more information, write to Manoj K. Chaudhury, Director, or Andrew Mercurio, Associate Director, Iacocca Hall, Lehigh University, 111 Research Drive, Bethlehem PA 18015; or call (610) 758-3082.

Sherman Fairchild Center for Solid-state Studies

The Sherman Fairchild Laboratory was established by a major grant from the Sherman Fairchild Foundation and was opened in the Fall of 1976. The laboratory houses an interdisciplinary staff consisting of faculty and students from the departments of physics, materials science and engineering, applied physics and computer science. While work on various aspects of solid-state science is carried out at many locations on the Lehigh campus, the Sherman Fairchild Center provides the focal point for studies of electronic materials and devices.

Research activities. The Sherman Fairchild Center’s faculty and students have a wide range of interests that include experimental and theoretical studies of the physics of defects in non-metallic solids and of disordered materials; advanced semiconductor processing technology; and semiconductor device design, fabrication, and characterization. The materials systems of interest are equally diverse and include silicon, silicon dioxide, compound semiconductors, wide bandgap semiconductors (SiC, ZnSe, and GaN), ferroelectrics and glasses.
The Sherman Fairchild Center houses several experimental laboratories. The Microelectronics Research Laboratory provides processing facilities for the fabrication of CMOS, CCD, MNSO, bipolar devices and integrated circuits. Available technology includes low-pressure chemical vapor deposition, RF metallization, plasma chemistry, photolithography, oxidation and diffusion. A new Display Research Laboratory has been established for work on electronic devices and thin-film materials for large flat panel displays. The Compound Semiconductor Research Laboratory has facilities for processing and characterizing high speed integrated circuits. A new facility for the growth of compound semiconductor thin films by metalorganic vapor phase epitaxy is being constructed.

A 3 MeV Van de Graaff accelerator provides a radiation facility that can be used to produce high energy electrons for the generation of point defects. Individual laboratories provide instrumentation for optical excitation and luminescence, electron paramagnetic resonance (EPR), deep level transient spectroscopy (DLTS), and Fourier transform infrared spectroscopy (FTIR) for the study of defects in semiconductors. There are also facilities for the study of transport in mesoscopic devices at millikelvin temperatures, Raman spectroscopy, and ultrasonic attenuation. Theoretical work is facilitated by the University's extensive network of workstations.

Current research programs include work on (1) VLSI microelectronics, a study of the characterization of small-geometry solid-state devices for VLSI, with emphasis on CMOS transistors; (2) nonvolatile semiconductor memories that offer the possibility of a "semiconductor disk"; (3) SiC materials for application in power electronics at high temperatures; (4) the fundamental properties of impurities and simple lattice defects in silicon and wide bandgap compound semiconductors. A variety of methods (crystal growth, diffusion, electron irradiation) are used to introduce defects which can be studied by spectroscopic techniques that include electron paramagnetic resonance (both conventional and optically detected), deep level transient spectroscopy, and infrared absorption spectroscopy; (5) the oxidation of Si$_2$-$\text{Ge}_{x}$ alloys and SiC with emphasis on the very early stages of oxidation and impurity enhanced oxidation; (6) quantum mechanical calculations of the structural, vibrational, and electronic properties of defects in SiO$_2$, and wide bandgap semiconductors like GaN; (7) the fabrication of prototype active matrix displays; (8) the fabrication and characterization of high speed compound semiconductor integrated circuits; (9) the collective dynamics of partially ordered and disordered ferroelectric structures and glasses.

Educational opportunities. Graduate students associated with the Sherman Fairchild Center usually enroll for the master of science or doctor of philosophy degree in the traditional discipline of their choice, such as physics, materials science and engineering, electrical engineering, etc., with specific course requirements and research participation coordinated through the appropriate department chairperson. Students are financially supported by graduate fellowships provided by the Sherman Fairchild Foundation and/or by university resources. In addition, teaching assistantships are available through the departments and a number of research assistant positions are supported by research grants and contract awards obtained by the laboratory staff. All of these arrangements typically permit graduate students in the solid-state studies to take three courses per semester in addition to their teaching or research activities. There are numerous opportunities for undergraduate students to participate in the research activities of the center with the possibility of support during summer through the Fairchild Summer Scholar Program.

For more information, write to Michael Stavola, Director, Sherman Fairchild Center for Solid State Studies, Sherman Fairchild Laboratory, Lehigh University, 16A Memorial Drive East, Bethlehem, Pa. 18015.

**Small Business Development Center**

(see Musser Center for Entrepreneurship)

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**Technology Studies Resource Center**

The Technology Studies Resource Center, based in the College of Arts and Science, creates and disseminates materials and programming that will lead a wide range of people to an understanding of the mutual interaction of technology and social institutions and values. Through the center, academics from all disciplines can collaborate on research and develop educational opportunities in technology studies with academic colleagues and with non-academic sponsors.

The Technology Studies Resource Center's activities embrace the needs of academics, pre-college and college students, and industrial, political, and public audiences, who seek information about technology as a force in contemporary society. Four principal areas for activities are the development and dissemination of resource materials, professional development programming, educational programming, and stimulation and coordination of technology studies and research projects. Specific activities include: collecting and distributing college-level course syllabi in technology studies; publishing bibliographies in specific areas of technology studies; publishing the SCIENCE, TECHNOLOGY, AND SOCIETY CURRICULUM DEVELOPMENT NEWSLETTER; maintenance of a data base of personnel, curricula, and materials resources in technology studies; sponsoring conferences, workshops, seminars, and institutes in technology studies; and integrating technology studies material with existing high school curricula and developing better courses in science and mathematics in cooperation with regional administrators and faculty.

For more information write to Stephen H. Cutcliffe, Director, Technology Studies Resource Center, Maginnies Hall, Lehigh University, 9 W. Packer Avenue, Bethlehem, Pa. 18015.

**Zettelmeyer Center for Surface Studies**

The Zettelmeyer Center for Surface Studies was established on February 1, 1966. The center has been successful in fostering interdisciplinary research in a broad range of surface-related phenomena including lipid membranes, catalysis, corrosion, environment-enhanced cracking in alloys, coatings, dispersions, printing inks, and colloids. Faculty members from the departments of chemistry, chemical engineering, mechanical engineering and mechanics, materials science and engineering, and earth and environmental sciences are associated with the center. The center develops and maintains research facilities, including laboratory and office space, and major experimental equipment used in interface and surface-related research. The center facilitates exchanges of ideas and interactions between faculty and students from different disciplines, thereby nurturing research at the forefront of science and broadening the educational opportunities for graduate as well as undergraduate students.

Financial support for the center comes largely from research projects with industries and governmental agencies.

The center is well-equipped with specialty instrumentation needed for advanced research in its field. Sinclair Laboratory houses equipment for experimental studies employing flash desorption, Mössbauer spectroscopy, Auger spectroscopy, laser Raman spectroscopy, infrared spectroscopy, X-ray photoelectron spectroscopy (electron spectroscopy for chemical analysis), high resolution electron energy loss spectroscopy, low energy electron diffraction, ultraviolet photoelectron spectroscopy, nanosecond fluorescence spectroscopy, ellipsometry, nonlinear resonant sum frequency spectroscopy, ultrahigh vacuum scanning tunneling microscopy, computerized spectrophotometer, positron annihilation spectroscopy, electrochemical impedance spectroscopy, microelectrochemistry, and continuous electrophoresis.

Other specialty equipment includes microbalances, integrated systems for continuous flow catalyst testing, testing machines for studies of environment-affected crackgrowth, gas adsorption for surface area measurements, and heat of immersion apparatus, wetting balances, apparatus for determining rheological properties, and apparatus for the preparation of reproducible dispersions and films.

**Research activities.** The center's research program includes a broad range of topics vital to modern science and technology.
Some of the active topics are: solid-state chemistry of catalysts; catalytic oxidation of methane; mechanisms of catalytic reactions and development of new catalyst; chemistry of NOx abatement; formation of monolayer oxides on oxides of a different metal; the interaction between these oxides and relationship with catalytic activity; surface magnetic properties; wetting of multiphase systems; characterization of surfaces; adsorption at electrochemical interfaces; self-assembly of chemically bound multilayers at surfaces and interfaces; structure and dynamics of surfactants at interfaces; microelectrophoresis and continuous electrophoresis; Moessbauer spectroscopy of surfaces; erosion and wear; chemical composition of surfaces; passivity and corrosion inhibition; chemistry of fracture surfaces; hydrogen embrittlement; environmentally affected crack growth; high-temperature corrosion; coatings for protecting microelectronic circuits; adhesion of coatings; corrosion under coatings; chemical state of ions in polymers; charge transport through organic coatings; effect of metallic cations on corrosion processes; water-based coatings; electrical properties of coatings; polymer surfaces; research related to lithographic, flexographic and gravure printing; rheology in non-Newtonian fluids; adhesion and flow of fluids in porous substrates; and computational chemical dynamics of surfaces, clusters, and zeolites.

**Educational opportunities.** The center is a facility in which graduate students undertake thesis and dissertation research leading to the M.S. and Ph.D. degrees in the departments of chemistry, chemical engineering, physics, mathematics, biology, materials science and engineering, mechanical engineering and mechanics, and earth and environmental science.

Potential and current graduate students whose interests are consistent with the center’s objectives are welcome to avail themselves of the experimental facilities. Research assistantships are available. Research topics are selected by mutual agreement, and interested students are encouraged to explore research opportunities in the center.

The center’s research also forms the basis of continuing educational programs designed primarily for industrial personnel. The conference center in Sinclair Laboratory accommodates the special seminars and short courses that are held periodically. Recent course topics include corrosion, printing ink technology, adhesion, and molecular design characterization of catalytic oxide materials.

The center provides opportunities for resident postdoctoral studies and for visiting scientists.

For more information, write to Zettlemoyer Center for Surface Studies, Sinclair Laboratory, Lehigh University, 7 Asa Drive, Bethlehem, PA 18015.

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**Organizational Headquarters for Applied Technology**

**Ben Franklin Technology Center**

The Northeast Tier Ben Franklin Technology Center (NET/BFTC), based in the Ben Franklin Building on the Murray H. Goodman Campus, was established in 1983 as part of the Commonwealth’s Ben Franklin Partnership. The Center supports and promotes business development in the Commonwealth through technological innovation.

The Partnership aims to combine the resources and expertise found throughout the state’s higher educational system with business’s technology-advancement efforts to create products and improve manufacturing processes and productivity. By building business/academic partnerships that address business needs, the Center helps companies to leverage innovative products and processes into competitive advantage. Faculty and students involved in these efforts gain experience in solving real issues for working businesses. Through these efforts, the Ben Franklin program serves to make the state’s economy more innovative and competitive, thus creating and retaining high quality job opportunities for Pennsylvanians.

Past efforts at the Center have been documented as creating or retaining over 13,500 jobs, and an independent study showed that taxes resulting from those jobs produce more to the state on a yearly basis than the funds appointed for the Center. The technology center at Lehigh is one of four centers in the state working with business, education and government toward these goals; the other centers are based at the University City Science Center, Philadelphia; Pennsylvania State University, University Park; and Carnegie-Mellon University/University of Pittsburgh.

The goals of the NET/BFTC include helping new technology-oriented businesses to form and grow, helping existing manufacturers to improve productivity through innovative application of new technologies and practices, and helping to ensure a qualified work force by seeding the development of creative new education and training programs that are driven by the needs of industry. Technical and business assistance services are provided on a year-round basis. The center also operates a business incubator center right on the Lehigh campus.

For the 1996-97 funding year, the NET/BFTC was awarded over $6 million from the state Department of Commerce with approximately $15 million in matching funds committed from private-sector businesses, educational institutions and other sources. Each year the NET/BFTC has about 30 to 40 projects with Lehigh, involving over 100 faculty members, research scientists, project engineers, students, technicians, and administrative staff.

For more information, contact Mark S. Lang, Executive Director, Ben Franklin Technology Center, Lehigh University, 125 Goodman Drive, Bethlehem, Pa. 18015-3715; (610) 758-5200. E-mail: Mark@NET.BFTC.ORG

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**Council on Tall Buildings and Urban Habitat**

The Council on Tall Buildings and Urban Habitat, an international organization sponsored by engineering, architectural, and planning professionals, was established in 1969 to study and report on all aspects of the planning, design, construction, and operation of tall buildings.

The Council’s nine professional society sponsors are: International Association for Bridge and Structural Engineering, American Society of Civil Engineers, American Institute of Architects, American Planning Association, International Union of Architects, American Society of Interior Designers, Japan Structural Consultants Association, Urban Land Institute, and International Federation of Interior Designers. In 1974 the Council was admitted as a consulting nongovernmental organization to United Nations Educational, Scientific and Cultural Organization.

The Council is concerned with the impact of tall buildings on the urban environment and in the role they play in urban life. This involves a systematic study of the problem of providing adequate space for life and work, considering not only technological factors, but social and cultural aspects as well. Important activities include the identification and stimulation of needed research and implementation of findings into codes, specifications, and standards.

The seven groups that carry out the major activities of the Council are:
- Planning and Environmental Criteria for Tall Buildings (PC).
- Development and Management (DM).
- Tall Building Systems and Concepts (SC).
- Building Service Systems (BSS).
- Tall Building Criteria and Loading (CL).
- Structural Design of Tall Steel Buildings (SB) and Structural Design of Tall Concrete and Masonry Buildings (CB).

A major focus of the Council is a comprehensive multi-volume monograph on the planning and design of tall buildings entitled Tall Buildings and the Urban Environment. They cover environmental aspects, transportation and other planning aspects; service systems, structural systems; the various loading systems; structural safety, foundations, and structural design methods and limit states-the latter covering both steel and concrete buildings.

The Council is not an advocate for tall buildings, per se, but in those situations in which such buildings are viable, it seeks to encourage the use of the latest knowledge in their implementation.

The headquarters of the Council is at Lehigh University. Nearly 1,200 specialists, primarily engineers, architects, planners, and sociologists...
from seventy countries, are involved in the work of its committees. A number of these committees provide advisory guidance for relevant Lehigh research projects.

For more detailed information, contact Lynn S. Beadle, Director, Council on Tall Buildings and Urban Habitat, Lehigh University, 13E. Packer Avenue, Bethlehem, Pa. 18015; Phone: (610) 758-3515, Fax: (610) 758-4522; e-mail: incub@lehigh.edu. Visit our website under Research Centers and Institutes on Lehigh’s homepage or at www.lehigh.edu/~incub.

Manufacturers Resource Center
The Manufacturers Resource Center (MRC) is one of eight Industrial Resource Centers Networked across Pennsylvania with the mission of helping small and medium-size manufacturers to remain competitive in the current global marketplace. MRC performs the same function as a member of the federally-funded Manufacturing Extension Partnership.

The MRC offers manufacturers valuable assistance by helping companies to use off-the-shelf technology and proven techniques to compete in today’s economy. That includes all aspects of business from quality to information systems and production constraints. One-on-one projects are the focal activity of the Center. Each staff manufacturing engineer provides customized analysis for each client, personally defining their particular constraints, and working with them through projects to arrive at solutions. Beyond the information and expertise, the staff engineers act as project managers to their projects as they work with a network of private and academic consultants.

Typical services fall into the following categories: manufacturing strategies and plant operations; technology improvement; production planning and inventory control; factory automation; materials management; information systems; equipment justification; plant layout; fixed asset and cost management; business planning and systems layout; work force development; market expansion; labor/management relations; and quality, productivity, marketing and information systems reviews.

Resources available through MRC are experienced staff and industry professionals, private and academic consultants, customized training programs, library of manufacturing materials and access to databases. Additionally, technical demonstration sites have been established where manufacturers are able to observe, learn, and try new technologies. These sites include CIMLab, Lehigh University, and Northampton Community College.

The MRC serves six counties in Northeast Pennsylvania and is a member corporation of Lehigh University. A sister organization to the Ben Franklin Technology Center, the Center is funded by the Pennsylvania Department of Commerce, the National Institute of Standards and Technology’s Manufacturing Extension Partnership and has the support of private industry.

Additional services available through MRC include industry initiatives, regional seminars/training, quality initiatives, ISO 9000 certification seminars and topic specific users groups. For further information or assistance, please contact Edith Ritter, Executive Director, at (610) 758-5599.

Structural Stability Research Council
The Structural Stability Research Council (formerly Column Research Council) was founded in 1944 by the Engineering Foundation to review and resolve the conflicting opinions and practices that existed at that time with respect to solutions to stability problems, and to facilitate and promote economical and safe design. The Council has been headquartered at Fritz Engineering Laboratory since 1966.

At the core of the Council’s activities are 17 task groups and 9 task reporters. At its Annual Technical Session, a forum is provided whereby the latest research results pertaining to these groups are presented. This represents a primary source of the highlights of the latest solutions to structural problems before they are eventually published in technical journals.

The Council offers guidance to specification writers and practicing engineers by developing both simplified and refined calculation procedures for the solution of stability problems, and assessing the limitations of these procedures. The Council’s major publication is the Guide to Stability Design Criteria for Metal Structures. Now in its fourth edition, this book is the most comprehensive treatment available anywhere in the world on stability problems associated with metal structures. The fifth edition is expected to be published in 1997.

The international membership of the Council is made up of representatives from governmental and private organizations concerned with specifications and design procedures for metal structures, representatives of consulting firms engaged in engineering practice, members-at-large selected from universities and design offices, and corresponding members from various countries who are in touch with stability research in their region.

A number of Fritz Engineering Laboratory research projects have received the guidance of the Council’s advisory committee. Many former Lehigh University graduate students and research workers are now active members of the Council.

For more information, contact Dr. James M. Ricles, Director, SSRC, Fritz Engineering Laboratory, 13E. Packer Avenue, Lehigh University, Bethlehem, PA 18015.
V.

Courses Programs and Curricula

This section includes listings of undergraduate and graduate courses offered by Lehigh University. For purposes of record, all approved courses are listed. It must be understood, however, that the offerings in any given semester are contingent upon a number of factors, including student needs as determined at the time of preregistration.

All academic departments are listed in alphabetical order.

Credit Hours
The number in parentheses following each course title indicates the credit value of the course in terms of semester hours ("credit hours").

Course Numbering
The course numbering system specifies which courses can be applied to the program of study as the student progresses toward the undergraduate or graduate degree. In general, the numbering series is as follows:

0-99. Courses primarily for freshmen or sophomores. Not available for graduate credit.

100-199. Intermediate-level undergraduate courses. Not open to freshmen except on petition. Not available for graduate credit.

200-299. Advanced undergraduate courses. Courses in the College of Business and Economics and specific departments as noted in the listings are open to freshmen and sophomores only on petition. Not available for graduate credit in the major field.

300-399. Advanced undergraduate courses. Same as 200-299, but available for graduate credit in major field.

400-499. Graduate-level courses, open to undergraduates only by petition.

Provisional Courses
Each instructional department is authorized to offer provisional courses, or those offered on a trial basis, as well as special opportunities courses. Such courses can become a permanent part of the university curriculum. These courses are numbered, as is appropriate, . . . 95-98 . . . 195-198, . . . 295-298 . . . 395-398, for a maximum of two semesters.

Apprentice Teaching and Cooperative Undergraduate Education
For details of these programs, see descriptions under "Apprentice Teaching" and "Cooperative Undergraduate Education," in section 111.

Prerequisites
Academic preparation required for admission to courses is indicated under "prerequisites" included at the end of each course description. Prerequisites are stated in most cases for purposes of convenience in terms of Lehigh courses. Academic status required for admission, where numbering does not fully describe this status, is also indicated under "prerequisites."

A student who does not have the status (e.g., sophomore standing) or the academic preparation set forth as prerequisites must, in order to be admitted to a course, file with the registrar at the time of registration and on a standard form provided, a waiver of prerequisites signed by the course instructor, the teaching department chair and either the chair of the student's major department or the associate dean. Academic work completed elsewhere must be attested in this manner as being substantially equivalent to prerequisites listed, unless the student's records in the Office of the Registrar show that the proper officers have so evaluated this preparation previously.

In a few cases, corequisites are indicated. In such instances the corequisite course is taken in the same semester.

Information Limits
The course descriptions are intended to guide the student in selecting appropriate courses. For reasons of space, descriptions are brief. In most cases, courses will have a significantly broader scope than the topics listed in the description. In some courses, material may change from what is described. If there is doubt concerning the appropriateness of any course for the individual's educational objectives, it is suggested that the student confer with the adviser.

Abbreviations
Whenever possible, course listings contain information indicating what requirements the course satisfies, the semester or semesters in which it is offered, and the name of the scheduled instructor or instructors.

While all information herein is subject to change, the information is included to serve as a guide in the selection of appropriate courses that best fulfill the student's academic requirements and personal goals.

The symbols following course descriptions for some College of Arts and Sciences courses include:

HU. Courses that meet the Humanities distribution requirements

NS. Courses that meet the Science distribution requirements

SS. Courses that meet the Social Science distribution requirements

MA. Mathematical

ND. Not designated to meet distribution requirements.

The symbols following course descriptions for some College of Engineering and Applied Science courses include:

ES. This code plus the following number indicates that the course satisfies a number of hours of engineering science requirements for ABET accreditation.

ED. This code plus the following number indicates that the course satisfies a number of hours of engineering design requirements for ABET accreditation.

Accounting


Associate Professors. D. Raymond Bainbridge, Ph.D. (Lehigh), C.P.A.; Karen M. Collins, Ph.D. (VPI), C.P.A.; Marilyn M. Greenstein, Ph.D. (Temple); Parveen P. Gupta, Ph.D. (Penn State); James A. Hall, Ph.D. (Oklahoma State); Manash R. Ray, Ph.D. (Penn State); James E. Rebele, Ph.D. (Indiana).

Assistant Professors. Donald R. Tripp, Ph.D. (South Carolina).

The Accounting Program offered through the Department of Business provides a variety of courses to support College of Business and Economics core requirements and to provide an undergraduate major in accounting. Within the accounting major, there is an opportunity to explore the various career opportunities within the broad field of accounting: financial, managerial, taxation, auditing, and information systems.

The mission of the Accounting Program is to provide rigorous professional accounting education that prepares high quality undergraduate students with diverse backgrounds for life-long learning and positions of leadership in the business community. Consistent with the missions of Lehigh University and the College of Business and Economics, the Accounting Program continuously seeks to be recognized as one of a select group of programs in the United States where an educational experience of the highest possible quality is obtainable.

Educational Objectives of the Accounting Program
The primary objectives of Lehigh’s Accounting Program are to:

- Develop in students a strong work ethic.
- Cultivate and develop each student’s ability to engage in a program of life-long learning.
- Provide students with a challenging academic program in liberal arts (including science and economics), business, and accounting.
- Provide students with a theoretical framework and develop their problem-solving skills in the areas of financial accounting, managerial accounting, information systems, auditing, and taxation.
- Develop students’ oral and written communication skills.
- Develop students’ interpersonal skills, including interpersonal dynamics, leadership, teamwork, and negotiation.

To the extent that the above objectives are achieved, Accounting Program graduates will be well-prepared for positions in public accounting, industry, not-for-profit organizations, and graduate school. Although preparation for professional examinations is not a primary objective of Lehigh’s Accounting Program, students successfully completing the accounting major will have the background to take professional examinations in accounting.

The Accounting Major
The undergraduate program in accounting is accredited by the American Assembly of Collegiate Schools of Business. This achievement places the program within a small group of schools which have satisfied a rigorous examination of the program, faculty, and students beyond the accreditation standards applied to the College of Business and Economics undergraduate and graduate programs.

The accounting major offered in the Department of Business requires 15 credit hours beyond core requirements. In addition, accounting majors must take the Accounting Information Systems (Act 311) alternative to Act 211 to fulfill the information systems requirement for the accounting major.

- Act 307 Fundamentals of Federal Income Taxation (3)
- Act 315 Financial Accounting I (3)
- Act 316 Financial Accounting II (3)
- Act 320 Fundamentals of Auditing (3)
- Act 324 Cost Accounting (3)

Undergraduate Courses
Act 108. Fundamentals of Accounting (3)
A one-semester survey of accounting principles and practices, including an introduction to industrial cost systems designed for those students planning to take only one accounting course. Other students should take the Act 151-152 sequence.

Act 151. Introduction to Financial Accounting (3)
The organization, measurement and interpretation of economic information. Introduction to accounting theory, concepts and principles, the accounting cycle, information processing, and financial statements. Exposure to controversial issues concerning income determination and valuation. Prerequisite: sophomore standing.

Act 152. Introduction to Managerial Accounting (3)
An introduction to internal accounting information for all levels of management. Topics include cost flow in a manufacturing operation; planning, evaluating and controlling through budgeting and standard costing; and decision-making using cost-volume-profit analysis, direct costing, and relevant costs. Prerequisite: Act 151.

Courses numbered 200 and above in the College of Business and Economics are open to sophomores only on petition.

Act 211. Management Information Systems (3)
This course examines the role of information and information systems in business organizations. Computer-based information systems play a fundamental role in data processing, management decision support, manufacturing/production control, and internal and external reporting. This course integrates system concepts, organization theory, decision making, and technology critical to the understanding of routine business applications and the strategic use of information systems. Prerequisites: Act 152, Mgt 1 and Mgt 270. Students will not receive credit for both Act 211 and Act 311.

For Advanced Undergraduates and Graduate Students
An introductory study of the principles and concepts of federal income taxation of individuals, corporations, partnerships, and fiduciaries; and federal gift and estate taxes. Determination of tax liabilities and opportunities for planning are emphasized. Problem-solving using the source materials of tax law and tax research are important components of the course. Prerequisite: Act 151.

Act 309. Advanced Federal Income Taxation (3)
An advanced study of the taxation of business organizations, estates, trust, and wealth transfer taxes. Planning and research are the basic components of the course. Problem-solving and written research are emphasized. Prerequisite: Act 307.

Act 311. Accounting Information Systems (3)
An introduction to the concepts underlying information systems as they relate to organizational structure, managerial decision making and accounting. The course acquaints students with the reports and documents generated by information systems, as well as procedures and controls employed in a variety of business applications. Students apply these concepts, techniques and procedures to the planning, analysis and design of manual and computer based information systems. Prerequisites: Act 152, Mgt 1, and Mgt 270. Students will not receive credit for both Act 211 and Act 311.

Act 315. Financial Accounting I (3)
Intensive study of the basic concepts and principles of financial accounting, emphasizing the problems of fair presentation of an entity’s financial position and operating results. Consideration of the conceptual framework of accounting, review of the accounting process, and measurement and valuation of current assets, current liabilities, plant assets, intangibles, investments, and long-term debt. Problem-solving skills and critical analysis are stressed. Prerequisite: Act 152.

Act 316. Financial Accounting II (3)
The sequel to Accounting 315, this course continues with intensive study of such topics as stockholders’ equity, valuation and disclosure of leases and pensions, income tax allocation, changing prices, revenue issues, earnings per share, and complexities related to the statement of changes in financial position. Analysis and interpretation of financial statements and problem-solving skills are integral parts of the course. Prerequisite: Act 315.
Acct 317. Advanced Financial Accounting (3)
A study of specialized topics in financial accounting, including partnership accounting, business combinations and consolidated financial statements, segment and interim reporting, foreign currency transactions and translation, and accounting and reporting for governmental and other nonprofit organizations. Involves considerable problem-solving and critical evaluation of controversial theoretical issues. Prerequisites: Acct 315 or 316.

Acct 320. Fundamentals of Auditing (3)
An introduction to auditing theory, objectives, and practices related largely to the responsibilities of independent professional accountants. The auditing environment, generally accepted auditing standards, internal control theory, and reporting alternatives are considered. Exposure to operational auditing is provided. Prerequisites: Acct 311 and 315.

Acct 324. Cost Accounting (3)
An in-depth study of cost concepts appropriate for product costing in a manufacturing operation, planning and controlling routine operations, and nonroutine decision-making. Topics include job order and process costing, joint and by-products, cost allocation, budgeting, standard costing, direct costing, cost-volume-profit analysis, and relevant costs for decisions. Prerequisite: Acct 152.

Acct 371. Directed Readings (1-3)
Readings and research in various fields of accounting; designed for superior students who have a special interest in some topic or topics not covered by the regularly rostered courses. Written term paper(s) required. Prerequisite: preparation acceptable to the department chairperson.

Acct 372. Special Topics (1-3)
Special problems and issues in accounting for which no regularly scheduled course work exists. When offered as group study, coverage varies according to interests of the instructor and students. Prerequisite: preparation in accounting acceptable to the program coordinator.

Graduate Courses
GBUS 401. Financial Flows and Accounting Measurements (3)

GBUS 404. Information Systems for Managers (3)
The emphasis of the course is on information (IS) topics that most directly affect operations level managers. The topics include: transactions cycles, management’s responsibility for establishing internal controls, alternative technologies for transactions processing, database management systems, distributed data processing and networks, end-user computing, management reporting systems and advanced systems technologies including Decision Support Systems, Expert Systems and Neural Networks. The course follows a lecture and mini-case format. Students work in teams to design an informations system for a term project. Prerequisite: GBUS 401 and GBUS 405 (or concurrently).

GBUS 407. Managerial Accounting and Decision-Making (3)
Traditional and emerging techniques of product costing; managerial accounting techniques for planning, control and decision making; manufacturing and operational performance measure; quality management, cost management by process design. Prerequisite: GBUS 401 or equivalent.

GBUS 413. Advanced Management Accounting (3)
Issues in management accounting including activity based costing, activity-based management, strategic cost management, theory of constraints, advanced manufacturing technologies, cost of quality, and life cycle costing. Readings and cases. Prerequisite: GBUS 407 or equivalent.

GBUS 414. Financial Statement Analysis and Interpretations (3)
This course focuses on analysis of financial statements. It develops the skills necessary to interpret and use financial statement information effectively to assess profitability and risk and is intended for individuals likely to become intensive users of financial accounting information. Requirements include readings, case studies, presentations and written analysis of actual financial statements. Prerequisite: GBUS 401 or permission of the instructor.

GBUS 415. Contemporary Issues in Financial Reporting (3)
Corporate financial reports from the perspective of the user-analyist: disclosure, price level accounting, foreign currency, business combinations, leases, and analysis of financial statements. Case studies. Prerequisite: Acct 413.

GBUS 416. Accounting Theory and Thought (3)
Critical and historical examination of modern accounting concepts. Measurement, communication, and interpretation of enterprise income, capital, and related economic data. Prerequisite: 15 credit hours of accounting.

GBUS 492-493. Special Topics (1-3)
Special problems and issues in accounting and law for which no regularly scheduled course work exists. When offered as group study, coverage varies according to interests of the instructor and students. Prerequisite: preparation in accounting acceptable to the department chairman. May be repeated.

GBUS 495. Directed Readings (1-3)
An extended study of an approved topic in the fields of accounting. May be repeated.

African American Studies

Professors. William R. Scott, Ph.D. (Princeton), Professor of History, program director; Elizabeth N. Filer, Ph.D. (Michigan), professor of English; William G. Shade, Ph.D. (Wayne State), professor of history; Jean R. Soderlund, Ph.D. (Temple), professor of history.


Adjunct professors. Tori Bronaugh, Ph.D. (City University of New York); Curtis Keim, Ph.D. (Indiana); Mildred Rivera-Martinez, Ph.D. (Stanford University).

Instructor. Ardenee Hall-Karame, M.A. (S.W. Texas State University).

The purpose of the African American Studies Program is to engender in Lehigh students an intellectual appreciation of the life and culture of people of African descent in the Americas, especially the United States thereby-enriching the Lehigh curriculum and increasing the relevance of a Lehigh education to a culturally diverse society and world. In the best tradition of a liberal arts education, African American Studies expands all Lehigh students' critical understanding of their own heritage in interaction with other cultures.

The minor in African American Studies is an interdepartmental and comparative program of study for undergraduates who wish to integrate the insights and methods of several disciplines to understand the history, culture, social, and political experience of African Americans. The African American Studies curriculum encompasses two interrelated
lines of inquiry: (1) the diverse influences in Africa and the diaspora that have shaped African American culture, and (2) the variety of ways that the African American experience has shaped and been shaped by American culture.

**The Minor**

The minor in African American Studies consists of a minimum of 15 credit hours taken in the courses (core and collateral) listed below. At least nine (9) credit hours must be selected from the Core Course grouping (excluding independent and special topics), no more than six hours of which may be offered by the same department. In addition to the listed courses, students are encouraged to pursue independent study opportunities with faculty in the African American Studies Program.

**Core Courses:**

Core courses concentrate on subject material directly relevant to the African American experience. They are devoted explicitly to the study of the African American experience or heritage.

**AAS 3. Introduction to African American Studies (4)**

An interdisciplinary study of key aspects of the past, the culture and political experience of African Americans. The history of Africans in American culture and the cultural continuities among African peoples worldwide, and social forces that have shaped modern African American life. Scott. (SS)

**AAS 5. (Hist 5) African Civilization (4)**

Sub-Saharan Africa through the millennia of the ancient world to the present. Human origins, state and non-state systems, the external slave trade; colonialism, resistance to European rule; independence movements; neocolonialism. Keim. (SS)

**AAS 38. (Engl 38) Introduction to African Literature (3)**

Sub-Saharan African literary themes and styles; historical and social contexts African folk tales; oral poetry; colonial protest literature; postcolonial writing; films on contemporary Africa. Staff. 0

**AAS 103. (SSP 103) Race Relations (3)**

Racism, discrimination and prejudice, racial and ethnic conflict, and racial oppression in American society; the Civil Rights Movement. Problems faced by Blacks, Hispanics, Native Americans, and Asians in contemporary United States. Staff. (SS)

**AAS 129. (Hist 129) Black Political Thought in America (4)**

Black leadership, organizations, and philosophy in America from Reconstruction to the Civil Rights Era; ideas and programs of Booker T. Washington, W.E.B. DuBois, Marcus Garvey, Malcolm X and Martin Luther King, Jr. Scott. (SS)

**AAS 130. (Hist 130) African American History (4)**

Blacks in America from the first immigration of Africans to the implementation of Civil Rights laws. West African origins, slave trade, slavery, free blacks and emancipation and study of Reconstruction, segregation, urbanization, and the struggle for racial equality. Scott (SS)

**AAS 140. (Theatr 140) African American Theatre (3)**


**AAS 148. Cultural Diversity in the Caribbean (4)**

Cultural diversity in the Caribbean islands and the Guyanas, with emphasis on the African, American, and Indian influences. The sociological and cultural implications of the region’s diversity, with special emphasis on ethnicity, slavery and indenture, emancipation and independence, modernization, immigration, the impact of tourism and the development of Creole cultures, Lecture and discussion. Rivera-Martinez. (SS)

**AAS 150. (Art 150) Africans in the New World (3)**

African-American art, architecture, and craft from pre-colonial Africa to the present. Early primitivism, neo-classicism, the Harlem renaissance, modernism, and contemporary directions. Guest lecturers, open dialog, gallery visits, and media presentations. Writing Intensive. Booth. (SS)

**AAS 171. (Hist 171) History of Southern Africa (4)**

Africa south of the Zambesi, especially after the arrival of the Europeans. Conflicts in the Cape between Africans, the Boers and British; exploitation of minerals; apartheid, American policy; socialism in Angola and Mozambique. Scott. (SS)

**AAS 331. (Hist 331) United States and Africa (4)**

Reciprocal relationships between North America and the African continent from the slave trade in seventeenth century to the twentieth century Afrocentric movement. Impact of Americans on shaping of modern Africa, Pan-African relations, influence of African Americans on U.S. policies toward Africa. Scott. (SS)

**AAS 332. (Hist 332) Slavery and the American South (4)**

The emergence and demise of the “peculiar institution” of African American slavery in British North America and the Old South. African background; colonial beginnings; nineteenth-century slave community; the ruling race and proslavery ideology; the death of slavery and its aftermath; slavery and freedom in a comparative context. Shade (SS)

**AAS 371, 372. Independent Study (1-3)**

Independent study in advanced areas of African American Studies. Independent research with an individual faculty member in the African American Studies program. Consent of director. (ND)

**AAS 379. (SSP 379) Race and Class in America (3)**

Race and class in America and how these two organizing principles affect the lives of African Americans and other racial minorities. “Race versus class debate, with special attention to differences between the Black underclass and Black middle class. Washington. (SS)

**AAS 381. Special Topics. (ND)**

**AAS 382. Seminar in a topic in African American Studies. (ND)**

**Collateral Courses**

Anth 12 Human Evolution and Prehistory
Hist 334 American Urban History, 1880 To Present
Pols 230 Movements and Legacies of the 1960s
Pols 252 Civil Rights

**American Studies**

American Studies Committee William G. Shade, Ph.D. (Wayne State), professor of history and director of American Studies; James R. Prakes, Ph.D. (Pennsylvania), Edmund W. Fairchild Professor of American Studies; Peter G. Beidler, Ph.D. (Lehigh), Lucy C. Moser Distinguished Professor of English; Edward J. Gallagher, Ph.D. (Notre Dame), professor of English; James R. Mcintosh, Ph.D. (Syracuse), professor of sociology; Howard R. Whitcomb, Ph.D. (S.U.N.Y. at Albany), professor of government; Michael L. Raposa, Ph.D. (Pennsylvania), associate professor of religion studies; John Pettigrew, Ph.D. (Washington), assistant professor of history; David Curran Amidon, Jr., M.A. (Penn State), lecturer in urban studies.

American Studies is an interdisciplinary major emphasizing the idea that the institutions and values of a society comprise a whole, not merely the sum of its parts. By concentrating on the unique expressions of individuals contained in both the arts and popular culture and by studying the historical movements and contemporary institutions within which these expressions develop, American Studies reveals
relationships that may not be clearly seen within the framework of a single discipline.

The broad interdisciplinary nature of American Studies equips the student with a well-rounded general education and a wide range of career opportunities. The student may choose to emphasize American history or literature to provide an excellent preparation for graduate school in these areas as well as in American Studies. In addition the major can be combined with other majors, such as journalism, to furnish a sound underpinning for careers in those areas. With suitable collateral courses, the major also can prepare students for advanced work in museum administration, library science, social work and for teaching in both secondary schools and community colleges.

The major requirements total nine courses or generally 36 hours. These consist of four introductory courses dealing with American history and literature, a concentration of two advanced courses in a single field; an advanced course outside the concentration; a course dealing with a minority group; and an American Studies seminar. In connection with the director of American Studies, who serves as the adviser for the major, students choose a concentration from the four areas of history, literature, politics, and society and structures a program that fits their own needs.

The courses listed below are recommended, but comparable courses in each of these areas may be substituted with written permission of the director of American Studies. Admission to honors is American Studies is by invitation or request in the student's junior year. The student must attain an average of 3.2 in major courses in addition to the university honors program and complete a four hour thesis beyond the normal nine course requirement.

required preliminary courses
Choose two from each category

**History**
- Hist 41: United States to 1865
- Hist 42: United States, 1865-1941
- Hist 43: United States Since 1939
- Hist 7: Machine in America

**English**
- Engl 123: American Literature I
- Engl 124: American Literature II
- Engl 163: Narrative Film
- Engl 189: Popular Literature

required American Studies seminar
*Choose one*
- Ams 111: The American Character
- AmS 311: Themes in Contemporary American Civilization

required upper level courses
Choose a concentration of two courses from one group and an elective of one course from another group.

**History**
- Hist 327: American Intellectual History to 1900
- Hist 328: American Intellectual History since 1900
- Hist 323: American Cultural History since 1900
- Hist 332: Slavery and the American South
- Hist 334: American Urban History

**English**
- Engl 376: Early American Literature
- Engl 377: American Romanticism
- Engl 378: American Realism
- Engl 379: Twentieth Century-American Literature
- Engl 380: Contemporary American Literature

**Pols**
- Pols 217: Political Parties and Elections
- Pols 219: The American Presidency
- Pols 230: Politics of the 1960s
- Pols 251: Constitutional Law
- Pols 252: Civil Rights

**Society**
- SSP 152: Alcohol, Science and Society
- SSP 141: Social Deviancy and Social Control
- SSP 165: Contemporary Social Problems
- SSP 328: Sociology of the Family
- US 321: White Protestant America

*minorities in America*
*Choose one course from*
- Engl 316: Native American Literature
- Pols 179: The Politics of Women
- Hist 124: Women in America
- Hist 130: African American History
- SSP 103: Race Relations

These are suggestions and other similar courses (for example: Hist 319, Colonial America or Afr 182, North American Indians) might be used in the concentration or as upper level electives outside the students concentration. Because of their cross-listing some courses (for example: Hist/SSP 325, History of Sexuality and the Family in the U.S.) can be used in more than one category although no course may be counted twice.

**Courses:**

**AmSt 111. The American Character (3)**
Chronological and methodological analyses of shifting conceptions of the American character. Readings from foreign and domestic observers. Special attention to conceptual difficulties of analyzing national character. (ND)

**AmSt 311. Themes in Contemporary American Civilization (3)**
A seminar open to juniors and seniors. Subject varies from semester to semester. (ND)

**AmSt 371. Special Topics in American Studies (1-3)**
Individual study under the direction of a faculty member. May be repeated for credit. Permission of program director required. (ND)

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**Anthropology**

See listings under Sociology and Anthropology.

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**Applied Mathematics and Statistics**

**Professors.** Bennett Eisenberg, Ph.D. (M.I.T.); B. K. Ghosh, Ph.D. (London); Samuel L. Gulden, M.A. (Princeton); Wei-Min Huang, Ph.D. (Rochester); Gregory T. McAllister, Ph.D. (Berkeley), head; George E. McCluskey, Ph.D. (Pennsylvania); Eric P. Salatke, Ph.D. (Brown); Murray Schecter, Ph.D. (N.Y.U.); Gilbert A. Stengle, Ph.D. (Wisconsin); Joseph E. Yukich, Ph.D. (M.I.T.).

**Associate professors.** Ramamirtham Venkataraman, Ph.D. (Brown); Penney Smith, Ph.D. (Poly. Inst. Brooklyn).

The Division of Applied Mathematics and Statistics was established within the Department of Mathematics to promote and administer undergraduate and graduate education in applied mathematics and statistics, and to foster interdisciplinary research in the mathematical sciences at Lehigh. Courses and programs offered by the Division may be found under the departmental listing.
Art and Architecture

Professors. Ivan Zakric, M. Arch. and Urban Planning (Princeton); Tom F. Peters, M.Arch (ETH Zurich (dipl.Arch.ETH) and Dr.sc. (tech.) ETH Zurich, director, Building and Architectural Technology Institute; Ricardo Viera, M.F.A. (R.I.S.D.), director of Lehigh University Art Galleries.

Associate professors. Bertriss W. Boothe, M.F.A. (Maryland Institute College of Art); Lucy Gans, M.F.A. (Pratt); Bruce Thomas, Ph.D. (University of Californ, Berkeley).

Assistant professor. Anthony Viscardi, M.Arch (Georgia Institute of Technology).

Lecturer. Christine Ussler-Trumbull, M.Arch (Columbia University).


Adjunct lecturers. Anthony Corallo, M.Arch (University of Pennsylvania); Steven Jacobson, M. Arch (University of Pennsylvania); Douglas Mason, B.F.A. (R.I.S.D.)

The department of art and architecture offers two major programs.

The architecture major is a multidisciplinary major based in a department that draws on the resources of all Lehigh’s colleges. Although architectural design is the primary concern of this major, other courses in architectural history, social sciences and the humanities are also required.

The architecture major leads to the liberal arts B.A. (Bachelor of Arts), a four-year degree. This degree is satisfactory for admission to graduate study in architecture and candidacy for the M.Arch professional degree or for planning, preservation, or history of architecture.

In recent years students have gone on to graduate study in architecture at Yale, Harvard, Penn, Columbia, University of Pennsylvania, Maryland and Washington University, among other schools, or to entry-level employment in the profession.

Double majors with Urban Studies are quite frequent and the Arts/Engineering five-year degree, in which the student earns both B.A. (architecture) and B.S. (civil engineering), is available for those interested in both fields. For engineering students considering graduate study in architecture or entry-level positions in an architectural-engineering firm an architecture minor might be appropriate.

A major in art introduces the student to the basic media of art such as drawing, sculpture, printmaking, painting, and photography. For those interested in becoming creative artists, intensive study at Lehigh as well as other Lehigh Valley colleges is recommended; such students can expect to take more than the required number of credits for the major. Cooperation with Moravian College allows students to register for art courses not offered at Lehigh, such as ceramics.

A major in art can also be combined with psychology for those who seek a career in art therapy. It may also be combined with theater for those interested in costume design or with architecture and theater for those interested in set design. A major in art and minor in education is available for students interested in becoming public school art teachers. A special track is available within the art major for students interested in art history.

The resources of the Lehigh University art collection are made available to many students taking classes in art. Prints, photographs, and paintings are often brought into the classroom and visits to art exhibitions on campus and elsewhere in the Lehigh Valley are a common part of art instruction.

Through the facilities of the Lehigh University Art Galleries it is possible to see first-rate works of art on a regular basis. The annual contemporary art show is a special event. Several major museums are within easy traveling distance and the department runs regular bus trips to New York City. An annual lecture series brings artists and artists to campus. In recent years Rodolfo Machado, Charles Gwathmey, Klaus Herbegg, Edmund Bacon, Steven Peterson, Tod Williams, Peter Eisenman, Thomas Armstrong, Rev. Howard Finster, Joyce Kozloff, Jonas Dos Santos, Geno Rodriguez, Harold Edgerton, Peter Berg and Jody Pinto have come to Lehigh.

In addition to these two major programs, individually structured programs may be planned, such as art with an emphasis on architectural design, art history with an emphasis on museum training, and architecture with an emphasis on planning, urban studies, graphic communication, or government. Minor programs have been established in architecture, art studio, art/architectural history, graphic communication, and museum studies. Course requirements are specified, and a list of courses acceptable for the minors is available in the department.

Departmental Honors:

Exceptional students in Art or Architecture may apply for departmental honors at the end of their junior year or beginning of their senior year. To be eligible, a student must have attained a 3.5 GPA in her/his major program and a minimum overall GPA of 3.0. Candidates should submit to the department chair a written proposal, prepared in consultation with a faculty advisor. The project could result in a research paper, design project, or exhibit, accompanied by an oral presentation. Successful completion of the project and presentation would result in the “Departmental Honors” designation being affixed to the student’s transcript.

Art Major

Forty-three credit hours are required.

required courses (22 credit hours)

Art 1 or Arch 1 Art History 1 or Architectural History 1 (3)
Art 2 Art History II (3)
Art 7 Basic Design (3)
Art 8 Foundation in Drawing and Design (4)
Art 13 Sculpture I (3)
Art 15 Figure I (3)
Art 220 20th-Century Art (3)

plus one of the following (3 credit hours)

Art 82 Art and Archaeology of Greece (3)
Art 121/WS 121 Women in Art(3)
Art 150/AAS 150 Africans in the New World (3)
Art 175 Introduction to Museum Work (3)
Art 206/Arch 206 Medieval Art and Architecture (3)
Art 207/Arch 207 Renaissance Art and Architecture (3)
Arch 210 20th-Century Architecture (3)
Arch 222 Seminar in Contemporary Art (3)

plus six studio major courses (18 credit hours)

Art studio; six courses, two at the advanced level

Students who desire an art history concentration are required to take Art 1 or Arch 1 and Art 2, Art 7, Art 8, Art 220 plus one other studio course. At least six courses in the history or philosophy of art and/or architecture must be selected in consultation with instructor.

Students selecting a graphic communication concentration are required to take Art 7 and Art 8 before completing the graphic communication sequence. Other recommended courses may be selected in consultation with instructor. Viera.

Architecture Major

Fifty credit hours are required.

Design Sequence (22 credit hours)

Arch 043 Architectural Design I (4)
Arch 143 Architectural Design II (6)
Arch 243 Architectural Design III (6)
Arch 343 Architectural Design IV (6)
Art Studio (10 credit hours)
Art8 Foundation in Drawing and Design (4)
plus two other studies (various choices) (6)

Architectural History (9 credit hours)
Art 1 or Arch 1 Art History 1 or Architectural History 1 (3)
Arch 2 Architectural History II (3)
Arch 210 20th Century Architecture (3)

Architecture and its intellectual context (9 credit hours)
(including Architecture and Technology courses)
Arch 107 History of American Architecture (3)
Arch 204 Ancient City and Society (3)
Arch 206/Art 206 Medieval Art and Architecture (3)
Arch 207/Art 207 Renaissance Art and Architecture (3)
Arch 209 Architecture and Ideas (3)
Arch 213 The City (3)
Arch 253 Paris, The Planning of a Metropolis (3)
Arch 254 Modern Architecture in France: New Directions (3)
Arch 342 Theory of Architecture (3)
Arch 367 Modernism to Post-Modernism (3)
Anth 128 Urban Ethnology (3)
Anth 335 Religion, Symbolism and Cosmology (3)
Eco 311 Environmental Economics (3)
Eco 312 Urban Economics (3)
Hist 334 American Urban History (4)
Phil 123 Aesthetics (3)
Psych 373 Sensation and Perception (4)
US 62 Contemporary Urban Issues (4)
US 363 Philadelphia: Development of a Metropolis (4)

Architecture and Technology
Arch 147 Building Materials and Methods (3)
Arch 351 Evolution of Highrise Building Construction (3)
Arch 352 Evolution of Long Span Bridges (3)
Arch 353 Evolution of Modern Building Techniques (3)
Arch 351 Computer Aided Design I (3)
Arch 352 Computer Aided Design II (3)

For the architecture major, students must fulfill the mathematics requirement with Math 21 & 22 or Math 51 & 52; the physical science requirement must be filled with Phys 11 & 12.

For students contemplating graduate studies in architecture, Mech 2 is recommended.

Undergraduate Courses in Art
Art 1. Art History I (3) fall
Survey of major movements of art and architecture from the prehistoric caves of Lascaux and Altamira through the Gothic cathedrals of Chartres and Notre-Dame of Paris, along with highlights of art and architecture of the non-Western civilizations of Africa, India, and China. Work seen in the context of cultural, historical, and technological developments. Prerequisite. (HU)

Art 2. Art History II (3) spring
Survey of Western painting and sculpture from Renaissance to present. Prerequisite. (HU)

Art 7. Basic Design (3) fall-spring
Form and space as foundation for design. Principles and practice of visual expression using line, color, space, mass, value, and texture. Staff. (HU)

Art 8. Foundation in Drawing and Design (4) fall-spring
Introduction to the heritage of design systems underlying classical drawing. Analytical methods of design such as the Golden Section. This course must be taken in sequence for Architecture and Graphic Communication. Barnstone. (HU)

Art 11. Drawing I (3)
Concepts and practice of drawing, both traditional and contemporary. Includes drawing from life and an introduction to materials and techniques. Staff. (HU)

Art 13. Sculpture I (3)
Projects directed toward developing design in sculpture. Exploration of materials and their application. Emphasis on sculptural form as it relates to techniques. Gans. (HU)

Art 15. Figure I (3)
Drawing and modeling in clay from direct observation of the human figure. Fundamental principles of drawing, and two and three dimensional design through analysis of the human form. In-class exercises cover basic scale, proportion, structure, drawing media and techniques, clay modeling. Emphasis on personal expression of the human figure as vehicle for narrative, abstract or formal drawings or sculpture. Gans. (HU)

Art 37. Survey of Printmaking I (3) fall
Introduction to various techniques in relief and intaglio printing: monoprints, woodcuts linocuts; drypoint, etching grounds, aquatint, and other intaglio techniques. Includes an historical survey through slides and actual examples. Viera. (HU)

Art 38. Survey of Printmaking II (3) spring
Introduction to the fundamentals of stone and metal lithography and the basics of screen printing as a fine art print medium: various screen stencils, blockouts, and color transparencies; drawing methods and transfer. Includes an historical survey through slides and actual examples. Viera. (HU)

Art 53. Graphic Communication I (3) fall
Design principles are explored with emphasis on visual communication. Students learn basic concepts for design and typography including the vocabulary and historical precedents of graphic design and computer graphics. Introduction to professional-level formal exercises contributes to the development of visual thinking and original ideas. Prerequisite: Art 7 and Art S. Staff. (HU)

Art 77. Photography I (3)
Introduction to photography as a fine art. Emphasis on interaction of technique, perception and communication in making and responding to photographic image. Lectures, demonstrations, critiques. Students must provide own hand camera. Mason. (HU)

Art 82. (Clas 82) Art and Archaeology of Greece (3)
The art and architecture of ancient Greece as revealed by archeology. Brief surveys of the political and cultural backgrounds to the various artistic periods: Bronze Age, Geometric, Orientalizing, Classical, Hellenistic and Roman. Lectures, Slides and films. (SS)

Art 111. Drawing II (3)
Projects in creative drawing designed to build on concepts and practices initiated in basic drawing and life drawing. Prerequisite: Art 8 or Art 11. Staff. (HU)

Art 113. Sculpture II (3)
Development of principles and techniques in Sculpture I. Modeling, casting, fabrication and carving. Emphasizes an approach to sculptural form and an exploration of the evolution of modern sculpture. Prerequisite: Sculpture I. Gans. (HU)

Art 115. Figure II (3)
Projects in figure modeling and drawing from direct observation of the human figure, designed to build on concepts and practices initiated in Figure I. Students may elect to concentrate in one particular medium, although the primary investigation of form will always incorporate both two and three dimensional work. Prerequisite: Art 15. Gans. (HU)
Art 121. (WS 121) Women in Art (3)
Women artists from Renaissance to present. Attitudes toward women artists and their work; changing role of women in the art world. Visits to museums and artists' studios. May be repeated for credit as topic varies. Gans. (HU)

Art 135. Painting I (3)
Painting in oil or acrylic oriented toward developing individual creative expression combined with an understanding of the physical nature of the materials. Studio prerequisite: Art 7, 8 or 11, or consent of department chairman. Booth. (HU)

Art 150. (AAS 150) Africans in the New World (3) spring
African-American art, architecture, and craft from pre-colonial Africa to the present. Early primitivism, neo-classicism, the Harlem renaissance, modernism, and contemporary directions. Guest lecturers, open dialogue, gallery visits, and media presentations. Writing Intensive. Booth. (SS)

Art 153. Graphic Communication II (3) spring
Aspects of design are inter-related in function, concept or planning processes. Students focus on the poster in order to solve a variety of contemporary design problems. Professional-level formal team exercises includes a series of informative posters, identity systems, publication, and advertising design. Computer graphics and Macintosh lab are introduced as integral design tools in graphic design. Prerequisite: Art 53. Viera. (HU)

Art 174. (Arch 174, Cls 174, Anth 174) Greek Archaeology (3)
Ancient Greek cultures from the neolithic to hellenistic periods. Reconstructions of Greek social dynamics from study of artifacts. Small. (SS)

Art 176. (Arch 176, Cls 176, Anth 176) Roman Archaeology (3)
Cultures of the Roman Empire. Reconstructions of social, political, and economic dynamics of the imperial system from study of artifacts. Small. (SS)

Art 177. Photography II (3)
Intensive work in photography as fine art. Advanced study of problems of the photographic images. Lectures, demonstrations, critiques. Students must provide own hand camera. Prerequisite: Art 77. Mason. (HU)

Art 179. History of Photography (1)
Photography as fine art from earliest images to present day. Problems in contemporary photography. Mason. (HU)

Art 206. (Arch 206) Medieval Art and Architecture (3)
Focus on art and architecture in Western Europe from 313 A.D. until ca. 1500 A.D. Topics include: the emergence of Christian art and architecture; the art of barbarian migrations; the Carolingian Renaissance; monasticism, pilgrimage and the Romanesque; the Gothic cathedral; and medieval manuscript illumination. Priester. (HU)

Art 207. (Arch 207) Renaissance Art and Architecture (3)
Survey of the art and architecture of the Italian Renaissance from its beginnings in 13th and 14th century Tuscany and its first flowering in 15th century Florence through the brilliant achievements of the masters of the High Renaissance and later 16th century. Priester. (HU)

Art 211. Drawing III (3)
Projects in traditional and contemporary drawing. Oriented toward developing an individual portfolio. Drawing as a vehicle for ideas, creative expression, and image making. Students investigate a broad range of materials, forms and traditions. Prerequisite: Art 111. Booth or Gans. (HU)

Art 215. Figure III (3)
Further exploration of the human figure as the subject of art. More advanced students may elect to concentrate in either two or three dimensional representations in any media. The emphasis will be on personal interpretation and independent work with the instructor. Prerequisite: Art 115. Gans (HU)

Art 218. Romanticism and Realism (2)
Painting and sculpture from late 18th-Century Romantic origins to 1860; artists such as Goya, Delacroix, Turner, Friedrich, the Hudson River School, Courbet and Daumier. Staff. (HU)

Art 220. 20th-Century Art (3)
A survey of the major movements of 20th century art including Cubism, Expressionism, Surrealism, Abstract Expressionism, Pop, Minimalism, Conceptual Art, Feminism and Post-Modernism. Priester. (HU)

Art 221. Impressionist and Post-Impressionist Painting (2)
Liberation of color in painting; form, emotion and imagination in the Impressionist and Post-Impressionist era. Staff. (HU)

Art 222. Seminar in Contemporary Art (3)
Recent aspects, developments in contemporary art. Exploring ideas and consequences of today's image-making. Studio shops, readings, discussions and museum visits. Prerequisite: Art 2. Staff. (HU)

Art 235. Painting II (3)
Problems in oil, watercolor, acrylic and mixed media. Prerequisite: Art 135. Booth. (HU)

Art 252. Advanced Studio Practice (3)
Advanced studio for art or architecture majors under guidance of faculty. Oral and written critiques. Variable media. May be repeated for credit. Prerequisites: Art 7, 11, 37, 135 or consent of department chairman. Staff. (ND)

Art 253. Graphic Communication III (3)
A combination workshop/seminar course in which the student, as part of a design team, through classroom and individual discussion with the instructor and respective non-profit clients, develops and produces a minimum of two major design projects. Readings and classroom discussions of contemporary graphic design history and current trends form an essential part of the course. Prerequisite: Art 153. Viera. (HU)

Art 269. Special Topics in Art History (3)
Directed projects for advanced students in the history of art or architecture. Prerequisite: consent of the department chairman. May be repeated for credit. Staff. (ND)

Art 273. Special Topics in Studio Practice (1-4)
Individual directed projects for advanced students capable of undertaking independent creative work in studio art. Prerequisite: consent of instructor. May be repeated for credit. Staff. (ND)

Art 277. Special Topics in Photography (1-4)
Individual directed projects in photography for advanced student capable of undertaking creative work in photography. Prerequisites: Art 77, 177 and consent of instructor. May be repeated for credit. Mason. (ND)

Art 335. Painting III (3)
Prerequisite: Art 235 or consent of the department chairman. May be repeated for credit. Staff. (HU)

Art 337. Printmaking Workshop (3) spring
A workshop in printmaking emphasizing individual instruction, and allowing students to explore the mediums of relief, intaglio, lithography, screenprinting, and or combinations while developing a relationship between the print and their other work. May be repeated for credit. Prerequisite: Art 37 and Art 38. Viera. (HU)
Art 350. Special Topics in Graphic Communication (1-4)
Independent study for graduate and advanced undergraduates in intermediate and advanced graphic communication course work in the Art 33, 153, 253, and 353 sequence. May be repeated for credit. Staff. (ND)

Art 355, Graphic Communication Internship (1-4)
Practical in-field experience in a communication design field. Pre-approved a semester in advance by instructor and host organization. A minimum of 15 hours per week. Prerequisite: Art 253, Viera. (ND)

Art 373. Studio Art: Internship (1-4)
Practical in-field experience in an artist’s studio or art-related apprenticeship opportunity. Requires approval a semester in advance by instructor and host organization. Staff. (ND)

Undergraduate Courses in Architecture
Arch 1. Architectural History I (3) fall
Survey of architecture from earliest building to the Renaissance, examined in the context of culture formation, design concepts, and the built environment. Slide lectures. Thomas. (HU)

Arch 2. Architectural History II (3) spring
Survey of architecture from the Renaissance to the present, examined in the context of culture formation, design concepts, and the built environment. Thomas. (HU)

Arch. 43. Architectural Design I (4)
Fundamental design studio for potential architecture majors or minors. Composition, spatial concepts; precedent; materials and detail; light and color in architecture. Instruction in basic communication techniques. Prerequisite: Art 7 or Art 8. Viscardi. (ND)

Arch 103. (Clss 103) Archaeology of Italy (3)
Neolithic, Terramara, Villanovan and Etruscan cultures. Rome the city: its buildings, monuments and streets, through the kingdom, republic, and empire. Survey of Pompeii, Herculanum and Ostia. Lectures, readings and reports. (SS)

Arch 107. History of American Architecture (3) spring
Survey of American building from European colonization to the present. Prerequisite: MArch 1 and Arch 2 or permission of instructor. Thomas. (HU)

Arch 143. Architectural Design II (6)
Studio format, introductory course in architectural design which introduces students to new ways of thinking about architecture and the perception of space, three-dimensional composition, drawing, and model-making. Previous or concurrent courses in studio art and/or architectural history are recommended. Prerequisite: Art 8 and Arch 43. Zaknic, Corallo. (ND)

Arch 147. Building Materials and Methods (3)
The primary structural materials: brick, wood, steel and reinforced concrete are examined in their relationship to architectural design. Peters. (ND)

Art/Arch 174. (Clss 174, Anth 174) Greek Archaeology (3)
Ancient Greek cultures from the neolithic to hellenistic periods. Reconstructions of Greek social dynamics from study of artifacts. Small. (SS)

Arch 176. (Art 176, Clss 176, Anth 176) Roman Archaeology (3)
Cultures of the Roman Empire. Reconstructions of social, political, and economic dynamics of the imperial system from study of artifacts. Small. (SS)

Arch 204. (Clss 204) Ancient City and Society (3)
Ancient theories of city and city planning; attitudes to life in the city; rise of urban civilization from Neolithic prototypes through the Near East, Egypt, Greece, and Rome; insights applicable to current urban problems. (SS)

Arch 206. (Art 206) Medieval Art and Architecture (3)
Focus on art and architecture in Western Europe from 313 A.D. until ca. 1500 A.D. Topics include: the emergence of Christian art and architecture; the art of barbarian migrations; the Carolingian Renaissance; monasticism, pilgrimage and the Romanesque; the Gothic cathedral; and medieval manuscript illumination. Priester. (HU)

Arch 207. (Art 207) Renaissance Art and Architecture (3)
Survey of the art and architecture of the Italian Renaissance from its beginnings in 13th and 14th century Tuscany and its first flowering in 15th century Florence through the brilliant achievements of the masters of the High Renaissance and later 16th century. Priester. (HU)

Arch 209. Architecture and Ideas (3)
Examination of philosophical, technological, and cultural forces shaping Western architecture and urbanism. Prerequisites: MArch 1 and Arch 2 or permission of instructor. Thomas. (HU)

Arch 210. 20th-Century Architecture (3)
History and theory of modern architecture. Analysis of buildings and architects, theories and manifestos, from industrial revolution to avant-garde movements. Prerequisite: Art 1 or Arch 1 and another course in architectural history is recommended. Zaknic. (HU)

Arch 213. The City (3)
Historical development of the modern city. Philosophical, technological, and cultural forces shaping urban experience. Western culture beginning with the Enlightenment. Prerequisites: Art 1 or Arch 1 and Arch 2 or permission of instructor. Thomas. (HU)

Arch 243. Architectural Design III (6)
Continuation of Arch 143. Design principles of space and form stressed in earlier studios to issues of “materality,” “structure,” “modes of representation” and the “process of making.” Prerequisites: Arch 1, 43, 143 and one art studio. Viscardi. (ND)

Arch 253. Paris, the Planning of a Metropolis (3)
alternate summers in Paris
The splendor of modern Paris is due in large part to bold, large-scale modernization and changes in the city’s patterns during the 19th century. This course which is part of LEHIGH IN PARIS summer program will cover a century of change and focus on the major accomplishments of its visionary planners. Zaknic (HU)

Arch 254. Modern Architecture in France: New Directions (3)
alternate summers in Paris
The course which is part of LEHIGH IN PARIS summer program will cover the most important contributions to modern architecture in the Paris region including Centre Pompidou, Musee d’Orsay, LeGrand Louvre, Parc de la Ville, La Defense, and the new satellite towns around Paris. Zaknic (IIU)

Arch 271. Special Topics in Architecture (1-4)
Directed projects for advanced students in architecture or architectural criticism. Prerequisites: Arch 1, 143, Art 8. Major standing in the department or consent of the department chairperson. Student must contact sponsoring professor and complete a contract sheet at preregistration. May be repeated for credit. Staff. (ND)

Arch 311. Portfolio (1)
The concept, layout, and preparation of a portfolio for graduate school application or employment search, including graphic techniques and reproduction methods. Prerequisite: Art 111 or Art 335 or Arch 243. Staff. (ND)

Arch 321. Architectural Internship (1-3)
Supervised internship in architectural firm, planning or preservation office. Internship plan must be approved in writing before it is pursued. Staff. (ND)
Art 342. Theory of Architecture (3)
Study of the genesis of form, its representation and its interrelationship to related artistic disciplines. Formal notions will be studied, compared and manipulated through the role of time, scale, perceptual analysis and material transformation. Permission of instructor required. Viscardi. (ND)

Art 343. Architectural Design IV (6)
Continuation of Arch 243. The design of buildings and building groups, with the emphasis on urban design and the city. Prerequisite: Arch 1, 43, 143, 210, 243 and one art studio. Ussler. (ND)

Art 345. Architectural Design V (3)
Undergraduate thesis. An individual design project exploring, with faculty approval, some aspect of architecture of interest to the student. Prerequisite: Architectural Design I-IV; all other courses required for major, previously or concurrently. Staff. (ND)

Art 351. Computer Aided Design I (3)
Use and role of computers in architecture. Computer aided design (CAD) system selection and operation, geometric modeling, design knowledge. Practical CAD work on a micro-CAD system through design and drafting of architectural projects. Prerequisite: Arch 143 or consent of instructor. Jacobson. (ND)

Art 352. Computer Aided Design II (3)
Use of computer aided design as a tool to design and draft in the area of art, architecture, urban design and structures. Advanced hands on experience both early and detailed stages of design using a micro-CAD system. Prerequisite: Arch 351 or consent of instructor. Jacobson. (ND)

Art 361. (Hist 361) Evolution of Highrise Building Construction (3)
The new materials iron and concrete led to new ways of thinking about building. The Industrial Revolution initiated the development of our modern concept of building and our current urban society. Peters. 0

Art 363. (Hist 363) Evolution of Long-span Bridge Building (3)
New materials, forms of education and technology contributed to advance structural understanding. Specialization and the rise of technological. Peters (HU)

Art 365. (Hist 365) Evolution of the Modern Building Process (3)
The criteria of trade time and money entered the world of building in the 19th century. The unplanned interlude between the design and the inauguration of a building became a new professional field: the building process. (HU)

Art 367. Modernism to Postmodernism (3)
Re-examine the central issues facing the great masters of twentieth-century architecture: how they formulated their principles, how they applied them, and how those who inherited the legacy interpreted it. The major attention will focus on either the great master builders such as Le Corbusier, Mies van der Rohe, Frank Lloyd Wright and Walter Gropius, or on second generation including the transitional figures such as Philip Johnson and other groups: The Whites, Greys, High-Tech, etc. Prerequisite: Art 1/Arch 1 or Art 2/Arch 2 and Arch 210. Zaknic. (HU)

Art 388. Advanced Architectural Design (3) spring
Intensive design projects under a sequence of visiting design instructors. Prerequisites: Arch 210, 243 and consent of the instructor. Zaknic. (ND)

Museum Studies
Art 175. Introduction to Museum Work (3) fall
Introduction to the methods and procedures of research and interpretation of art objects, historical material, sites, documents, specimens, and living entities. The nature of museum work in its practical aspects. Field trips and workshops. Each student completes several interactive projects. Viera. (ND)

Art 275. Museography and Museology (3) fall/spring
Theory and practice in contemporary museums and galleries. Practicum in the L.U.A.G. Museum operation, dealing with collection management, exhibition, and interpretation issues. Student completes a research report or equivalent. Recommend that concentration/minors repeat this course. Prerequisite: Art 175. Viera. (ND)

Art 370. Special Topics in Museum Studies (1-4)
Special project and/or internship for graduate and advanced undergraduates in the Museum Studies sequence: Art 175, 275, 375. Viera (ND)

Art 375. Museum Internship (3) fall/spring
Internship under professional supervision in one or more of the following areas: education/interpretation, collection management, curatorial, exhibition/installation, and development/PR, administration; in one of the following regional organizations: Allentown Art Museum, Lehigh County Historical Society, Kemerer Museum of Decorative Art, Hugh Moore Park, Canal Museum. Prerequisite: Art 275. Viera. (ND)

Arts and Sciences

1-9. Choices and Decisions (1)
Introduction to decision making with emphasis on curriculum, career planning, and social options. Techniques for using values, family history, and social norms as guidelines for decision making processes. Pass-fail grading.

250. Interpersonal Development in a Changing Society (3)
Writing-intensive experiential focus on development of social roles required for effective functioning in a diverse American society. Models of interpersonal communication in groups; cognitive processes in handling individual differences in race, gender, class, sexual orientation and culture in traditional American institutions; synthesis of classroom experiences with readings; social role implications of personal choices. Prerequisite: permission of instructors. A team-taught course. (ND)

Arts-Engineering

The Arts-Engineering program provides the student with an opportunity to experience the breadth of an arts education and simultaneously follow the more focused curriculum of an engineering major. This is a five-year, dual-degree program administered by the College of Arts and Science. An Arts-Engineering graduate is awarded two Bachelors degrees, one from the College of Arts and Science and another from the College of Engineering and Applied Science.

A typical Freshman year class schedule for an Arts-Engineer is shown below.

**freshman year, first semester (16 credit hours)**
- Art 2 Choices & Decisions 1 (P/F)
- Engl 1 Composition/Literature 3
- Math 21 Calculus 4
- Chm 21 Intro Chemical Principles 4
- Chm 22 Intro Chem Princ Lab 1 (Dept) 90 College Seminar 3

**freshman year, second semester (16 credit hours)**
- Engl to be selected 3
- Math 22 Calculus II 4
- Phy 11 Intro Physics I 4
- Phy 12 Intro Physics Lab I 1
- Engr 1 Engineering Computations 3
- Engr 2 Intro to Engineering 1 (P/F)
Selection of a major in the College of Engineering and Applied Science occurs prior to beginning the Sophomore year. A major leading to a degree in the College of Arts and Science should be chosen prior to beginning the Junior year.

Basic Arts-Engineering programs leading to a Bachelor of Arts degree from the College of Arts and Science and a Bachelor of Science degree in an area of engineering are suggested below. The listed courses may be taken in any order if prerequisites are met. Arts-Engineering candidates should recognize that pursuit of a Bachelor of Science degree (e.g., biology, chemistry, biochemistry, earth and environmental science, and math) or a Bachelor of Arts program with larger than average credit requirements (e.g., art, architecture, physical sciences, cognitive science, international careers, among others) will severely restrict choices of free electives. For these students, very careful planning of the academic program is necessary to guarantee completion of all major, distribution and total credit requirements for the two degrees in five years.

The designation AS-courses/electives refers to those courses which meet the major and distribution requirements for the degree in College of Arts and Science. When selected properly, courses which meet distribution requirements in the College of Arts and Science will also satisfy most distribution requirements of the College of Engineering and Applied Science.

**Arts-Chemical Engineering**
A total of 165 credit hours is needed for the bachelor of arts and the bachelor of science degree.

See electives (b) through (e) for the chemical engineering program in Section 111. Careful planning is required so that these may be scheduled during the senior year and fifth year of the program. Any order that does not violate prerequisites is acceptable.

**Sophomore year, first semester** (17 credit hours)
- ChE 31 Material and Energy Balances of Chemical Processes (3)
- Chm 31 Chemical Equilibria in Aqueous Solutions (3)
- Math 23 Calculus III (4)
- Eco 1 Economics (4)
- AS course/elective (3)

**Sophomore year, second semester** (18 credit hours)
- ChE 44 Fluid Mechanics (4)
- Phy 21 Introductory Physics II (4)
- Phy 22 Introductory Physics Lab II (1)
- Chm 187 Physical Chemistry I (3)
- Math 205 Linear Methods (3)
- AS courses/electives (3)

**Junior year, first semester** (18 credit hours)
- ChE 151 Introduction to Heat Transfer (3)
- Chm 51 Organic Chemistry I (3)
- Chm 53 Organic Chemistry Laboratory I (1)
- Chm 192 Physical Chemistry Laboratory (2)
- AS courses/electives (9)

**Junior year, second semester** (17 credit hours)
- ChE 244 Mass Transfer and Separation Processes (3)
- ChE 210 Chemical Engineering Thermodynamics (4)
- ChE 179 Professional Development (1)
- Chm 52 Organic Chemistry II (3)
- AS courses/electives (6)

**Senior year, first semester** (18 credit hours)
- ChE 201 Methods of Analysis in Chemical Engineering (3)
- Chm 189 Physical Chemistry II (3)
- AS courses/electives (6)

**Senior year, second semester** (18 credit hours)
- ChE 211 Chemical Reactor Design (3)
- ChE 242 Introduction to Process Control and Simulation (3)
- electives for engineering major* (6)
- AS courses/electives (6)

**Fifth year**
See program description for senior year of Chemical Engineering.

*These electives are chosen with the chemical engineering adviser.

**Arts-Civil Engineering**
A total of 162 credit hours is needed for the bachelor of arts and the bachelor of science degrees.

**Sophomore year, first semester** (16 credit hours)
- Math 23 Calculus III (4)
- Mech 2 Elementary Engineering Mechanics (3)
- EES 101 Geology for Engineers (3)
- AS courses/electives (6)

**Sophomore year, second semester** (17 credit hours)
- Math 205 Linear Methods (3)
- Mech 12 Strength of Materials (3)
- Phy 21 Introductory Physics II (4)
- Phy 22 Introductory Physics Lab II (1)
- CE 15 Graphics for Civil Engineering (3)
- AS course/elective (3)

**Junior year, first semester** (16 credit hours)
- Mat 192 Structural Materials (3)
- CE 14 Measurements and Problem Solving in Civil Engineering (4)
- CE 121 Mechanics of Fluids (3)
- Engineering Science Elective* (3)
- AS course/elective (3)

**Junior year, second semester** (16 credit hours)
- CE 117 Numerical Methods in Civil Engineering (2)
- CE 222 Hydraulic Engineering (4)
- Eco 1 Economics (4)
- AS courses/electives (6)

**Senior year, first semester** (17 credit hours)
- CE 143 Soil Mechanics (4)
- CE 159 Structural Analysis I (4)
- AS courses/electives (9)

**Senior year, second semester** (17 credit hours)
- CE 160 Structural Design (4)
- CE 270 Water Supply and Wastewater Management (4)
- AS courses/electives (9)

**Fifth year, first semester** (17 credit hours)
- CE 202 Civil Engineering Planning and Engineering Economics (3)
- CE 203 Professional Development (2)
- Civil Engineering electives** (6)
- AS courses/electives (6)

**Fifth year, second semester** (15 credit hours)
- CE 207 Transportation Engineering (3)
- CE 290 Civil Engineering Design Project (3)
- Civil Engineering electives** (3)
- AS courses/electives (6)

*Mech 102, ME 104, or ESE 81
**Elective that requires approval of the Civil Engineering Department Chairperson.
**Arts-Computer Engineering**

A total of 167 credit hours is needed for the bachelor of arts and the bachelor of science degrees.

**sophomore year, first semester** (16 credit hours)
- Math 23 Calculus III (4)
- Phy 21 Introductory Physics II (4)
- Phy 22 Introductory Physics Lab II (1)
- ECE 33 Introduction to Computer Engineering (4)
  AS course/electives (3)

**sophomore year, second semester** (17 credit hours)
- Csc 17 Structured Programming and Data Structures (4)
- Math 205 Linear Methods (3)
- Eco 1 Economics (4)
  AS courses/electives (6)

**junior year, first semester** (16 credit hours)
- ECE 81 Introduction to Electrical Engineering (4)
- Math 231 Probability and Statistics (3) or Math 309 Theory of Probability (3)
  AS courses/electives (9)

**junior year, second semester** (17 credit hours)
- ECE 82 Sophomore Laboratory (1)
- ECE 108 Signals and Systems (4)
  AS courses/electives (1 2)

**senior year, first semester** (17 credit hours)
- ECE 121 Electronic Circuits Laboratory (2)
- ECE 123 Electronic Circuits (3)
- Csc 262 Programming Languages (3)
  approved technical elective* (3)
  AS courses/electives (6)

**senior year, second semester** (15 credit hours)
- ECE 138 Digital Systems Laboratory (2)
- ECE 201 Computer Architecture (3)
- ECE 216 Software Engineering (3)
- Csc 261 Discrete Structures (3)
  AS courses/electives (4)

**fifth year** (36 credit hours)

See program description for senior year of computer engineering.

*Approved technical electives, chosen with the advisor's consent, are subjects in the area of science and technology. They are not restricted to offerings in the department of computer science and electrical engineering. One elective must be an engineering science elective from another department.

**Arts-Electrical Engineering**

A total of 166 credit hours is needed for the bachelor of arts and bachelor of science degrees.

**sophomore year, first semester** (15 credit hours)
- Math 23 Calculus III (4)
- Phy 21 Introductory Physics II (4)
- Phy 22 Introductory Physics Lab I (1)
  AS courses/electives (6)

**sophomore year, second semester** (15 credit hours)
- Math 205 Linear Methods (3)
  approved elective* (3)
  AS courses/electives (9)

**junior year, first semester** (17 credit hours)
- ECE 33 Introduction to Computer Engineering (4)
- ECE 81 Principles of Electrical Engineering (4)

**Math 208** Complex Variables (3)
  AS courses/electives (6)

**junior year, second semester** (17 credit hours)
- ECE 82 Sophomore Laboratory (1)
- ECE 108 Signals and Systems (4)
- ECE 126 Fundamentals of Semiconductor Devices (3)
- Math 231 Probability and Statistics (3)
  AS courses/electives (6)

**senior year, first semester** (18 credit hours)
- ECE 121 Electronic Circuits Laboratory (2)
- ECE 123 Electronic Circuits (3)
- ECE 202 Introduction to Electromagnetics (3)
- Eco 1 Economics (4)
  approved elective* (3)
  AS courses/electives (3)

**senior year, second semester** (14 credit hours)
- ECE 125 Circuits and Systems (3)
- ECE 138 Digital Systems Laboratory (2)
- ECE 203 Introduction to Electromagnetic Waves (3)
  approved technical elective* (3)
  AS courses/elective (3)

**fifth year** (36 credit hours)

See program description for senior year of electrical engineering, under Electrical Engineering and Computer Science.

*Approved technical electives, chosen with the advisor's consent, are listed in the catalog after the description of the Bachelor of Electrical Engineering degree. Students must select a minimum of four courses from that listing, with a minimum of two courses in each of two technical areas described in the list. Students must also choose at least one Science elective in physics, chemistry or biology. For students interested in solid state electronics, quantum mechanics is recommended for the Science elective.

**Arts-Engineering Physics**

A total of 161 credit hours is needed for the bachelor of arts and bachelor of science degrees.

**sophomore year, first semester** (17 credit hours)
- Phy 21 Introductory Physics II (4)
- Phy 22 Introductory Physics Lab II (1)
- Math 23 Calculus III (4)
- Eco 1 Economics (4)
- ECE 81 Principles of Electrical Engineering (4)

**sophomore year, second semester** (16 credit hours)
- Phy 31 Introduction to Quantum Mechanics (3)
- Phy 190 Electronics (3)
- Math 205 Linear Methods (3)
- Math 208 Complex Variables (3)
- ECE 108 Signals and Systems (4)

The student must choose either the Solid State Electronics or the Optical Sciences concentration, listed below.

**Solid State Electronics Concentration**

**junior year, first semester** (18 credit hours)
- Phy 212 Electricity and Magnetism I (3)
- Phy 260 Laboratory Techniques (2)
- ECE 33 Introduction to Computer Engineering (4)
- ECE 123 Electronic Circuits (3)
- Math 322 Methods of Applied Analysis I (3)
  AS courses/electives (3)

- Math 208 Complex Variables (3)
  AS courses/electives (6)

**junior year, second semester** (17 credit hours)
- ECE 82 Sophomore Laboratory (1)
- ECE 108 Signals and Systems (4)
- ECE 126 Fundamentals of Semiconductor Devices (3)
- Math 231 Probability and Statistics (3)
  AS courses/electives (6)

**senior year, first semester** (18 credit hours)
- ECE 121 Electronic Circuits Laboratory (2)
- ECE 123 Electronic Circuits (3)
- ECE 202 Introduction to Electromagnetics (3)
- Eco 1 Economics (4)
  approved elective* (3)
  AS courses/electives (3)

**senior year, second semester** (14 credit hours)
- ECE 125 Circuits and Systems (3)
- ECE 138 Digital Systems Laboratory (2)
- ECE 203 Introduction to Electromagnetic Waves (3)
  approved technical elective* (3)
  AS courses/elective (3)

**fifth year** (36 credit hours)

See program description for senior year of computer engineering.

*Approved technical electives, chosen with the advisor's consent, are listed in the catalog after the description of the Bachelor of Electrical Engineering degree. Students must select a minimum of four courses from that listing, with a minimum of two courses in each of two technical areas described in the list. Students must also choose at least one Science elective in physics, chemistry or biology. For students interested in solid state electronics, quantum mechanics is recommended for the Science elective.

**Arts-Engineering Physics**

A total of 161 credit hours is needed for the bachelor of arts and bachelor of science degrees.

**sophomore year, first semester** (17 credit hours)
- Phy 21 Introductory Physics II (4)
- Phy 22 Introductory Physics Lab II (1)
- Math 23 Calculus III (4)
- Eco 1 Economics (4)
- ECE 81 Principles of Electrical Engineering (4)

**sophomore year, second semester** (16 credit hours)
- Phy 31 Introduction to Quantum Mechanics (3)
- Phy 190 Electronics (3)
- Math 205 Linear Methods (3)
- Math 208 Complex Variables (3)
- ECE 108 Signals and Systems (4)

The student must choose either the Solid State Electronics or the Optical Sciences concentration, listed below.

**Solid State Electronics Concentration**

**junior year, first semester** (18 credit hours)
- Phy 212 Electricity and Magnetism I (3)
- Phy 260 Laboratory Techniques (2)
- ECE 33 Introduction to Computer Engineering (4)
- ECE 123 Electronic Circuits (3)
- Math 322 Methods of Applied Analysis I (3)
  AS courses/electives (3)
junior year, second semester (17 credit hours)
Phy 213 Electricity and Magnetism II (3)
Phy 261 Optics, Spectroscopy, and Quantum Physics Laboratory (2)
Phy 362 Atomic and Molecular Structure (3)
ECE 126 Fundamentals of Electronic Devices (3)
AS courses/electives (6)

senior year, first semester (16 credit hours)
Phy 215 Classical Mechanics (4)
Phy 363 Physics of Solids (3)
SSE Elective* (3)
SSE Elective* or AS courses/electives (3)
AS courses/electives (3)

senior year, second semester (16 credit hours)
SSE Electives* (5)
AS courses/elective or SSE elective (3)
AS courses/electives (8)

fifth year, first semester (15 credit hours)
Phy 340 Thermal Physics (3) or
ME 104 Thermodynamics I (3)
AS courses/electives (12)

fifth year, second semester (15 credit hours)
Phy 171 Physics Proseminar (1)
AS courses/electives (14)

*The 11 credit hours of SSE electives must include ECE 251 or 252 or Phy 273 (must be a design project with an engineering co-advisor). Your advisor has a list of approved SSE electives. Must include at least 30 credits taught by engineers and sufficient engineering design and engineering science credits to satisfy ABET guidelines.

Optical Sciences Concentration
junior year, first semester (16 credit hours)
Phy 212 Electricity and Magnetism I (3)
Phy 215 Classical Mechanics (4)
Math 322 Methods of Applied Analysis I (3)
OE Elective** (3)
AS courses/electives (3)

junior year, second semester (17 credit hours)
Phy 213 Electricity and Magnetism II (3)
Phy 261 Optics, Spectroscopy, and Quantum Physics Laboratory (2)
Phy 362 Atomic and Molecular Structure (3)
OE Elective** (3)
AS courses/electives (6)

senior year, first semester (17 credit hours)
Phy 260 Laboratory Techniques (2)
Phy 352 Modern Optics (3)
OE Elective** (6)
AS courses/electives (6)

senior year, second semester (17 credit hours)
Phy 355 Lasers and Non-linear Optics (3)
OE Elective** (6)
AS courses/electives (8)

fifth year, first semester (15 credit hours)
Phy 340 Thermal Physics or
ME 104 Thermodynamics I (3)
AS courses/electives (12)

fifth year, second semester (15 credit hours)
Phy 171 Physics Proseminar (1)
AS courses/electives (14)

**The 18 credit hours of Optical Engineering electives must include ECE 251 or 252 or Phy 273 (must be a design project with an engineering co-advisor). Must include at least two of ECE 347, 348, 371, and 372. Your advisor has a list of approved OE electives. Must include at least 30 credits taught by engineers and sufficient engineering design and engineering science credits to satisfy ABET guidelines.

Arts-Industrial Engineering
A total of 159 credit hours is needed for the bachelor of arts and bachelor of science degrees.

sophomore year, first semester (17 credit hours)
Math 23 Calculus III (4)
Phy 21 Introductory Physics I (4)
Phy 22 Introductory Physics Lab I (1)
IE 111 Engineering Probability and Statistics (3)
IE 112 Computer Graphics (1)
Eco 1 Economics (4)

sophomore year, second semester (17 credit hours)
IE 121 Applied Engineering Statistics (3)
IE 122 Software Tools (1)
IE 131 Work Systems and Facilities Planning (3)
IE 132 Work Systems Laboratory (1)
Acct 108 Introduction to Accounting (3)
AS courses/electives (6)

junior year, first semester (15 credit hours)
Math 205 Linear Methods (3)
IE 221 Operations Research-Probabilistic Models (3)
Mat 33 Engineering Materials and Processes (3)
AS courses/electives (6)

junior year, second semester (16 credit hours)
IE 222 Operations Research-Deterministic Models (3)
ECE 81 Principles of Electrical Engineering (4)
IE 224 Information Systems Analysis and Design (3)
AS courses/electives (6)

senior year, first semester (16 credit hours)
IE 115 Fundamentals of Modern Manufacturing (3)
IE 116 Manufacturing Laboratory (1)
Mech 2 Elementary Engineering Mechanics (3)
AS courses/electives (9)

senior year, second semester (15 credit hours)
IE 124 Engineering Economy (3)
ME 104 Thermodynamics (3)
IE 305 Simulation (3)
AS courses/electives (6)

summer
IE 100 Industrial Employment (0)

fifth year

See program description for senior year of Industrial Engineering.

Arts-Materials Science and Engineering
A total of 165 credit hours is needed for the bachelor of arts and bachelor of science degrees, depending on the option selected.

sophomore year, first semester (16 credit hours)
Mat 33 Engineering Materials and Processes (3)
Math 23 Calculus III (4)
Phy 21 Introductory Physics II (4)
Phy 22 Introductory Physics Lab II (1)
Mat 10 Materials Laboratory (1)
AS courses/elective (3)
sophomore year, second semester (17 credit hours)
Mech 2 Elementary Engineering Mechanics (3)
Math 205 Linear Methods (3)
Mat 203 Computational Methods in Materials Science (2)
Mat 205 Structure and Characterization of Materials (3)
Mat 205 Thermodynamics and Phase Diagrams (3)
AS courses/electives (3)

junior year, first semester (16 credit hours)
Chm 209 Chemistry of Materials (3)
Mat 216 Diffusion and Phase Transformations (3)
Mat 218 Mechanical Behavior of Materials (3)
Eco I Economics (4)
AS courses/electives (3)

junior year, second semester (15 credit hours)
Mat 204 Processing and Properties of Polymeric Materials (3)
Mat 206 Processing and Properties of Metals (3)
Mat 214 Processing and Properties of Ceramic Materials (3)
AS courses/electives (6)

senior year, first semester (18 credit hours)
AS courses/electives (18)

senior year, second semester (15 credit hours)
ECE 81 Principles of Electrical Engineering (4)
Mat 101 Professional Development (2)
AS courses/electives (9)

fifth year (36 credit hours)

See program description for senior year of Materials Science and Engineering

Note: Students interested in the industrial or research options should consult with the department chairperson prior to their fourth year. Students selecting the research option should elect Mat 240, Research Techniques, in the first semester of the senior year.

Arts-Mechanical Engineering
A total of 158 credit hours is needed for the bachelor of arts and the bachelor of science degrees.

sophomore year, first semester (16 credit hours)
Phy 21 Introductory Physics II (4)
Phy 22 Introductory Physics Lab II (1)
Math 23 Calculus III (4)
ME 10 Graphics for Engineering Design (4)
AS course/electives (3)

sophomore year, second semester (18 credit hours)
Mech 2 Elementary Engineering Mechanics (3)
ME 104 Thermodynamics I (3)
Math 205 Linear Methods (3)
AS courses/electives (9)

junior year, first semester (16 credit hours)
Mech 12 Strength of Materials (3)
ME 205 Thermodynamics II (3)
ECE 81 Principles of Electrical Engineering (4)
AS courses/electives (6)

junior year, second semester (14 credit hours)
Mech 102 Dynamics (3)
ME 21 Mechanical Engineering Laboratory I (1)
ME 231 Fluid Mechanics (3)
ECE 162 Electrical Laboratory (1)
AS courses/electives (6)

senior year, first semester (16 credit hours)
ME 111 Professional Development (1)
Mat 33 Engineering Materials and Processes (3)
Math 208 Complex Variables (3) or
Math 231 Probability and Statistics (3)
ME 252 Mechanical Elements (3)
AS courses/electives (6)

senior year, second semester (15 credit hours)
ME 101 Mechanical Engineering Design I (2)
ME 242 Mechanical Vibrations (3)
ME 240 Manufacturing (3)
ME 121 Mechanical Engineering Laboratory II (1)
AS courses/electives (6)

fifth year
See program description for senior year of Mechanical Engineering & Mechanics.

Arts-Master of Business Administration Program

The arts-master of business administration two-degree program is a special opportunity offered by the College of Arts and Sciences. See Section III for a description.

Asian Studies

Constance Cook, Ph.D. (U.C., Berkeley), associate professor of Chinese language and literature; director, Asian studies.

Professor. John Gatewood, Ph.D. (Illinois), Sociology and Anthropology; Norman Girardot, Ph.D. (Chicago), Religion Studies;
Michael Notis, Ph.D. (Lehigh), Materials Science and Engineering;

Associate professors. Constance Cook, Ph.D. (U.C., Berkeley),
Modern Foreign Language; Kenneth Kraft, Ph.D. (Princeton),
Modern Foreign Languages; David Pankenier, Ph.D. (Stanford), Modern Foreign Languages; Nicola Tansu, Ph.D. (Iowa), Sociology and Anthropology.

Assistant professors. Gail Cooper, Ph.D. (U.C., Santa Barbara),
History; Kari Lee, Ph.D. (Harvard), Modern Foreign Languages,
Michael Mendelson, Ph.D. (San Diego), Philosophy.

The Asian Studies program affords undergraduates in any college within Lehigh an opportunity to acquire a systematic knowledge of Asia, specifically East Asia, Southeast Asia, and the Pacific. The program focuses on the rich historical and cultural heritage of the countries of Asia, as well as their growing importance in world affairs and their critical relationship to the national interests of the United States.

The major in Asian Studies may have a Chinese studies or a Japanese studies concentration, each requiring a minimum of 9 courses or 36 credits. Chinese or Japanese language to intermediate level (2 years) is required, in addition to other courses in the humanities and social sciences. The major is based on an approved list of courses in Asian Studies, chosen in consultation with the major advisor, Dr. David Pankenier, Modern Foreign Languages, 516 Maginnes Hall, 758-3090.

The minor in Asian Studies is composed of a minimum of 4 courses or 15 credits in Asian Studies, chosen from an approved list in consultation with the minor advisor, Dr. David Pankenier, Modern Foreign Languages, 516 Maginnes Hall, 758-3090.

Additional courses are offered at other LVAIC institutions and may be taken for credit by Lehigh students. In addition, students may avail themselves of a variety of extracurricular activities that are offered in Asian Studies, such as special lectures and seminars, films, performances and exhibits.
Students are encouraged to spend a summer, semester or year abroad in an approved study program in China, Japan, Korea, Southeast Asia or the Pacific. Subject to prior approval, credits acquired abroad can be transferred back to Lehigh. For details on various programs currently available, consult Cas Sowa, Study Abroad Coordinator, International Education Office, 344 Whitaker Laboratory, 758-3351.

The program cooperates with the LVAIC Asia Seminar, which meets four times a year (twice a semester) to discuss current research in various fields. While the seminar primarily involves faculty, Asian Studies majors and minors are also encouraged to participate. The seminar coordinator is Dr. Norman Girardot, Religion Studies, 243 Maginnes Hall, 758-3364.

The overall program is administered by the Asian Studies Committee, an interdisciplinary body of faculty members with a special interest in the region. This committee oversees both the formal academic work within the program as well as the extracurricular activities sponsored by the university. It also cooperates with the Asian Cultural Society and other campus organizations involved in aspects of Asian Studies.

The courses are regularly offered in the program and new ones are currently under development in a number of subject areas. (Consult the Registrar's Schedule of Classes for specific offerings in any particular semester.)

For further information, interested students should consult Dr. Constance Cook, Director, Asian Studies Program, 519 Maginnes Hall, 758-3091 or any of the Asian Studies faculty listed above.

**Major in Asian Studies**

The Asian Studies major is designed to accomplish three goals: to ground the student in a regional language and culture (Chinese or Japanese); to survey various disciplines in Asian Studies more broadly; and to provide advanced research opportunities in the upperclass years. The program, when completed successfully, will prepare the student for further graduate work, professional education, or employment in the public or private sector. There is an increasing demand for graduates who combine three in a disciplinary field (e.g., business, economics, international relations) with a second major (or minor) in Asian Studies, including Chinese or Japanese language competence.

The major in Asian Studies may have a Chinese studies or a Japanese studies concentration, each requiring a minimum of 9 courses (36 credits). The distribution of the credits is as follows, subject to the guidance of the academic advisor, Dr. David Pankenier, Modern Foreign Languages, 515 Maginnes Hall, 758-3090. Full descriptions of all Asian Studies courses are provided in the listings of individual departments.

**Minor in Asian Studies**

The minor in Asian studies is intended as a complement to a student's major field of study, and it is flexible according to individual needs. Students are free to survey the field broadly or concentrate in a special area such as Chinese or Japanese studies. The minor is composed of a minimum of 4 courses (16 credits) in Asian studies, chosen from an approved list in consultation with the minor advisor, Dr. David Pankenier, Modern Foreign Languages, 515 Maginnes Hall, 758-3090.

**Study Abroad Programs**

Students are encouraged to spend a summer, semester or year in an approved study program in China, Japan, Korea, Southeast Asia or the Pacific. Students who wish to study abroad, and who wish to have the academic work taken in that program count toward a Lehigh degree, must have a GPA of 2.0 or higher. Any student with a lower GPA may petition the Committee on Standing of Students for an exception to this rule before applying to an approved study abroad program. These programs are open to all LVAIC students subject to the regulations of their home institutions. For details on all programs, contact Cas Sowa, Lehigh Abroad Program Officer, International Education Office, 343 Whitaker Laboratory, 758-3351.

1. Core Requirements

**A. Language and Culture**: Chinese or Japanese to intermediate level (2 years); 4 courses (16 credits), based on placement, chosen from the following *

- Chin 1
- Chin 2
- Chin 11
- Chin 12
- Chin 41
- Chin 42
- Chin 91
- Chin 191
- Jnps 1
- Jnps 2
- Jnps 11
- Jnps 12
- Jnps 91
- Jnps 191

*Note 1. Students with prior knowledge of Chinese or Japanese will be placed on the basis of a competence test. Native speakers placing out of the language requirement in part or whole will be required to take additional Asian studies courses to make up a minimum of 36 credit hours.

**B. Humanities and Social Sciences**: 3 courses (minimum 10 credits) chosen from the following:

- Asia 31 (Hist 31)
- Asia 61 (IR 61)
- Asia 62 (Rel 62)
- Asia 64 (Rel 64)
- Asia 65 (Rel 65)
- Asia 67 (Rel 67)
- Asia 73 (MFL 73)
- Asia 74 (MFL 74)
- Asia 75 (Hist, MFL 75)
- Asia 77 (Rel 77)
- Asia 125 (MFL 125)
- Asia 140 (Phil 140)
- Asia 141 (STS 141)
- Asia 160 (Rel 160)
- Asia 161 (IR 161)
- Asia 162 (Rel 162)
- Asia 163 (IR 163)
- Asia 164 (IR, Rel 164)
- Asia 168 (Rel 168)
- Asia 169 (Rel 169)
- Asia 177 (Hist, MFL 177)
- Asia 184 (Anth 184)
- Asia 187 (Anth 187)

11. Advanced Electives

Two courses (7 or 8 credits) chosen from the following, 1 course (4 credits) of which must be at the 300 level:

**A. Language and Culture**:

- Chin 141
- Chin 142
- Chin 251
- Chin 291
- Chin 371
- Jnps 141
- Jnps 142
- Jnps 195
- Jnps 196
- Jnps 290
- Jnps 291

**B. Area Study**: at least 1 course (4 credits) in an area of study:

- History of Japanese Industrialization since 1800 (3 SS)
- East Asian International Relations (4) SS
- Religions of India (4) HU
- Religions of China (4) HU
- Religions of Japan (4) HU
- Introduction to Japanese Civilization (4) HU/SS
- Fiction into Film: Modern Chinese Literature (4) HU
- Chinese Cultural Program (1-6) HU/SS
- Chinese Civilization (4) HU/SS
- The Islamic Tradition (4) HU
- The Islamic Tradition (4) HU
- Immortal Images: Traditional Chinese Literature (4) HU
- Literature in Translation (4) HU
- Eastern Philosophy (3) HU
- Science and Technology in East Asia (4) SS
- The Taoist Tradition (4) HU
- China in World Affairs (4) SS
- Zen Buddhism (4) HU
- Japan in World Affairs (4) SS
- Buddhism in the Modern World (4) HU
- Japan's Response to the West (4) HU/SS
- Buddhism in the Modern World (4) HU
- Classics of Asian Religions (4) HU
- Classics of Asian Religions (4) HU
- China Enters the Modern Age (4) HU/SS
- Science and Technology in East Asia (4) SS
- Cultures of the Pacific (3) SS
- Cultures of the Pacific (3) SS
- Peoples of Southeast Asia (3) SS
- Peoples of Southeast Asia (3) SS
B. Humanities and Social Sciences:

Asia 221 (Rel 221) Topics in Asian Religions (4) HU/SS
Asia 361 Internship in Asian Studies (1-4) HU/SS
Asia 364 (IR 364) Seminar in the International Relations of East Asia/Pacific Rim (4) SS
Asia 371 Advanced Readings in Asian Studies (4) HU/SS
Asia 381 Special Topics in Asian Studies (4) HUBS
Asia 391 Senior Seminar in Asian Studies (4) HU/SS
Asia 399 Senior Thesis in Asian Studies (4) HUBS

C. Other suitable courses at LVAIC or other approved institutions in the United States.

D. Other suitable courses in approved study abroad programs in East Asia.

ASIAN STUDIES COURSES NOT CROSS LISTED ELSEWHERE IN THE CATALOG

ASIA 361. Internship in Asian Studies (1-4)
Internship in public or private agency involved in some aspect of Asian studies. Individual faculty mentor. Written report required. May be repeated for credit. Program permission required. (HU/SS depending on topic)

ASIA 371. Advanced Readings in Asian Studies (4)
Directed course of reading and writing in advanced topic not covered in regular Asian Studies course offerings. May be repeated for credit. Program permission required. (HU/SS depending on topic)

ASIA 381. Special Topics in Asian Studies (4)
Advanced study of aspects of Asian studies not covered in regular course offerings. Individual faculty supervision. Research paper required. May be repeated for credit. Program permission required. (HU/SS depending on topic)

ASIA 391. Senior Seminar in Asian Studies (4)
Advanced seminar focusing on discussion and research on specialized subjects in Asian studies. Variable subject matter. Offered by faculty on rotating basis. May be repeated for credit. Program permission required. (HU/SS depending on topic)

ASIA 399. Senior Thesis in Asian Studies (4)
Advanced, individual research project on topic agreed between faculty and student. Research paper and oral defense required. May be repeated for credit. Open to Asian studies majors only. Program permission required. (HU/SS depending on topic)

Astronomy

Professor, George E. McCluskey, Ph.D. (Pennsylvania), head.

Astronomy is offered in the department of mathematics.

1. The Solar System (3) fall
Apparent motions of celestial bodies on the celestial sphere; rotation and revolution of planets and satellites; properties of the planets, their satellites, asteroids, comets, and meteoroids; origin of the solar system; the Sun. (NS)

2. Stellar Astronomy (3) spring
Apparent brightnesses, colors, spectra, and absolute properties of stars; the birth, evolution and death of single and binary stars; the interstellar medium; the Galaxy; galaxies and clusters of galaxies; the nature of the universe. (NS)

171. Readings (1-3) fall-spring
For nonscience majors to study an area of astronomy more deeply than at the introductory level. Individual supervision. Prerequisites: Astr 1 or Astr 2, and Math 21 or Math 31 or Math 41. May be repeated for credit with the consent of the division head.

211. Stellar Structure and Evolution (3) fall, even-numbered years

221. Stellar Atmospheres (3) fall, odd-numbered years
Observation and theory of stellar spectra. Model atmospheres and chemical abundance. Extended atmospheres, stellar winds and mass loss. Theory of gaseous nebulae. Prerequisites: Math 23 or Math 32 or Math 44, previously or concurrently, and Phys 21. (NS)

332. (Phy 332) High-Energy Astrophysics (3) spring, odd-numbered years
Observation and theory of X-ray and gamma-ray sources, quasars, pulsars, radio galaxies, neutron stars, black holes. Results from ultraviolet, X-ray and gamma ray satellites. Prerequisites: Math 23 or Math 32 or Math 44, previously or concurrently, and Phys 21. (NS)

342. (Phy 342) Relativity and Cosmology (3) spring, even-numbered years
Special and general relativity. Schwarzschild and Kerr black holes. Supermassive stars. Relativistic theories of origin and evolution of the universe. Prerequisites: Math 23 or Math 32 or Math 44, previously or concurrently, and Phys 21. (NS)

350. Topics in Astrophysics (3) fall-spring
For science or engineering majors who desire to study an active area of research in astrophysics. Individual supervision. Prerequisites: Astr 2, and Math 23 or Math 32. May be repeated for credit with the consent of the division head. (NS)

Biochemistry

Interdepartmental B.S. Biochemistry majors are offered in both the College of Engineering and Applied Science and the College of Arts and Sciences. The chemistry, biochemistry and collateral science requirements differ somewhat for the two programs. The B.S. in biochemistry degrees in both colleges are managed by an interdepartmental committee composed of biochemists (Alhabedoff, Behe, Lowe-Krentz, and Schrader), bioorganic chemists (Foster, Heindel, and Regen), and Molecular/Cellular Biologists (Cassimeris and Ware). The committee administers the degree, monitors the academic program, provides research possibilities, and advises student majors. The director of the program is currently Linda J. Lowe-Krentz.

Bachelor of Science Degree in Biochemistry College of Engineering and Applied Science

freshman year (see Section 111) (30 credit hours)
Note: It is recommended that, where possible, students planning to major in chemistry take Chemistry 75 in the fall semester and Chemistry 76 in the spring semester of the freshman year. For such students, the Humanities, Social Science elective in the spring semester is displaced to a subsequent semester. The Chemistry 21/22/21 sequence may be substituted.

sophomore year, first semester (16 credit hours)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chm 51</td>
<td>Organic Chemistry I (3)</td>
</tr>
<tr>
<td>Chm 53</td>
<td>Organic Chemistry Lab I (1)</td>
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<tr>
<td>Phys 21</td>
<td>Intro. Physics II (4)</td>
</tr>
<tr>
<td>Phys 22</td>
<td>Intro. Physics Lab II (1)</td>
</tr>
<tr>
<td>Math 23</td>
<td>Analytic Geometry and Calculus III (4)</td>
</tr>
<tr>
<td></td>
<td>modern foreign language requirement (3)*</td>
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</tbody>
</table>

*modern foreign language requirement may be transferred to the major program.
Biochemistry 85

II. Collateral Science Requirements at least 24 hours
   a. Physics 11, 12, 13, 14 (or 21, 22) 9 (or 10 hours)
   b. Mathematics 51, 52, 43 (or 21, 22, 23) and a statistics course at least 12 hours
   c. Computer Science 11 or Engineering 1 3 hours

III. Required Chemistry Courses 25 to 26 hours
   a. Introductory Chemistry 75, 76 8 hours*
   b. Organic Chemistry 51, 52, 53 8 hours
   c. Inorganic Chemistry 205 or 307 2 or 3 hours
   d. Physical Chemistry 187 or 194 3 hours
   e. Analytical Chemistry 332 3 hours

   *The Chemistry 21/22/31 sequence may be substituted.

IV. Required Biological Science courses 24 hours
   a. Biochemistry 371, 372, 377 9 hours
   b. Introduction to Cell and Molecular Biology 31, 32 4 hours
   c. Advanced Laboratory 4 hours
d. Electives in Biological Sciences 6 hours minimum*
 f. Technical Writing 2 hours minimum

   *The six credit hours of biological sciences electives are chosen with the approval of the adviser.

Model Pattern Roster

freshman Year

Chm 75, 76 Concepts, Models, and Experiments I and II (8)
Bios 31, 32 Intro. to Cell and Molecular Biology and Laboratory (4)
Math 51, 52 Survey of Calculus I and II (7) or
Math 21, 22 Calculus I and II (8)
FS 90 College Seminar (3)
A&S 1 Choices & Decisions (1)
Engl 1, 2 Composition and Literature (6)
Phy 11, 12 Introductory Physics I and Laboratory (5)

sophomore Year

Chm 51, 52, 53, 58 Organic Chemistry and Laboratory (8)
Phy 13, 14 Introductory Physics II-B and Laboratory (4) or
Phy 21, 22 Introductory Phys. II and Laboratory
Math 43 Linear Algebra (3) or
Math 23
Bios 110 Experimental Design and Statistical Analysis**
Chm 187 Physical Chemistry (3)*
Bios elective

*Alternatively, if Chm 194 is elected, it would be taken fall of junior year

**A statistics course from the Math department could also fulfill the statistics requirement

junior year

Chm 332 Analytical Chemistry (3)
Bios 371, 372 Elem. of Biochemistry I and II (6)
Bios 377 Biochem. Lab (3)
Chm 205 Main Group Elements (2)*
CSc 11 Introduction to Structured Programming (3)
Tech Writing (2)

*If Chm 194 is taken in the junior year, Chm 205 would be displaced to senior year. If Chm 307 is elected in place of Chm 205, it would be taken in the senior year.

senior year

Bios Advanced laboratory course(s)
Bios elective

Summary
Total required chemistry hours 37
Total required biological science hours 18*
Total required physics, mathematics, computer hours 28
Total required college distribution hours 24**
Unrestricted elective hours 18
Program total hours requirement is 126.

*The nine credit hours of biological sciences electives are chosen with the approval of the adviser.

**The department modern foreign language requirement would normally meet college distribution requirements and be included in the 24 hours. In the event that this is not the case, the unrestricted elective hours will have to be used to meet this modern language requirement.

Bachelor of Science Degree in Biochemistry

College of Arts and Science

I. College and University Requirements 28 hours
   a. English 1, 2 6 hours
   b. Arts and Science 1 1 hour
   c. First Year Seminar 3 hours
   d. Non-science electives 16 hours to be broadly distributed in fields of thought other than natural science and mathematics, including at least 8 hours each in humanities and social sciences.
Biological Sciences

Professors, Neal Simon, Ph.D. (Rutgers), chairperson; John H. Abel, Ph.D. (Brown); Dave Cundall, Ph.D. (Arkansas); Murray Izkowitz, Ph.D. (Maryland); Steven Krawiec, Ph.D. (Yale); John Nyby, Ph.D. (Texas); Jeffrey A. Sands, Ph.D. (Penn State).

Associate professors, Barry Bean, Ph.D. (Rockefeller); Michael J. Behe, Ph.D. (Pennsylvania); Lynne Cassimers, Ph.D. (North Carolina); Michael R. Kuchka, Ph.D. (Carnegie-Mellon); Linda J. Lowe-Krentz, Ph.D. (Northwestern); Jill Schneider, Ph.D. (Wesleyan); Class of 1961 Professor, Jennifer Swann, Ph.D. (Northwestern); Vassie C. Ware, Ph.D. (Yale).

Assistant professors, Agnes Aymé-Southgate, Ph.D. (Geneva).

Adjunct professors, Janice A. Phillips, Ph.D. (Pennsylvania); Martin L. Richter, Ph.D. (Indiana).

Instructor, James J. Campanella, Ph.D. (Case Western Reserve).

The biological sciences include the study of living systems at levels ranging from the structure and function of molecules to the behavior and evolution of communities of organisms. The Department offers four different routes to mastering skills and knowledge in this broad area. The B.A. and B.S. programs in Biology provide a broad introduction to biology with opportunities for students to create a program of study suited to their specific interests. Programs of study focused on particular aspects of biology are the B.A. and B.S. degrees in the areas of Behavioral Neuroscience and Molecular Biology, and the two interdepartmental B.S. degrees in Biochemistry managed in conjunction with the Chemistry Department (one of the biochemistry degrees is in the engineering college). For programs in Ecology and Environmental Biology, see the Department of Earth and Environmental Sciences listing.

The requirements for the B.A. and B.S. in Biology, Behavioral Neuroscience, and Molecular Biology are listed below. Research interests of the faculty and instrumentation are described in the section on graduate education.

For programs in ecology and environmental biology, see the Department of Earth and Environmental Sciences listing.

B.A. with Major in Biology

College and university requirements (26 credit hours)
Engl Composition and Literature (6)
A&S 1 Choices and Decisions (1)
First Year Seminar (3)
Social Sciences (8)
Humanities (8)

Major Program (48-49 credit hours)

Biology (30 credit hours)
EES 31 Intro. to Environmental and Organismal Biology (4)
Bios 31 Intro. to Cell and Molecular Biology (3)
Bios 32 Intro. Cell and Molecular Laboratory (1)
Bios 101 Genetics (3)
Bios 102 Genetics Laboratory (1)
Electives Biology approved electives (18 credit hours)

Mathematics (7 credit hours)
Math 51 Survey of Calculus I (4)*
Math 52 Survey of Calculus II (3)*

Chemistry/Physics (11 credit hours)
Chm 21 Introductory Chemical Principles (4)*
Chm 22 Chemical Principles Laboratory (1)*
Chm 51 Organic Chemistry (3)

and one of the following:
Chm 31 Chemical Equilibrium in Aqueous Systems (3) or
Chm 194 Physical Chemistry for Biological Sciences (3) or
Phy 11 Introductory Physics I (4)

*Although no specific sequence is required, it is recommended that courses marked with an asterisk be completed during the freshman year.

The B.S. in Biology

The Bachelor of Science in biology offers broad scientific preparation in biology to facilitate advanced work in the life sciences. Progression through the program is best served through early commitment.

Requirements for the B.S. in Biology

College and university requirements (26 credit hours)
Engl Composition and Literature (6)
A&S 1 Choices and Decisions (1)
First Year Seminar (3)
Social Sciences (8)
Humanities (8)

Major Program (84 credit hours)

Biology (35 credit hours)
Bios 31 Intro. to Cell and Molecular Biology (3)
Bios 32 Intro. Cell and Molecular Laboratory (1)
Bios 101 Genetics (3)
Bios 102 Genetics Laboratory (1)
Bios 317 Evolution (3)
Electives Biology electives (26)

*Biology electives must include one course from list A, one course from list B and at least four credits of laboratory experience (e.g. two 2 credit laboratory courses). These will be chosen in consultation with the major advisor.

List A
Bios 313 Vertebrate Histology (4)
Bios 314 Vertebrate Development (3)
Bios 335 Animal Behavior (3)
Bios 337 Behavioral Ecology (3)
Bios 375 Neuroanatomy of Behavior (3)
Bios 382 Endocrinology of Behavior (3)

List B
Bios 324 Bacteriology (3)
Bios 345 Molecular Genetics (3)
Bios 353 Virology (3)
Bios 356 Human Genetics and Reproduction (3)
Bios 357 Cell Biology (3)
Bios 371 Elements of Biochemistry I (3)

Mathematics (12 credit hours minimum)
either
Math 51, 52, 43 Survey of Calculus I, II and Linear Algebra (10)
or
Math 21, 22, 23 Analytic Geometry and Calculus I, II, III (12)
and
Bios/Psysc 110 Experimental Design and Statistical Analysis (4)

Collateral Sciences (37 credit hours)
Chm 75, 76 Concepts, Models and Experiments I and II (8)
Chm 51, 52 Organic Chemistry I and II (6)
Chm 53, 58 Organic Chemistry Laboratory I and II (2)
Phy 11 Introductory Physics I (4)
Phy 12 Introductory Physics Laboratory I (1)
Phy 13 General Physics (3)
Phy 14 General Physics Lab (1)
Recommended B.S. Biology Sequence

Freshman Year
Bios 31 Intro. to Cell and Molecular Biology (3)
Bios 32 Intro. Cell/Molecular Laboratory (1)
Math 51, 52 Survey of Calculus I and II (7)
Chm 75, 76 Concepts, Models and Experiments I and II (8)
FS 90 First Year Seminar (3)
A&S 1 Choices & Decisions (1)

Sophomore Year
Bios 101 Genetics (3)
Bios 102 Genetics Laboratory (1)
Chm 51, 52, 53, 58 Organic Chemistry and Laboratory (8)
Math 43
Bios/Psyc 110 Experimental Design and Statistical Analysis (4)
elective Approved Biology elective (3-4)

Junior Year
Phy 11, 12 Introductory Physics I and Laboratory (5)
Phy 13, 14 General Physics and Laboratory (4)
elective Approved Biology electives including one from list A and one from list B (9-12)

Senior Year
Bios 317 Evolution (3)
elective Biol electives including at least 4 cr of laboratory (10-14)

Minor in Biology
A minor in biology may be achieved by completing the following requirements (27 credits):
EES 31 Intro. to Environmental/Organismal Biology (4)
Bios 31, 32 Intro. to Cell and Molecular Biology and Laboratory (4)
Bios 101, 102 Genetics and Genetics Laboratory (4)
Chm 21, 22 Introductory Chemical Principles and Laboratory (5)
Chm 51 Organic Chemistry (3)
Math 51 Survey of Calculus I (4)
elective Biology electives (3)

B.A. in Behavioral Neuroscience
The B.A. in Behavioral Neuroscience is a natural science major for B.A. distribution purposes.

Required Major Courses

Core Courses
Psyc 1 Introduction to Psychology (4)
EES 31 Intro. to Environmental/Organismal Biology (4)
Bios 31 Intro. to Cell and Molecular Biology (3)
Bios 32 Intro. to Cell and Molecular Biology Laboratory (1)
Bios 101 Genetics (3)
Bios/psych 110 Experimental Design and Statistical Analysis (3)
Bios 277 Experimental Neuroscience Laboratory (4)
Psyc 210 Experimental Psychology (4)
Bios 375 Introduction to Behavioral Neuroscience (3)
Bios 382 Neuroanatomy of Behavior (3)

Major electives (6 credits)
Bios 134 Comparative Vertebrate Anatomy (4)
Bios 221 Human Histology (4)
Bios 229 Immunology (3)
Bios 313 Vertebrate Histology (4)
Bios 314 Developmental Biology (3)
Bios 317 Evolution (3)
Bios 324 Bacteriology (3)

Bios 335 Animal Behavior (3)
Bios 337 Behavioral Ecology (3)
Bios 345 Molecular Genetics (3)
Bios 353 Virology (3)
Bios 356 Human Genetics and Reproduction (3)
Bios 367 Cell Biology (3)
Bios 371 Elements of Biochemistry 1 (3)
Bios 372 Elements of Biochemistry II (3)
Bios 373 Sensation and Perception (3)
Bios 377 Biochemistry Laboratory (3)
Chm 31 Chemical Equilibria in Aqueous Systems (3)
Psyc 77 Drugs and Behavior (3)
Psyc 117 Cognitive Psychology (3)
Psyc 153 Personality (3)
Psyc 154 Introduction to Clinical Psychology (3)
Psyc 171 Learning Processes and Applications (3)
Psyc 176 Mind and Brain (3)
Psyc 305 Abnormal Psychology (3)
Psyc 307 Seminar in Cognition (3)
Psyc 377 Seminar in Physiological Psychology (3)
EES 361 Animal Physiology (4)

Required Courses in Math and Chemistry
Math 51, 52 Survey of Calculus I and II (7) or
Math 21, 22 Calculus I and II (8)
Chm 21 Introductory Chemical Principles (4)
Chm 22 Chemical Principles Laboratory (1)
Chm 51, 52 Organic Chemistry (6)
Chm 53, 58 Organic Chemistry Laboratory I and II (2)

Other Options
The B.A. in Behavioral Neuroscience is a traditional liberal arts degree which can be structured for a wide variety of possibilities (see listing of recommended elective courses). By using free electives to take additional science, the B.A. also can serve as a preprofessional degree for many graduate and professional schools. Students interested in a particular career-based program should consult their advisor or the program director (Professor John Nyby).

B.S. in Behavioral Neuroscience
B.S. majors are required to take the core courses of the B.A. program and to fulfill the elective requirements of the B.A. program. An early commitment to the B.S. is desirable to meet all the requirements of this program. Additional requirements are shown below.

Math and science requirements for the B.S.
Math 21, 22, 23 Calculus I, II & III (12)
Chm 21, 22 Introductory Chemical Principles & Lab (5)
Chm 51, 52 Organic Chemistry I & II (6)
Chm 53, 58 Organic Chemistry Laboratory (2)
Bios 154 Comparative Vertebrate Anatomy (4)
Bios 371 & 372 Elements of Biochemistry I & II (6)
Bios 377 Biochemistry Laboratory (3)
Phy 11, 12 Introductory Physics and Laboratory (5)
Phy 13, 14 General Physics and Laboratory (4)
Phy 21, 22 can substitute for Phys 13, 14 (5)

University and College requirements for the B.S.
Engl 1 Composition and Literature (3)
Engl 2, 4, 6, 8 or 10 Composition and Literature (3)
A&S 1 Choices and Decisions (1)
First Year Seminar (3)

Nonscience Electives (16) to be broadly distributed in fields of thought other than the natural sciences and mathematics, including at least 8 credit hours each in the humanities and social sciences.
Requirements for the B.A. in Molecular Biology

College and University requirements (see Section 111).

A. A&S 1, Choices and Decisions 1 credit
B. College Seminar 3 credits
C. English composition 6 credits
D. Mathematical sciences 3-4 credits*
E. Sciences 8 credits
F. Social sciences 8 credits
G. Humanities 8 credits*

The BA in Molecular Biology

Molecular Biology (30 credit hours)
Bios 31, 32 Introduction to Cell & Molecular Biology (3) and Lab (1)
Bios 101, 102 Genetics (3) and Lab (1)
Bios 324, 325 Bacteriology (3) and Lab (2)
Bios (Chm) 371 Biochemistry (3)
Bios 345, 346 Molecular Genetics (3) and Lab (2)
Bios 367 Cell Biology (3)
Bios electives (6 credit hours)

Mathematics (8-10 credit hours)
Math 21 and 22 Calculus (8) or Calculus (10)
Math 51, 52, and 43 Calculus (10)

Chemistry (13 credit hours)
Chm 21, 22 Introduction to Chemical Principles (3) and Lab (1)
Chm 51, 52, 53, 58 Organic Chemistry and Lab (8)

Physics (5 credit hours)
Phy 11, 12 Introductory Physics and Lab (5)

Physics/Chemistry elective (3 or 4 credit hours)
Chm 31 or Chemistry Equilibria (3)
Chm 194 or Physical Chemistry (3)
Phy 13, 14 General Physics and Lab (4)

Philosophy (3 credit hours)
Phil 128 Philosophy of Science (3)

Mathematics (12 credit hours)
Math 21, 22, 23 Calculus I, II and III (12 credit total)
Math 51, 52, 43 and one of Math 12, or 231 (13-14 credit total)

Chemistry (19 credit hours)
Chm 21 Introductory Chemical Principles (4)
Chm 22 Chemical Principles Laboratory (1)
Chm 51, 52 Organic Chemistry (6)
Chm 53, 58 Organic Chemistry Laboratory (2)
Chm 31, 194 Chemical Equilibria in Aqueous (or 187) Systems and Physical Chemistry for Biological Sciences (6)

Physics (9-10 credit hours)
Phy 11 Introductory Physics I (4)
Phy 12 Introductory Physics Laboratory I (1)
Phy 13 (or 21) General Physics (3 or 4)
Phy 14 (or 22) General Physics Lab (1)

Natural sciences, mathematics or computing science (6 credit hours)
electives (6)

Free electives (12 credit hours)

Molecular Biology (37-39 credit hours)
Bios 31 Intro. to Cell and Molecular Biology (3)
Bios 32 Intro. to Cell and Molecular Biology Lab (1)
Bios 101 Genetics (3)
Bios 102 Genetics Laboratory (1)
Bios 324 Bacteriology (3)
Bios 325 Bacteriology Laboratory (2)
Bios 345 Molecular Genetics (3)
Bios 346 Molecular Genetics Laboratory (2)
Bios 367 Cell Biology (3)
Bios (Chm) 371 Elements of Biochemistry I (3)
Bios (Chm) 372 Elements of Biochemistry II (3)

Approved Molecular Biology Electives (10-12)

Recommended sequence for the B.S. in Molecular Biology

Freshman year
Bios 31 Intro. to Cell and Molecular Biology (3)
Bios 32 Intro. Cell/Molecular Laboratory (1)
Math 21, 22 Calculus I and II (8)
Chm 21, 22 Introductory Chemical Principles and Lab (5)

Sophomore year
Bios 101 Genetics (3)
Bios 102 Genetics Laboratory (1)
Math 23 Calculus III (4)
Chm 51, 52 Organic Chemistry (6)
Chm 53, 58 Organic Chemistry Laboratory (2)
Phy 11, 12 Introductory Physics I and Lab (5)
Phy 13, 14 General Physics and Laboratory (4 or 5)

Junior year
Bios 324 Bacteriology (3)
Bios 325 Bacteriology Laboratory (2)
Bios 345 Molecular Genetics (3)
Bios 346 Molecular Genetics Laboratory (2)
Chm 31 Chemical Equilibria in Aqueous Systems (3)
Chm 371, 372 Elements of Biochemistry I and II (6)

Approved Molecular Biology Electives (3-4)

Senior year
Approved Molecular Biology electives (7-8)
Bios 367 Cell Biology (3)
Chm 194 Physical Chemistry for Biological Sciences (3)
Natural science electives (6)
Molecular Biology Minor
The molecular biology minor program consists of Bios 31 (3), 32 (1), 101 (3), 102 (1), 345 (3), 346 (2), and a minimum of 4 additional credits of Bios coursework above the 100 level. Collateral coursework must include: Math 51 or 21 (4 credit hours), Chm 21 (4), Chm 22 (1), and chm 51 (3).

Departmental Honors
A student may apply for admission to the departmental honors program through a potential thesis advisor. Detailed requirements for the program may be obtained from the advisor or from the department office.

Undergraduate Courses in Biological Sciences
1. Molecular Biology and Society (3)
   Basic and applied molecular biology for non-science majors. Gene cloning; human gene therapy; cancer; reproduction; contraception; viral infections including AIDS. Ethical considerations. May not be used in satisfaction of life science major or minor programs. (NS)

2. Animal Survival and Adaptation (3) summer
   Introductory course in evolutionary biology for non-science majors. Why species appear, change, become successful, divide into several species, and eventually become extinct. Lecture and laboratory experience. (NS)

7. Human Reproduction (3)
   Basic and applied human reproductive biology for non-science majors. May not be used in life science major or minor programs. (NS)

31. Introduction to Cell and Molecular Biology (3)
   Introduction to the structure, function, and evolution of cells at the level of molecules, organelles, and differentiated cell types. Includes basic structure and expression of genes, cell physiology, and the molecular/cellular basis of disease and immunity. Prerequisite: Chm 21 previously or concurrently. (NS)

32. Introduction to Cell/Molecular Biology Lab (1)

77. Drugs and Behavior (3)
   Basic principles of drug action in the central nervous system. Effects of stimulants, depressants, narcotics, and hallucinogens. Drug abuse and behavioral function. Clinical use of drugs in the treatment of various psychological and psychiatric disorders. (NS)

101. Genetics (3)
   The structure, function, and continuity of hereditary information. Major topics include mechanisms and regulation of gene expression, replication and transmission of genetic material, mutation, and organization and change of genetic material in populations. Prerequisites: Bios 31. (NS)

102. Genetics Laboratory (1)
   Laboratory work that demonstrates major principles of genetics: included are experiments on microorganisms and the common fruit fly Drosophila melanogaster. Prerequisite: Bios 101, preferably concurrently.

110. (Psy 110) Experimental Design and Statistical Analysis (4)
   Principles of experimental design and statistical analysis: characteristics of data and data collection; descriptive statistics; hypothesis testing theory and practice; correlation, chi-square test, t-test, analysis of variance. (ND)

133. Invertebrate Zoology (4)
   Survey of representative invertebrates. Structure and behavior of selected types and concepts of evolutionary relationships among the major groups. Two lectures and two laboratory periods. Prerequisite: EES 31 or Bios 31/32. (NS)

134. Comparative Vertebrate Anatomy (4)
   A course in vertebrate zoology with emphasis on the study of homologous body structures in the various vertebrate classes and their relationship to the functional demands of habitat and environment in each class. Detailed dissections of representative vertebrates are made in the laboratory. Two lectures and two laboratory periods. Prerequisite: Consent of department. (NS)

161. Supervised Research (1-3) fall-spring
   Apprenticeship in ongoing faculty research program. Literature review, experimental design, data collection and analysis, and professional writing under faculty supervision. May be repeated once for credit. Prerequisite: Consent of Department. (ND)

177. (Psy 177) Introduction to Behavioral Neuroscience (3)
   Nervous system functioning with varying emphasis on neurophysiology, neuroanatomy, behavior genetics, information transmission, research techniques, sensory and motor functions. Prerequisite: Psy 1 or EES 31 or Bios 31. (NS)

202. Biomedical Externship (1 or 2)
   Analysis of individualized experiences at external biomedical clinical or research sites. Limited enrollment. May not be taken for pass-fail grading. Prerequisite: Consent of department chairperson required. (NS)

221. Human Histology (4)
   Human tissues and organs. Emphasis on structural and functional interrelationships of cells. Disease states and pathologies. Two lectures and one laboratory. Prerequisite: Bios 101. (NS)

225. Introduction to Biological Research (3)
   Literature and methods of research in an area of department faculty expertise. Requires development of detailed proposal for research to be performed in senior year. Prerequisites: Major in any Biological Sciences degree program; junior standing; GPA of 3.0 in major; and consent of the department chairperson. (ND)

229. Immunology (3)
   Distinction of “self” and “non-self” through humoral and cellular mechanisms. Antigens; biochemical structures; cellular mechanisms; genetic control and processing; phylogenetic distribution; diseased states. Prerequisite: Bios 101. (NS)

241. Vertebrate Natural History (4)
   An introduction to the ecology, behavior, distribution and evolution of vertebrates, with emphasis on the North American fauna. Two lectures, one tutorial and one laboratory and field trip. Fulfills junior level writing requirements. Prerequisite: Bios 134. (NS)

251. Writing and Biological Sciences (3)
   A course designed to acquaint students with some of the intellectual foundations of science, with attention to the distinctiveness of molecular biology. Format includes readings, intensive writing, extemporaneous speaking, and discussion. Prerequisite: Consent of Department. (NS)

261. Special Topics in Biological Sciences (1-3)
   Research, conferences and reports on selected topics not covered in the general undergraduate offerings. May be taken more than once for credit. Prerequisite: Consent of the department chairperson. (NS)

277. Experimental Neuroscience Laboratory (4)
   Nervous system structure; preparation of nervous tissues for microscopic examination; experiments on behavioral assays of nervous system function. Report writing and an independent research project. Fulfills junior level writing requirement. Prerequisites: Bios 177 and consent of department chairperson. (NS)
For Advanced Undergraduates and Graduate Students

313. Vertebrate Histology (4)
Microstructural and ultrastructural properties of vertebrate cells and tissues. Techniques of tissue preparation. Two lectures and two labs. Prerequisite: Bios 134. (ND)

314. Vertebrate Development (3)
Germ cell formation, fertilization, early development, and the origin of the principal organ systems. Location, structure, and regulation of information from molecular to organismal levels of organization. Prerequisite: Bios 101 and Bios 134. (NS)

317. Evolution (3)
Mechanisms of evolution, emphasizing genetic structure and variation of populations, and isolation. Origin of species and higher taxa. Rates of evolution, extinction. Prerequisite: Bios 101. (NS)

324. Bacteriology (3)
The structure, physiology, growth, genetics and taxonomy of prokaryotes. Prerequisites: Chm 51 and Bios 101. Corequisite: Bios 325. (NS)

325. Bacteriology Laboratory (2)
Standard procedures and metabolic tests used in determinative bacteriology: aseptic technique, sterilization, enumeration, and control of bacterial growth; other selected topics. Corequisite: Bios 324.

329. Herpetology (3)
Biology of amphibians and reptiles. Two lectures, one laboratory or field trip per week. Prerequisite: Consent of department. (ND)

335. (Psych 335) Animal Behavior (3)
Discussion of the behavior of invertebrates and vertebrates and analysis of the physiological mechanisms responsible for behavioral stimuli, and adaptive value of specific behavior patterns. Prerequisite: EES 31 or Bios 101. (NS)

336. Animal Behavior Laboratory (2)
Experiments and field observations illustrating principles discussed in Bios 335. Emphasis on observing animals, performing experiments, collecting and analyzing data, and individual research. Six hours of laboratory per week. Corequisites: Bios 335 or 337.

337. Behavioral Ecology (3)
Social systems of vertebrate and invertebrate groups. Emphasis on ecological and evolutionary factors that influence social behavior. Prerequisites: EES 31 or Bios 101. (NS)

345. Molecular Genetics (3)
The organization and replication of genetic material; mutagenesis; mechanisms of regulation; mechanisms of gene transmission involving prokaryotes and eukaryotes and their viruses; techniques for intervention into genetic organization and expression. Prerequisite: Bios 101. (NS)

346. Molecular Genetics Laboratory (2)
Laboratory experiments related to the topics covered in Bios 345. Emphasis is on molecular characterization of DNA and the principles of gene isolation and transfer. Corequisite: Bios 345.

347. Advanced Topics in Genetics (3)
Lectures and student projects on selected aspects of genetics such as the genetics and evolution of particular organisms, regulation of gene expression and transmission, human genetics, gene therapy, etc. Prerequisites: Bios 345 or consent of department chairperson. (NS)

353. Virology (3)
Structure and replication of viruses. Emphasis on the organization, replication, and regulation of expression of viral genomes; the mechanisms of virus assembly and release; and on virus-host interactions. Special attention given to human pathogenic viruses. Prerequisite: Bios 101. (NS)

356. Human Genetics and Reproduction (3)
Processes and mechanisms of human heredity. Emphasis at the cellular and molecular levels. Analysis, organization, expression, and evolution of human genome. Genetic aspects of reproduction and development, mapping human chromosomes, cell hybridization, molecular analysis of gene structure and function, behavior and intelligence, primate origins and evolution, immunogenetics, cancer and oncogenes, genetic technologies. Prerequisite: Bios 101. (NS)

361. Special Topics (3)
Readings, conferences, and reports on a selected topic not covered in other course offerings. May be taken only once for credit. Prerequisites: Consent of instructor. (NS)

367. Cell Biology (3)
Molecular aspects of cell biology. Emphasis on membrane structure and function, organelle biogenesis, cell motility, the cytoskeleton, and extracellular matrix. Prerequisite: Bios 101. (NS)

370. Plant Molecular Biology (3)
Molecular aspects of photosynthesis; chloroplast biogenesis; plant gene expression; plant development; plant-microbe interactions; genetic engineering in plant systems. Prerequisite: Bios 345. (NS)

371. (Chm 371) Elements of Biochemistry I (3) fall
A general study of carbohydrates, proteins, lipids, nucleic acids and other biological substances and their importance in life processes. Protein and enzyme chemistry are emphasized. Prerequisite: one year of organic chemistry. (NS)

372. (Chm 372) Elements of Biochemistry II (3) spring
Dynamic aspects of biochemistry; enzyme reactions including energetics, kinetics and mechanisms; metabolism of carbohydrates, lipids, proteins and nucleic acids; photosynthesis, electron transport mechanisms, coupled reactions, phosphorylations, and the synthesis of biological macromolecules. Prerequisite: Chm 371. (NS)

373. (Psych 373) Sensation and Perception (3) spring
Receptor processes of vision, audition, touch, taste, and smell. Psychological dimensions of such processes leading to consideration of perception as characteristic of organisms. Prerequisite: Psy 65 or 176 or 177. (SS)

375. (Psych 375) Neuronatomy of Behavior (3)
Neuronatomy and neurophysiology of animal and human behavior. Feeding, thirst, sleep, emotions, learning, and psychopathology. Prerequisite: BioSPscy 177. (ND)

376. Classical & Molecular Embryology (3)
Differentiation of multicellular organisms from a single cell. Axis determination; gradients; induction and pattern formation viewed through modern analysis of regulated gene expression. Prerequisite: Bios 345 (previously or concurrently). (NS)

377. Biochemistry Laboratory (3) fall
Laboratory studies of the properties of chemicals of biological origin and the influence of chemical and physical factors on these properties. Laboratory techniques used for the isolation and identification of biochemicals. Prerequisite: BioS/Chm 371 previously or concurrently. (ND)

378. Biochemical Preparations (1-3) spring
A laboratory course involving the preparation or isolation, purification and identification of chemicals of biological origin. Prerequisites: Bios/Chm 377 and 372, previously or concurrently. (ND)
382. (Psy 382) Endocrinology of Behavior (3)
Hormonal effects upon animal and human behavior. Emphasis on neuroendocrinology of steroid hormone involvement in reproductive behaviors. Prerequisite: BioS/Psysc 177. (NS)

383. Biological Sciences Colloquia (1)
Analysis of weekly colloquia in molecular biology. For senior biology and molecular biology majors. May be taken twice for credit. (ND)

387. Biological Sciences Honors Seminar (1)
Development, presentation and implementation of research proposals, and discussions of research. Required for senior biology and molecular biology majors pursuing departmental honors. Departmental permission required. (ND)

388. Biological Sciences Honors Seminar (1)
Continuation and extension of BioS 387. Departmental permission required. (ND)

391. Undergraduate Research (1-3)
Laboratory research under tutorial with a faculty member. May be taken more than once for credit. Prerequisites: junior standing; and consent of instructor. (ND)

393. Thesis (3) fall
Literature review and design of project in selected area. Intended for senior majors in BioS only. Prerequisite: Consent of faculty sponsor (ND)

394. Thesis (3) spring
Execution of project designed in BioS 393. Final report and oral presentation. Prerequisite: BioS 393 and consent of faculty sponsor. (ND)

Special Health Professions Programs
Students may apply for admission to an accelerated B.A.-Doctor of Medicine program and a B.A.-Doctor of Medical Dentistry program. A six-year B.A.-M.D. program is offered in conjunction with the Medical College of Pennsylvania, and a seven-year B.A.-D.M.D. program is offered in conjunction with the University of Pennsylvania School of Dental Medicine. Students in these programs receive a B.A. from Lehigh and a graduate degree from the designated professional school within a six- or seven-year period. For details concerning admission to these programs, see Health Professions, Section III. Undergraduate courses, please see listings for BioS and EES.

Graduate Study in the Biological Sciences
Rigorous, research-oriented graduate programs leading to a doctor of philosophy are offered in three divisions of the Department of Biological Sciences: Molecular Biology (Ph.D. in molecular biology), Behavioral and Evolutionary Biology (Ph.D. in either behavioral neuroscience or behavioral and evolutionary biology), and Biochemistry (Ph.D. in biochemistry). The graduate school requires students to register for 72 postbaccalaureate credits to earn the Ph.D. The types of registered credits may include core courses, electives, research, dissertation, special study, or seminar credits.

In the Division of Molecular Biology, research areas include microbial evolution and genetics, plant and animal molecular genetics, developmental genetics, eukaryotic cell biology, regulation of gene expression, and virology. Each student is initially guided by his or her own faculty committee. A separate Ph.D. committee later directs progress toward the advanced degree and tailors the program to fit special needs and interests of the student. Ph.D. requirements include three formal examinations, the qualifying exam, the general exam, and the dissertation defense.

In the Division of Behavioral and Evolutionary Bioscience (BEBS), research areas include behavioral neuroendocrinology in rodents, ecology and animal behavior in a variety of animals including coral reef fishes, and functional morphology in reptiles. 30 credit hours of course work, including 24 hours of 300-400 level courses from at least 3 different professors teaching courses in this area are required for the master's degree. For the Ph.D., three additional advanced 400 level seminar courses appropriate to the student's level of specialization are required beyond the master's requirements. Students are required to pass a general examination after completing the master's and upon entering the Ph.D. program. There are three research requirements each of which includes a written and oral presentation to the faculty in this area: First-year research project, master's thesis, and a doctoral dissertation.

In the Division of Biochemistry, research areas include DNA structure and function, and regulation of protein synthesis. Students admitted to graduate study in biochemistry will typically have an undergraduate degree in chemistry or biochemistry. Students with an undergraduate degree in a related discipline will be expected to have the following undergraduate preparation for graduate study beyond introductory chemistry and a year of organic chemistry: at least one semester of analytical chemistry and one semester of physical chemistry - thermodynamics and kinetics, with appropriate math. Students without that background will be expected to take courses to fulfill those requirements as part of their graduate study. Required courses: BioS 371, 372 Students with one year of undergraduate biochemistry can fulfill this requirement by passing a proficiency test at the time of matriculation. BioS 459, 470, Chm 423, BioS 345, and a seminar course. BioS 408 or Chm 400 must also be completed before beginning research. Additional courses (from biochemistry, molecular biology and bio-organic chemistry) will be chosen with the help of the advisor to reach a minimum of 24 course credits (at least 12 of which must be at the 400 level). Research is the other major component of the graduate degree program (6 credits minimum are required at the MS level). Research is continued until the completion of work needed for the dissertation. Degree requirements include a two part general exam and the dissertation defense.

Graduate study leading to the M.S. and Ph.D. degree in biology is also available. Course requirements for the Ph.D. degree are determined on an individual basis by the student and the dissertation committee. The centerpiece of the doctoral program is a concentrated research effort that culminates in a significant contribution to the field of biology. Sometime prior to seven months before finishing the dissertation, the student must pass a general examination administered by the dissertation committee. The defense of the dissertation serves as the final examination for the doctorate. It is expected that the results of the dissertation research will be published in primary journals.

Facilities available for research in the Biological Sciences include core facilities with equipment (for example, for DNA synthesis, digital imaging, chromatography, cell culture, centrifugation, controlled environments, gamma and scintillation counting, flow cytometry, and rodent surgery). Individual research laboratories and advanced teaching laboratories contain a variety of additional equipment. Ongoing interactions with a variety of private companies contribute additional opportunities for student experiences.

Graduate Courses in the Biological Sciences

404. (Psy 404) Behavioral Neuroscience (3)
Theoretical and empirical issues in biopsychology. Prerequisite: Graduate standing or consent of instructor.

405. Special Topics in Molecular Biology (1-3)
Research, conferences, and reports on selected topics not covered in the general graduate offerings. May be taken more than once for credit.

406. Molecular Biological Seminar (1)
An advanced seminar in current developments including departmental research. Required for candidates for graduate degrees in Molecular Biology. May be taken more than once for credit.

407. Research in Biological Science (1-9)
Laboratory investigations in one of the department's research areas.
408. Responsible Conduct of Science (0)
Responsible practice in research. Training in general laboratory 
methods; human subjects concerns; radiation safety; chemical hazards; 
aesthetic technique; physical, mechanical, biological, and fire hazards; 
animal welfare. Occupational and workplace considerations. 
Recombinant DNA guidelines; patent and proprietary rights; 
controversies over applications of science. Appropriate aspects 
required of investigators in all departmental research projects.

409. Advanced Morphology (3)
A laboratory course in special phases of morphology, such as 
comparative osteology, comparative morphology or embryology 
of the vertebrates, etc., to meet the individual interests of the student.

410. Special Topics in Behavioral and Evolutionary Bioscience 
(1-3)
Readings and discussions on selected topics not covered in the general 
graduate offerings. May be taken more than once for credit.

411. Advanced Cell Biology (3)
Cell structure and biochemistry, as related to specialized cell functions.

412. Metabolic Influences on Behavior (3)
Sensory systems that detect metabolic energy availability and affect the 
behavior of mammals and other animals: food intake and body weight 
regulation, sexual and parental behavior, aggression, learning, and body 
temperature regulation. Prerequisite: Bio 404 and consent of instructor.

414. Sexual Differentiation (3)
Genetic and hormonal events mediating the development and expression of 
sexual dimorphisms in physiology and behavior. Current theoretical 
models; emphasis on biochemical, neuroanatomical, and molecular biological 
considerations. Prerequisite: Bio 404 and consent of instructor.

415. Neuropharmacology (3)
Mechanism of drug action in the central nervous system, including cell 
surface receptors and second messenger systems. Drug use/abuse and 
cellular changes mediating behavioral effects. Drug use in clinical 
therapy. Prerequisite: Bio 404 and consent of instructor.

418. Analysis of Reproduction and Mating Systems (3)
Study of reproduction and sexuality in plants and animals with 
emphasis on current hypotheses as reported in the literature. Topics 
include hermaphroditism, neoteny, larval forms, parental investment, 
complex life cycles, population structure. Readings from primary source 
material and review articles. One review paper and one research 
proposal are required, and together with readings form the basis for 
discussion sections and examinations. Prerequisite: Consent of the department 
depart Chairperson.

419. Bacterial Genetics (3)
Structure and function of genetic information in prokaryotes. 
Composition, size, and organization of chromosomes and accessory 
elements; mechanisms of replication, recombination, transmission, and 
mutation; variation within and among strains.

420. Pheromonal Communication (3)
Mechanisms of pheromone synthesis, biochemistry, sensory 
transduction, neuroanatomy/neuroendocrinology, and adaptive 
significance. Prerequisite: Bio 404 and consent of instructor.

421. Molecular Cell Biology I (3)
Molecular aspects of cell structure, cell motility, intracellular transport, 
and biomembrane dynamics. Prerequisite: Bio 411 or equivalent.

422. Molecular Cell Biology II (3)
Molecular aspects of gene expression, including genome structure and 
replication, RNA synthesis/processing, and protein synthesis. 
Prerequisite: Bio 345 or equivalent.

425. Male Reproductive Biology (2 or 3)
Molecular, cellular, and genetic aspects of the mammalian male 
reproductive system. Prerequisite: Bio 367 or equivalent.

427. Techniques in Cell and Molecular Biology (3)
Laboratory experiences in eukaryotic and molecular biological 
techniques: gel electrophoresis, gel electrophoresis; polymerase 
chain reaction; DNA/RNA sequencing; molecular hybridization 
techniques; fluorescence microscopy; video enhanced microscopy; flow 
cytometry; electron microscopy tissue preparation; immunological 
detection methods; molecular cloning techniques; oocyte microinjection 
techniques; tissue culture methods; and autoradiography.

429. Advances in Herpetology (3)
Lectures and readings from the primary literature on current research in 
amphibian and reptilian biology. Two lectures, one discussion session 
and one laboratory or field trip. In addition, a week-long field trip during 
Spring vacation is required. Not open to students who have received 
credit for Bio 329.

431. Advanced Topics in Cell Biology (3)
Current research problems in cell biology. May be repeated when a 
different topic is offered. Prerequisite: Bio 367 or equivalent.

432. Advanced Topics in Molecular Genetics (3)
Current research in molecular genetics. May be repeated when a 
different topic is offered. Prerequisite: Bio 345 or equivalent.

433. Advanced Topics in Developmental Biology (3)
Current research problems in developmental biology. May be repeated 
when a different topic is offered. Prerequisite: Bio 345 or equivalent.

437. (Chm 437) Pathophysiological Chemistry (3)
Biochemical basis of human diseases involving abnormal metabolism of 
proteins, nucleic acids, carbohydrates, and lipids. Emphasis on the 
correlation of the clinical presentation of disease processes seen as 
physiological dysfunctions with clinical laboratory methods. Lectures, 
student presentations, and clinical case discussions. Prerequisite: 
consent of the department Chairperson.

439. Advanced Behavioral Ecology (3)
Critical evaluation of the theoretical foundation in sociobiology. 
Emphasis placed on kinship, altruism, mate choice, parental investment, 
parent-offspring conflict, etc. Lectures and seminars. Not open to 
students who have taken Bio 337.

445. Systematics and Evolution (3)
Theoretical, philosophical and methodological foundations of the 
classification of eukaryotic organisms and the manner in which systematic 
theory and method relate to evolutionary theory. Two lectures and one 
lab-recitation-discussion session. Prerequisite: Bio 317.

463. Advances in Plant Molecular Biology (3)
Gene expression and molecular biology of plant systems. Biochemistry of 
photosynthesis and chloroplast development; higher plant developmental 
genetics; plant/microbe interactions; plant viruses; advances in genetic 
engineering in plants. Prerequisite: Bio 345 or equivalent.

464. Molecular Biology of Eukaryotic Organisms (3)
Comparative analysis of several eukaryotes as model systems in cell 
biochemistry, developmental biology, genetics, and molecular biology. 
Prerequisite: Bio 345 or equivalent.

466. Structure and Function of RNAs and Ribonucleoprotein 
Complexes (3)
Biochemistry and function of small nuclear RNPs, RNase P, ribosomes, 
self-splicing introns, signal recognition particle, RNA viruses. Functions 
of RNA in DNA replication, in regulation, as an enzyme, and as a 
repressor. Prerequisite: Bio 345 or equivalent.
467. (Chm 467) Principles of Nucleic Acid Structure (3) alternate years
An examination of the principles underlying nucleic acid structure including stereochemistry, electrolytic hydration, torsional constraints, sequence specific effects, and interaction with nuclear proteins. Special emphasis will be placed on DNA structure. Prerequisite: one year of biochemistry and one year of physical chemistry or permission of the department chair.

468. (Chm 468) Principles of Protein Structure (3) alternate years
An examination of the principles underlying protein structure including stereochemistry, preferred tertiary structures, protein homology, excluded volume effects, time dependent structural fluctuations, and prediction of protein structure from sequence information. Prerequisite: one year of biochemistry and one year of physical chemistry or permission of the department chair.

469. (Chm 469) Biochemical Problem Solving I (1) fall
Applications of material covered in BioS/Chm 371 including techniques used in research. Prerequisite: BioS/Chm 371 previously or concurrently.

470. (Chm 470) Biochemical Problem Solving II (1) spring
Applications of concepts covered in BioS/Chm 372 including techniques used in research. Prerequisite: BioS/Chm 372 previously or concurrently.

471. (Chm 471) Eukaryotic Biochemistry (3) alternate years
Biochemistry of selected eukaryotic processes including hormone chemistry, blood clotting, immunchemistry, vision chemistry, muscle chemistry and photosynthesis. The second part of the course will involve presentation and discussion of the current literature by class participants. Prerequisite: BioS/Chm 372 or consent of department chairperson.

472. (Chm 472) Lipids and Membranes (3) alternate years
Structure, physical properties and functions of lipids and their biological aggregates. Techniques for studying lipid assemblies, enzymes which act on lipids, membrane proteins and lipoproteins will also be discussed. Prerequisite: BioS/Chm 372 or consent of department chairperson.

473. (Chm 473) Biochemistry of Complex Carbohydrates (3) alternate years
Consideration of the structure, function and metabolism of complex carbohydrates (glycolipids, glycoproteins and proteoglycans) with particular emphasis on glycoproteins. The first part of the course will consist of lectures to familiarize the student with basic terms, concepts and processes. The second part will involve critical readings, presentation and discussion of the current primary research literature by class participants.

477. (Chm 477) Topics in Biochemistry (1-3)
Selected areas of biochemistry; such as mechanisms of enzyme action, new developments in the chemistry of lipids, nucleic acids, carbohydrates and proteins. May be repeated for credit when different topics are offered. Prerequisite: consent of the department chairperson.

479. (Chm 479) Biochemical Techniques (3)
Laboratory studies of the techniques and principles involved in the isolation, identification, and biochemical transformation of carbohydrates, lipids, nucleic acids and proteins. Prerequisite: Bio 371 or its equivalent previously or concurrently.

480. (Chm 480) Advanced Biochemical Preparations (1-3)
An advanced laboratory course in the preparation, isolation, purification, and identification of organically produced materials. Emphasis is placed on materials and procedures of current interest in biochemistry. Prerequisite: consent of the department chairperson.

483. (Psy 483) Special Topics in Behavioral Neuroscience (3)
Examination of the biological substrates of behavior. Topics may include animal communication, sociobiology, behavioral endocrinology, or behavior genetics. May be repeated for credit. Prerequisite: Bio 404 or consent of department.

488. Seminar in Neuroscience, Behavior, and Evolution (1)
Advanced seminar in current research developments. May be taken more than once for credit.

Biology

Biology courses at Lehigh University are offered in two departments. The Department of Biological Sciences offers molecular, cellular, and organismal biology as well as biochemistry and neuroscience, while the Department of Earth and Environmental Sciences offers courses in Ecology and Environmental Biology. See separate catalogues for course listings and more information.

Chemical Engineering

Professors. Mohamed S. El-Aasser, Ph.D. (McGill), chairperson and Iacocca Professor; Fred P. Stein, Ph.D. (Michigan), associate chairperson; Philip A. Blythe, Ph.D. (Manchester, England); Hugo S. Caram, Ph.D. (Minnesota); Marvin Charles, Ph.D. (Brooklyn Polytechnic); John C. Chen, Ph.D. (Michigan), Carl R. Anderson Professor; Chrisos Georgakas, Ph.D. (Minnesota); James T. Hsu, Ph.D. (Northwestern); Andrew Klein, Ph.D. (North Carolina State); William L. Lubyten, Ph.D. (Delaware); Janice A. Phillips, Ph.D. (Pennsylvania); William E. Schiesser, Ph.D. (Princeton), McCann Professor; Ank K. Sengupta, Ph.D. (Houston); Leslie H. Sperling, Ph.D. (Duke); Cesar A. Silebi, Ph.D. (Lehigh); Harvey G. Stenger, Jr., Sc.D. (M.I.T.), dean of college of engineering and applied science; Israel E. Wachs, Ph.D. (Stanford).

Associate professors. Manoj K. Chaudhury, Ph.D. (SUNY-Buffalo), Dow Corning associate professor; Maria M. Santore, Ph.D. (Princeton).

Adjunct professor. William R. Hencke, M.S.E. in ChE (Michigan).

Research engineers. E. David Sudol, Ph.D. (Lehigh); Kornel Tuzla, Ph.D. (Technical University of Istanbul).

Research scientist. Eric S. Daniels, Ph.D. (Lehigh).


Chemical engineers serve a wide variety of technical and managerial functions within the chemical processing industry. For a lifetime of effectiveness they need a sound background in the fundamental sciences of chemistry and physics; a working capability with mathematics, numerical methods, and application of computer solutions; and a broad education in humanities, social sciences, and managerial techniques.

These bases are applied in a sequence of chemical engineering courses in which logic and mathematical manipulation are applied to chemical processing problems. With the resulting habits of precise thought coupled to a broad base in scientific and general education. Lehigh graduates have been effective throughout industry and in advanced professional education. No effort is made toward any specific industry, but adaptation is rapid and the fundamental understanding forms the base for an expanding career.

The program is also designed to prepare a student for graduate study in chemical engineering. Further study at the graduate level leading to advanced degrees is highly desirable if an individual wishes to participate in the technical development of the field. The increasing complexity of modern manufacturing methods requires superior education for men and women working in research, development, and the design fields or for teaching.
Physical facilities. The Chemical Engineering Department is the only engineering department located on Lehigh's 780-acre Mountaintop Campus. Here the department occupies approximately one-third of Iacocca Hall, the 200,000-square-foot flagship building that contains offices, classrooms, and laboratories. Additional plant facilities, and the undergraduate chemical processing laboratory occupy approximately 10,000-square-feet in the adjacent Imb building.

These facilities provide excellent support for a wide range of general laboratory equipment for undergraduate study of the behavior of typical chemical processing and production; special equipment for biochemical engineering and for the study of polymers; digital computation for process dynamics study; and special equipment for the study of thermodynamics, kinetics, heat transfer, and mass transfer.

Career Opportunities
Chemical engineers play important roles in all activities bearing on the chemical process industry. These include the functions of research, development, design, plant construction, plant operation and maintenance, corporate planning, technical sales, and market analysis.

The industries that produce chemical and/or certain physical changes in fluids, including petroleum and petrochemicals, rubbers and polymers, pharmaceuticals, metals, industrial and fine chemicals, foods, and industrial gases, have found chemical engineers to be vital to their success. Chemical engineers are also important participants in pollution abatement, energy resources, national defense programs, and more recently in the manufacture of microelectronic devices and integrated circuits.

Special Programs and Opportunities
The department, in conjunction with the College of Engineering and Applied Science, operates a cooperative program that is optional for specially selected students who are entering their junior year. This program affords early exposure to industry and an opportunity to integrate an academic background with significant periods of engineering practice. Our program is unique in offering two work experiences and still allowing the co-op students to graduate in four years with their class.

The Opportunities for Student Innovation (OSI) program seeks to develop the students' propensity for critical assessment and innovative solution of meaningful problems. The OSI program affords selected seniors an opportunity to experience team research leading toward technological benefits. Each project is hosted by a company and carried out under the supervision of a Lehigh faculty member. Students register for OSI through ChE 185 and 186.

Chemical Engineering offers specialization certificates in polymer science, biotechnology, and process modeling and control.

Requirements of the Major
freshman year (see Recommended Freshman Year)
ChE 31 Material and Energy Balances of Chemical Processes (3)
Chm 31 Chemical Equilibria in Aqueous Systems (3)
Phy 21 Introductory Physics I (4)
Phy 22 Introductory Physics Laboratory I (1)
Math 23 Analytic Geometry and Calculus III (4) elective (3)

sophomore year, first semester (18 credit hours)
ChE 44 Fluid Mechanics (4)
ChE 210 Chemical Engineering Thermodynamics (4)
ChE 179 Professional Development (1)
Chm 187 Physical Chemistry I (3)
Math 205 Linear Methods (3) elective (3)

sophomore year, second semester (18 credit hours)
ChE 151 Introduction to Heat Transfer (3)
ChE 201 Methods of Analysis in Chemical Engineering (3)
Chm 51 Organic Chemistry I (3)

junior year, second semester (18 credit hours)
ChE 242 Introduction to Process Control and Simulation (3)
ChE 244 Mass Transfer and Separation Processes (3)
ChE 211 Chemical Reactor Design (3)
Chm 52 Organic Chemistry II (3) elective (6)

senior year, first semester (17 credit hours)
Chm 189 Physical Chemistry II (3)
ChE 202 Chemical Engineering Laboratory I (2)
ChE 233 Process Design I (3) elective (9)

senior year, second semester (15 credit hours)
ChE 203 Chemical Engineering Laboratory II (2)
ECE 81 Principles of Electrical Engineering (4)
ChE 234 Process Design II (3) elective (6)

The total number of credits required for graduation is 135. A total of 36 credits in electives must be taken. These electives are of six types:
(a) Humanities/Social Sciences: A total of 18 credits of electives in humanities and social science must include Eco 1. (Note that these electives are in addition to the 6 hours of required freshman English). See description of HSS in Section III.
(b) Approved courses in other engineering departments (CE, EECS, IE, MEM, MAT): and/or in science (chemistry, physics, mathematics, molecular biology or earth and environmental sciences): 6 credit hours total are required; at least 3 credit hour must be in other engineering departments.
(c) Chemistry: 3 credits hours of 200-level or higher.
(d) Chemical Engineering: A total of 3 credits hour is required. At least 1 credit hour must be of engineering design.
(e) Free electives: 6 credit hours in any subject area (including advanced chemical engineering) are required.

Undergraduate Courses
31. Material and Energy Balances of Chemical Processes (3) fall
Material and energy balances with and without chemical reaction. Introduction to phase equilibrium calculations. Applications in chemical process calculations and in design of separations: binary distillation, liquid-liquid extraction. Plant trips and special lectures introducing the profession. Prerequisite: Chem 21 or equivalent and Eng 1 previously or concurrently. (ES 2), (ED 1)

44. Fluid Mechanics (4) winter

60. Unit Operations Survey (3) spring
The theory of heat, mass and momentum transport. Laminar and turbulent flow of real fluids. Heat transfer by conduction, convection, and radiation. Application to a wide range of operations in the chemical and metallurgical process industries. (ES 2), (ED 1)

151. Introduction to Heat Transfer (3) fall
Fundamental principles of heat transfer. Fourier's law. Conduction, convection and radiation. Analysis of steady and unsteady state heat transfer. Evaporation and condensation. Applications to the analysis and design of chemical processing units involving heat transfer. Prerequisite: Phys 44. (ES 2), (ED 1)
179. Professional Development (1) spring
Elements of professional growth, registration, ethics, and the responsibilities of engineers both as employees and as independent practitioners. Proprietary information and its handling. Patents and their importance. Discussions with the staff and with visiting lecturers. A few plant trips. (ES 0), (ES 0)

185. Undergraduate Research I (3)
Independent study of a problem involving laboratory investigation, design, or theoretical studies under the guidance of a senior faculty member. (ES 3), (ED 0)

186. Undergraduate Research II (3)
A continuation of the project begun under ChE 185. Prerequisite: ChE 185 or consent of the department chairperson. (ES 2), (ED 1)

201. Methods of Analysis in Chemical Engineering (3) fall
Analytical and numerical methods of solution applied to dynamic, discrete and continuous chemical engineering processes. Laplace Transforms. Methods of analysis applied to equilibrium, characteristic value and non-linear chemical engineering problems. Prerequisite: Math 205 previously or concurrently and ChE 44. (ES 2), (ED 0)

202. Chemical Engineering Laboratory I (2) fall
The laboratory study of chemical engineering unit operations and the reporting of technical results. One three-hour laboratory and one lecture period per week. Independent study and both group and individual reporting. Prerequisite: ChE 151. (ES 1), (ED 1)

203. Chemical Engineering Laboratory II (2) spring
Laboratory experience with more complex chemical processing situations including processes involving chemical reactions and those controlled automatically. Prerequisite: ChE 244 and ChE 210. (ES 1), (ED 1)

207. (Math 207) Introduction to Biomedical Engineering and Mathematical Physiology (3) fall
Topics in human physiology and mathematical analysis of physiological phenomena, including the cardiovascular and respiratory systems, biomechanics, and renal physiology: broad survey of bioengineering. Independent study projects. Prerequisite: Math 205. (ES 2), (ED 1)

210. Chemical Engineering Thermodynamics (4) spring
Energy relations and their application to chemical engineering. Consideration of flow and nonflow processes. Evaluation of the effects of temperature and pressure on the thermodynamic properties of fluids. Heat effects accompanying phase changes and chemical reactions. Determination of chemical and physical equilibrium. Prerequisite: ChE 31. (ES 3), (ED 1)

211. Chemical Reactor Design (3) spring
The application of chemical kinetics to the design and operation of chemical reactors. Plug flow and continuous stirred tank reactors. Homogeneous and heterogeneous reaction kinetics. Design of isothermal and adiabatic reactors. Prerequisite: ChE 151, ChE 210 or equivalent. (ES 11), (ED 2)

233. Process Design I (3) fall
Design of chemical plants incorporating traditional elements of engineering economics and synthesis of steady-state flowsheets with (1) both heuristic and rigorous optimization methods and (2) consideration of dynamic controllability of the process. Economic principles involved in the selection of process alternatives and determination of process capital, operating costs, and venture profitability. Energy conservation, pinch techniques, heat-exchanger networks, and separation sequences. Considerations of market limitations, environmental and regulatory restrictions, and process safety. Use of modern computer-aided software for steady-state and dynamic simulation and optimization. Group design projects. Prerequisites: ChE 211, ChE 242 and ChE 244. (ES 01), (ED 3)

234. Process Design II (3) spring
Continuation of ChE 233. Prerequisite ChE 233. (ES 0), (ED 3)

242. Introduction to Process Control and Simulation (3) spring
Dynamic simulation of chemical processes. Transfer functions and block diagrams. Introduction to process control equipment. Open-loop and closed-loop stability analysis using root locus and Nyquist techniques. Design of control systems. Prerequisite: ChE 201, ChE 151, and Engr 1. (ES 1), (ED 2)

244. Mass Transfer and Separation Processes (3) spring
Diffusion, fluxes, and component conservation equations. Fick’s law. Unsteady state diffusion. Convective mass transfer. Interphase mass transport coefficients. Design of multicomponent-distillation, absorption, extraction, and fixed-bed processes. Prerequisite: ChE 31 and ChE 44. (ES 1), (ED 2)

For Advanced Undergraduates and Graduate Students

301. Process Design (3)
Study of the strategy of chemical process design with emphasis on optimum order of steps, flow diagrams, energy balances, recycle ratios and their effect on the economics of the operation. Survey of methods for ordering equations. Discussion of process optimization for non-linear systems. Effects of uncertainty in process design. (ES 0), (ED 3)

312. (Chem 312, Mat 312) Fundamentals of Corrosion (3)
Corrosion phenomena and definitions. Electrochemical aspects including reaction mechanisms, thermodynamics, Pourbaix diagrams, kinetics of corrosion processes, polarization, and passivity. Non-electrochemical corrosion including mechanisms, theories, and quantitative descriptions of atmospheric corrosion. Corrosion of metals under stress. Cathodic and anodic protection, coatings, alloys, inhibitors, and passivators. Prerequisite: Met 210, Chem 187, or equivalent. (ES 3), (ED 0)

320. Waste Water Control (3)
The physical processes of importance in the design of industrial wastewater treatment facilities. Topics will include sedimentation and filtration processes as well as advanced methods such as adsorption, ion exchange, osmosis, foaming, freezing, and hydrate formation. Prerequisite: ChE 211. (ES 2), (ED 1)

321. Fundamentals of Air Pollution (3)
Introduction to the problems of air pollution including such topics as: sources and dispersion of pollutants: sampling and analysis; technology of economics and control processes; legislation and standards. Prerequisite: senior standing in the College of Engineering and Applied Sciences. (ES 1), (ED 2)

331. Separation Processes (3) fall, every other year
Industrial separation chemistry and processes. Computer solutions for simple and complex multicomponent distillation columns. Azeotropic and extractive distillation. Adsorption, ion exchange and chromatography in packed beds, moving beds and cyclic operation. Synthesis of polymer membrane and its applications to industrial separation processes. (ES 1), (ED 2)

334. (Mat 334, EES 338) Electron Microscopy and Microanalysis (4) fall
Fundamentals and experimental methods in electron optical techniques including scanning electron microscopy (SEM) conventional transmission (TEM) and scanning transmission (STEM) electron microscopy. Specific topics covered will include electron optics, electron beam interactions with solids, electron diffraction and chemical microanalysis. Applications to the study of the structure of materials are given. Prerequisite: consent of the department chairperson. (ES 4), (ED 0)
335. (Mat 335) Principles of Semiconductor Materials Processing (3)
Description and analysis of the processing steps involved in microelectronic material fabrication. Emphasis will be placed on the chemistry of the fabrication steps, mathematical modeling of the transport and chemical reaction phenomena, and interpretation of experimental methods and data. Prerequisites: a course in thermodynamics, and senior standing. (ES I), (ED 0)

341. Biotechnology I (3) fall
Applications of material and energy balances; heat, mass, and momentum transfer; enzyme and microbial kinetics; and mathematical modeling to the engineering design and scale-up of bio-reactor systems. Prerequisites: Math 22, Phys 11, and Chem 187, or the equivalent of each and the consent of the instructor. (ES I), (ED 2)

342. Biotechnology II (3) spring
Engineering design and analysis of the unit operations used in the recovery and purification of products manufactured by the biotechnology industries. Requirements for product finishing and waste handling will be addressed. Prerequisite: ChE 341 or equivalent. (ES I), (ED 1.5)

350. Special Topics (1-3)
A study of areas in chemical engineering not covered in courses presently listed in the catalog. May be repeated for credit if different material is presented.

360. (ME 360) Nuclear Reactor Engineering (3)
A consideration of the engineering problems in nuclear reactor design and operation. Topics include reactor fuel and core materials, thermal aspects, instrumentation and control problems, radiation protection, health physics, and reactor design. Prerequisite: senior standing in the College of Engineering and Applied Sciences. (ES I), (ED 1.5)

367. (MAT 367) Metal Films and Coatings Processing, Structure, and Properties (3)
Focus will be on the processing, structure, and properties of metal films and coatings. Processing methods will include evaporation, sputtering, chemical vapor deposition (CVD), plasma-assisted CVD, ion implantation, electrodeposition, metal bath solidification, weld overlay, thermal spraying and diffusion. Characterization of thin films and coatings will be done with the use of sophisticated analytical instrumentation, including spectroscopic methods, microscopy and diffraction techniques. Characterization methods are explored in conjunction with processing techniques and film/coating properties via class assignments that are designed to introduce students to the archival literature. Prerequisite: Senior standing in Chemical Engineering or Materials Science and Engineering, or permission of the instructor(s). (ES I), (ED 1.5)

370. Process Safety and Hazard Analysis (3)
A study of the methodology now available for analyzing hazard frequency and level in chemical processes. Applications to real process examples using hazard and operability analysis, fault tree and event tree analysis, "what-if" analysis, and preliminary hazard analysis. Also includes a survey of the field of industrial safety. (ES I), (ED 1.5)

380. Design Projects (1-6) fall-spring
Design project work as a member of a team preferably including students from different disciplines. The project attacks a problem which, when possible, involves one of the local communities or industries. Specific projects are normally guided by faculty from several departments with consultants from off the campus. The course may be repeated for credit. (ED all)

386. Process Control (3) fall
Open-loop and closed-loop stability analysis using root locus and Nyquist techniques, design of feedback controllers with time and frequency domain specifications. Experimental process identification. Control of multivariable processes. Introduction to sampled-data control theory. Prerequisite: ChE 242 or equivalent. (ES I), (ED 2)

387. (ECE 387, ME 387) Digital Control (3) spring
Sampled-data systems; z-transforms; pulse transfer functions; stability in the z-plane; root locus and frequency response design methods; minimal prototype design; digital control hardware; discrete state variables; state transition matrix; Liapunov stability state feedback control (2 lectures and one laboratory per week). Prerequisite: ChE 386 or ECE 212 or ME 342 or consent of instructor. (ES I), (ED 1.5)

388. (Chem 388, Mat 388) Polymer Synthesis and Characterization Laboratory (3) spring
Techniques include: free radical and condensation polymerization; molecular weight distribution by gel chromatography; crystallinity and order by differential scanning calorimetry; pyrolysis and gas chromatography; dynamic mechanical and dielectric behavior; morphology and microscopy; surface properties. Prerequisite: senior level standing in ChE, Chem. or Mat, or permission of the instructor. (ES I), (ED 1)

389. (ECE 389, ME 389) Control Systems Lab (2) spring
Experiments on a variety of mechanical, electrical and chemical dynamic control systems. Exposure to state-of-the-art control instrumentation: sensors, transmitters, control valves, analog and digital controllers. Emphasis on comparison of theoretical computer simulation predictions with actual experimental data. Lab teams will be interdisciplinary. Prerequisite: ChE 386, ECE 212, or ME 343. (ES I), (ED 1)

392. (Chem 392) Polymer Science (3) fall
Introduction to concepts of polymer science. Kinetics and mechanism of polymerization, synthesis and processing of polymers, characterization. Relationship of molecular conformation, structure and morphology to physical and mechanical properties. Prerequisite: Chem 187 or equivalent. (ES I), (ED 1.5)

393. (Chem 393, Mat 393) Physical Polymer Science (3) fall
Structural and physical aspects of polymers (organic, inorganic, natural). Molecular and atomic basis for polymer properties and behavior. Characteristics of glassy, crystalline, and paracrystalline states (including viscoelastic and relaxation behavior) for single and multicomponent systems. Thermodynamics and kinetics of transition phenomena. Structure, morphology, and behavior. Prerequisite: senior level standing in ChE, Chem, or Mat, or permission of the instructor. (ES I), (ED 1.5)

394. (Chem 394) Organic Polymer Science (3) spring
Organic chemistry of synthetic high polymers. Functionality and reactivity of monomers and polymers. Theory of step growth and chain growth polymerization in homonuclear and heterogeneous media. Polymerization by addition, elimination, substitution and coupling reactions. Ionic free-radical and coordinate catalysis. Prerequisite: one year of physical chemistry and one year of organic chemistry. (ES I), (ED 0)

395. (Chem 395) Colloid and Surface Chemistry (3)
Physical chemistry of everyday phenomena. Intermolecular forces and electrostatic phenomena at interfaces, boundary tensions and films at interfaces, mass and charge transport in colloidal suspensions, electrostatic and London forces in disperse systems, gas adsorption and heterogeneous catalysis. Prerequisite: Chem 187 or equivalent. (ES I), (ED 0)

Graduate Programs
The department of chemical engineering offers graduate programs leading to the master of science, master of engineering, and doctor of philosophy degrees. The programs are all custom tailored for individual student needs and professional goals. These individual programs are made possible by a diversity of faculty interests that are broadened and reinforced by cooperation between the department and several research centers on the campus.
A free flow of personnel and ideas between the centers and academic departments ensure that the student will have the widest choice of research activities. The student is also exposed to a wide range of ideas and information through courses and seminars to which both faculty and center personnel contribute. In addition, strong relationships with industry are maintained by the department and the research centers, some of which operate industrially sponsored liaison programs whereby fundamental nonproprietary research is performed in areas of specific interest to participating sponsors.

While the department has interacted with most of the centers on campus, it has had unusually strong and continuing liaisons with Emulsion Polymers Institute, Process Modeling and Control Research Center, Institute for Thermo Fluid Engineering and Science, Materials Research Center, Polymer Interfaces Center, and Zetlenmoyer Center for Surface Studies.

In addition to interacting with the centers, the department originates and encourages programs that range from those that are classical chemical engineering to those that are distinctly interdisciplinary. The department offers active and growing programs in adhesion and tribology; emulsion polymerization and latex technology; bulk polymer systems; process control; process improvement studies; rheology; computer applications; environmental engineering; thermodynamics; kinetics and catalysis; enzyme technology; and biochemical engineering.

Career Opportunities
Master of science, master of engineering, and doctor of philosophy graduates in the chemical engineering area are sought by industry for activities in the more technical aspects of their operations, especially design, process and product development, and research. Many of these graduates also find opportunities in research or project work in government agencies and in university teaching and research.

Physical Facilities
The department is well equipped for research in adhesion and tribology, polymer science and engineering, catalysis and reaction kinetics, thermodynamic property studies, fluid dynamics, heat and mass transfer, process dynamics and control, and enzyme engineering and biochemical engineering.

The Departmental and University computing facilities include Pentium-based PCs and RS/6000 workstations, connected by a University-wide high speed network. The central computers in this Unix distributed computing environment include ten RS/6000 Model 990 workstations for compute-intensive applications and worldwide networking via Internet/WWW. The distributed computing network is expanded as the demand for computing resources and services grows thereby ensuring the Chemical Engineering Department access to the latest computing technology.

Special Programs
Master of engineering design option. For those interested in design, the department offers the master of engineering design option. In this program, the student works on a design project proposed by the process design group of a cooperating industry. Direction of the design project is shared by the cooperating industry and a member of the faculty. Students desiring to enroll in this program should indicate such at the time they apply for admission. Six hours of graduate credit are earned for the design project and the final report.

Polymer science and engineering. The polymers industry includes work done in the Department of Chemical Engineering as well as the Departments of Chemistry, Materials Science and Physics, the Materials Research Center, the Center for Surface and Coatings Research, the Center for Polymer Science and Engineering, the Emulsion Polymers Institute, and the Polymers Interface Center. More than 20 faculty members from these organizations or areas have major interests in polymers and cooperate on a wide range of research projects. For students with deep interest in the area, degree programs are available leading to the master of science and doctor of philosophy degrees in polymer science and engineering.

Research activities in which chemical engineering students and faculty are involved include studies of the mechanism of reactions in emulsion polymerization and copolymerization; colloidal surface and interfacial aspects of emulsion polymers; the processes involved in their preparation, with special attention to the relationship between process parameters and properties of polymers; work on polymer blends, especially interpenetrating polymer networks, and the application of these materials to sound-deadening; rheology of viscoelastic materials; crystallization behavior from polymer melts and solutions; polymer film characteristics and the tailoring of these properties for selective transfer rates; latex film drying rates; polymer interdiffusion studies; characteristics of polymer surfaces and interfaces; and the preparation of polymeric materials from agricultural raw materials.

Major Requirements
Requirements for the masters degrees are listed in the section on The Graduate School.

All candidates for the Master of Science degree are required to complete a research report or thesis for which six hours of graduate credit are earned. Course selection is done individually for each student, although CHE 400, CHE 410, CHE 415 and CHE 461 are required courses.

Candidates for the Master of Engineering degree do not do research; all 30 credit hours are fulfilled with course work. Course selection is done individually for each student, although CHE 400, CHE 410, CHE 415 and CHE 461 are required courses.

The requirements for the doctor of philosophy degree also are listed in the section on The Graduate School. In addition to an approved course and thesis program, the Ph.D. student must pass a qualification examination given during the second year of residence.

Advanced Courses in Chemical Engineering
400. Chemical Engineering Thermodynamics (3) fall Applications of thermodynamics in chemical engineering. Topics include energy and entropy, heat effects accompanying solution, flow of compressible fluids, refrigeration including solution cycles, vaporization and condensation processes, and chemical equilibria. Prerequisite: an introductory course in thermodynamics. Stein, Santore

401. Chemical Engineering Thermodynamics II (3) spring, every other year
A detailed study of the uses of thermodynamics in predicting phase equilibria in solid, liquid, and gaseous systems. Fugacities of gas mixtures, liquid mixtures, and solids. Solution theories; uses of equations of state; high-pressure equilibria. Stein

410. Chemical Reaction Engineering (3) spring
The application of chemical kinetics to the engineering design and operation of reactors. Non-isothermal and adiabatic reactions. Homogeneous and heterogeneous catalysis. Residence time distribution in reactors. Prerequisite: CHE 211.

413. Heterogeneous Catalysis and Surface Characterization (3) fall, every other year
History and concepts of heterogeneous catalysis. Surface characterization techniques, and atomic structure of surfaces and adsorbed monolayers. Kinetics of elementary steps (adsorption, desorption, and surface reaction) and overall reactions. Catalysis by metals, metal oxides, and sulides. Industrial applications of catalysis: selective oxidation, pollution control, ammonia synthesis, hydrogenation of carbon monoxide to synthetic fuels and chemicals, polymerization, hydrocracking, and cracking. Wachs

415. Transport Processes (4) spring
A combined study of the fundamentals of momentum transport, energy transport and mass transport and the analogies between them. Evaluation of transport coefficients for single and multicomponent systems. Analysis of transport phenomena through the equations of continuity, motion, and energy. Prerequisite: CHE 461 or equivalent. Silebi, Schiesser
419. (Mech 419) Asymptotic Methods in the Engineering Sciences (3)
Introductory level course with emphasis on practical applications. Material covered includes: Asymptotic expansions, Regular and singular perturbations; asymptotic matching; Boundary value problems; distinguished limits; Multiple scale expansion. W.K.B. Theory, far field theories. Blythe

421. Heat Transfer (3)

427. (ME 427) Multiphase Flow and Heat Transfer (3)
Heat transfer and fluid dynamics of multiphase systems. Subcooled, nucleate, and film boiling; bubble nucleation; dynamics of bubble growth and collapse; vapor-liquid concurrent flow regimes; two-phase pressure drop and momentum exchange, low instabilities; convective-flow boiling; simultaneous heat and mass transfer. Prerequisite: CHE 421 or ME 321, or courses in the area of transport phenomena. Chen

428. Rheology (3)
An intensive study of momentum transfer in elastic viscous liquids. Rheological behavior of solution and bulk phase polymers with emphasis on the effect of molecular weight, molecular weight distribution and branching. Derivation of constitutive equations based on both molecular theories and continuum mechanics principles. Application of the momentum equation and selected constitutive equations to geometries associated with viscometric flows. Silebi

430. Mass Transfer (3) fall, every other year
Theory and developments of the basic diffusion and mass transfer equations and transfer coefficients including simultaneous heat and mass transfer, chemical reaction and dispersion effects. Applications to various industrially important operations including continuous contact mass transfer, absorption, humidification, etc. Brief coverage of equilibrium stage operations as applied to absorption and to binary and multicomponent distillation. Carr, Silebi

433. (ECE 433, ME 433) State Space Control (3) fall
State-space methods of feedback control system design and design optimization for invariant and time-varying deterministic, continuous systems; pole positioning, observability, controllability, modal control, observer design, the theory of optimal processes and Pontryagin’s Maximum Principle, the linear quadratic optimal regulator problem, Lyapunov functions and stability theorems, linear optimal open-loop control; introduction to the calculus of variations; introduction to the control of distributed parameter systems. Intended for engineers with a variety of backgrounds. Examples will be drawn from mechanical, electrical and chemical engineering applications. Prerequisite: M.E. 343 or E.C.E. 212 or Ch.E. 386 or consent of instructor. Johnson, Georgakis

434. (ECE 434, ME 434) Multivariable Process Control (3)
A state-of-the-art review of multivariable methods of interest to process control applications. Design techniques examined include loop interaction analysis, frequency domain methods (inverse Nyquist Array, Characteristic Loci and Singular Value Decomposition) feed forward control, internal model control and dynamic matrix control. Special attention is placed on the interaction of process design and process control. Most of the above methods are used to compare the relative performance of intensive and extensive variable control structures. Prerequisite: Ch.E. 433 or M.E. 433 or E.C.E. 433 or consent of instructor. Georgakis

436. (ECE 436, ME 436) Systems Identification (3)
The determination of model parameters from time-history and frequency response data by graphical, deterministic and stochastic methods. Examples and exercises taken from process industries, communications and aerospace testing. Regression, quadraticization and invariant-imbedding techniques for nonlinear system parameter identification included. Prerequisite: Ch.E. 433 or M.E. 433 or E.C.E. 433 or consent of instructor. Johnson

437. (ECE 437, ME 437) Stochastic Control (3)
Linear and nonlinear models for stochastic systems. Controllability and observability. Minimum variance state estimation. Linear quadratic Gaussian control problem. Computational considerations. Nonlinear control problem in stochastic systems. Prerequisite: Ch.E. 433 or M.E. 433 or E.C.E. 433 or consent of instructor.

438. Process Modeling and Control Seminar (1) fall, spring
Presentations and discussions on current methods, approaches, and applications. Credit cannot be used for the M.S. degree.

444. Bioseparations (3)
Separation techniques for biomolecule isolation and purification. Theory and problems of bioaffinity chromatography, electromigration processes, and aqueous two-phase polymer extraction systems. Engineering principles for scaling-up bioseparation processes. Prerequisite: Consent of the instructor.

445. Enzyme Engineering (3)
Enzyme characteristics including nomenclature, physical properties, kinetics, and assay methods with emphasis on practical application at commercial scale. Methods of enzyme production and purification. Design and analysis of industrial-scale reactors employing soluble and immobilized enzymes. Prerequisite: Consent of the instructor.

446. Biochemical Engineering Laboratory (3)
Laboratory and pilot-scale experiments in fermentation and enzyme technology, tissue culture, and separations techniques. Prerequisites: Ch.E. 341 and Ch.E. 444 or Ch.E. 342 previously or concurrently.

448. Topics in Biochemical Engineering (3)
Analysis, discussion, and review of current literature for a topical area of biotechnology. Course may be repeated for credit with the consent of the instructor. Prerequisite: Consent of the instructor.

450. Special Topics (1-12)
An intensive study of some field of chemical engineering not covered in the more general courses. Credit above three hours is granted only when different material is covered.

451. Problems in Research (1)
Study and discussion of optimal planning of experiments and analysis of experimental data. Discussion of more common and more difficult techniques in the execution of chemical engineering research.

455. Seminar (1-3) fall, spring
Critical discussion of recent advances in chemical engineering. Credit above one hour is granted only when different material is covered.

460. Chemical Engineering Project (1-6)
An intensive study of one or more areas of chemical engineering, with emphasis on engineering design and applications. A written report is required. May be repeated for credit.

461. Mathematical Methods in Chemical Engineering (3) fall
Solution of chemical engineering problems with emphasis on chemical reactions and transport phenomena. Specific topics include Linear Vector Spaces; Eigenvalues, Eigenvectors and Eigenfunctions; First and Higher Order Linear Differential Equations; Bessel and Legendre Functions; Green’s Functions, Sturm-Liouville Problems, Qualitative and Quantitative Methods for Nonlinear Ordinary Differential Equations; Phase Plane; Separation of Variables; Fourier Transform Methods; Method of Characteristics. Example problems from the chemical engineering literature. Georgakis
480. Research (3)
Investigation of a problem in chemical engineering.

481. Research (3)
Continuation of ChEn 480.

482. (Chm 482, Mat 482) Engineering Behavior of Polymers (3)
A treatment of the mechanical behavior of polymers. Characterization of experimentally observed viscoelastic response of polymeric solids with the aid of mechanical model analogs. Topics include time-temperature superposition, experimental characterization of large deformation and fracture processes, polymer adhesion, and the effects of fillers, plasticizers, moisture, aging and mechanical behavior.

483. (Chm 483) Emulsion Polymers (3)
Examination of fundamental concepts important in the manufacture, characterization, and application of polymer latexes. Topics to be covered will include colloidal stability, polymerization mechanisms and kinetics, reactor design, characterization of particle surfaces, latex rheology, morphology considerations, polymerization with functional groups, film formation and various application problems. El-Aasser, Klein

484. (Chm 484) Crystalline Polymers (3)
An in-depth treatment of the morphology and behavior of both polymer single crystals and bulk crystallized systems. Emphasis is placed on the relationship between basic crystal physics, thermal and annealing history, orientation and resulting properties. A detailed discussion of the thermodynamics and kinetics of transition phenomena and a brief treatment of hydrodynamic properties and their relationship to crystallization and processing properties. Prerequisite: ChEn 392 or ChEn 393 or equivalent.

485. (Chm 485, Mat 485) Polymers Blends and Composites (3)
spring, every other year
An intensive study of the synthesis, morphology, and mechanical behavior of polymer blends and composites. Mechanical blends, block and graft copolymers, interpenetrating polymer networks, polymer impregnated concrete, and fiber and particulate reinforced polymers are emphasized. Prerequisite: any introductory course in polymers. Sperling

486. Polymer Processing (3)
Application of fundamental principles of mechanics, fluid dynamics and heat transfer to the analysis of a wide variety of polymer flow processes. A brief survey of the rheological behavior of polymers is also included. Topics include pressurization, pumping, die forming, calendaring, coating, molding, fiber spinning and elastic phenomena. Prerequisite: ChEn 392 or equivalent. Silebi

487. Polymer Interfaces (3) spring, every other year
An intensive study of polymer surfaces and interfaces, with special emphasis on thermodynamics, kinetics, and techniques for characterization. Chemistry and physics of adsorbed polymer chains. Diffusion and adhesion at polymer-polymer interfaces, especially as related to mechanical properties such as fracture and toughness will be described. Prerequisite: Introductory polymer course.

492. (Chm 492) Topics in Polymer Science (3)
Intensive study of topic selected from areas of current research interest such as morphology and mechanical behavior, thermodynamics and kinetics of crystallization, new analytical techniques, molecular weight distribution, non-Newtonian flow behavior, second-order transition phenomena, novel polymer structures. Credit above three hours is granted only when different material is covered. Prerequisite: Chem 392 or equivalent.

Chemistry

Professors. Keith J. Schray, Ph.D. (Penn State), chair; Jack A. Alhadeff, Ph.D. (Oregon Medical School); Ned D. HeinDEL, Ph.D. (Delaware), Howard S. Bunn, Professor of Chemistry; Leonard E. Klebanoff, Ph.D. (California-Berkeley); Kamiel Kier, Ph.D. (Czechoslovak Academy of Science, Prague), university professor; Charles S. Krahnkel, Ph.D. (Wisconsin-Madison); John W. Larsen, Ph.D. (Purdue); Steven L. Regen, Ph.D. (M.I.T.); Gary W. Simmons, Ph.D. (Virginia); Daniel Zeroka, Ph.D. (Pennsylvania).

Associate professors. Gregory S. Ferguson, Ph.D. (Cornell); Natalie Foster, Ph.D. (Lehigh); James E. Roberts, Ph.D. (Northwestern), associate chair.

Assistant professors. John W. Benbow, Ph.D., (Indiana); Michael Freund, Ph.D. (University of Florida); Marie C. Messmer, Ph.D. (California-San Diego).

Adjunct professors. William R. Anderson (San Jose State); Andrew K. Godwin, Ph.D. (Pennsylvania); Thomas Hamilton, Ph.D. (Wales); Gary D. Kruth, M.D./Ph.D. (Baylor); Tibor Sipos, Ph.D. (Lehigh); James E. Sturm, Ph.D. (Notre Dame).

Active emeriti. Fortunato M. Micalle, Ph.D. (Lehigh); James E. Sturm, Ph.D. (Notre Dame); John W. Vanderhoff, Ph.D. (Buffalo).

Chemistry is a versatile subject area and the pursuit of a career in chemistry can be a most intellectually satisfying experience. No other basic science touches and shapes as many aspects of modern society as does chemistry. The study of chemistry has provided solutions to complex problems and has improved the quality of all phases of human life from soft contact lenses and synthetic blood to longer lasting paint and alternative fuels. A particular strength of this department is in Surface and Interface Chemistry, which bridges many areas of modern science and technology.

Chemists at all levels of education find a market for their skills and knowledge in many employment areas. Chemists provide the technical backbone for the manufacturing industries (pharmaceuticals, plastics, paper, semiconductor electronics technology, agriculture), for service industries (clinical and forensic laboratories, academic, environmental protection, information science) and for governmental positions in regulatory agencies and in science policy analyses. Many chemists are employed in nontraditional areas, such as patent law, insurance underwriting, sales, product management, journalism, and even banking.

The alluring challenge of chemistry inspires many bachelor degree recipients to study for advanced degrees within the discipline of chemistry and in other areas, as well. Chemistry or biochemistry is the strongest preparation for graduate studies or for professional school in the health-related disciplines (medicine, pharmacology, biochemistry), and for other science programs (material science, polymers, biotechnology, environmental studies, mineralogy).

The study of chemistry opens doors to satisfying careers, to a stimulating view of the world, and to a professional life in which one's natural tendency to ask "Why?" can lead to personally rewarding endeavors. The undergraduate curriculum in chemistry contains many of the prerequisites for biology, earth and environmental sciences, materials science, molecular biology, physics, and chemical engineering, allowing students to transfer the majority of credits through the sophomore year.

Chemistry students have the opportunity to design their undergraduate curricula for specialization in a variety of fields:
health-related chemistry (including premedical students)
suggested biological sciences electives: 31, 32, 101, 102, 324, 345, 353, 367.
chemistry of materials (polymers, solid state, surfaces)
suggested physics electives: 31, 363.
suggested chemistry electives: 12, 388, 391, 392, 393, 394, 396.

environmental chemistry
suggested earth and environmental sciences 31, 351
suggested biological sciences electives: 31, 32, 101, 102.
suggested chemical engineering electives: 320, 321.
suggested chemistry electives: 391.
suggested civil engineering elective: 374.
geochemistry
suggested earth and environmental sciences electives: 21, 131.
suggested chemistry electives: 337, 396.

chemistry management
suggested accounting electives: 151, 152, 324.
suggested law elective: 201.
suggested management electives: 269, 270, 302, 321 or 333.
suggested economics electives: 105, 119, 145.
suggested marketing electives: 211, 312.
suggested finance electives: 225, 330.

Certain of the above courses can be used to waive required graduate courses for the M.B.A. at Lehigh.

B.S. and B.A. Degrees in Chemistry
The Department of Chemistry offers B.S. Chemistry programs in both the College of Arts and Sciences and the College of Engineering and Applied Science. In addition, the department offers a B.A. Chemistry program in the College of Arts and Sciences. The B.S. chemistry programs in the two colleges are identical in their chemistry and collateral science requirements and are pre-professional in nature.

Students planning to attend graduate school in chemistry or an allied science should elect the B.S. program in whichever college to which they have been admitted. The B.A. program in the College of Arts and Sciences is not a pre-professional program and may be elected by students who do not plan to do graduate work in chemistry or allied science but wish to have a stronger background in chemistry than is provided in the Chemistry Minor program. The B.A. program also provides a useful tie-in with health-related chemistry, environmental chemistry, geochemistry or chemistry management options (see above). Students may transfer from the B.S. to B.A. programs or vice-versa as late as the junior year, since basic requirements are the same for the two. Students who are in the B.A. program and make a late decision to attend graduate school in chemistry or allied science will have minimal chemistry preparation for this by electing Chemistry 307: Advanced Inorganic Chemistry.

Department Modern Foreign Language Requirement.
The modern foreign language requirement is met by one of three options: 1. Completion of the second semester of a modern foreign language; 2. Certification of language equivalent to this level taken in high school; 3. Substitution of six credits of science electives. If science electives are chosen, non-science distribution requirement must still be met.

B.S. Degree in Chemistry, College of Arts & Sciences

Summary of Requirements

I. College and University
   a. Arts I
      (1 credit)
   b. English 1, 2
      (6 credits)
   c. College Seminar
      (3 credits)
   (26 credits)

II. Collateral Sciences
   a. Physics 11, 12, 21, 22
      (10 credits)
   b. Math 21, 22, 23, 205
      (15 credits)
   c. Engr 1 or CSE 11
      (3-4 credits)
   (28-29 credits)

III. Chemistry Courses
   a. Introductory Chemistry
      Chm 75, 76
      (8 credits)
      [Chm 71, 21, 22, 31 sequence may be substituted.]
   b. Organic Chemistry
      Chm 51, 52, 53, 58, 353
      (10 credits)
   c. Inorganic Chemistry
      Chm 205, 207
      (5 credits)
   d. Physical Chemistry
      Chm 187, 192, 341
      (9 credits)
   e. Analytical Chemistry
      Chm 332, 338, 339
      (7 credits)
   f. Technical Writing
      Chm 201 (W-I course)
      (2 credits)
   g. Advanced Chemistry Elective
      (3 credits)
   (44 credits)

IV. Free Electives
   (23 credits)

Total Credits
   (121 credits)

Model Roster

freshman year, first semester (15 credits)
Arts 1
   Choices and Decisions (1)
Engl 1
   Composition and Literature (3)
Chm 75
   Concepts, Models, and Experiments I (4)
Math 21
   Calculus I (4)
   College Seminar (3)

freshman year, second semester (16 credits)
Engl 2
   Composition and Literature (3)
Phy 11, 12
   Introductory Physics I and Laboratory (5)
Math 22
   Calculus II (4)
Chm 76
   Concepts, Models, and Experiments II (4)
sophomore year, first semester (16-17 credits)
Chm 51
   Organic Chemistry I (3)
Chm 53
   Organic Lab I (1)
Phy 21
   Introductory Phys. II (4)
Phy 22
   Introductory Phys. II Lab (1)
Math 23
   Calculus III (4)
Engr 1 or CSE 11
   Computer Programming (3-4)
sophomore year, second semester (16 credits)
Chm 52
   Organic Chemistry II (3)
Chm 58
   Organic Chemistry Lab II (1)
Chm 187
   Physical Chem. I (3)
Math 205
   Linear Methods (3)
   distribution requirement -- free elective (6)
junior year, first semester (15 credits)
Chm 192
   Physical Chemistry Lab (2)
Chm 234
   Analytical Chemistry Lab (1)
Chm 332
   Analytical Chemistry (3)
Chm 341
   Chem. Physics and Bonding (4)
Chm 205
   Main Group Elements (2)
   modern foreign language requirement (4)
junior year, second semester (15 credits)
Chm 201
   Technical Writing (2)
Chm 307
   Advanced Inorganic Chem. (3)
Chm 338
   Instrumental Analysis Lab (2)
Chm 339
   Instrumental Analysis (2)
Chm 333
   Organic Analysis Laboratory (2)
   modern foreign language requirement (4)
senior year, first semester (14 credits)
advanced chemistry elective (3)*
distribution requirements -- free electives (11)

senior year, second semester (14 credits)
advanced chemistry elective (3)*,**
distribution requirements -- free electives (11)

* See list of choices which appears below.
** This becomes a free elective if the advanced chemistry elective was taken in the fall semester of the senior year.

Advanced Chemistry Elective Requirement

One 3-credit course selected from the following:

Chm 358       Advanced Organic Chemistry
Chm 371       Elements of Biochemistry I
Chm 376       Advanced Chemistry Research Lab
Chm 381       Radiation and Structure
Chm 382       Spectroscopy and Photochemical Kinetics
Chm 391       Colloid and Surface Chemistry
Chm 392       Introduction to Polymer Science
Chm 393       Physical Polymer Science
Chm 394       Organic Polymer Science
Phy 363       Physics of Solids

Students are encouraged to take any second course that sequences the first by means of a free elective.

B.A. Degree in Chemistry, College of Arts and Sciences

Summary of Requirements

I. College and University (26-27 credits)
   a. Arts 1
   b. English 1, 2
   c. College Seminar
   d. College distribution

II. Collateral Sciences (28-29 credits)
   a. Physics 11, 12, 21, 22
   b. Math 21, 22, 23, 205
   c. Engr 1 or Cse 11

II. Chemistry Courses (32 credits)
   a. Introductory Chemistry
      Chm 75, 76
      [Chm 21, 22, 31 sequence may be substituted.]
   b. Organic Chemistry
      Chm 51, 52, 53, 58
   c. Inorganic Chemistry
      Chm 205
   d. Physical Chemistry
      Chm 187, 192, 341
   e. Analytical Chemistry
      Chm 332
   f. Technical Writing
      Chm 201 (W-I course)
   g. College Seminar

IV. Free Electives (35 credits)

Total Credits (121 credits)

Model Roster

freshman year, first semester (15 credits)
Arts 1       Choices and Decisions (1)
Engl 1       Composition and Literature (3)
Chm 75       Concepts, Models and Experiments I (4)
Math 21      Calculus I (4)
              College Seminar (3)

freshman year, second semester (16 credits)
Engl 2       Composition and literature (fiction, poetry, drama) (3)
Phy 11, 12   Introductory Physics I and Laboratory (5)

Chm 76       Concepts, Models, and Experiments II (4)
Math 22      Calculus II (4)

sophomore year, first semester (16-17 credits)
Chm 51       Organic Chemistry I (3)
Chm 53       Organic Chemistry Laboratory I (1)
Phy 21       Introductory Physics II (4)
Phy 22       Introductory Physics Laboratory II (1)
Math 23      Calculus III (4)
Engr 1 or Cse 11 Computer Programming (3-4)

sophomore year, second semester (16 credits)
Chm 52       Organic Chemistry II (3)
Chm 58       Organic Chemistry Lab II (1)
Chm 187      Physical Chemistry I (3)
Math 205     Linear Methods (3)
distribution requirements -- free electives (6)

junior year, first semester (15 credits)
Chm 192      Physical Chemistry Lab (2)
Chm 205      Main Group Elements (2)
Chm 332      Analytical Chemistry (3)
Chm 341      Chem. Physics and Bonding (4)
modern foreign language requirement (4)

junior year, second semester (15 credits)
Chm 201      Technical Writing (2) (W-I course)
modern foreign language requirement (4)
distribution requirements -- free electives (9)

senior year, first semester (14 credits)
distribution requirements -- free electives (14)

senior year, second semester (14 credits)
distribution requirements -- free electives (14)

B.S. Degree in Chemistry, College of Engr. & Applied Science

Summary of Requirements

I. College distribution
   24 credits

II. Physics, math, and computing
   28 credits

III. Chemistry
    44 credits

IV. Unrestricted electives
    27 credits

Total credits
    123 credits

Model Roster

freshman year (30-31 credits)
A student should follow the normal freshman year in the College of E&AS and observe the following note.
Note: It is recommended that, where possible, students planning to major in chemistry take Chemistry 75 in the fall semester and Chemistry 76 in the spring semester of the freshman year. For such students the elective in the spring semester is displaced to a subsequent semester. The Chemistry 21/22/31 sequence may be substituted.

sophomore year, first semester (17 credits)
Chm 51       Organic Chemistry I (3)
Chm 53       Organic Chemistry Laboratory I (1)
Phy 21       Introductory Physics II (4)
Phy 22       Introductory Physics Laboratory II (1)
Math 23      Calculus III (4)
modern foreign language requirement (4)* (See details above)

sophomore year, second semester (16 credits)
Chm 76       Concepts, Models, and Experiments II (4)
Math 22      Calculus II (4)

Chm 31 Chemical Equilibria will displace this modern foreign language requirement to a subsequent semester if Chm. 31 was not taken in the freshman year.
sophomore year, second semester (17 credits)
Chm 52  Organic Chemistry II (3)
Chm 58  Organic Chemistry Laboratory II (1)
Chm 187 Physical Chemistry I (3)
Math 205 Linear Methods (3)
modern language requirement (4)
(See details above)
Humans and Social Science requirement (3)

junior year, first semester (15 credits)
Chm 192 Physical Chemistry Laboratory (2)
Chm 205 Main Group Elements (2)
Chm 332 Analytical Chemistry (3)
Chm 341 Chemical Physics and Bonding (4)
Eco 1 Economics (4)

junior year, second semester (17 credits)
Chm 201 Technical Writing (2)
Chm 307 Advanced Inorganic Chem. (3)
Chm 338 Instrumental Analysis Lab (2)
Chm 339 Instrumental Analysis (2)
Chm 353 Organic Chemistry Laboratory (2)
Humans and Social Science requirement (3)
free elective (3)

senior year, first semester (14 credits)
advanced chemistry elective (3)
Humans and Social Science requirement (3)
free electives (8)

senior year, second semester (13 credits)
advanced chemistry elective (3)*
free electives (10)

*See list of choices for the advanced chemistry elective requirement under the B.S. degree in Chemistry/College of Arts and Sciences.
**This becomes a free elective if the advanced chemistry elective requirement was taken in the fall of the senior year.

Five-Year Bachelor's/Master's Programs

Five-year programs may be arranged for students to receive B.S. or B.A. degrees and the M.S. degrees in chemistry with a concentration in one of several fields of chemistry (inorganic, organic, analytical, physical, polymers, biochemistry, or materials chemistry). Such a program offered by the Department of Chemistry is the five-year B.S./M.S. program which focuses on materials education from a chemistry perspective. Students are awarded B.S. and M.S. degrees in Chemistry upon completion of all requirements. Specific features of the program include participation in a weekly seminar during the academic year for credit, and summer internships for credit in university, industrial, government, or national laboratories. Materials-related electives are selected from suggested lists of courses in materials science, polymers, solid state chemistry, and physics. Additional information may be obtained from Professor Kralhansel or Professor Krier.

Five-Year B.S./M.S. Program in Chemistry of Materials

Model Roster

freshman year (30-31 credits)
A student should follow the normal B.S. in Chemistry freshman year for the college in which the student is enrolled and should observe the following note.
Note: It is recommended that, where possible, students planning to major in chemistry take Chemistry 75 in the fall semester and Chemistry 76 in the spring semester of the freshman year. For such students the elective in the spring semester is displaced to a subsequent semester. The Chemistry 21/22/31 sequence may be substituted.

summer I
Chm 163 Chemistry of Materials I (4)

sophomore year, first semester (17-18 credits)
Chm 51 Organic Chemistry I (3)
Chm 53 Organic Chemistry Laboratory I (1)
Math 23 Calculus III (4)
Phy 21 Introductory Physics I (4)
Phy 22 Introductory Physics Lab I (1)
Elective, Engr 1 CSc 11 or Modern Foreign Language (3-4)
Chm 363 Science Seminar (1)

sophomore year, second semester (17 credits)
Chm 52 Organic Chemistry II (3)
Chm 58 Organic Chemistry Laboratory II (1)
Chm 187 Physical Chemistry II (3)
Math 205 Linear Methods (3)
** Elective, Engr 1, CSc 11 or Modern Foreign Language (6)
Chm 363 Science Seminar (1)

summer II
Chm 263 Chemistry of Materials II (4)

junior year, first semester (16 credits)
Chm 192 Physical Chemistry Laboratory (2)
Chm 205 Main Group Elements (2)
Chm 332 Analytical Chemistry (3)
Chm 234 Analytical Chemistry Laboratory (1)
Chm 341 Chemical Physics and Bonding (4)
Chm 363 Science Seminar (1)
** Distribution requirement/elective (3)

junior year, second semester (15 credits)
Chm 20 Technical Writing (2)
Chm 307 Advanced Inorganic Chemistry (3)
Chm 363 Science Seminar (1)
** Program related electives (6)

summer III
Off-campus experience in an industrial, national or government laboratory

senior year, first semester (16 credits)
Chm 363 Science Seminar (1)
ACE Advanced Chemistry Elective (3)
** Distribution requirement (3)
*** Program related electives (9)

senior year, second semester (16 credits)
Chm 363 Science Seminar (1)
Electives (6)
*** Program related electives (9)

fifth year leading to MS degree

summer IV
Chm 421 Chemistry Research (3)

fifth year, fall semester (10 credits)
Chm 402 Physical Inorganic Chemistry (3)
Chm 421 Chemistry Research (3)
*** Program related electives (4)

fifth year, spring semester (10 credits)
Chm 443 Solid State Chemistry (3)
Chm 481 Graduate Seminar (1)
*** Program related electives (6)
31. Chemical Equilibria in Aqueous Systems (3) fall-spring
A study of the theoretical basis and practical applications of equilibria in aqueous solutions, including acid-base, precipitation-solubility, metal-ligand, oxidation-reduction, and distribution equilibria. Introduction to chemical thermodynamics, spectrophotometry, potentiometry and chromatography. The laboratory work emphasizes the qualitative and quantitative analysis of equilibria in aqueous media. Prerequisite: Chm 21, Math 21. Two lectures and one three-hour laboratory period. (NS)

51. Organic Chemistry I (3) fall
Systematic survey of the typical compounds of carbon, their classification, and general relations; study of synthetic reactions. Prerequisite: Chm 21 or 75. (NS)

52. Organic Chemistry II (3) spring
Continuation of Chm 51. Prerequisite: Chm 51. (NS)

53. Organic Chemistry Laboratory I (1) fall
Preparation of pure organic compounds. Modern techniques of characterization. Prerequisite: Chm 51 previously or concurrently. (NS)

58. Organic Chemistry Laboratory II (1) spring
Continuation of Organic Chemistry Laboratory I. Prerequisite: Chm 53 previously; Chm 52 previously or concurrently. (NS)

75. Concepts, Models and Experiments I (4) fall
A first-semester course in chemistry for students planning to major in chemistry, biochemistry, chemical engineering, materials science, or other chemistry-related fields. Chemical and physical properties, structures, bonding concepts, and quantitative analysis. Laboratory includes synthesis, separation, and analysis procedures; computer applications to chemistry. Three lectures, one laboratory. (NS)

76. Concepts, Models and Experiments I (4) spring
Continuation of Chemistry 75. Three lectures, one laboratory. Prerequisite: Chm 75 or departmental consent. (NS)

163. Chemistry of Materials I (4) summer
Research laboratory for students enrolled in the five-year B.S.M.S. chemistry of materials program. (NS)

177. Introduction to Research (1-2) fall-spring
For advanced freshmen and sophomore chemistry majors. May be repeated for credit. Prerequisite: Consent of department chair. (NS)

187. Physical Chemistry I (3) spring
Development of the principles of thermodynamics and their application to systems in which composition is of major concern: solutions, chemical and phase equilibria. Elements of chemical reaction kinetics. Prerequisite: Chm 31 or 76, and Math 21 or 41 previously or concurrently. (NS)

189. Physical Chemistry II (3) fall

192. Physical Chemistry Laboratory (2)
Laboratory studies that illustrate the various fields of study in experimental physical chemistry. Prerequisite: Chm 187. (NS)

194. Physical Chemistry for Biological Sciences (3) fall
The principles and applications of physical chemical concepts to systems of biological interest, including the gas laws, thermodynamics of metabolic reactions, colligative properties, electrochemical equilibria, reaction kinetics and enzyme catalysis, and transport of macromolecules and viruses. Prerequisite: Chm 21 or 75. (NS)
201. Technical Writing (2)
Principal types of written communications used by professional chemists including informative abstracts, research proposals, progress reports, executive summaries for nonchemist decision makers and proper written experimental procedures, tables, schemes and figures. Prerequisite: Junior standing in Chemistry major or consent of the department chair. (ND)

205. Main Group Elements (2) fall
Chemistry of the main group elements. Prerequisite: Chm 31 or 76. (NS)

209. Chemistry of Organic and Inorganic Materials (3) fall
A systematic study of the most important organic and inorganic structures, covering synthesis, nomenclature, reactions, and properties. Grouping of elements with similar properties within the periodic table is stressed. The nature of the covalent bond will be developed. Reactions involving alkynes (especially vinyls), hydroxyl, amine, oxime, and halogen groups will be emphasized. Crystal structures and physical properties. Prerequisite: Chm 21 or 75. Sperling. (NS)

250. Special Topics (1-3)
Selected topics in chemistry. May be repeated for credit when different topics are offered. (NS)

263. Chemistry of Materials II (4) summer
Research laboratory for students enrolled in the five-year B.S./M.S. chemistry of materials program. (NS)

307. Advanced Inorganic Chemistry (3) spring
Introduction to transition metal complexes; theories of bonding; kinetics and mechanisms of transition metal complex reactions; selected aspects of organometallic chemistry; bioinorganic chemistry. Prerequisite: Chm 341. (NS)

312. (ChE 312, Mat 312) Fundamentals of Corrosion (3) fall
Corrosion phenomena and definitions. Electrochemical aspects including reaction mechanisms, thermodynamics, Pourbaix diagrams, kinetics of corrosion processes, polarization and passivity. Non-electrochemical corrosion including mechanisms, theories and quantitative descriptions of atmospheric corrosion. Corrosion of metals under stress. Cathodic and anodic protection, coatings alloys, inhibitors, and passivators. Prerequisite: Mat 205 or Chm 187. (NS)

322. Analytical Chemistry (3) fall
Theory and practice of chemical analysis. Principles of quantitative separations and determinations; theory and application of selected optical and electrical instruments in analytical chemistry; interpretation of numerical data, design of experiments, solute distribution in separation methods. Prerequisites: Chm 31 and 51. (NS)

336. Clinical Chemistry (3) spring
Applications of analytical chemistry to clinical problems. Discussion of methods in common use and the biochemical-medical significance of the results. Prerequisites: Chm 332 and 52. Schray. (NS)

337. (EES 337, Mat 333) X-ray Diffraction of Materials (3) fall
Introduction to crystal symmetry, point groups, and space groups. Emphasis on materials characterization by X-ray diffraction and electron diffraction. Specific topics include crystallographic notation, stereographic projections, orientation of single crystals, textures, phase identification, quantitative analysis, stress measurement, electron diffraction, ring and spot patterns, convergent beam electron diffraction (CBED), and space group determination. Applications in mineralogy, metallurgy, ceramics, microelectronics, polymers, and catalysts. Lectures and laboratory work. Prerequisite: Mat 203 or EES 133 or senior standing in chemistry. Lyman, Chan. (NS)

338. Instrumental Analysis Laboratory (2) spring
Laboratory studies of modern methods of instrumental analysis emphasizing function and characteristics of instrumentation, data, processing, and experimental design. Prerequisites: Chm 339 previously or concurrently. (NS)

339. Instrumental Analysis (2) spring
Principles and applications of modern methods of analytical analysis including optical spectroscopy, nuclear magnetic resonance spectroscopy, mass spectrometry, electrochemical methods, chromatography, thermal methods, and surface characterization. Prerequisite: Chm 332 (NS)

341. Chemical Physics and Bonding (4) fall

350. Special Topics (1-3)
Selected advanced topics in chemistry. May be repeated for credit when different topics are offered. (NS)

353. Organic Analysis Laboratory (3) spring
Identification of organic compounds as single components and mixtures. Application of combined chemical and spectral assay techniques. Use and interpretation of data from nuclear magnetic resonance, infrared, and mass spectroscopic examinations. Separation techniques for mixtures. Prerequisites: Chm 52 and 58. (NS)

358. Advanced Organic Chemistry (3) fall
Reaction mechanism types and supporting physical-chemical data. Classes of mechanisms include elimination, substitution, rearrangement, oxidation-reduction, enolate alkylation, and others. Prerequisite: one year of organic chemistry. (NS)

363. Science Seminar (1) fall-spring
Discussion of current research in materials chemistry. For students enrolled in the five-year B.S./M.S. chemistry of materials program. May be repeated for credit. (NS)

368. Advanced Organic Laboratory (2)
The synthesis and study of organic compounds illustrating the important techniques and special pieces of apparatus commonly used in organic chemical research. Prerequisite: one year of organic chemistry and laboratory. (NS)

371. (Bios 371) Elements of Biochemistry I (3) fall
A general study of carbohydrates, proteins, lipids, nucleic acids, and other biological substances and their importance in life processes. Protein and enzyme chemistry are emphasized. Prerequisite: one year of organic chemistry. (NS)

372. (Bios 372) Elements of Biochemistry II (3) spring
Dynamic aspects of biochemistry: enzyme reactions including energetics, kinetics and mechanisms, metabolism of carbohydrates, lipids, proteins and nucleic acids, photosynthesis, electron transport mechanisms, coupled reactions, phosphorylations, and the synthesis of biological macromolecules. Prerequisite: Chm 371. (NS)

375. Research Chemistry Laboratory (1-3) fall-spring
An introduction to independent study or laboratory investigation under faculty guidance. Prerequisite: consent of faculty research supervisor. (NS)

376. Advanced Research Chemistry Laboratory (1-6) fall-spring
Advanced independent study or laboratory investigation under faculty guidance. Prerequisite: 3 credits of Chm 375. Consent of faculty research supervisor. May be repeated for credit. (NS)
377. (Bios 377) Biochemistry Laboratory (3) fall
Laboratory studies of the properties of chemicals of biological origin and the influence of chemical and physical factors on these properties. Laboratory techniques used for the isolation and identification of biochemicals. Prerequisite: Chm 371, previously or concurrently. (NS)

378. (Bios 378) Biochemical Preparations (1-3) spring
A laboratory course involving the preparation or isolation, purification and identification of chemicals of biological origin. Prerequisites: Chm 377 and 372, previously or concurrently. (NS)

381. Radiation and Structure (3) spring
Quantum chemistry and group theory applied to molecular orbital theory of bonding, structure, and spectroscopy. Study of selection rules for chemical and photochemical reactions. Prerequisites: Chm 341 and Math 205. (NS)

382. Spectroscopy and Photochemical Kinetics (3) spring
Applications of electronic, infrared, and microwave spectroscopy to the study of molecular structure. Chemical consequences of intramolecular excitation; quantum efficiencies and reaction mechanisms; pulse excitation and dynamics of elementary processes. Prerequisite: Chm 341. (NS)

385. Physical Chemistry of Printing Inks (3) fall
Physical chemical mechanisms of printing processes; composition, dispersion processes for pigments rheology and printability of inks; color-matching; development of solventless inks and specialty inks. Prerequisite: Chm 187 or equivalent. (NS)

388. (Che 385) Polymer Synthesis and Characterization Laboratory (3) spring
Techniques include: free radical and condensation polymerization; molecular weight distribution by gel chromatography; crystallinity and order by differential scanning calorimetry; pyrolysis and gas chromatography; dynamic mechanical and dielectric behavior; morphology and microscopy; surface properties. Prerequisite: Chm 187, 189 or 341 and 51. El-Aasser. (NS)

389. (Che 391) Colloid and Surface Chemistry (3) fall
Physical chemistry of everyday phenomena. Interfacial forces and electrostatic phenomena at interfaces, boundary tensions and films at interfaces, mass and charge transport in colloid suspensions, electrostatic and London forces in disperse systems, gas adsorption and heterogeneous catalysis. Prerequisite: Chm 187 or equivalent. Chaudhury. (NS)

390. (Che 392) Introduction to Polymer Science (3) spring
Introduction to concepts of polymer science. Kinetics and mechanisms of polymerization; synthesis and processing of polymers; characterization. Relationship of molecular conformation, structure and morphology to physical and mechanical properties. Prerequisite: Chm 187 or equivalent. Sperling. (NS)

393. (Che 393, Mat 343) Physical Polymer Science (3) fall
Structural and physical aspects of polymers (organic, inorganic, natural). Molecular and atomic basis for polymer properties and behavior. Characteristics of glassy, crystalline and paracrystalline states (including viscoelastic and relaxation behavior) for single and multi component systems. Thermodynamics and kinetics of transition phenomena. Structure, morphology and behavior. Prerequisite: one year of physical chemistry. Sperling. (NS)

394. (Che 394) Organic Polymer Science 1(3) spring
Organic chemistry of synthetic high polymers. Polymer nomenclature, properties, and applications. Functionality and reactivity of monomers and polymers. Mechanism and kinetics of step-growth and chain-growth polymerization in homogenous and heterogenous media. Brief description of emulsion polymerization, ionic polymerization, and copolymerization. Prerequisite: one year of physical chemistry and one year of organic chemistry. (NS)

396. (Mat 396) Chemistry of Nonmetallic Solids (3) spring
Chemistry of intrinsic and electronic defects in nonmetallic solids and their influence on chemical and physical properties. Intrinsic and impurity controlled defects nonstoichiometric compounds, defect interactions. Properties to be discussed include: diffusion, sintering, ionic and electronic conductivity, solid-state reactions, and photoconductivity. Prerequisite: Chm 187 or Mat 205 or equivalent. (NS)

Graduate Programs in Chemistry
The department of chemistry offers graduate studies leading to several advanced degrees. These include master of science and doctor of philosophy degrees in chemistry, a doctor of arts in chemistry, master of science and doctor of philosophy degrees in physiological chemistry and a master of science in clinical chemistry. Master of science and doctor of philosophy degrees in chemistry may be obtained by study and research in the following areas of chemistry - analytical, biochemistry, inorganic, organic, physical and polymers. Additional information concerning the physiological chemistry and clinical chemistry programs may be obtained from Section IV of this catalog.

The department of chemistry offers graduate studies leading to several advanced degrees. These include master of science and doctor of philosophy degrees in polymer science and engineering. These are interdisciplinary programs which are described in Section IV of this catalog and are not administered by the chemistry department. The following information on admissions, proficiency examinations and other policies applies to all of the programs listed above but not to the interdisciplinary polymer science and engineering program.

Admission to graduate study in chemistry assumes that a student has met, or is willing to meet though further study, minimum undergraduate requirements for a bachelor’s degree in chemistry. This would include (beyond two semesters of introductory chemistry) two semesters of general chemistry, two semesters of physical chemistry, two semesters of analytical chemistry and one semester of inorganic chemistry. A promising student whose degree is in a field related to chemistry (e.g., biology, chemical engineering) may be admitted to graduate study in chemistry provided that any deficiencies in basic chemistry preparation are made up in the first year of graduate study and noting that some of the courses required for this may not carry graduate credit.

The Chemistry Department will administer proficiency examinations in analytical, biochemistry, inorganic, organic and physical chemistry to all regular graduate students at the time of matriculation. Each student is required to take three examinations. Information regarding material to be covered on these examinations will be sent to each student several months in advance of matriculation. It is expected that each student will prepare diligently for these tests. A student who performs well on one or more of these tests has an opportunity to take advanced level and special topics courses at an earlier than normal time and may in fact begin graduate research during the first year. A Ph.D. candidate must show proficiency in three areas and an M.S. candidate in two areas within the first year in residence. A student who fails one or more of the proficiency examinations will meet with Professor Roberts, Faculty Graduate Coordinator, to determine an appropriate course of action in light of the exam performance, projected major and degree aspiration. Two optional routes are available for demonstration of proficiency. (1) The student through self-study and auditing of appropriate courses may prepare for a retesting of a proficiency examination at the beginning of the second semester in residence. (2) Alternatively, the student may enroll in appropriate 300 or 400 level courses during the first year in residence. A grade of A or better in an appropriate 300-400 level course will be considered equivalent to passing the proficiency examination in that area. Courses taken as a means of demonstrating
proficiency will be acceptable on the M.S. or Ph.D. graduate program.

Work for the master's degree requires at least 30 credits — a minimum of 24 course credits and 6 credits of research (which may involve either a laboratory or literature research project). Except for research and 1 credit of Chem 481 (seminar), there are no required courses for the M.S., once proficiency has been established. The courses taken are those deemed appropriate for the student's area of concentration. There is a one credit seminar requirement for the M.S. Normally, work for the master's degree can be completed in 1 1/2 calendar years.

Completion of a doctor of philosophy degree program normally requires a minimum of four years full-time work after entrance with a bachelor's degree. There are no specific course credit requirements for the Ph.D.; however, approved degree programs generally have at least 30 credits of course work (including any applied toward a master's degree) and 6 credits of research. Thus, the program consists of approximately one-third formal course work and two-thirds independent study and research. There is a foreign language requirement for the Ph.D. First year college proficiency in one of the four languages — French, German, Russian or Japanese — must be established on some basis. There is also a two credit seminar requirement. After Ph.D. proficiency has been established and the research advisor selected (this must be done by the end of the first year in residence), the major hurdles are the doctoral examinations (both written and oral) in the student's area of concentration which must be passed by the end of 2 years of residence. If this hurdle is surmounted, the remaining time is spent completing (and ultimately defending) the dissertation research under the guidance of the research advisor and the dissertation committee.

Most of the chemistry facilities are housed in the 90,000-square-foot chemistry complex, first occupied in 1975. The seven-story Seeley G. Mudd Building affords laboratory space of modern design; the top three floors are devoted to research laboratories. Most of the research laboratories in the adjacent Sinclair Laboratory are assigned to chemistry professors who specialize in research in surface and interface chemistry. Biochemistry research is located in Iacocca Hall of the Mountain Top Campus. Physiological chemistry research is located in the Seeley G. Mudd Building. Solid state chemical research is located in the Sherman Fairchild Laboratory, in Whittaker Laboratory, in the Seeley G. Mudd Building, and in Sinclair Laboratory. Polymer chemistry research laboratories are located in Whittaker Laboratory, Sinclair Laboratory, Iacocca Hall on the Mountain Top Campus, and the Seeley G. Mudd Building.

Current Research Projects

Current research projects of interest are listed below.

Analytical chemistry. NMR studies of organic solids, clinical-biomedical applications, mechanisms of electrode processes, adsorption; redox behavior of transition metal complexes; development of novel immunoassays for clinical diagnosis; atomic resolution surface analysis, electrochemical scanning tunneling microscopy, sensor array design and response pattern recognition.

Biochemistry. Characterization of lysosomal glycosidases and glycosyltransferases; functional role of carbohydrates in glycoproteins; abnormal glycoprotein metabolism in human diseases; synthesis and characterization of novel polyolefins; sequence dependence of the B-Z transition of DNA; non-isotopic immunoassays; protein surface binding phenomena; development of in vitro evaluation techniques for prescreening candidate pharmaceuticals; structural dynamics and molecular associations of biologically significant molecules; relaxation phenomena in NMR and the development of contrast enhancement agents for medical imaging.


Physical chemistry. Colloid and surface research include latexes, surface coatings, colloidal stability, adhesion, surface properties of catalysts relating powder flow to their surface chemistry, water at surfaces, fundamental studies of gas-solid surface reactions, printing inks, chemical reactions in small confined volumes, microanalytic and FTIR spectrometric studies of Lewis acid-base interactions at interfaces and surface spectroscopy. Solid-state chemistry includes studies of point defects in oxides and oxide growth. Other fields include photochemical dynamics, nuclear magnetic resonance and applications of quantum mechanics and statistical mechanics to problems of chemical interest. Single crystal vibrational and electron surface spectroscopy; structure-function relationships in catalysis; intrazeolitic transition metal ion complexes-spectroscopy, structure and reactivity; kinetics of heterogenously catalyzed reactions. Spin-resolved photoemission studies of surface and interface magnetism. Nonlinear optical studies of buried interface structure and dynamics of adsorption at interfaces.

Polymer chemistry. Synthesis, structure, conformation and properties of high polymers; techniques and kinetics of emulsion polymerization and film formation; acoustic, optical, permeability, dielectric and mechanical behavior of thin films, coatings and bulk polymers; molecular structure, relaxation behavior and energetics of fracture; elastic and viscoelastic behavior of interpenetrating and rubbery networks; effects of ordering in the glassy state and crystallization on physical properties; crystallization under the influence of shear gradients; physical chemistry of polymer composites such as polymer-concrete and filled polymers; interfacial characteristics and interactions in polymer-inorganic systems; mechanical properties of polymer printing plates; NMR studies of polymers in aqueous solutions and gels; ionic motion through polymer films.

Major Instrumentation

Chemistry research spans all areas: analytical, biochemistry, inorganic, organic, physical, and polymer. Special equipment available for graduate research in chemistry is as follows.

Biochemistry research facilities — HPLCs, GCs, FPLC, ultracentrifuges, DNA synthesizer, scintillation and gamma counters, cold rooms, cell disintegrator, zone and disc electrophoresis apparatus, column chromatograph, autoclave, ultra-low temperature freezers (-90°C and -135°C), rotary evaporator, Milli-Q water purification system, shaking heated water baths, spectrophotometer with circular dichroism capability. Cell culture facilities — complete with optical microscopes having fluorescent and photographic capabilities, liquid scintillation equipment. Catalysis facility — fully automated high pressure reactors with on-line gas chromatographs. Coal research and analysis facility — complete with ultracentrifuge, gas chromatographs, gel permeation chromatograph, vapor pressure osmometer, dry boxes. Electron optical facilities — transmission electron microscopy with x-ray fluorescence analysis capability, scanning electron microscope, and scanning electron microprobe. Gas chromatographs, including a PE Sigma 3 for inverse gas chromatography. Liquid chromatographs — high performance for analytical and preparative work. NMR spectrometers — 90 MHz.
multinuclear, 300 MHz solid state, 360 MHz for solutions and imaging, 500 MHz spectrometer for solutions. Photochemistry equipment — lamps and filters for selected wavelength work. Polarographs, chronopotentiometers, electrophoresis apparatus, electrochemical impedance, electrochemical scanning tunneling microscopy, potential, and rotating disk electrode. Titration equipment (automated and computer interfaced), portable data interface (8-channel 50 KHz), digital readout polarimeter, Vibration. Eclivexisometers, radio-tracer equipment, including a gamma counter, differential refractometer, photometer. Spectrometers — uv/visible double beam automated, uv/visible/near ir, Fourier transform ir with diffuse reflectance, photoacoustic and attenuated total reflectance capability, laser Raman, GC mass spectrometers, time-of-flight (TOF) mass spectrometer with 3He/Cd desorption source. Mössbauer spectrometer, position annihilation spectrometer. Surface analysis facilities — rotating anode high-sensitivity high-energy resolution ESCA with imaging capability (ESCA is equipped with automated angular data acquisition). Surface science facility — Auger electron spectroscopy, low energy electron diffraction (LEED), high resolution electron energy loss spectroscopy (HREELS), photorelation spectroscopy for sub-micron particle analysis. Ellipsometer, contact angle capabilities, gas adsorption apparatus (BET), temperature programmed desorption (TPD), atomic force microscope, instructional scanning tunneling microscope, and light scattering. Mirocalorimeter (flowing with uv and refractive index detectors), differential scanning calorimeter (DSC).

The NMR Laboratory is jointly operated with Air Products and Chemicals and the ESCA Laboratory is jointly operated with AT&T. A microcomputer laboratory consisting of 18 pentium-based personal computers and a computer laboratory with five IBM 6000 RISC workstations are jointly operated with LCCC.

Graduate Courses in Chemistry

400. Laboratory Safety (0) fall
Accident prevention; emergency response; government regulations; facilities for handling and storage disposal of hazardous materials; emergency facilities; liabilities. Lectures, multi-media presentations, hands-on training by practitioners.

402. Physical Inorganic Chemistry (3) alternate years
Aufbau principle and coupling of angular momenta is used to describe atomic and molecular term states. Group theoretical principles will be utilized in studies of molecular orbital and ligand field theories of bonding. Prerequisite: Chm 341 or equivalent. Klier

403. Advanced Topics in Inorganic Chemistry (1-3) alternate years
Topics of contemporary interest in inorganic chemistry. This course may be repeated when a different topic is offered. Prerequisite: Chm 307 or equivalent.

405. Organometallic Chemistry (3) alternate years
The chemistry of compounds containing carbon to metal bonds. Among topics covered are the following: organic compounds of the representative elements from Group I to IV; the chemistry of ferrocene and related pi-bonded organometallic complexes; metal carbonyl and nitrosyl complexes; dioxygen and dinitrogen complexes; organic synthesis utilizing organometallic catalysts. Kranz

411. Teaching Internship (3-6) fall-spring
The preparation, teaching and grading of one or two undergraduate lecture courses with appropriate supervision by senior faculty members. Observation and evaluation of the intern is effected by classroom visits and videotape review. Prerequisite: candidacy in the doctor of arts program or permission of the department chair. May be repeated for credit.

421. Chemistry Research (1-6)
Research in one of the following fields of chemistry: analytical, inorganic, organic, physical, polymer, biochemistry.

423. Bio-organic Chemistry (3) alternate years
An examination of biochemistry on the basis of organic chemical principles. Emphasis on reaction mechanisms of biochemical transformations and methods for elucidation of these mechanisms, i.e., kinetics, isotope effects, exchange techniques, inhibition studies, substrate analog effects and organic model studies. Prerequisite: Chm 358. Schray

424. Medicinal and Pharmaceutical Chemistry (3) alternate years
Principles of drug design, structure-activity relationships in antibacterial, antimalarial, anti-inflammatory and psychoactive drugs; synthesis and modes of action of pharmacologically active agents radioactive pharmaceuticals. Prerequisite: one year of organic chemistry. Heindel

430. Chemical and Biochemical Separations (3) spring, alternate years
Theory and applications of equilibrium and nonequilibrium separation techniques at both the analytical and preparative levels. Solvent and buffer extractions, chromatographic separations (e.g., thin layer, partition, gas liquid, gel filtration, ion exchange, affinity, supercritical fluid), electrophoretic separations (e.g., gel, capillary, isoelectric focusing, immunoelectrophoresis), centrifugal separations (e.g., differential, velocity sedimentation, density gradient) and other separation methods (e.g., dialysis, ultrafiltration). Examples will focus on biological applications. Alhadef

431. Contemporary Topics in Analytical Chemistry (1)
Discussion of the current literature in analytical chemistry, including spectrosopy, separations, and electrochemistry. Students find current papers and lead discussions. May be repeated for credit.

432. Chemometrics (3) fall, alternate years
Mathematical and statistical methods for experimental design, calibration, signal resolution, and instrument control and optimization. Freund

433. Electroanalytical Chemistry (3) alternate years
Theory and applications of selected electrochemical techniques; solutions to mass transport problems, treatment of electron transfer kinetics and kinetics of associated chemical reactions, and critical evaluation of adsorption and other factors associated with electrochemical processes. Prerequisite: Chm 332 or equivalent. Freund

434. Advanced Topics in Spectroscopy (3) fall, alternate years
Fundamentals of interactions of electromagnetic radiation with matter: electronic, vibrational, scattering based spectroscopies, instrumentation and signal processing. Advanced applications to the analysis of molecular structure and chemical processes including surface analysis, time-resolved spectroscopies, and ultrasensitive spectroscopic techniques. Messmer

435. Advanced Topics in Clinical Chemistry (3)
Selected areas of clinical chemistry such as chemical toxicology, pathogenic microtial biochemistry in vivo diagnostic methodology, therapeutic drug monitoring, or other advanced topics. May be repeated for credit when a different topic is offered.

436. Special Topics in Analytical Chemistry (1-3)
Topics of contemporary interest in analytical chemistry. May be repeated for credit when a different topic is offered.

437. (Bios 437) Pathophysiological Chemistry (3) spring
Biochemical basis of human diseases involving abnormal metabolism of proteins, nucleic acids, carbohydrates, and lipids. Emphasis on the metabolism of the clinical presentation of disease processes seen as physiological dysfunctions with clinical laboratory methods. Lectures, student presentations, and clinical case discussions. Prerequisite: consent of the department chair. Alhadef
438. Advanced Topics in NMR (3) spring, alternate years
Fundamental aspects of NMR analysis; instrumental design; data
acquisition and processing parameters; nuclear spin relaxation; theory of
spin dynamics; product operator formalism; density matrix theory;
multidimensional methods; analysis strategies. Roberts

441. Chemical Kinetics (3) alternate years
A study of kinetic processes. Phenomenological chemical kinetics;
order, mechanism effect of external variables on rate. Theories of the rate
constant. Relation between thermodynamics and kinetics. Applications
to selected systems such as unimolecular decompositions, molecular
beams and diffusion-limited processes. Prerequisite: one year of
physical chemistry.

443. (Mat 443) Solid-state Chemistry (3) alternate years
Crystal structure, diffraction in crystals and on surfaces, bonding and
energy spectra in solids dielectrics, surface states and surface fields
in crystals. Prerequisite: one course in linear algebra and one course in
quantum mechanics. Klier

445. Elements of Physical Chemistry (4)
Quantum chemistry of simple systems, molecular structure and
spectroscopy, statistical and classical thermodynamics. Prerequisite:
Chem 341 or its equivalent.

451. Physical Organic Chemistry (3) alternate years
An introduction to quantitative organic chemistry including
relationships between structure and reactivity, medium effects on
reactions, introduction to orbital symmetry effects in organic reactions,
and reaction mechanisms. Prerequisite: Chem 358 or consent of
department chair. Larsen

453. Heterocyclic Compounds (3) alternate years
An intensive study of the syntheses, reactions and properties of
heterocyclic compounds including derivatives of thiope, pyrrole,
furan, indole, pyridine, quinoline, the azoles and the diazines - all
considered from the viewpoint of modern theories of structure and
reaction mechanisms. Prerequisite: Chem 358.

455. Organic Reactions (3) alternate years
Intensive survey of modern synthetic organic chemistry from a
mechanistic standpoint. Classical Name-reactions, olefin synthesis,
organometallic reagents in synthesis, Woodward-Hoffman rules,
electrocyclic processes, enolate chemistry, and related reactions.
Prerequisite: Chem 358. Benbow

456. Spectral Analysis (3) fall
Use of data from nuclear magnetic resonance, infrared, ultraviolet, and
mass spectrometric techniques for the determination of structure of
organic compounds. Emphasis on information from one- and
two-dimensional proton and carbon NMR, and a mechanistic interpretation
of data from mass spectrometry. Foster

457. Organic Reaction Mechanisms (3)
Intensive in-class problem solving that involves the formulation of
reasonable reaction mechanisms for complex multistep pathways, i.e.
organic transformations that proceed via highly energetic intermediates
such as carboxylates, carbanions, free radicals, carbenes, and nitrenes.

458. Topics in Organic Chemistry (3)
An intensive study of limited areas in organic chemistry. May be
repeated when a different topic is offered.

466. Advanced Organic Preparations (2-3)
A laboratory course of instruction in advanced techniques of the
preparation of organic compounds.

467. (Bios 467) Principles of Nucleic Acid Structure (3)
alternate years
An examination of the principles underlying nucleic acid structure
including stereochemistry, electrostatics, hydration, torsional
constraints, sequence specific effects, and interaction with nuclear
proteins. Special emphasis will be placed on DNA structure.
Prerequisite: one year of biochemistry and one year of physical
chemistry or permission of the department chairman. Behe

468. (Bios 468) Principles of Protein Structure (3) alternate years
An examination of the principles underlying protein structure including
stereochemistry, preferred tertiary structures, protein homology,
excluded volume effects, time dependent structural fluctuations, and
prediction of protein structure from sequence information. Prerequisite:
one year of biochemistry and one year of physical chemistry or
permission of the department chairman. Behe

469. (Bios 469) Biochemical Problem Solving I (1) fall
Applications of material covered in Chem 371 including techniques used
in research. Prerequisite: Chem 371 previously or concurrently.

470. (Bios 470) Biochemical Problem Solving II (1) spring
Applications of concepts covered in Chem 372 including techniques used
in research. Prerequisite: Chem 372 previously or concurrently.

471. (Bios 471) Eucaryotic Biochemistry (3) alternate years
Biochemistry of selected eucaryotic processes including hormone
chemistry, blood clotting, immunobiology, vision chemistry, muscle
chemistry and photosynthesis. The second part of the course will
involve presentation and discussion of the current literature by class
participants. Prerequisite: Chem 372 or consent of department chair.
Low-Krentz

472. (Bios 472) Lipids and Membranes (3) alternate years
Structure, physical properties and functions of lipids and their biological
aggregates. Techniques for studying lipid assemblies, enzymes which act
on lipids, membrane proteins and lipoproteins will also be discussed.
Prerequisite: Chem 372 or consent of department chair. Low-Krentz

473. (Bios 473) Biochemistry of Complex Carbohydrates (3)
alternate years
Consideration of the structure, function and metabolism of complex
carbohydrates (glycolipids, glycoproteins and proteoglycans) with
particular emphasis on glycoproteins. The first part of the course will
consist of lectures to familiarize the student with basic terms, concepts
and processes. The second part will involve critical readings,
presentation and discussion of the current primary research literature by
class participants. Alhadef

475. Advanced Topics in Chemistry (1)
Audiovisual courses in topics such as acid-base theory, NMR,
chromatography, electroanalytical chemistry and mass-spectroscopy
interpretation; course material obtained from the American Chemical
Society. May be repeated for credit.

477. (Bios 477) Topics in Biochemistry (1-3)
Selected areas of biochemistry, such as mechanisms of enzyme action,
new developments in the chemistry of lipids, nucleic acids,
carbohydrates and proteins. May be repeated for credit when different
topics are offered. Prerequisite: consent of the department chair.

479. (Bios 479) Biochemical Techniques (3)
Laboratory studies of the techniques and principles involved in the
isolation, identification, and biochemical transformation of
carbohydrates, lipids, nucleic acids and proteins. Prerequisite: Chem 371
or its equivalent previously or concurrently.

480. (Bios 480) Advanced Biochemical Preparations (1-3)
An advanced laboratory course in the preparation, isolation,
purification, and identification of biochemically produced materials.
Emphasis is placed on materials and procedures of current interest in
biochemistry. Prerequisite: consent of the department chair.
481. Chemistry Seminar (1-6)  
Student presentations on current research topics in the student’s discipline but not on subjects close to the thesis. A one-hour presentation and attendance at other presentations are required for credit. May be repeated for credit, up to six times.

482. (ChE 482, Mat 482) Engineering Behavior of Polymers (3) spring  
Mechanical behavior of polymers. Characterization of experimentally observed viscoelastic response of polymeric solids with the aid of mechanical model analyses. Topics include time-temperature superposition, experimental characterization of large deformation and fracture processes, polymer adhesion, and the effects of fillers, plasticizer, moisture, and aging on mechanical behavior.

483. (ChE 483) Emulsion Polymers (3) fall  
Fundamental concepts important in manufacture, characterization, and application of polymer latexes. Topics include colloidal stability, polymerization mechanisms and kinetics, reactor design, characterization of particle surfaces, latex rheology, morphology considerations, polymerization with functional groups, film formation and various application problems. Prerequisite: previous course in polymers. El-Aasser

484. (ChE 484, Mat 484) Crystalline Polymers (3) spring  
Morphology and behavior of both polymer single crystals and bulk crystallized systems. Relationship between basic crystal physics, thermal and annealing history, orientation and resulting properties. Thermodynamics and kinetics of transition phenomena and a brief treatment of hydrodynamic properties and their relationship to crystallization and processing properties.

485. (ChE 485, Mat 485) Polymer Blends and Composites (3) fall  
Synthesis, morphology and mechanical behavior of polymer blends and composites. Mechanical blends block and graft copolymers, interpenetrating polymer networks, polymer impregnated solids and fiber and particulate-reinforce polymers are emphasized. Prerequisite: any introductory course in polymers. Sperling

487. Topics in Colloid and Surface Chemistry (3)  
Applications of colloid chemistry, special topics in surface chemistry. Lectures and seminar. May be repeated for credit as different topics are covered. Prerequisite: Chm 391.

488. Advanced Topics in Physical Chemistry (1-3)  
Advanced topics in physical chemistry, such as photochemistry and molecular beam dynamics, Fourier transform spectroscopy, kinetics of rapid reactions, theory of magnetic resonance, liquids and solutions. May be repeated for credit when different topics are offered.

489. (ChE 489) Organic Polymer Science II (3) alternate years  
Continuation of Chem 394. Theory and mechanism ofionicvinyl-addition chain-growth polymerization. Chain copolymerization by radical and ionic mechanism. Mechanism of ring-opening polymerization, Stereoregularity of polymerization including ionic, coordination, and Ziegler-Natta mechanisms. Reactions of polymers, including cross-linking, reaction of functional groups, graft and block copolymers, and polymer carriers and supports. Prerequisite: Chm 394 or equivalent.

491. Physical Chemistry of Organic Polymer Coatings (3) alternate years  
Pigment/binder geometry. Oil absorption of pigments. Critical Pigment Volume Concentration concept. Pigment dispersion including surface tension, capillarity, works of dispersion, transfer and flocculation, and dispersing-mixing equipment. Solubility parameter concept. Coating viscosity and viscometers. Evaporation of solvents including water. Coating rheology, mill base letdown, and pigment settling. Film application including leveling, sagging, slumping and draining. Prerequisite: Chm 393 or 394 or equivalent.

492. (ChE 492) Topics in Polymer Science (3)  
Intensive study of topics selected from areas of current research interest such as morphology and mechanical behavior, thermodynamics and kinetics of crystallization, new analytical techniques, molecular weight distribution, non-Newtonian flow behavior, second-order transition phenomena, novel polymer structures. Credit above three hours is granted only when different material is covered. Prerequisite: Chm 392 or equivalent

493. Organic Chemistry of Organic Polymer Coatings (3) alternate years  
Film information from solution and dispersion, and application of coatings. Mechanism and kinetics of curing glyceride oligomers, varnishes and alkyd resins, unsaturated polyesters, thermoplastics cellulose, acrylate and vinyl resins, epoxy resins, polyurethanes, amine- and phenol-formaldehydes, thermosetting vinyl and acrylic copolymers, water-based systems, natural and synthetic rubber, and silicone resins. New solutions coatings. Prerequisite: Chm 393 and 394 or equivalent.

494. Quantum Chemistry (3) alternate years  
Principles and applications of quantum mechanics to chemical problems. Applications to chemical bonding, molecule structure, reactivity and spectroscopy. Prerequisite: Chm 445 or consent of the department chair.

495. Statistical Thermodynamics (3) alternate years  
Principles and applications of statistical mechanics to chemical problems. A study of the techniques for evaluating the properties of matter in bulk from the properties of molecules and their interactions. Prerequisite: Chm 445 or consent of the department chair.

Civil and Environmental Engineering

Professors. Le-Wu Lu, Ph.D. (Lehigh), chair; Celal N. Kostem, Ph.D. (Arizona) associate chair and undergraduate officer; Ben-Tseng Yen, Ph.D. (Lehigh), graduate officer; John W. Fisher, Ph.D. (Lehigh), Joseph T. Stuart Professor and director, Center for Advanced Technology for Large Structural Systems; Gerard P. Lemon, Ph.D. (Cornell); Arup K. SenGupta, Ph.D. (Houston); Robert M. Sorenson, Ph.D. (U.C. Berkeley); Richard N. Weissman, Ph.D. (Cornell); James M. Riggs, Ph.D. (U.C. Berkeley); Richard Sause, Ph.D. (U.C. Berkeley).

Associate professors. Peter Mueller, Dr. sc. tech. (ETH, Zurich); Sibel Pamucka, Ph.D. (L.S.U.); Stephen P. Passik, Ph.D. (Cornell); James M. Riggs, Ph.D. (U.C. Berkeley); Richard Sause, Ph.D. (U.C. Berkeley).

Assistant professors. Scott A. Raschke, Ph.D. (Michigan); Horace Moo-Young, Ph.D. (RPI); Weixian Zhang, Ph.D. (Johns Hopkins)

Active emeritus. Lynn S. Beedle, Ph.D. (Lehigh); George C. Driscoll, Ph.D. (Lehigh); Ti Huang, Ph.D. (Michigan); Alexios Ostapenko, Sc.D. (M.I.T.); David A. VanHorn, Ph.D. (Iowa State).

Civil engineering occupies a prominent position as one of the major fields in the engineering profession. Civil engineers are concerned with all aspects of the conception, planning, design, construction, operation, and maintenance of major physical works and facilities that are essential to modern life. Civil engineering projects are typically characterized by extreme size, complexity, durability, and cost. Examples include bridges, buildings, transportation facilities, tunnels, coastal facilities, dams, foundations, waterways, sewage and sewage treatment facilities, and water supply and purification systems.

The undergraduate program, which leads to the B.S. degree in Civil Engineering, includes a strong base of mathematics and the physical sciences, followed by a broad range of courses in the areas of engineering science and civil engineering analysis and design. In civil engineering, the courses extend across the areas of structural, geotechnical, hydraulic, environmental, and transportation engineering, along with planning,
Economics, probability and statistics, and measurements. The program is enriched with a series of required and elective courses in the humanities and social sciences. In addition, there are a number of elective opportunities to enable students to pursue specialization in environmental engineering, structural engineering, hydraulic and coastal engineering, and geotechnical engineering. Over the entire curriculum, emphasis is placed on the development of a solid knowledge of civil engineering fundamentals. Concomitantly, the program is threaded with instruction and opportunities in utilizing the computer, including computer graphics, throughout the field of civil engineering.

The civil engineering program prepares individuals for entry into the engineering profession or for entry into high quality programs of graduate study. With proper selection of electives, students may also prepare for entrance into schools of law or medicine, or into master’s-level programs in engineering management or business administration.

For students interested in geological engineering, a five-year program is available, leading to two bachelor of science degrees, in civil engineering and in earth and environmental sciences.

Recommended Sequence of Courses
Freshman engineering year (see Section III)

**Sophomore year, first semester** (17 credit hours)
- Math 23 Analytic Geometry and Calculus III (4)
- EES 101 Geology for Engineers (3)
- Mech 2 Elementary Engineering Mechanics (3)
- CE 14 Measurements and Problem Solving in Civil Engineering (4)
- Eco 1 Economics (4)

**Sophomore year, second semester** (17 credit hours)
- Math 205 Linear Methods (3)
- Mech 12 Strength of Materials (3)
- CE 15 Graphics for Civil Engineering (3)
- Phys 21 Introductory Physics II (4)
- Phys 22 Introductory Physics Lab II (1)
- HSS Humanities/Social Sciences Elec. (3)

**Junior year, first semester** (17 credit hours)
- Mat 192 Structural Materials (3)
- CE 121 Mechanics of Fluids (3)
- CE 143 Soil Mechanics (4)
- CE 159 Structural Analysis I (4)
- HSS Humanities/Social Sciences Elec. (3)

**Junior year, second semester** (17 credit hours)
- CE 117 Numerical Methods in Civil Engineering (2)
- CE 160 Structural Design (4)
- CE 222 Hydraulic Engineering (4)
- CE 270 Water Supply and Wastewater Management (4)
- *Engineering Science Elective (3)

**Senior year, first semester** (17 credit hours)
- CE 202 CE Planning and Engineering Economics (3)
- CE 203 Professional Development (2)
- HSS Humanities/Social Sciences Elec. (3)
- Approved Elective (6)
- Free Elective (3)

**Senior year, second semester** (18 credit hours)
- CE 207 Transportation Engineering (3)
- CE 290 CE Design Project (3)
- HSS Humanities/Social Sciences Elec. (3)
- Approved Electives (6)
- Free Elective (3)

*Mech 102, ME 104, or ECE 81*

Elective opportunities total 36 credit hours. The selection of elective courses is to be in consultation with student’s academic adviser in the Department of Civil and Environmental Engineering. A total of 134 credit hours is required for the degree in civil engineering.

**Undergraduate Courses**

14. Measurements and Problem Solving in Civil Engineering (4)
   Description: An introduction to civil engineering, including problem solving in the specialty areas of environmental, geotechnical, hydraulic and structural engineering; presentation of typical civil engineering problems followed by selected laboratory exercises emphasizing fundamental concepts. Theory and practice of basic engineering surveying measurements including angles, distances, and elevations; systematic and random errors, error compensation; concepts of probability and probability distributions; propagation of errors; estimation of mean and variance from sample observations; random variable correlation; testing of hypothesis. Emphasis will be on applications relating to a range of civil engineering activities. Prerequisite: Math 22, (ES 2), (ED 0)

15. Graphics for Civil Engineering (3)
   Description: Basic theoretical and technical study of computer graphics systems with practical applications in civil engineering. Theory of orthographic and perspective projection. Problems of point, line and plane in descriptive geometry. Emphasis on visualization and geometric logic. Prerequisite: Engr 1, (ES 0), (ED 0)

104. Readings in Civil Engineering (1-3)
   Description: Study of selected technical papers, with abstracts and reports. May be repeated for credit. Prerequisite: consent of the department chairperson.

117. Numerical Methods in Civil Engineering (2)
   Description: Techniques for computer solution of linear and non-linear simultaneous equations; eigenvalue analysis; finite differences; numerical integration; numerical solutions to ordinary differential equations. Case studies in the various branches of Civil Engineering. Prerequisites: Engineering 1, Math 205. (ES 2), (ED 0)

121. Mechanics of Fluids (3)
   Description: Fluid properties and statics; concepts and basic equations for fluid dynamics. Forces caused by flowing fluids and energy required to transport fluids. Dynamics similitude and modeling of fluid flows. Includes laboratory experiments to demonstrate basic concepts. Prerequisite: Mech 2, (ES 3), (ED 0)

140. Special Topics in Surveying (3)
   Description: Geodetic coordinates, map projections, triangulation, photogrammetry, construction surveys, hydrographic surveys, underground surveys, adjustment of horizontal and vertical control nets, precise leveling, doppler satellite surveys, and aerial pollution control surveys. Field and office work. Prerequisite: CE 14. Limited enrollment. (ES 3), (ED 0)

143. Soil Mechanics (4)
   Description: Fundamental physical, chemical and mechanical properties affecting the engineering behavior of soils. Identification; classification; permeability; effective stress and pore water pressures; compaction, compression and consolidation; stress-strain behavior and shear strength; laboratory tests for engineering properties; application of theories and principles in engineering practice. Prerequisite: Mech 12 or consent of the department chairperson. (ES 3.5), (ED 0.5)

159. Structural Analysis I (4)
   Description: Elastic analysis of statically determinate beams, frames, and trusses; deflections by the methods of virtual work and moment area; influence lines for determinate structures; modeling for structural analysis; flexibility, stiffness, and approximate methods of analysis of indeterminate structures. Prerequisite: Mech 12, (ES 4), (ED 0)
160. Structural Design (4) spring
Principles of structural design. Safety and economy. Strength, stability and serviceability criteria. Selection of simple structural members to resist tensile, compressive, bending, and shearing loads. Various structural materials will be covered, especially steel and reinforced concrete. Prerequisite: CE 159. (ES I), (ED3)

172. Fundamentals of Environmental Pollution (3) spring
Introduction to water, air, noise, solid waste, radiation and hazardous substance pollution problems. Regulatory standards and rationale, risk and hazardous assessment, economic consequences, technology for control. (ES 3), (ED 0)

202. CE Planning and Engineering Economics (3) fall
The planning and management of civil engineering projects. Modeling and optimization methods, project management techniques. Financial decision-making among alternatives. Present value and discounted cash flow analysis; incremental analysis and rate-of-return criteria. (ES I), (ED 2)

203. Professional Development (2) fall
Elements of professionalism; professional ethics; engineering registration; continuing education; responsibilities of an engineer in industry, government, private practice; role of professional and technical societies. Prerequisite: consent of the department chairperson. (ES 0), (ED 0)

205. Design Problems (1-6)
Supervised individual design problems, with report. Prerequisite: consent of the department chairperson.

207. Transportation Engineering (3) spring
Principles of the design of transportation facilities with emphasis on highways and airports in the areas of geometric, drainage, and pavement design. Design problems. Prerequisites: CE 14 and senior standing. (ES 01), (ED 3)

211. Research Problems (1-6)
Supervised individual research problems, with report. Prerequisite: consent of the department chairperson.

215. Probability and Statistics in Civil Engineering (3) fall
Basic concepts of probability; probability distributions; estimation of parameters; regression and correlation. Analysis of stochastic engineering data. Emphasis on applications to civil engineering problems; structural stability, random loading, risk analysis, traffic flow and water-resource problems, hazard assessment for toxic materials. Prerequisites: Math 23, Mech 12, previously or concurrently. (ES I), (ED 0)

217. Computer Integrated Civil Engineering Systems (3) spring
Basic characteristics of modern interactive analysis and design systems. Data structures; 2-D and 3-D graphics modeling; user interfaces; integrated analysis/graphics/ data management. Decision tables. Introduction to Knowledge Based Systems and Artificial Intelligence. Numerous case studies and use of interactive systems. In depth experience with computer-integrated systems. (ES 0), (ED 1)

222. Hydraulic Engineering (4) spring
Flow measurements, pipe hydraulics, open-channel flow and river engineering, hydraulics structures and model studies. Laboratory experiments in applied hydraulics. Prerequisite: CE 121. (ES 2), (ED 2)

223. Hydraulics for Earth and Environmental Scientists (3) spring, alternate years
Basic fluid mechanics and hydraulics for non-engineers. Topics include: fluid statics; conservation of mass, energy and momentum; boundary layer flow and fluid drag; flow in pipelines and pumps; open channel flow; groundwater flow; hydrologic analysis; and coastal processes. Prerequisite: Basic courses in calculus and physics.

244. Foundation Engineering (3) spring
Application of theories and principles of soil mechanics to foundation design of constructed facilities. In-situ soil test and measurement, subsurface exploration and soil sampling. Bearing capacity, settlement, lateral earth pressure principles. Design of shallow foundations: spread footings, beams on elastic foundations, mat foundations. Design of retaining walls: mechanically stabilized earth, concrete and sheet pile walls, walls for excavations. Design of deep foundations: single piles, pile foundations, drilled piles and caissons. Prerequisite: CE 143 (ES 1.5), (ED 1.5)

258. Structural Laboratory (3) spring
Experimental study of behavior of members and structures. Planning, executing, and reporting experimental studies. Introduction to instrumentation and data acquisition. Nondestructive testing of civil engineering structures. Steel, reinforced concrete, and other materials. Prerequisite: CE 160. (ES 2), (ED 1)

259. Structural Analysis II (3) spring
Analysis of statically indeterminate structures, methods of slope deflection and moment distribution; consideration of side-sway and nonprismatic members. Influence lines for determinate and indeterminate structures. Flexibility and stiffness matrix methods for computerized analysis. Use of computer language programs. Prerequisite: CE 159. (ES 3), (ED 0)

261. Structural Steel Design (3) fall
Design of steel structures, including plate girders, other built-up members, trusses, frames, grilles, shell-type structures and thin-gage members. Additional topics include connections, composite beams, and fatigue and fracture concepts related to structural design. Prerequisite: CE 160. (ES 0.5), (ED 2.5)

263. Structural Concrete Design (3) fall
Design of reinforced concrete structural members and simple systems, including continuous beams, columns, frames, one-and two-way slabs, and footings. Deflection, cracking, and column slenderness. Introduction to prestressing and torsion. Prerequisite: CE 160. (ES 1), (ED 2)

266. Project Management (3) spring
An overview of the management and control of engineering ventures and projects. Emphasis on systems theory, life-cycle approach, resource management, financial controls, contracts, labor relations and organizational forms. Case studies and lectures from industry. Prerequisite: CE 202 or consent of the department chairperson. (ES I), (ED 2)

270. Water Supply and Wastewater Management (4) spring
Qualitative and quantitative evaluation of water sources. Transport, storage, purification and distribution of water supplies. Analysis and design of systems for collection and management of spent and excess storm water; wastewater treatment processes for return to the natural ecosystem. Field trips to water and wastewater process facilities. Laboratory determination of water quality parameters and wastewater characterization for incorporation into management practice. Prerequisites: Chem 21, 22 and CE 121. (ES I), (ED 3)

281. Special Topics (1-6)
A study of selected topics in civil engineering, not included in other formal courses. A report is required. Prerequisite: consent of the department chairperson.

290. CE Design Project (3) spring
Supervised design projects applying the fundamentals of engineering science and the concepts of planning and systems analysis in the design of practical engineering works. The scope includes needs analysis, formulation of the design problem statement and evaluative criteria; analysis of alternative solutions and the generation of specifications. Economic, social, environmental, aesthetic and safety constraints are
considered. Practicing professional engineers are invited to serve as consultants. Written and oral reports are required. Prerequisite: Senior standing. (ES 0), (ED 3)


321. Open Channel Hydraulics (3) fall Energy and momentum concepts, frictional resistance in open channels. Rapidly and gradually varied flow in open channels; unsteady flow in open channels; channel and culvert design. Prerequisite: CE 222. (ES 2), (ED 1)

322. Hydrodynamics (3) Ideal fluid flow, vortex flow, creeping motion; laminar boundary layers, turbulent shear stress and turbulent boundary layers; turbulent jet and diffusion. Prerequisites: Math 205 and CE 222. (ES 3), (ED 0)

324. (Mech 323) Fluid Mechanics of the Ocean and Atmosphere (3) Hydrostatics of the ocean and atmosphere. Vertical stability. Fluid motion in a rotating coordinate system. Geostrophic flow; ocean currents; surface and internal waves. Prerequisite: ME 231 or CE 121.

326. Engineering Groundwater Hydrology (3) spring The study of subsurface water, its environment, distribution, and movement. Also included are hydraulics of pumping wells, seawater intrusion, artificial recharge, and an introduction to the movement of contaminants. A design project is included to simulate drawdown and movement of contaminants in a regional aquifer using a finite-difference model. Prerequisite: CE 222. (ES 2), (ED 1)

CE 327. Surface Water Quality Modeling (3) spring Fundamentals of modeling water quality parameters in receiving water bodies, including rivers, lakes, and estuaries. Modeling of dissolved oxygen, nutrients, temperature, and toxic substances. Emphasis on water quality control decisions as well as mechanics and model building. Prerequisites: CE 121, CE 222 and CE 270. (ES 3), (ED 0)

335. Coastal Engineering (3) fall Linear wave theory and wave characteristics; survey of nonlinear theories; tides, tsunamis, storm surge and basin resonance; wind-generated wave spectra, statistics and forecasting; wave-structure interaction; nearshore circulation and sediment transport; interaction of littoral processes with structures. Prerequisite: CE 121. (ES 2), (ED 1)

336. Harbor and Coastal Engineering Design (3) spring Team design approach to the preliminary design and cost analysis of a harbor and coastal engineering project. Project components typically include: definition of wave, surge and tide conditions; layout of harbor and ancillary navigation channels; design of all harbor and coastal structures; control of potential erosion problems; establishment of dredging requirement; description of anticipated environmental impacts; and estimate of project costs. Each team will prepare a design report with necessary drawings and make an oral presentation. Prerequisite: CE 335. (ES 0), (ED 3)

341. Ground Improvement Engineering (3) spring The mechanisms of soil stabilization; principles and techniques; grouting and injection methods; reinforced earth methods, dynamic consolidation; deep compaction; sand drains; laboratory and field studies; geotextiles and geomembranes. Prerequisite: CE 143 or equivalent. (ES 1.5), (ED 1.5)

342. Experimental Geotechnical Engineering (3) fall Experimental studies dealing with the measurement of soil properties in the laboratory and in situ; application of these properties to design; consolidation; strength of soils in triaxial compression, tensile strength, and other shear tests, including measurement of pore water pressures; model design and analysis; dynamic tests; field measurement of in situ soil properties; laboratory and field instrumentation. Prerequisites: CE 143 and senior standing. (ES 1.5), (ED 1.5)

343. Seepage and Earth Structures (3) spring Long- and short-term stability of embankments and cut slopes; numerical and graphical methods of stability analysis; seepage through soil; design of earth dams, embankments and excavations; influence of embankment stability; construction control, field measurement of pore pressures and earth movements; model studies. Prerequisite: CE 143 or equivalent. (ES 2), (ED 1)

344. Behavior of Soils as Engineering Materials (3) spring Soil mineralogy, bonding, crystal structure and surface characteristics; clay-water electrolyte system; soil fabric and its measurement; soil structure and physical property relationships; soil depositional and compositional characteristics; engineering properties of soils as they relate to soil mineralogy, fabric and composition; volume change behavior, intergranular stresses, shear strength and deformation behavior, conduction behavior, coupled and direct flow phenomena. Prerequisite: CE 143. (ES 3), (ED 0)


CE 346. Fundamentals of Designing with Geosynthetics (3) spring Fundamental and current theories of designing soil structures with geosynthetics. Roads and highway applications; reinforced embankments; slope stabilization; waste containment systems; erosion control; filtration and drainage. Prerequisite: CE 143. (ES 1.5), (ED 1.5)


359. Plastic Analysis and Design (3) spring Plastic analysis and design of steel structures. Strength and behavior of frames and component parts beyond the elastic limit. Methods of predicting strength and deformation in the plastic range. Studies of industrial and multistory frames. Comparison of plastic design techniques with allowable-stress design methods. Current research. Prerequisite: CE 259 or consent of the department chairperson. (ES 2), (ED 1)

360. Structural Engineering Project (3) spring Team approach to the design of structures including bridges, buildings, or other structures in steel, reinforced concrete, or prestressed concrete. Project includes conceptual and preliminary design, preliminary cost analysis, and detailed final design and cost analysis. All aspects of the structure are treated including foundations, substructure, and superstructure, considering requirements of economy, strength and in-service performance. Prerequisites or co-requisites: CE 259, CE 261 and CE 263. (ES 0), (ED 3)
365. Prestressed Concrete (3) spring
Principles of prestressing. Analysis and design of basic flexural members. Prestress losses. Additional topics may include continuity, partial prestressing, compression members, circular prestressing, etc. Prerequisite: CE 263 or consent of the department chairperson. (ES 2)

370. Water and Wastewater Treatment (3) spring
Unit operations and processes in water and wastewater treatment, sedimentation, coagulation, flocculation, filtration, disinfection, chemical treatment, ion exchange, adsorption, biological oxidation, sludge dewatering and stabilization. Kinetics, reactor theory, mass balances, application of fundamental physical, chemical and biological principles to analysis and design. Prerequisite: CE 270 or equivalent. (ES 1)

374. Environmental Water Chemistry (3) fall
Chemical principles and applications of those principles to the analysis and understanding of aqueous environmental chemistry in natural waters and wastewaters. The chemistry of ionic equilibria, redox reactions, precipitation/dissolution, acid-base concepts, buffer capacity, complexation, hydrolysis and biological reactions. Laboratory experiments. Prerequisite: Chem 31 or equivalent, or CE 270. (ES 2)

375. Environmental Engineering Laboratory (3)
Application of laboratory based techniques to solution of environmental engineering problems. Chemical and microbiological analysis for key pollution parameters. Use of small pilot and bench scale equipment to generate design parameters. Illustration of techniques for scale-up using parameter values generated in laboratory. Practice in use of automated instrumentation for analysis. Prerequisite: CE 370, previously or concurrently. (ES 1.5)

378. Water Resources Engineering Design (3) spring
Project-oriented design utilizing principles of hydraulics, hydrology and environmental engineering. Course will include lectures on selected water resource engineering topics and a design project. Prerequisites: CE 222 and either CE 320 or 321. (ES 0)

381. Special Topics (1-3)
A study of selected topics in civil engineering, not included in other formal courses. A report is required. Prerequisite: consent of the department chairperson.

385. Research Procedures Seminar (1) fall
Planning and execution of research projects, survey of current research, elements of proposals and budgets. Literature search procedures. Presentation of data, and of written and oral reports. Guidelines for visual aids.

Graduate Programs
Graduate studies in civil engineering enable the student to build upon the broad background of undergraduate education in preparation for professional practice at an advanced level, for research and development, or for teaching.

The selection of graduate courses and research opportunities offered in the department permits the development of individual program objectives that may be concentrated in one of the technical specialty areas, or, alternatively, may extend over the broad field of civil engineering. The department offers advanced work in the specialty areas of structural engineering, geotechnical engineering, hydraulic engineering, hydrology, coastal engineering, and environmental engineering, leading to the degrees of master of science, master of engineering, and doctor of philosophy in civil engineering.

A graduate program leading to the M.S. normally is concentrated in one, or possibly two, of the technical specialty areas, and consists of a number of courses designed to fulfill the individual student’s program objectives. Each candidate for the M.S. is required to submit a thesis representing three to six credit hours (CE 491, listed below), or alternatively, a report based on a research course of at least three credits (CE 429, 439, 449, 469, 479 or 481). The balance of the program will consist of courses in the specialty area(s).

A graduate program leading to the Ph.D. degree stresses engineering applications and design. The courses may extend across the various specialty areas in civil engineering. Each candidate for the Ph.D. may choose to complete an individual engineering project representing three to six credits in place of the thesis or research report required for the M.S. (CE 480), or to take a minimum of thirty course credits without a research or design project.

The doctoral program, which leads to the Ph.D., normally includes courses in the major field, courses in minor fields, and a dissertation presenting results of original research. Holders of master's degrees planning to become candidates for the Ph.D. take a qualifying examination at the first opportunity following one semester in residence. After qualification, the program of work is formulated by the candidate, the candidate’s departmental Ph.D. committee, and the department chairperson.

The laboratories of the department are located in the Fritz Engineering Laboratory. The laboratory offers outstanding facilities for research and instruction in structural engineering, geotechnical engineering, hydraulic engineering, hydrology, coastal engineering, environmental engineering, and related fields. In particular, the structural testing equipment includes dynamic testing machines, a five-million-pound universal hydraulic testing machine, and other special loading apparatus. Included in the latter are the facilities of the Center for Advanced Technology for Large Structural Systems (ATLSS center) located on the mountain top section of the campus. These include the largest 3-dimensional test bed in the U.S.A. and specialized earthquake testing facilities. The hydraulic facilities include a wave tank, several flumes, a 10 cfs recirculating flow system, and two multipurpose tanks for model studies. An interdisciplinary relationship with the Environmental Studies Center facilitates the development of research programs in environmental engineering. Brochures describing the research facilities and programs are available on request.

In addition to departmental courses, a number of courses offered by the departments of mechanical engineering and mechanics, chemistry, chemical engineering, materials science and engineering, geological sciences, and biology may also be considered a part of the major field in civil engineering. A list of such courses is available through the department chairperson.

A number of research assistantships and teaching assistantships are available to provide financial aid to students of outstanding promise. The half-time research or teaching activities required of holders of assistantships provide a valuable educational experience that supplements the formal course offerings. The graduate course offerings of the department are programmed to fit the schedule of half-time assistants, and to accommodate part-time students. A very limited number of scholarships and fellowships are available to provide financial aid for full-time study.

Graduate Courses in Civil Engineering

405. Analytical and Numerical Methods I (3)
Analytical and numerical methods used in Civil Engineering, with emphasis on ordinary and partial differential equations. Analytical and numerical solutions of ordinary and partial differential equations. Initial and boundary value problems. Numerical integration, numerical error, and approximations of functions and data points. Finite differences, solution of systems of linear equations, eigenvalue problems, and solution of nonlinear equations. Prerequisite: Math 205 or equivalent.

408. Computer Methods in Civil Engineering II (3)
Numerical and computer-oriented methods specially applicable to the solution of complex problems arising in various fields of civil engineering. Solutions of well- and ill-conditioned linear and nonlinear systems. Eigenvalue formulation of stability and dynamic problems. Reduction techniques, integration schemes for large structural systems.
Optimal design by linear programming. Introduction to problem-oriented languages and computerized design. Prerequisite: CE 405

409. Finite Element Method in Structural Mechanics (3) spring
Basic principles and equations governing the finite element method. Analysis of planar, axisymmetric, plate and articulated structures, with emphasis on analytical modeling. Accuracy and convergence studies, utilizing different discretizations and various types of elements. Case studies include application and extension to material nonlinearities, bridges, containment vessels, and soil-structure interaction. Prerequisites: CE 405 and CE 413 or equivalent.

412. Methodologies of Structural Design (2)
Probabilistic analysis of uncertainties associated with structural design. Characterization of loads including dead and live loads, wind, earthquake, and vehicular loads. Variability of structural resistance based on strength limit states as well as serviceability. Assessment of safety and reliability. Deterministic and probabilistic methodologies of design. Prerequisite: CE 215 or permission of instructor.

413. Mechanics and Behavior of Structural Members (3) fall

420. Surface Wave Mechanics (3)
Elements of hydrodynamics and wave boundary conditions; linear wave theory and wave characteristics; nonlinear wave theories and application; wave motion generation, analysis and prediction; long waves; design wave determination; laboratory investigation of surface waves. Prerequisite: consent of instructor.

424. Surface Water Hydrology (3)
Advanced analysis and methods in surface water hydrology. Linear and non-linear hydrograph methods. Kinematic wave and other hydraulic routing techniques. Advanced techniques for evaporation, infiltration, snow melt. Prerequisite: CE 325 or equivalent.

425. Hydraulics of Sediment Transport (3)

427. Transport of Contaminants in Groundwater (3)
Groundwater flow, transport and dispersion of contaminants in the groundwater system, including review of selected biological and chemical reactions such as ion exchange, carbonate equilibrium. Computer-based state-of-the-art groundwater contaminant transport models will be used. Selected case studies will be analyzed. Prerequisite: CE 326 or equivalent.

428. Advanced Topics in Hydraulics (1-3)
Recent developments in hydromechanics and hydraulics. Topics to be selected from: wave mechanics, theory of flow through porous media, dispersion, hydrodynamic forces on structures, potential flow, free streamline theory, open channel hydraulics, computer methods. Prerequisites: CE 322 and consent of the department chairperson. May be repeated for credit.

429. Hydraulic Research (1-6)
Individual research problems with reports. May be repeated for credit.

436. Advanced Topics in Coastal Engineering (1-3)
Advanced study of selected topics in coastal engineering such as: nonlinear wave theory, design of coastal structures, shore protection and stabilization, numerical solution of coastal hydrodynamics. Selection of topics will depend on particular qualifications of staff, as well as on the interests of the students. Prerequisite: CE 335. May be repeated for credit.

439. Coastal Engineering Research (1-6)
Individual research problems with reports. May be repeated for credit.

441. Soil Dynamics (3) fall
Vibration of elementary systems, wave propagation, dynamic soil properties, vibration of soils, foundation vibrations, dynamic bearing capacity, dynamic earth pressure problem and retaining wall, liquefaction of soils, earthquake problems. Prerequisite: CE 244 or consent of the department chairperson.

443. Advanced Soil Mechanics I (3) fall
The origin, composition, and physico-chemical properties of soils and their influence on the engineering properties and behavior of soils; transmission of water in saturated and unsaturated soils; advanced theory of compaction; compression and consolidation; theories of shear strength. Prerequisite: a course in soil mechanics.

444. Advanced Soil Mechanics II (3) spring
Fundamental and advanced theories of soil mechanics applicable to earth structures and foundation design; stresses in homogeneous and layered systems for ideal elastic, plastic and visco-elastic soils; lateral earth pressures, thermo-geotechnics. Prerequisite: CE 443.

445. Advanced Foundation Engineering (3) fall
Current theory and practice relating to the design of foundations for buildings and other structures. Analysis and limitation of settlements; bearing capacity analyses of shallow and deep foundations; flexible and rigid retaining structure design; dynamic effects; anchor and other special foundations; site investigations; design criteria for foundations; load and environmental factors. Prerequisite: a course in soil mechanics.

447. Advanced Topics in Geotechnical Engineering (3)
Advanced studies in selected subjects related to geotechnical engineering. The general areas may include: stress-strain-time relationships of soils, colloidal phenomena in soils, ground water flow and see page, soil dynamics, soil plasticity, numerical methods applied to soil mechanics, earth dam design, theories of layered systems and their application to pavement design, rock mechanics. The studies specifically undertaken in any particular semester depend on the availability of staff and the interest of students. Prerequisite: consent of the department chairperson. May be repeated for credit.

448. Plasticity and Limit Equilibrium in Geotechnical Engineering (3) spring
Application of plasticity in soil mechanics, new concepts and theories and the requirements for modeling of actual test performance of soils, limit yield/failure criteria, constitutive relations of stress-strain-time, concepts of critical state soil mechanics, rheological performance, application to problems of stability of slopes, bearing capacity of foundations and active/passive earth pressures. Prerequisite: CE 244, or consent of the department chairperson.

449. Geotechnical Research (1-6)
Individual research problems relating to soil engineering, with report. Prerequisite: a course in soil mechanics.

450. Advanced Structural Analysis I (3)
Theory and methods of linear and second order structural analysis. Linear theory and stiffness properties of structural members and linear transformations of structural analysis. Application of virtual work principles and development of displacement (stiffness) method of
451. Advanced Structural Theory (3) fall

452. Fatigue and Fracture of Structures - An Interdisciplinary View (3)
This course examines the fatigue and fracture characteristics of steel structures from metallurgical, mechanical and structural engineering views. Both theory and experimental background are provided and applied to case studies and code development.

453. Structural Members and Frames (3) fall
General torsion of thin-walled open, closed, and combined open and closed cross-sections; general instability of thin-walled members; inelastic instability; special problems in stability. Desirable preparation: Mech 415. Prerequisites: CE 405 and consent of the department chairperson.

454. Plate and Shell Structures (3)

455. Advanced Structural Dynamics (3)
Analysis and design of structures to resist wind, earthquake, and blast loading. Matrix methods and computer applications. Non-linear and elastic-plastic response. Damping characteristics of structures and structural components, spectral analysis, dynamic instability. Characteristics of aerodynamic and seismic forces and explosions. Introduction to vibration of three-dimensional structural systems. Prerequisites: CE 352 or Mech 406, CE 405 and CE 450 or equivalent.

456. Behavior and Design of Earthquake Resistant Structures (3)

457. Theory and Design of Steel Structures (3)
Analysis and design of steel structures; structural connections; composite steel-concrete systems and other components. Consideration of residual stress; brittle fracture; fatigue strength; fastener systems. Study of current research and application to design practice.

458. Repair and Retrofit of Steel Structures (3)
Various types of construction problems experienced during the fabrication, erection, and service of steel structures are examined. Problems include material-related defects, repair of welds, mix matches, stability and erection-related deformation. Case studies of failures and serious construction deficiencies are reviewed and evaluated.

459. Advanced Topics in Plastic Theory (3) fall
Fundamentals of the mathematical theory of plasticity; the general theorems of limit analysis and their applications to beams under combined loading, arches, space frames, plates and shells. Limit analysis of two- and three-dimensional problems in soil, concrete, rock, and metal. Current developments. Prerequisite: CE 359.

460. Experimental Methods in Structural Engineering (3)
Study of methods and equipment used in a modern structural engineering research laboratory. Topics include small-scale modeling theory, operational and performance characteristics of transducers; detailed examination of specific transducers for measurement of strain, force, displacement, velocity, acceleration, and temperature; loading systems and controls; data acquisition and signal conditioning; introduction to nondestructive testing of structures.

461. Advanced Bridge Engineering (3)
Students in CE 461 cover the same topics described under CE 360, but in more depth. In addition each student conducts an intensive study of a bridge-related topic of his or her choice. A short written technical report on the findings of this study is required. Prerequisites: CE 261 and CE 263.

464. (Mech 416) Analysis of Plates and Shells (3)
Bending of rectangular and circular plates, plates under lateral loads, plates with thermal and inelastic strains, effect of in-plane forces, large deflections, buckling of plates. Geometry and governing equations of shells, shells of revolution, membrane states, edge solutions, solution by numerical integration, nonsymmetric problems, buckling of shells, applications to pressure vessels. Prerequisites: Math 205; Mech 305 or equivalent course in advanced mechanics of materials.

465. Advanced Topics in Concrete Structures (3) fall
Advanced topics in reinforced concrete with or without prestress. Analysis and design for torsion. Limit design concepts. Design of slab systems: strength design method, yield line theory and strip method. Other topics may include composite members, probabilistic basis of design codes, and building and bridge design. Prerequisites: CE 263 or equivalent, or consent of department chairperson.

466. Concrete Shell Structures (3)
Analysis and design of concrete shell structures. Folded plates, cylindrical shells, and shells of double curvature. Typical practical problems. Prerequisites: CE 405 and consent of the department chairperson.

467. Advanced Topics in Structural Engineering (1-3)
Advanced study of selected topics in structural mechanics and engineering, such as: finite element methods, suspension system; space frames; stability of nonlinear systems; coldformed and lightweight construction; optimization and reliability; second-order phenomena in structures; interaction of structures with the environment; structural use of plastics; composite construction, etc. Selection of topics will depend on particular qualifications of the staff, as well as on the interests of the students. Prerequisite: consent of the department chairperson. May be repeated for credit.

468. (Mech 415) Stability of Elastic Structures (3)

469. Structural Research (1-6)
Individual research with reports. May be repeated for credit.

470. Reaction Kinetics in Environmental Engineering (2)
Theory of reaction kinetics and its application to the design and operation of chemical, physico-chemical and biological reactors in water and wastewater treatment. Basic design equations for various types of reactors and migration of pollutants in the environment.
471. Water Treatment Facilities (3)
Theory and design of water treatment system components. Emphasis on coagulation, filtration, sedimentation, disinfection, and solid phase. Kinetics and thermodynamics of important reactions. Prerequisite: CE 370 or equivalent.

472. Waste Water Treatment Facilities (3)
Theory and design of wastewater pollution control systems. Emphasis on solids, oxidation and stripping in water and wastewater treatment. Kinetics, reactor theories, and modeling in wastewater and treatment systems. Prerequisite: CE 370 or equivalent.

473. Advanced Treatment Processes in Environmental Engineering (3)
Adsorption, ion exchange, reverse osmosis, electrodialysis, chemical oxidation, and stripping in water and wastewater treatment. Kinetics, reactor theories, and modeling in water and wastewater treatment systems. Prerequisite: CE 470 or equivalent.

474. Aquatic Chemistry (3)
Applying basic principles of aquatic chemistry for quantifying complex, environmental systems. Specific examples of air-water-soil interactions and consequences. Heterogeneous equilibria with more than one solid phase. Kinetics and thermodynamics of important reactions. Prerequisite: CE 374.

475. Advanced Topics in Environmental Engineering (1-3)
Advanced, concentrated study of a selected topic in environmental engineering such as non-point source pollution control, water reuse systems, new concepts in treatment technology, toxic substances control, etc. Topic is selected by the instructor and student. Courses may include specialized laboratory research, literature review, specialty conference attendance. Prerequisite: Department chairperson approval.

476. Environmental Engineering Microbiology (3)
Fundamentals of microbiology and biochemistry applied to environmental systems and water quality control. Systems ecology, energetics, and kinetics of microbial growth, nutrition, and toxicology, use of microorganisms for pollution control, and monitoring and control. Pathogenicity and disease transmission, water quality using biological indices. Prerequisite: CE 370 or a suitable course in Biology.

477. Transport of Pollutants in Surface Waters (2)
Fundamentals of models of pollutant migration in streams, estuaries, and oceans. Diffusion, mass transport, dispersion, biological, physical, and chemical interactions. Effects on water quality especially oxygen nutrient and toxic levels. Prerequisites: CE 470, 471, 472.

478. Toxic and Hazardous Wastes (3)
Regulations for collection, transportation, disposal, and storage of hazardous wastes. Containment systems, monitoring, types of liners, new and available technologies to eliminate or recover the hazardous components of wastes. Prerequisite: CE 370 or CE 374.

479. Environmental Engineering Research (1-6)
Individual research problems in environmental engineering with report. May be repeated for credit.

480. Civil Engineering Project (1-6)
An intensive study of one or more areas of civil engineering, with emphasis on engineering design and applications. A written report is required. May be repeated for credit.

481. Special Problems (1-6)
An intensive study, with report, of a special field of civil engineering, which is not covered in the other courses. A design project or an interdisciplinary study of a problem related to civil engineering may also be included. May be repeated for credit.

483. Graduate Seminar (1-3)
Study of current topics in civil engineering.

491. Thesis (1-6)

499. Dissertation (1-15)

Civil Engineering and Earth and Environmental Sciences

This program is designed for students interested in geological engineering, and leads to one bachelor of science degree in civil engineering and earth and environmental sciences, both awarded at the end of the fifth year.

The program provides alternatives for students who may decide not to complete the two-degree program. Students who make this decision prior to the beginning of the fourth year may qualify for the bachelor of science in civil engineering, as well as the minor in earth and environmental sciences. The other hand, if the student decides after two years to pursue only the bachelor of science in earth and environmental sciences, it is possible to complete the requirements in four years. If the decision to pursue this degree is made during the fourth year, at least one additional semester is required to qualify for either bachelor degree. Interested students should consult with the undergraduate officer in the department of civil engineering.

Freshman Engineering Year (see section 111)

Second Year, First Semester (16 Credit Hours)
- Math 23 Analytic Geometry and Calculus III (4)
- Mech 2 Elementary Engineering Mechanics (3)
- EES 101 Geology for Engineers (3)
- CE 15 Graphics for Civil Engineering (3)

Second Year, Second Semester (18 Credit Hours)
- Phy 21 Introductory Physics II (4)
- Phy 22 Introductory Physics Laboratory II (1)
- Mech 12 Strength of Materials (3)
- CE 113 Life and Climate in the Rock Record (3)
- Math 205 Linear Methods (3)
- CE 14 Measurements and Problem Solving in Civil Engineering (4)

Third Year, First Semester (16 Credit Hours)
- CE 121 Mechanics of Fluids (3)
- CE 143 Soil Mechanics (4)
- EES 122 Introduction to Plate Tectonics (3)
- EES 133 Introduction to Mineralogy (3)
- Mat 192 Structural Materials (3)

Third Year, Second Semester (19 Credit Hours)
- CE 117 Numerical Methods in Civil Engineering (2)
- CE 222 Structural Analysis I (4)
- CE 270 Water Supply and Wastewater Management (4)
- EES 134 Introduction to Optical Mineralogy and Crystallography (3)
- EES 326 Geologic Evolution of North America (3)
- CE 101 Economic (4)

Fourth Year, First Semester (18 Credit Hours)
- CE 203 Professional Development (2)
- CE 159 Structural Analysis II (4)
- EES 135 Introduction to Lithology and Petrography (3)
- EES 213 Sedimentology and Stratigraphy (3)
- EES 223 Structural Geology (3)
- EES 316 Hydrogeology (3)
fourth year, second semester (16 credit hours)
CE 160  Structural Design (4)
**Engineering Science Elective (3)
EES 112  Geomorphology (3)
EES 307  Case Histories in Engineering Geology (3)
HSS  Humanities/Social Sciences Elective (3)

summer (6 credit hours)
EES 341  Field Geology (6)

fifth year, first semester (18 credit hours)
CE 202  Civil Engineering Planning and Engineering
Economics (3)
EES 301  Introduction to Geophysics (3)
EES 373  Geochemical Thermodynamics (3) or
Chm 187  Physical Chemistry (3)
CE  Civil Engineering Elective (3)
HSS  Humanities/Social Sciences Elective (6)
**MEch 102, ME 104, or ECE 81
*Elective that requires approval of the Civil Engineering Department Chairperson.

A total of 172 credit hours is required to earn both degrees.

Classical Studies

Professor. Charles Robert Phillips, Ill, Ph.D. (Brown).
Associate professors. Barbara Pavlock, Ph.D. (Cornell), head of the program; David B. Small, Ph.D. (Cambridge).

The study of classics examines firstly the origins and growth of Greek and Roman culture in the Mediterranean area and secondly its impact on that area (and others) until the present. This study is by nature interdisciplinary: the study of language and literature, history, philosophy and religion, archaeology, economics and science all contribute to an appreciation of Greco-Roman civilization.

Students in either major or minor programs may concentrate in various combinations of these and other disciplines as they relate to ancient civilization. The diversity of professional interest in the program should encourage the student to follow her or his special interests while simultaneously gaining an overview of classical civilization.

Courses in ancient Greek and Latin lead to proficiency in language while introducing the student to major literary texts. The Joseph A. Maurer Classics Prize is awarded yearly, at the discretion of the program, to the senior(s) who has demonstrated outstanding achievement in Classics (ancient Greek or Latin) and/or Classical Civilization. Courses in classical civilization require no knowledge of the ancient languages; they offer introductions to various disciplines of classics with frequent reference to modern perspectives. Upper-level courses tend to be small, fostering closeness between faculty and students.

Petitions are required for freshmen to take 100-level or higher courses and for sophomores to take 200-level or higher courses.

Major programs. Students may major either in Classical Civilization or Classics. The Classics major offers a comprehensive view of language and culture; it is possible to begin an ancient language at Lehigh and to complete the major program successfully. Depending on interests and preparation, the student should derive equal educational benefit from either major program. The program welcomes double majors and the educational perspectives to be derived from combining ancient and modern studies.

Classics as a major has stood the test of time, offering helpful preparation for careers in widely diverse fields in the professions, business, and public service. Lehigh classics majors have gone on to law school, the ministry, business school, with appropriate science courses to medical school, graduate work in classics, and to all kinds of entry-level employment.

Departmental Honors. A student may be recommended for Program Honors by vote of the program based on the student’s course work.

Minor program. The minor in Classical Civilization or Classics consists of a minimum of fifteen credit hours. Students may focus on any aspect of classical studies, either singly or in combination. The program can arrange individual courses of study.

Study abroad. Lehigh University is a cooperating institution of the Intercollegiate Center for Classical Studies at Rome and of the American School of Classical Studies at Athens. Lehigh students are eligible for tuition grants at Athens and Rome.

Major in Classical Civilization

This major allows the student to gain an overview of Greco-Roman culture through the literature, archaeology, and history along with basic language study. A minimum of thirty to thirty-three credit hours, depending upon previous preparation in language study, required for this major.

Any four of the following:
Clss 52 (Engl 52) Classical Epic (3)
Clss 54 (Engl 54, Thtr 54) Greek Tragedy (3)
Clss 56 (Engl 56) The Ancient Novel (3)
Clss 58 (Engl 58, Thtr 58) Greek and Roman Comedy (3)
Clss 174 (Anth 174, Art 174, Arch 174) Greek Archaeology (3)
Clss 176 (Anth 176, Art 176, Arch 176) Roman Archaeology (3)

Any two courses in ancient history

Any two electives from the remaining classics offerings (Anth 178 may be included)

One course in either Latin or Greek on the intermediate level (or Lat/Grk 1, 2, 11, or 12, depending on previous background)

Major in Classics

This major allows the student to concentrate in ancient Greek, Latin or both. Specific programs for this major are worked out for each student with due consideration for the individual’s particular previous study of the language(s). Thus a student may begin ancient Greek or Latin at Lehigh and successfully complete a major in it.

A minimum of thirty to thirty-three credit hours, depending upon previous language study, required for this major.

Required major courses
Latin 1 and 2 or Greek 1 and 2, depending on prior preparation
Latin 11 and 12, or Greek 11 and 12, depending on prior preparation
three advanced courses in the major language minimum
any two ancient history courses
at least two electives from the remaining Classics offerings
Courses in Classical Civilization (Clss)

Clss 5. Mythology (3) fall
Introductory study of the myth-making process, both ancient and modern; emphasis on Greek myth. (SS)

Clss 21. (Hist 21) Greek History (3) fall
The development of civilization from palaeolithic times to the world empire of Alexander the Great. The social, economic, religious, philosophic, artistic and literary development of the ancient world, the origin of political institutions. Phillips (SS)

Clss 22. (Hist 22) Roman History (3) spring
Rome from its origins to A.D. 476. Political, social and religious developments. Transformation of the late Roman Empire to the early medieval period. Phillips (SS)

Clss 52. (Eng 52) Classical Epic (3)
Study of major epic poems from Greece and Rome. Works include Homer’s Iliad and Odyssey, Apollonius’ Argonautica, Vergil’s Aeneid, and Ovid’s Metamorphoses. Pavlock (HU)

Clss 54. (Eng 54, Thtr 54) Greek Tragedy (3)
Aspects of Greek theatre and plays of Aeschylus, Sophocles, and Euripides in their social and intellectual contexts. Pavlock (HU)

Clss 56. (Eng 156) The Ancient Novel (3)
Examination of the origins of the novel in Greece and Rome. Includes the picaresque novel. Pavlock (HU)

Clss 58. (Eng 58, Thtr 58) Greek and Roman Comedy (3)
Study of comedy as a social form through plays of Aristophanes, Menander, Plautus, and Terence. Pavlock (HU)

Clss 74. (Anth 74) Cultures of the Greeks and Romans (3)
Analysis of Greek and Roman cultures. Focus on kinship, political and economic organization, sexual practices, burial practices, gender construction, religions, art, literature and warfare. Small (SS)

Clss 108. Ancient Technology (3) spring
Technology and technique from the stone age to the beginning of the industrial age; their effects on society. Attitudes to technology in ancient myth literature, philosophy, and religion. (SS)

Clss 112. (Anth 112) Doing Archaeology (3)
Principles of archaeological method and theory. Excavation and survey methods, artifact analysis, dating techniques, and cultural reconstruction. Course includes field project. Small (SS)

Early Christianity from its beginnings until the end of the second century. Coverage includes the Jewish and Hellenistic matrices of Christianity, traditions about the life of Jesus and his significance, and the variety of belief and practice of early Christians. Emphasis on encountering primary texts. Wright. (HU)

Clss 121. (Anth 121) Environment and Culture (3)
Impact of environment upon cultural variability and change. Comparative study of modern and past cultures and their environments as well as current theories of human/environmental interaction. Small (SS)

Clss 127. (Anth 127) Early Civilizations (3)
Introduction to early civilizations in the Near East, Mediterranean, Africa, Europe, and the New World. Similarities and differences in economics, politics, social organization, and religion. Small (SS)

Clss 131. (Phil 131) Ancient Philosophy (3) fall
Historical study of philosophy in the classical world from the pre-Socrates to Plato, Aristotle, and the Neo-Platonists, as the originators of the western tradition in philosophy and as interacting with the religious, political, and scientific life of their times. (HU)

Clss 132. (Phil 132) Hellenistic Philosophy (3)
Historical survey of selected texts and issues in Post-Aristotelian Greek and Roman philosophy from the fourth century B.C. to the third century A.D. Areas of focus may include epieureanism, stoicism, academic and pyrrhotian skepticism, and neoplatonism. (HU)

Clss 152. (Hist 152, WS 152) Women in Antiquity (4)
Interdisciplinary study of women in Greece and Rome. Literary, archaeological and historical evidence and approaches. Cross-cultural material. (SS)

Clss 161. (Hist 161) Roman Law (4)
Examination of Roman legal systems from the Twelve Tables to the Digest of Justinian. Emphasis on development of legal concepts and their historical context. Readings in primary sources; lectures; discussion. Phillips (SS)

Clss 174. (Anth 174, Art 174, Arch 174) Greek Archaeology (3)
Ancient Greek culture from the neolithic to hellenistic periods. Reconstructions of Greek social dynamics from study of artifacts. Small (SS)

Clss 176. (Anth 176, Art 176, Arch 176) Roman Archaeology (3)
Cultures of the Roman Empire. Reconstructions of social, political, and economic dynamics of the imperial system from the study of artifacts. Small (SS)

Clss 204. (Arch 204) Ancient City and Society (3)
Ancient theories of city and city planning; attitudes to life in the city; rise of urban civilization from Neolithic prototypes through the Near East, Egypt, Greece, Rome, and New World; insights applicable to current urban problems. Small (SS)

Clss 213. (Rel 213) Ancient Roman Religion (3)

Clss 231. (Phil 231) Figures/Themes in Ancient Philosophy (3)
This seminar course will involve in-depth focus upon a major ancient thinker (e.g. Plato, Aristotle, Sextus Empiricus, Plotinus, etc.) or the classical treatment of a particular theme (e.g. “human nature,” “the good life,” ethical or political theory, etc.). Content varies. May be repeated more than once for credit. (HU)

Clss 251. (Rel 251) Classical Mythology (3)
Myth, religion, and ritual in ancient Greece and Rome. Emphasis on primary sources; introduction to ancient and modern theories of religion. Cross-cultural material. (SS)
Class 281. Readings (3) fall
Advanced study of a historical period or theme. Emphasis on primary sources. Prerequisite: Class 21 or 22 and consent of the department chairperson. (ND)

Class 282. Readings (3) spring
Advanced study of a historical period or theme. Emphasis on primary sources. Prerequisite: Class 21 or 22 and consent of the program head. (ND)

Class 312. (Hist 312) Decline and Fall of the Roman Empire (4)
Political, social, and economic history of the Roman Empire, A.D. 117-1165. Romanization of the provinces, diffusion of Christianity, and special attention to transformation to medieval period. Includes readings in translation of primary sources. Phillips (SS)

Class 313. (Hist 313) Golden Age of Greek Democracy (4)
Greek history of the seventh through fifth centuries B.C. Emphasis on the contrasting political and social systems of Athens and Sparta with consideration of related economic and military history. Attention to art, gender, literature, religion. Discussion and lectures; papers. Phillips (SS)

Class 314. (Hist 314) Age of Caesar and Christ (4) spring
Roman history of the first century A.D. political, cultural, and socio-economic changes; special attention to the evolution of absolute power. Lectures, discussions, papers. Phillips (SS)

Class 345. (Anth 345) Evolution of the State (3)
Theories of state formation. Comparison of evolutionary trajectories of early states in the Near East, Mediterranean, and the New World. Small (SS)

Courses in Ancient Greek

Grk 1. Elementary Ancient Greek (3) fall
Fundamentals of the Greek language. Readings in the easier authors. Staff (HU)

Grk 2. Elementary Ancient Greek (3) spring
Continued work in Greek vocabulary, forms, and syntax. Selected readings in Greek. Prerequisite: Grk 1. Staff (HU)

Grk 11. Intermediate Ancient Greek (3) fall
Readings in Herodotus, Homer, or Xenophon. Grammar review. Prerequisite: Grk 1 and 2, or one year of entrance Greek, or consent of the program head. (HU)

Grk 12. Intermediate Ancient Greek (3) spring
Plato: Euthyphro, Apology and Crito, or other dialogues. Prerequisite: Grk 11. (HU)

Grk 111. Greek Drama (3) fall, alternate years
Representative plays of Sophocles, Euripides and Aristophanes. Literary study of the drama. Prerequisite: Grk 12. (HU)

Grk 112. Greek Drama (3) spring, alternate years
Continuation of Grk 111. Prerequisite: Grk 12. (HU)

Grk 113. Greek Historians (3) fall, alternate years
Selections from Herodotus, Thucydides or Xenophon. Study of Greek historiography. Prerequisite: Grk 12. (HU)

Grk 271. Readings (3) fall
Intensive readings in one author or in a selected genre. Prerequisite: six credit hours at the 100 level and consent of the program head. (HU)

Grk 272. Readings (3) spring
Intensive readings in one author or in a selected genre. Prerequisite: six credit hours at the 100 level and consent of the program head. (HU)

Courses in Latin

Lat 1. Elementary Latin (4) fall
Fundamentals of grammar and syntax. Emphasis on language structure and vocabulary building. (HU)

Lat 2. Elementary Latin (3) spring
Continuation of grammar, easy Latin prose and poetry. Prerequisite: Lat 1 or one to two years of entrance Latin. (HU)

Lat 11. Intermediate Latin (3) fall
Readings in Latin prose or poetry. Consolidation of reading ability; introduction to literary analysis. Prerequisite: Lat 2 or consent of the program head. (HU)

Lat 12. Intermediate Latin (3) spring
Readings in Latin prose or poetry. Consolidation of reading ability; introduction to literary analysis. Prerequisite: Lat 2 or consent of the program head. (HU)

Lat 111. Catullus and Horace (3)
Translation and analysis of selected lyrics, focusing on imagery systems. Introduction to metrics. Prerequisite: Lat 12 or consent of the program head. (HU)

Lat 112. Latin Prose (3)
Readings from Latin Prose literature of the late republic and early empire; selections may include Cicero’s letters, Sallust, Pliny’s letters. Prerequisite: Lat 12 or consent of the program head. (HU)

Lat 113. Vergil (3)
Selections from the Aeneid. Vergil’s creation of a Latin epic and its ambiguities. Metrics. Prerequisite: Lat 12, or consent of the program head. (HU)

Lat 114. Livy (3)
Selections from the early books of Livy’s histories focusing on his creation of a Roman myths. Style. Prerequisite: Lat 12 or consent of the program head. (HU)

Lat 115. Ovid (3)
May include selections from the Ars Amatoria, Fasti, and the Metamorphoses, with attention to the problem of ideology. Prerequisite: Lat 12 or consent of the program head. (HU)

Lat 116. Petronius (3)
Selections from the Satyricon, focusing on language usage and epic parody. Prerequisite: Lat 12 or consent of the program head. (HU)

Lat 211. Readings (3) fall
Intensive readings in one author or in a selected genre. Prerequisite: six hours of courses at the 100 level and consent of the program head. (HU)

Lat 212. Readings (3) spring
Intensive reading in one author or in a selected genre. Prerequisite: six hours of courses at the 100 level and consent of the program head. (HU)
Cognitive Science

Mark H. Bickhard, Ph.D. (U. of Chicago), Director, Cognitive Science Program
758-3633; MBBO

Cognitive science is the interdisciplinary study of how humans think and how machines think: How can our understanding of the way humans think improve the performance of machines that are meant to behave intelligently? How can our understanding of the ways to make machines behave intelligently improve our understanding of the way humans think? The disciplines most commonly involved in cognitive science studies are psychology, computer science, philosophy, linguistics, neuroscience, and anthropology.

The College of Arts and Sciences offers an undergraduate major and minor in Cognitive Science, as well as a graduate minor. Because of its broad interdisciplinary character, a cognitive science major prepares a student for a wide variety of careers or graduate study programs. The courses required for the major also readily lend themselves to a double major for those students in the humanities, natural sciences, social sciences, or computer science who have overlapping interests in cognitive science.

The B.A. with a major in Cognitive Science requires a minimum of 13 courses: 11 within the major itself and 2 in collateral areas. All majors are required to take Cognitive Science 7, an introduction to cognitive science. The remainder of the major is built around a core of four introductory courses, one from each of four disciplines central to cognitive science: cognitive psychology, artificial intelligence, linguistics, and philosophy. In addition, majors must complete five elective courses, five in three topical areas related to cognitive science (with no more than two in one area). The final integration of coursework occurs in the required senior seminar, Cogs 301, in which students focus on a topic of their choice from a branch of cognitive science.

The collateral course requirements are Math 9 Introduction to Finite Mathematics (Fall) or Math 21 Calculus I, and CSc 11 Introduction to Computing. Students who take CSc 261 to satisfy the major electives requirement should choose Math 21 (a prerequisite of CSc 261) rather than Math 9. Additional coursework in mathematics is strongly recommended, as are: Psychology 1, Biology 21 and 22, and Anthropology 12.

**Required Introductory Course**

- **Cogs 7** Introduction to Cognitive Science (3 hours, Spring)

**Collateral Requirements**

- **Math 9** Introduction to Finite Mathematics
- or **Math 21** Calculus I
- **CSc 11** Introduction to Computing

**Disciplinary Core Courses**

- **CSc 327** Artificial Intelligence Theory and Applications
- **Phil 250** The Minds of Robots, and Other People
- **Psych 117** Cognitive Psychology
- **Cogs 140 (Mfl 140; Psych 140; Anth 140)** Introduction to Linguistics

**Major Electives**

After completing the introductory sequence and the four core courses, students must complete a minimum of five courses from three of the following groups with no more than two courses from any one group.

**Artificial Intelligence and Expert Systems:**

- **CSc 17** Structured Programming and Data Structures
- **CSc 262** Programming Languages

- **CSc 365** Natural Language Understanding (prereq: CSc 17)
- **CSc 368** Artificial Intelligence (prereq: CSc 17)

Students who qualify may take:

- **CSc 413** Robotics and Intelligent Machines, or
- **CSc 414** Expert Systems

**Formal Models:**

- **Phil 114** Foundations of Logic
- **Phil 214** Logical Theory
- **CSc 261** Discrete Structures (prereq: Math 21 and either CSc 11 or Eng 1)
- **CSc 318** Automata and Formal Grammars (prereq: CSc 261)

**Philosophy:**

- **Phil 139** Contemporary Philosophy
- **Phil 220** Knowledge and Justification

**Cognitive Psychology:**

- **Psych 307** Seminar in Cognition (prereq: Psych 117)
- **Psych 320** Psycholinguistics
- **Psych 351** Cognitive Development in Childhood (prereq: Psych 107 or Psych 117)

**Sociocultural Influences on Cognition:**

- **SPsy 135** Human Communication
- **SPsy 314** Attitudes, Attributes, and Actions
- **Anth 376** Culture and the Individual

**Neuroscience:**

- **Psych 176** Mind and Brain
- **Psych 177** Introduction to Physiological Psychology
- **Psych 373** Sensation and Perception (prereq: Psych 176)
- **Psych 375** Neuroanatomy of Behavior (prereq: Psych 177)

**Senior Seminar (3 hours)**

After completing the sophomore introductory sequence and the four core courses, students pursue their own interests in their selections of major electives. The required senior seminar brings classmates together so that they can teach each other what they have learned in their respective concentrations. This integrates the material in the program and provides students the opportunity to undertake independent projects.

**Recommended Timing of Courses**

**Freshman**

- **Cogs 7 (spring)**
- **2 Core Courses**
- **CSc 11**
- **Math 9**

**Sophomore**

- **2 Core Courses**
- **Major electives**
- **Cogs 301 (spring)**

**Minor in Cognitive Science**

The minor in Cognitive Science requires the following courses:

- **Cogs 7 Introduction to Cognitive Science**
- **Math 9 Introduction to Finite Mathematics** or **CSc 261 Discrete Structures**
CSc 327 Artificial Intelligence Theory and Applications
Phil 250 The Minds of Robots, and Other People
Psyc 117 Cognitive Psychology
Cogs 140 Introduction to Linguistics

Course Descriptions

Cogs 7 Introduction to Cognitive Science (3) spring
What is a mind? How is the mind related to the brain? Could we make an artificial mind? Issues concerning knowledge representation and intelligence in minds and computers as investigated by psychologists, philosophers, linguists, neuroscientists, and researchers in artificial intelligence.

Cogs 140 (Mfl 140; Psyc 140; Anth 140) Introduction to Linguistics.
Relationship between language and mind; formal properties of language; language and society; how languages change over time.

Cogs 161 Supervised Research (2-4)

Cogs 301 Senior Seminar in Cognitive Science (3) spring
Integration of the material from cognitive science via topics chosen by the students.

Cogs 361 Independent Research (2-4)

Cogs 399 Thesis (2-4)

Cogs 478 (Psyc 478) Ontological Psychology.
Principles and constraints for modeling psychological phenomena. Representation; perception; memory; knowing; learning; emotions; consciousness; language; rationality.

Survey of fundamental theory and methodologies from artificial intelligence, linguistics, cognitive psychology, philosophy, and neuroscience, as well as salient research problems such as knowledge acquisition and representation, natural language processing, skill acquisition, perception and action, and the philosophical question of intentionality.

Graduate Minor in Cognitive Science
The graduate minor or concentration in Cognitive Science is available to graduate students (primarily doctoral) majoring in Psychology or Computer Science. It gives students an opportunity to develop expertise in the interdisciplinary study of information processing by humans as well as intelligent machines. Graduate students investigating mental processes such as language processing, reading, perception and action, planning, problem-solving, learning, category formation, or applications such as artificial intelligence or educational technology are encouraged to participate, with the approval of an advisor in their major program, by contacting the director of the Cognitive Science Supervisory Committee. On completion of the program, the director of the Cognitive Science program will issue a letter to the student certifying that he or she has met the requirements of the minor.

The minor requires 5 graduate level courses: 4 electives from the list below, plus Cogs 4xx, a graduate seminar. At least 2 of the 4 electives must be taken outside the student's home department. Special topics courses with a cognitive science emphasis may also count toward the minor, with the approval of the Cognitive Science Supervisory Committee. Courses taken toward the minor may also fulfill requirements of the student's major program, with the approval of the major department.

Cogs 4xx (Psyc 4xx). Foundations of Cognitive Science. Survey of fundamental theory and methodologies from artificial intelligence, linguistics, cognitive psychology, philosophy, and neuroscience, as well as salient research problems such as knowledge acquisition and representation, natural language processing, skill acquisition, perception and action, and the philosophical question of intentionality.

Computer Science:
CSc 413: Robotics and Intelligent Machines
CSc 465: Seminar in Natural Language Processing.
CSc 368: Artificial Intelligence Programming.

Psychology:
Psyc 403: Cognitive Psychology.
Psyc 405: Developmental Psychology.
Psyc 448: Seminar in Psychology of Language (prerequisite: Psyc 403), or Psyc 320: Psycholinguistics.
Psyc 476: Seminar in Cognition (prerequisite: Psyc 403).
Psyc 480: Seminar in Cognitive Development.
Psyc 478 (Cogs 478): Ontological Psychology.

Education:
Educ 430: Advanced Topics in Reading.
Edit 405: Hypermedia Theory and Applications.

Philosophy: (Note: 200-level courses may be taken by graduate students if the courses are not the student’s major.)

Phil 250: The Minds of Robots, and Other People.

Anthropology/Social Relations:
Anth 376: Culture and the Individual.

Industrial Engineering:
IE 405: Introduction to Neural Networks.

Roy Eckardt College Scholar Program

Director, Ian Duffy, professor of history.
Advisory Council. Mark Bickhard, professor of psychology; Bobb Carson, professor of earth and environment sciences; Robin Dillon, professor of philosophy; Beall Fowler, professor of physics; Edward Gallagher, professor of English; Lucy Gans, professor of art and architecture; Norman Girardot, professor of religion studies; Charles Kraihezel, professor of chemistry.
For program requirements, see College Scholar Program, section III.

389. Honors Project for College Scholars (1-8)
Opportunity for College Scholars to pursue an extended project for senior honors. May be repeated for credit up to a maximum 12 credit hours. Transcript will identify department in which project was completed. Prerequisite: consent of department chairperson.
281-284. College Scholar Seminar (3)
Seminars for College Scholars. May be repeated for credit. Prerequisite: consent of program director.

Communication

See listings under Minor Programs in the College and under Journalism and Communication.

Computer Engineering

See listings under Electrical Engineering and Computer Science.

Computer Science

See listings under Electrical Engineering and Computer Science.

Cooperative Undergraduate Education

The College of Engineering and Applied Science offers opportunities to students for cooperative work assignments with industrial or business firms and government agencies. In all cases, cooperative work assignments are optional on the part of the student and there is no obligation for the student to accept permanent employment nor for the cooperating organization to offer permanent employment.

When on a cooperative assignment, the student must register for the non-credit course, Cooperative Undergraduate Education, to maintain continuous student status. The fee for this course is established by the University Treasurer. Participation in a cooperative education program does not relieve the student from any regular requirement for the academic curriculum in which he or she is enrolled.

200. Cooperative Undergraduate Education (0)
Supervised cooperative work assignment to obtain practical experience. Prerequisite: consent of the college dean.

Counseling

See listings under Education.

Design

Program director: Richard Roberts, Ph.D. (Lehigh), professor of mechanical engineering and mechanics.

Program faculty: Alden S. Bean, Ph.D. (Lehigh), Wm R. Kenan, Jr. professor of management and technology; Keith M. Gardiner, Ph.D. (Manchester, England), professor of industrial and manufacturing system engineering; Ben Marcune; John Ochs, Ph.D. (Penn State), professor of mechanical engineering and mechanics; Tom F. Peters, M.Arch ETH Zurich (dipl.Arch.ETH) and Dr.sc. (Techn.) ETH Zurich, professor of art and architecture; George Shortess, Ph.D. (Brown), professor emeritus psychology; Ricardo Viera, M.F.A. (R.I.S.D.) professor of art and architecture; Ivan Zaknic, M.Arch. And Urban Planning (Princeton), professor of art and architecture.

The Master of Science in Design Program is built upon an undergraduate engineering degree. It is anticipated that with time similar programs will develop for students with degrees from undergraduate arts or business programs. The curriculum is technological in nature, emphasizing design practice, design history, and design communication. It also focuses on issues related to aesthetics, business communication, management of people and technology, mathematics and modeling, manufacturing and manufacturing methods. The program requires at least 30 credit hours of graduate level work as set forth below.

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
<th>Impact</th>
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<tbody>
<tr>
<td>Design Studio</td>
<td>6</td>
<td>Provides major design experience and commentary on behavioral issues. Work on real design problems from industry and government.</td>
</tr>
<tr>
<td>MSE 423</td>
<td>3</td>
<td>Provides modeling and math skills</td>
</tr>
<tr>
<td>MSE 431</td>
<td>3</td>
<td>Provides management/business skills</td>
</tr>
<tr>
<td>MSE 427</td>
<td>3</td>
<td>Provides manufacturing skills</td>
</tr>
<tr>
<td>MAT 458</td>
<td>3</td>
<td>Provides materials application and processing</td>
</tr>
<tr>
<td>ART 395</td>
<td>3</td>
<td>Provides rendering industrial design skills</td>
</tr>
<tr>
<td>Electives</td>
<td>9</td>
<td>To be selected in consultations with an advisory committee</td>
</tr>
<tr>
<td>TOTAL</td>
<td>30</td>
<td></td>
</tr>
</tbody>
</table>

Graduate Courses

Design Studio (6) The Design Studio affords students and faculty the opportunity to collaborate on design related problems. The studio experience, which is the equivalent of a six-credit thesis, is modeled after the design studio concepts used by the Department of Art and Architecture. Students in this program are expected to provide designs in response to problem need statements and to defend the solutions both in writing and orally. Faculty feedback is provided to students relative to the design and the effectiveness of the written and oral presentation. The critiques are offered by the “Design Faculty” from the Colleges of Engineering & Applied Science, Business and Economics, and Arts and Sciences. As part of this process, faculty discuss the pros and cons of the specific design, as well as the design process or processes used for producing the designs. These discussions are an ongoing part of the design studio and afford students the opportunity to reflect on the design process and how it should be executed in real worlds situations. As appropriate and as needed, personnel from industry and government are asked to participate in the review/critique process. Regular design meetings and seminars are used to provide input to this process and to provide continuity for the students over the course of their studio experience.

ART 395. Rendering/Industrial Design Skills (3)
MAT 458. Materials Design (3)
Analysis of design requirements for materials components. Selection of materials and processes. Study of failures in process and service and application of recent metallurgical and materials engineering knowledge for improved design. Solution and discussion of industrial problems and outline of experimental approach.

MSE 423. Product Design & Analysis (3)
Presents an integrated approach to design and analysis of products and systems. Principles for robust design and use of computer-aided engineering to model, evaluate, and enhance design. The course includes case studies and design assignments.

MSE 427. Production Systems (3)
Modern production and assembly methods used in the mechanical and electrical/electronics industries; techniques for deciding the most appropriate production methods for a new product; computer-aided process planning, group technology, robotics, numerical control, and other automated manufacturing methods are included in this course.

MSE 431. Marketing and the Invention to Innovation Process (3)
Organizational issues and decision-making for capital investments in new technologies. The commercialization process is traced from research and development and marketing activities through the implementation phase, involving the manufacturing function. A term project is a commercialization plan for a new manufacturing technology.

Electives. (9)
The specific electives will be chosen for each student based on their background and interests. These choices will be worked out by the student and an advisory committee from the identified “Design Faculty.” This will also include the need for any remedial courses which will not count toward the 30 credit requirement for the degree.

For further information, contact Professor Richard Roberts, program director, 200 West Packer Avenue, Bethlehem, PA 18015, (610) 758-3848, fax (610) 758-6527.

Earth and Environmental Sciences

Professors. Peter K. Zeilinger, Ph.D. (Dartmouth), chairperson; Bobb Carson, Ph.D. (Washington); Edward B. Evenson, Ph.D. (Michigan); Kenneth P. Kodama, Ph.D. (Stanford); Paul B. Myers, Jr., Ph.D. (Lehigh); Craig E. Williamson, Ph.D. (Dartmouth).

Associate professors. David J. Anastasio, Ph.D. (Johns Hopkins); Gray E. Babbit, Ph.D. (U.C., Los Angeles); Bruce R. Hargreaves, Ph.D. (U.C., Berkeley); Anne S. Melzer, Ph.D. (Rice); Carl O. Moses, Ph.D. (Virginia).

Assistant professors. Sherilyn C. Fritz, Ph.D. (Minnesota); Donald P. Morris, Ph.D. (Colorado).

Visiting assistant professor. Eugene S. Ilton, Ph.D. (Johns Hopkins).

The Department of Earth and Environmental Science (EES) offers courses in ecology, environmental science, and geoscience and provides undergraduate and graduate programs leading to B.A., B.S., M.S., and Ph.D. degrees. These broad fields entail the study of complex systems consisting of air, life, rocks, and water. Those systems have existed, interacted, and coevolved over billions of years, and although humans are relative newcomers, we are driven to acquire knowledge and understanding of such systems because we are curious. Progress in scientific understanding often requires the study of well-defined ‘model’ systems or topically constrained subjects, but we also aspire to an integrated understanding of systems and the processes by which they interact.

The Department’s undergraduate major programs combine course and laboratory work, fieldwork, and experiential learning to convey concepts, develop analytical skills, and promote critical thinking. The programs are designed to ensure a firm foundation in mathematics, communication skills, and the traditional sciences (chemistry, physics, geology, and biology) and to provide a breadth of understanding of earth and environmental systems and processes. Academic advising in EES requires each student to articulate one’s academic interests and aspirations and to take an active role in designing one’s individual course of study within program guidelines. The BA program allows more flexibility in course selection, which may be used to pursue a minor or a second major. The BS program requires more math and collateral sciences and more focus within EES. In particular, the BS program requires a student to choose a concentration in Ecology, Environmental Science, or Geoscience. Each concentration provides specific requirements and recommendations to meet the needs of its students.

BA students may choose to follow one of the concentrations or to sample more broadly from the EES curriculum. During the senior year, all EES majors participate in one of the Department’s senior seminar courses.

Many EES courses include field trips that complement course instruction and provide students with opportunities to make measurements in the field, but the EES field experience requirement goes beyond course-related fieldtrips. In meeting the field experience requirement, which does not necessarily entail course credits, EES majors must commit time and effort to collecting samples or data in the field. The purpose of this requirement is to give all EES students an opportunity to work in and to learn from the ultimate laboratory: the real world. The field experience requirement can be satisfied through appropriate field courses (such as EES 341 and 384) or through participation in approved research jobs, or internships (with EES faculty in non-academic settings as corporations or government agencies). Participation in research is encouraged, and course credit for research projects can be easily arranged (see EES 293 and 393). A department honors program is available for qualified students who conduct original research with a faculty mentor and write a senior thesis.

An undergraduate degree in Earth and Environmental Sciences prepares a student for graduate study in ecology, environmental science, or geoscience (see the description of EES graduate programs and courses below). Depending on one’s interests and choice of electives, EES majors may be prepared for graduate study in other fields of science or in education, law, medicine, business, or policy studies. Employment opportunities exist in a number of fields, including environmental or geotechnical consulting, manufacturing, natural resources development, conservation, finance, law, policy, education, and advocacy.

A minor in Earth and Environmental Sciences is available for students who wish to combine an interest in environmental science with technical or non-technical majors, such as engineering, economics, government, journalism, international relations, and others.

Students interested in an EES major or minor program can obtain more information through the Department office or on the worldwide web (http://www.lehigh.edu/~ees/ees.html).

Tier structure of courses in the EES Degree
Tier 0 courses for non-EES majors; no prerequisites
Tier 1 2-semester introductory sequence (EES 21 and 31); no prerequisites; required for EES majors
Tier 2 intermediate EES courses; may have prerequisites (Tier 1, math/collateral sciences)
Tier 3 advanced EES courses; may have prerequisites (Tier 1, Tier 2, math/collateral sciences)
Courses designated for EES Tier 2 and Tier 3 are listed in the BS program description.
Introductory Sequence

The EES Tier 1 (EES 21 and 31) is required for EES majors. EES 3 and 11 are principally intended for non-majors, and a student who declares the EES major after taking EES 3 or 11 must still take EES 21 and 31. The credits earned for EES 3 or 11 cannot count toward the major programs, but they will count as free electives.

Some substitutions are permitted for EES 21, but the following conditions apply owing to the overlap of material in the introductory Earth science courses.

LEES 101. A student who declares the EES major after taking LEES 101 may substitute the credits for EES 101 for EES 21 in the major program (declared majors should take EES 21 rather than EES 101). Students may not receive course credit for both EES 101 and EES 21. Note that EES 101 is a 3-credit course and that there is a minimum number of credits that must be earned for the EES major.

2. EES 41.
   A. A student who takes EES 41 without having taken EES 21, 101, or 112 will receive eight credits for EES 41.
   B. In the EES major program, four credits from EES 41 substitute for EES 21 and four substitute for EES 112.
      i. If a student takes EES 41 after taking EES 21 (not having taken EES 112), four credits will be awarded for EES 41. In the EES major, those four credits substitute for EES 112. A total of eight credits is awarded for the EES 21 and 41 combination.
      ii. If a student takes EES 41 after taking EES 101 (not having taken EES 112), five credits will be awarded for EES 41. In the EES major, four credits substitute for EES 112 and one credit applies to the introductory sequence requirement. A total of eight credits is awarded for the EES 101 and 41 combination.
   C. A student may not receive course credit for EES 21, EES 101, or EES 112 after taking EES 41.
   D. A student may not receive course credit for EES 41 after taking both EES 21 (or EES 101) and EES 112.

Major Requirements for BA in Earth and Environmental Sciences

The BA in EES requires a minimum of 121 credits:

1. University and College Requirements (at least 26 credits):
   a. Arts and Science 1 (1 credit)
   b. College Seminar (3 credits)
   c. English Composition (2 courses for 6 credits)
   d. Distribution requirements (at least 2 humanities courses for at least 8 credits and at least 2 social sciences courses for at least 8 credits)

2. Math and Collateral Science Requirements for the BA in EES (at least 20 credits):
   a. 2 semesters of calculus equivalent to Math 21 and 22 or Math 51 and 52 (at least 7 credits)
   b. 1 semester of chemistry equivalent to Chem 21/22 (5 credits)
   c. 1 semester of physics equivalent to Phys 11/12 (5 credits)
   d. 1 additional course approved by the adviser: at least 3 credits in math (including approved statistics courses outside the Math Department), chemistry (beyond 21/22), or physics (beyond 11/12)

3. Required courses for the major (at least 44 credits):
   a. Tier 1 introductory sequence (2 courses for 8 credits; see Introductory Sequence section above)
   b. Tier 2 courses (at least 5 courses for at least 20 credits); two of these courses must be selected from the group of EES foundation courses designated by the BS concentration program (see listings under the BS program section)
   c. Tier 3 courses (at least 4 courses for at least 16 credits); one of these courses must be a designated EES senior seminar course (see listings under the BS program section)

4. Free electives: courses chosen from anywhere in the University’s curriculum; sufficient credits to bring the total to a minimum of 121.

5. Field experience: course, internship, or employment pre-approved by the adviser to meet the EES field experience requirement (no course credit required)

6. Justification of course selection: The student must prepare a written justification, subject to approval by the major adviser, of courses selected to fulfill the EES Tier 2 and Tier 3 requirements before enrolling in any course in the major beyond the student’s second Tier 2 course.

Students are advised that many graduate programs in science and many employment opportunities require additional courses in math and collateral sciences, as well as additional courses in the major.

Furthermore, Math 22 is a prerequisite for Math 23, which in turn is a prerequisite for many math courses. Refer to the note at the end of the BS program description for further discussion.

Recommended Sequence of Courses, BA in Earth and Environmental Sciences

<table>
<thead>
<tr>
<th>Freshman Year</th>
<th>Fall</th>
<th>Spring</th>
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<tbody>
<tr>
<td>English Comp.</td>
<td>EESTier 1 (21 or 31)</td>
<td>Math 52 or 22</td>
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<tr>
<td>Math 51 or 21</td>
<td>College Seminar</td>
<td>Chem 21/22</td>
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<td>A&amp;S 1</td>
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<th>Fall</th>
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<td>Dist. Requirement</td>
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<td>Phys 11/12</td>
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</tr>
<tr>
<td>EES Tier 2 foundation</td>
<td>EES Tier 2 foundation</td>
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<tr>
<td>Free Elective</td>
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</table>

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<thead>
<tr>
<th>Junior Year</th>
<th>Fall</th>
<th>Spring</th>
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<tr>
<td>EES Tier 2</td>
<td>EES Tier 2</td>
<td></td>
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<tr>
<td>EES Tier 3</td>
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<tr>
<td>Free Elective</td>
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</table>

Summer following junior year:

field experience

<table>
<thead>
<tr>
<th>Senior Year</th>
<th>Fall</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>EES Tier 3</td>
<td>EES Tier 3</td>
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<tr>
<td>Free Elective</td>
<td>Free Elective</td>
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<tr>
<td>Free Elective</td>
<td>Free Elective</td>
<td></td>
</tr>
</tbody>
</table>

*Math and collateral science

Note: This schedule assumes that most distribution requirement and free-elective courses earn 4 credits.

Major Requirements for BS in Earth and Environmental Sciences

The BS in EES requires a minimum of 121 credits:

1. University and College Requirements (at least 26 credits):
   a. Arts and Science 1 (1 credit)
   b. College Seminar (3 credits)
   c. English Composition (2 courses for 6 credits)
   d. Distribution requirements (at least 2 humanities courses for at least 8 credits and at least 2 social sciences courses for at least 8 credits)

2. Math and Collateral Science Requirements for the BS in EES (at least 26 credits):
   a. 2 semesters of calculus equivalent to Math 21 and 22 or Math 51 and 52 (at least 7 credits)
   b. 1 semester of chemistry equivalent to Chem 21/22 (5 credits)
   c. 1 semester of physics equivalent to Phys 11/12 (5 credits)
   d. 3 additional courses approved by the adviser: at least 9 credits in math (including approved statistics courses outside the Math
Department), chemistry (beyond 21/22), or physics (beyond 11/12).

3. Required courses for the major (at least 47 credits):
   a. Tier 1 introductory sequence (2 courses for 8 credits; see Introductory Sequence section above)
   b. Tier 2 courses (at least 5 courses for at least 20 credits); two of these courses are the required foundation courses for the student’s concentration (see item 7 below)
   c. Tier 3 courses (at least 4 courses for at least 16 credits); one of these courses must be a designated EES senior seminar course for the student’s concentration (see item 7 below)
   d. additional course approved by the major adviser, 1 course selected from EES Tier 2 or Tier 3 or from courses at the 100-level or above in other math, science, or engineering departments (at least 3 credits)

4. Free electives: courses chosen from anywhere in the university’s curriculum; sufficient credits to bring the total to a minimum of 121

5. Field experience: course, internship, or employment pre-approved by the adviser to meet the EES field experience requirement (no course credit required)

6. Justification of course selection: The student must prepare a written justification, subject to approval by the major adviser, courses selected to fulfill the EE Tier 2 and Tier 3 requirements (including the approved additional course in the major) before enrolling in any course in the major beyond the student’s second Tier 2 course

7. Concentration: The student must select a concentration in ecology, environmental science, or geoscience and follow the required selection of Tier 2 and Tier 3 courses prescribed for the concentration (see below). The student should also note other requirements or recommendations pertinent to one’s chosen concentration, including selection of math and collateral science courses and field experience.

Students are advised that many graduate programs in science and many employment opportunities require additional courses in math and collateral sciences, as well as additional courses in the major. Many graduate programs will require calculus beyond Math 22, statistics, or math courses like differential equations, linear methods, or numerical analysis. Many graduate programs will also require a full year each of chemistry and physics, and some may require more (e.g., organic chemistry). Students may need to use a free elective to acquire math and collateral science for certain programs. Students should obtain information about the requirements for graduate programs in their areas of interest, consult with their major advisers, and plan accordingly. Consult the concentration descriptions below for specific requirements and recommendations.

Recommended Sequence of Courses, BS in Earth and Environmental Sciences

**Fall**

<table>
<thead>
<tr>
<th>Freshman year:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Eng</td>
<td>English Comp</td>
</tr>
<tr>
<td>EES Tier 1 (21 or 31)</td>
<td>EES Tier 1 (21 or 31)</td>
</tr>
<tr>
<td>Math 21</td>
<td>Math 22</td>
</tr>
<tr>
<td>College Seminar</td>
<td>Chem 21/22</td>
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<tr>
<td>A&amp;S I</td>
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</table>

**Sophomore year:**

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<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
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<td>Dist. Requirement</td>
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**Senior year:**

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*Math and collateral science

Note: This schedule assumes that most distribution requirement and free elective courses earn 4 credits.

**Concentration in Ecology**

Two semesters of organic chemistry (chem 51/53 and 52/58) are required as two of the additional math and collateral science courses for the ecology concentration. Students concentrating in ecology are also strongly urged to take statistics (EES 382, Math 12, Math 231, or another course selected in consultation with the adviser) as one of their additional math and collateral science courses in preparation for advanced study or employment. Note that EES 41 and EES 384 meet the field experience requirement.

Tier 2 and Tier 3 courses for the Ecology Concentration

| Tier 2 (at least 5 courses for at least 20 credits) |
|---|---|
| Required foundation courses |
| EES 251 General Ecology (4) |
| EES 282 Climate, Geosphere, and Biosphere (4) |

| Tier 2 choices |
|---|---|
| EES 112 Geomorphology (4) (note possible substitution by EES 41) |
| EES 113 Paleontologic Evidence for Earth Evolution (4) |
| EES 151 Plant Communities (4) |
| EES 213 Sedimentology and Stratigraphy (4) |
| EES 283 The Atmosphere (2) |
| EES 284 Dynamics of Nature (4) |
| EES 373 Environmental Thermodynamics (4) |
| Bio 31 Introduction to Cell and Molecular Biology | 0(3) |
| Bio 32 Introduction to Cell and Molecular Biology | 0(3) |
| Bio 341 Introduction to Vertebrates (4) |
| Bio 343 Genetics (3) |
| Bio 345 Genetics Laboratory (1) |
| Bio 347 Comparative Vertebrate Anatomy (4) |
| CEE 223 Hydraulics for Earth and Environmental Scientists (3) |

Tier 3 choices (at least 4 courses for at least 16 credits, one of which must be a senior seminar course, designated with *)

| EES 293 Supervised Internship (variable credit) |
| EES 315 Soil Genesis (4) |
| EES 316 Hydrogeology (4) |
| EES 319 Environmental Applications of GIS (4) |
| EES 351 Limnology* (4) |
| EES 353 Environmental Microbiology* (4) |
| EES 354 Methods in Limnology and Microbial Ecology (4) |
| EES 355 Ecological Field Methods* (4) |
| EES 356 Quaternary Paleoecology* (4) |
| EES 361 Animal Physiology (4) |
| EES 376 Geochemistry of Natural Waters (4) |
| EES 382 Statistical Applications (4) |
| EES 383 Environmental Data (4) |
| EES 384 Lake Ecosystems (4) |
| EES 385 Computational Methods (2) |
| EES 393 Supervised Research (variable credit) |
| Bio 371 Evolution (3) |
| Bio 324 Bacteriology (3) |
| Bio 325 Bacteriology Laboratory (1) |
| Bio 329 Herpetology (3) |
| Bio 335 Animal Behavior (3) |
| Bio 336 Animal Behavior Laboratory (2) |
| Bio 337 Behavioral Ecology (3) |
| Bio 345 Molecular Genetics (3) |
Bios 346 Molecular Genetics Laboratory (1)
Bios 367 Cell Biology (3)
Bios 370 Plant Molecular Biology (3)
CEE 320 Flood Hydrology and Hydraulics (3)
CEE 326 Engineering Groundwater Hydrology (3)

**Concentration in Environmental Science**

Students concentrating in environmental science are strongly urged to take statistics (EES 382, Math 12, Math 231, or another course selected in consultation with the adviser) as one of their additional math and collateral science courses in preparation for advanced study or employment. Note that EES 41 and EES 384 meet the field experience requirement.

**Tier 2 and Tier 3 courses for the Environmental Science Concentration**

**Tier 2**
- Required foundation courses
  - EES 282 Climate, Geosphere, and Biosphere (4)
  - EES 284 Dynamics of Nature (4)
- Tier 2 choices
  - EES 112 Geomorphology (4) (note possible substitution by EES 41)
  - EES 113 Paleontological Evidence for Earth Evolution (4)
  - EES 123 Structural Geology and Tectonics (4)
  - EES 131 Introduction to Rocks and Minerals (4)
  - EES 151 Plant Communities (4)
  - EES 201 The Earth's Potential Fields (4)
  - EES 203 Seismology, the Earth and the Environment (4)
  - EES 213 Sedimentation and Stratigraphy (4)
  - EES 251 General Ecology (4)
  - EES 283 The Atmosphere (2)
  - EES 373 Environmental Thermodynamics (4)
  - CEE 143 Soil Mechanics (4)
  - CEE 223 Hydraulics for Earth and Environmental Scientists (4)

**Tier 3 choices (at least 4 courses for at least 16 credits, one of which must be a senior seminar course, designated with *)
- EES 221 Plate Tectonics: How it Works (2)
- EES 293 Supervised Internship (variable credit)
- EES 303 Active Tectonics (4)
- EES 307 Case Histories in Engineering Geology (4)
- EES 309 Mineral Magnetism and Earth Processes (4)
- EES 313 Depositional Environments and Facies Analysis* (4)
- EES 315 Soil Genesis (4)
- EES 316 Hydrogeology (4)
- EES 319 Environmental Applications of GIS (4)
- EES 341 Field Geology (8)
- EES 351 Limnology* (4)
- EES 353 Environmental Microbiology* (4)
- EES 354 Methods in Limnology and Microbial Ecology (4)
- EES 355 Ecological Field Methods (4)
- EES 356 Quaternary Paleocology* (4)
- EES 376 Geochemistry of Natural Waters* (4)
- EES 382 Statistical Applications (4)
- EES 383 Environmental Data (4)
- EES 384 Lake Ecosystems (4)
- EES 385 Computational Methods (2)
- EES 393 Supervised Research (variable credit)
- CEE 320 Flood Hydrology and Hydraulics (3)
- CEE 326 Engineering Groundwater Hydrology (3)

**Minor in Earth and Environmental Sciences**
The minor program in EES requires a minimum of 15 hours, which must include the EES Tier 1 sequence (EES 21 and 31) and at least 2 additional EES courses from Tier 2 or Tier 3 (see listings under the BS program description).

**Combined BA or BS and MS Program in Earth and Environmental Sciences**
The Department of Earth and Environmental Sciences offers a 5-year combined BA or BS and MS program. The Department offers MS degrees in Geological Science and Environmental Science (refer to the description of Graduate Programs in EES following the listing of undergraduate course descriptions). Students working toward the BA or BS degrees who are enrolled in this program complete the full requirements for both degrees and apply some 300- and 400-level course credit taken as an undergraduate towards the MS degree without additional undergraduate tuition cost. The program is designed for those students who (1) will have at least 9 credits of appropriate MS course credit in excess of undergraduate requirements completed by the end of the senior year, including one EES graduate core course (EES 415, 426, or 484), (2) have completed a minimum of 3 credits of EES 393 (Supervised Research) as part of the Baccalaureate program, and (3) have demonstrated superior academic achievement.

Application for admission to the program should be made no later than the beginning of the first semester of the senior year and must be approved by the Department's Graduate Instruction Committee. The application must include (1) a current Baccalaureate degree audit, (2) the proposed MS course program, and (3) a letter of recommendation from the proposed MS thesis adviser. Students enrolled in this program should make application for admission to full-time graduate status during the first semester of the senior year.

After receiving the bachelor's degree and becoming enrolled in the graduate program students in the dual-degree program become eligible for financial aid, including appointment to a teaching or research assistantship or graduate fellowships. Admission to the program does not guarantee financial aid.

**Concentration in Geoscience**

EES 341 Field Geology), which is a Tier 3 course and satisfies the EES field experience requirement, is required for the geoscience concentration. The eight credits awarded for EES 341 are partitioned equally between the Tier 3 requirement and the BS requirement for an additional course at Tier 2 or Tier 3. Students concentrating in Geoscience must, therefore, complete EES 341, one of the senior seminars (see below), and at least two other courses for at least 8 credits from the Tier 3 selections below.
Department Honors in Earth and Environmental Sciences

Students in either the BA or BS degree programs may undertake a program that leads to graduation with Department Honors. To participate, the student must (1) have a minimum overall cumulative GPA of 3.0, (2) file a written request with the EES undergraduate instruction coordinator to receive honors no later than the beginning of the senior year (preferably during the junior year), and (3) complete at least four credits of EES 393 (Supervised Research in Earth and Environmental Sciences). An advisory committee of two EES faculty plus the student’s research supervisor must be constituted to supervise and guide the research and to approve the required honors thesis. For the thesis to qualify for Department honors, the student must give an oral presentation of its results and conclusions at a Department seminar before the last day of classes in the second semester of the senior year.

Earth and Environmental Sciences

Undergraduate Courses

3. Global Environmental Change (4)
Review of the environmental systems that carry out the exchange of energy and matter between the solid earth, the oceans, and the atmosphere. Examination of the global environment that has been a fact of life on Earth for several billion years, the role of humans in causing global environmental change, and the potential impact of such change on humans; debate over what course of actions is required to ensure the continued habitability of this planet. The course is intended for non-science majors wishing to learn more about the science behind current environmental issues, and fulfills a distribution requirement in science. Lectures, class discussions, debates, and group projects. Meltzer and Zeitler. (NS)

11. Environmental Geology (3)
Analysis of the dynamic interaction of geologic processes and human activities. Catastrophic geologic processes (earthquakes, volcanoes, landslides), pollution of geologic systems, and engineering case studies. Evenson (NS)

21. Introduction to Planet Earth (4)
Processes within the Earth and dynamic interactions among the solid earth, the atmosphere, and the hydrosphere. Lectures, laboratories, and field trips. Anastasio, Kodama (NS)

31. Introduction to Environmental/Organismal Biology (4)
Introduction to the structure, function, and evolution of living systems, with emphasis at the levels of organism, population, community, and ecosystem. Lectures and laboratories. Hargreaves, Morris (NS)

41. Physical Geology and Geomorphology in the Rocky Mountains (8) summer
Geology of Wyoming and Idaho. Six weeks of morning lectures and afternoon field exercises conducted in field settings in South Dakota, Wyoming, and Idaho during the summer session. See EES 341 description for location details. May substitute for either EES 21 or 101 and EES 112 (see EES 21 and 112 descriptions for content); see Introductory Sequence section of EES program description for restrictions on overlapping credit. Prerequisite: consent of Field Camp Director Evenson (students must apply through the Lehigh Field Camp Program). Evenson (NS)

90. College Seminar (3)

101. Geology for Engineers (3)
A study of the materials that make up the earth, the physical, chemical, and environmental history that they relate, and the processes that act to change them. Designed primarily for upperclass science and engineering majors. Lectures and laboratory. Myers (NS)

112. Geomorphology (4)
Systematic study of the origin, evolution, and distribution of the Earth’s topographic features; land forms analyzed in terms of chemical and physical processes responsible for their development. Lectures and required 3-day field trip. Prerequisites: EES 11, 21, or 101. Evenson (NS)

113. Paleontologic Evidence for Earth History: Life and Climate in the Rock Record (4)
Physical and chemical formation of early earth and its atmosphere; appearance of life; evolution of life forms as recorded in the sedimentary record. Environmental changes and responses to plate tectonic movements and extra-terrestrial factors. Lectures, seminars. Lab and field trips. Prerequisites: EES 21 or EES 101. Carson and Zeiller (NS)

123. Structural Geology and Tectonics (4)
Application of basic concepts of stress, strain, and material properties to the study of folds, faults, and rock fabrics. Plate tectonic processes and plate margin deformation. Introduction to map and field techniques. Lectures, laboratories, and two all-day field trips. Prerequisite: EES 21. Anastasio (NS)

131. Introduction to Rocks and Minerals (4)
Hand-specimen identification of the major mineral groups and rock types. Atomic structure of minerals; relationship of mineral structure to chemical and physical properties. Placement of igneous, sedimentary, and metamorphic rocks into a plate tectonics context. Introduction to optical mineralogy and x-ray diffraction techniques. Lectures, laboratories, field trips. Prerequisite: EES 21 or EES 101 or EES 41 or consent of instructor. Bebout (NS)

151. Plants and Plant Communities (4)
Structure and function of plants and plant communities. Discussion of plant physiology and environmental factors controlling plant distribution; structural and physiological adaptations of plants to their environment; the role of the physical environment, competition, herbivory, and disturbance in structuring plant communities; the evolution of plants and communities. Prerequisite: EES 31. Fritz (NS)

201. Seismology, the Earth, and the Environment (4)
An examination of how earthquakes and active source seismology are used to image subsurface structure and stratigraphy. Fundamentals of seismic wave propagation in the Earth. Study of earthquakes, reflection and refraction techniques both at crustal scale (kilometers) and in high-resolution (1 to 100 m) applications, and ground-penetrating radar. Practical applications to both Earth and environmental sciences. Field and laboratory projects. Prerequisites: EES Tier 1 sequence (EES 21 and 31), one semester each of calculus and physics. Meltzer (NS)

203. The Earth’s Potential Fields (4)
Theory and application of potential fields to environmental and geologic problems. Topics include gravity, magnetic, electrical, heat flow, and borehole geophysical methods. Students will collect, analyze, and model data to solve a geologic/environmental problem designed by the class. Prerequisites: EES 21, one semester each of calculus and physics. Kodama (NS)

213. Sedimentology and Stratigraphy (4)
Processes of sediment transport, deposition, and diagenesis of clastic and non-clastic sediments; sedimentary textures and structures; lithostratigraphy and stratigraphic correlation using biologic, magnetic, seismic, and radiometric methods. Lectures and laboratories. Prerequisites: EES 113 or consent of department chairperson. Carson (NS)

221. Plate Tectonics: How it Works (2)
Historical development of the plate tectonic model from the 1950s to the present. Quantification of the modern plate tectonic model. Emphasis is on how to do plate tectonics, i.e., how to calculate spreading rates, angular velocity vectors, finite rotations, relative Euler
pales, total plate reconstruction poles and stage poles, global plate circuits, and absolute plate motion. Other topics include using paleomagnetic apparent polar wander paths for plate reconstructions and plate driving forces. Lectures and laboratories (7 weeks)
Prerequisites: EES 123, one semester of calculus. Kodama (NS)

234. Petrology of the Crust and Mantle (4)
Crust and mantle evolution as recorded by the mineralogy, texture, and geochemistry of igneous, sedimentary, and metamorphic rock. Origin of the three rock types in various plate tectonic settings. Mass and energy transfer among the crust, mantle, hydrosphere, biosphere, and atmosphere through time. Petrographic study of selected rock suites and introduction to other modern analytical techniques used in petrology/geochemistry. Lectures, laboratories, field trips. Prerequisite: EES 131 or consent of instructor. Bebout (NS)

251. General Ecology (4)
Basic principles and applications of ecological interrelationships. Examination of ecological phenomena at the individual, population, community, and ecosystem levels. Impact of human activities on global ecosystems. Prerequisite: EES 31. Williamson (NS)

282. Climate, Geosphere, and Biosphere (4)
Interactions of Earth-surface fluids (air and water) with the organic and inorganic components of the Earth system, as expressed through climate, landscape evolution, biogeography, and biogeochemical cycles. Modern processes and historical perspective on environmental change. Lectures, discussion, and laboratory. Prerequisites: one semester each of calculus, chemistry, and physics; EES Tier 1 sequence (EES 21 and 31). Fritz, Moses (NS)

283. The Atmosphere (2)
Brief introduction to the physics and chemistry of the Earth's atmosphere, both in modern times and over Earth history. Atmospheric structure, composition, and dynamics, including weather. Interactions of the atmosphere with solar and terrestrial radiation and with Earth's lithosphere, hydrosphere, and biosphere. Lectures and recitation (7 weeks). Prerequisites: EES Tier 1 sequence (EES 21 and 31); one semester each of calculus, chemistry, and physics; or consent of instructor. Moses (NS)

284. Dynamics of Nature (4)
Survey of the organization of Earth and environmental systems and the important processes governing the exchange of energy and matter in these systems. The focus is on quantitative descriptions of processes and will include attempts at building numerical models. Lectures, discussions, analysis of case studies, and computing work. Prerequisites: one semester of calculus and one EES Tier 1 course (EES 21 or 31). Zeitler (NS)

293. Supervised Internship in Earth and Environmental Sciences (1-4)
Experiential learning opportunities supervised by EES faculty, including data collection or analysis, literature review, information management. A maximum of 4 credits of EES 293 and no more than 8 credits combined from EES 293 and 393 may be applied to EES major (additional credits apply to free electives). Prerequisite: consent of supervising faculty.

Advanced Undergraduates and Graduate Students

303. Active Tectonics (4)
An integrative look at how internal and external processes shape the Earth. Review of the observations and evidence leading to a unified understanding of how physical processes in the Earth's interior shape the external surface on which we roam. Topics include issues in continental dynamics such as mountain building, basin formation, and the interplay between tectonics and climate. Lectures, problem sets, modeling exercises, student projects and presentations. Prerequisites: EES Tier 1 sequence (EES 21 and 31), at least five courses in EES Tier 2 or 3. Meltzer (NS)

307. Case Histories in Engineering Geology (4)
Methods of geological investigation at engineering sites. Assessing suitability of a proposed site, acquiring geological information for proper engineering design, and recognizing potential geotechnical problems during and after construction. Prerequisite: Junior standing in the Department of Earth and Environmental Sciences or consent of instructor. Myers (NS)

309. Mineral Magnetism and Earth Processes (4)
The use of Earth material magnetic properties to study environmental and geologic systems and processes. Techniques of magnetic measurements, characteristics of the Earth's magnetic field, and mineral magnetism. Prerequisites: EES 21, Phys 11/12. Kodama (NS)

313. Depositional Environments and Facies Analysis (4)
Interpretation of sedimentary records on the basis of sedimentary rock composition and structures; characteristics of continental, continental margin, and marine deposits; facies as indicators of source, depositional environment, and tectonic setting; principles of basin analysis and sequence stratigraphy. Lectures, laboratories, and field trips. Prerequisites: EES 113, EES 131, and EES 213. Carson. (NS)

315. Soil Genesis (4)
Genesis, classification, and application of pedology. Weathering of parent materials; chemistry of soils; geologic, biologic, and climatic controls on soil formation; application to geologic and engineering concepts. Lectures and two all-day field trips. Prerequisite: EES 213 or consent of instructor. Ewens, Myers (NS)

316. Hydrogeology (4)
Interrelationships of geologic materials and processes with water; entry, storage, interaction, and flow of water through permeable earth materials; evaluation, development, and management of ground-water resources. Lectures and recitation/laboratory. Prerequisites: EES 21 or EES 101. Myers (NS)

319. Environmental Applications of Geographic Information Systems (4)
Use of spatial database system (ARC/INFO) in the storage and manipulation of data necessary for the evaluation and management of ground-water systems. Prerequisite: EES 316 or equivalent. Myers (NS)

326. Geologic Evolution of North America (4)
A senior seminar on the lithologic, tectonic, and morphologic evolution of North America; developed within the framework of the plate tectonic theory. Prerequisites: EES Tier 1 sequence (EES 21 and 31), at least five courses in EES Tier 2 or 3. Anastasio and Myers (NS)

337. (Chem 337, Mat 333) Crystallography and Diffraction (3)
Introduction to crystal symmetry, point groups, and space groups. Emphasis on materials characterization by x-ray diffraction and electron diffraction. Specific topics include crystallographic notation, stereographic projections, orientation of single crystal, textures, phase identification, quantitative analysis, stress measurement, electron diffraction, ring and spot patterns, convergent beam electron diffraction (CBED), and space group determination. Applications in mineralogy, metallurgy, ceramics, microelectronics, polymers, and catalysts. Lectures and laboratory work. Prerequisite: Mat 203 or EES 131 or senior standing in chemistry. Lyman, Chan. (NS)

338. (Mat 334) Electron Microscopy and Microanalysis (4)
Fundamentals and experimental methods in electron optical techniques including scanning electron microscopy (SEM), conventional transmission (TEM), and scanning transmission (STEM) electron microscopy. Specific topics covered will include electron optics, electron beam interactions with solids, electron diffraction and chemical microanalysis. Applications to the study of the structure of materials are given. Prerequisite: consent of the department chairperson. Williams, Lyman. (NS)
341. Field Geology (8) summer
Field study and geologic mapping of sedimentary, igneous, metamorphic, and glacial deposits in the Rocky Mountains of northwestern Wyoming and southeastern Idaho. Additional studies in the Badlands and Black Hills of South Dakota, the Grand Teton, Yellowstone Park, Craters of the Moon Park, and other areas in the Rocky Mountain region. Six weeks in the field; summer session.
Prerequisite: consent of Field Camp Director Evenson (students must apply through the Lehman Field Camp Program); major in EES, EES 21 and 131 (EES 112, 113, 123 recommended). Evenson, Myers, Anastasio, Bebout (NS)

351. Limnology (4)
Physical, chemical, and biological aspects of freshwater environments, including cyclic and seasonal changes. Major groups of organisms and their interactions. Prerequisite: EES 31. Williamson (NS)

353. Environmental Microbiology (4)
The role of microorganisms in the environment. Topics include: Survey of microbial classification, structure, and metabolism; study of microbes at population, community, and ecosystem levels of organization; role of microbes in biogeochemical cycles; application of microbes to bioremediation and resource recovery problems. Fall (alternate, every other year). Prerequisite: EES 31 and EES 251 or consent of instructor. Morris (NS)

354. Methods in Limnology and Microbial Ecology (4)
Investigation of topics in limnology and microbial ecology using an integrative approach that encompasses data acquisition, data analysis, and communication of results. Chief issues: (1) theory and application of standard techniques in limnology and microbial ecology; (2) quantitative analysis or modeling of existing or acquired data sets; and (3) data presentation and scientific report writing. Full-time College Writing Intensive course requirement. Students must attend several Saturday field trips during the semester. Lectures and laboratories. Prerequisite: EES 21 or 31, second semester physics (covering electricity), and Department approval. Hargreaves (NS)

355. Ecological Field Methods (4)
An intensive field course designed to familiarize students with field sampling techniques, data analysis, and report writing related to field-based ecological research. Includes description and mapping of plant and animal communities, population dynamics, and plant-animal interactions in both terrestrial and aquatic habitats. Weekend field trip to Lacawac Sanctuary. Pre-requisite: EES 251. Williamson (NS)

356. Quaternary Paleoclimatology (4)
Analysis and interpretation of Quaternary paleoclimatic data from marine, glacial, terrestrial, and lacustrine archives. Includes an overview of paleoenvironmental proxy records, techniques and issues in data analysis, and the major forcings of environmental change. Emphasis on current issues in Quaternary paleoclimatology, including history and dynamics of terrestrial ecosystems, lakes, and atmosphere, as well as issues related to cultural history and pollution. Work will include readings from the primary literature, student presentations, and reports, and computer exercises. Prerequisite: EES Tier 1 sequence (EES 21 and 31), EES 282. Fritz (NS)

361. Animal Physiology (4)
Structure and function of animals at the level of tissues, organs, organ systems, and whole organisms interacting with the environment.
Prerequisites: EES 31, one semester each of chemistry and physics. Hargreaves (NS)

373. Environmental Thermodynamics (4)
Development of fundamental macroscopic thermodynamic principles with applications to geochemical, atmospheric, and aquatic systems. Topics include the laws of thermodynamics, thermodynamic relationships, phase transitions, aeroelastic diagrams, chemical equilibria, chemical potential diagrams, and stability in different systems. Lectures and recitation. Prerequisites: two semesters of calculus, one semester each of chemistry and physics; EES Tier 1 sequence. Moses (NS)

376. Geochemistry of Natural Waters (4)
Introduction to aqueous geochemistry. Applications of thermodynamics, mass balance, systems science, and kinetics to understanding mineral-water interactions in natural aquatic systems on a variety of spatial and temporal scales. Laboratories emphasize analytical and computer methods. Lectures, discussion, student presentations, and recitation/laboratory. Prerequisites: two semesters of calculus, one semester each of chemistry and physics; EES Tier 1 sequence (EES 21 and 31); at least two courses from EES Tier 2 (EES 131 recommended); or consent of instructor. Moses (NS)

382. Statistical Applications in Earth and Environmental Sciences (4)
Univariate and bivariate statistical models with specific reference to geological, hydrological, and biological field and laboratory studies. Analysis of variance, applications of the Chi-square distribution, analysis of covariance, linear, nonlinear, and multiple regression, and distribution-free methods. Carson (NS)

383. Environmental Data: Acquisition, Analysis, and Management (4)
Acquisition, analysis, and management of environmental datasets with emphasis on aquatic ecosystems and electronic tools. Data from a variety of computer-controlled and programmable field instruments and from existing databases available through computer networks. Lectures and laboratories. Prerequisites: EES 21 or 31, second semester physics (covering electricity), and Department approval. Hargreaves (NS)

384. lake Ecosystems (4)
Advanced concepts and methods in lake ecosystem ecology. The course provides a theoretical framework but emphasizes hands-on laboratory and field techniques for measurement of physical, chemical, and biological properties of aquatic ecosystems. This 3-week residential field course is offered at the Lacawac Sanctuary field station in the Pocono Mountains of Pennsylvania. The course typically begins during the last week of May. Prerequisite: EES 31 and EES 251 or consent of instructors. Limited enrollment. Hargreaves, Morris, and others. (NS)

385. Computational Methods in Earth and Environmental Sciences (2)
Use of the computer to quantitatively analyze data or model natural processes. Topics include parameter estimation, numerical analysis, time-series analysis, and systems analysis. Examples drawn from physiology, ecology, climatology, and geochemistry. Lectures and computer laboratories (7 weeks). Prerequisites: two semesters of calculus, one semester of statistics, eight credits of EES Tier 2 courses, and Department permission; EES 284 is recommended. Moses (NS)

391. Supervised Research in Earth and Environmental Sciences (1-4)
Research opportunities supervised by EES faculty, including exposure to problem definition, selection of research approach, and communication of results. A maximum of 4 credits of EES 293 and no more than 8 credits combined from EES 293 and 393 may be applied to EES major (additional credits apply to free electives). Prerequisite: consent of supervising faculty.

For Graduate Students

The Department of Earth and Environmental Sciences offers graduate degree programs leading to the MS or PhD in Geological Sciences and Environmental Science. Research is an important and integral part of the graduate programs; a student selects a research problem through consultation with one's adviser. Graduate students make annual presentations of their research to the Department. M.S. students
complete 30 credits of coursework and present a written thesis reporting their investigation of a specific problem. Candidates for the Ph.D. must pass a qualifying examination administered by an examination committee prior to the start of an individual student’s second semester and the general examination, which includes the public oral defense of the written dissertation proposal, prior to the end of the student’s third semester. Ph.D. candidates also defend their written dissertation at a public oral presentation. All graduate students work with an adviser who chairs the individual student’s supervisory committee. In addition, each graduate student must take two of the Department’s three graduate core courses (EES 415, 426, and 484). For details beyond the following summary, please contact the Department.

Program in Geological Sciences. The Department’s Geological Sciences program emphasizes studies of the Earth’s crust in both tectonic and surficial regimes. Graduate research in the Geological Sciences program is oriented toward geological processes in the general areas of structural geology, metamorphic petrology, isotope geochemistry, sedimentation, glacial and Quaternary geology, geomorphology, paleomagnetism, reflection seismology, aqueous geochemistry, hydrology, and plasticization. Aside from the core-course requirement, course selection is determined by the student in consultation with the supervisory committee.

Program in Environmental Science. The Department’s Environmental Science program stresses the interaction of biotic and abiotic components as the basis for understanding natural environmental systems. Process- and system-oriented graduate research opportunities in Environmental Science include sedimentation, glacial and Quaternary geology, environmental physiology, paleoecology, and palaeoclimatology, environmental magnetism, microbial ecology, aquatic geochemistry, hydrology, and plasticization. Three course programs are available, providing concentrations of Environmental Biology or Surfacial Processes or providing more general training in Environmental Science. In addition to completing the Department’s core course requirement, students opting for a concentration must complete three of the designated courses in either Aquatic Ecosystems or Surfacial Processes and one designated course in another category, while students seeking general training in Environmental Science take two courses from each category. All students in the Environmental Science program must take a course in quantitative methods. M.S. theses are defended in a public oral presentation.

Special departmental research facilities of interest include: Philips APD-3600 automated x-ray powder diffractometer; Philips AXS automated x-ray fluorescence spectrometer; Delye-Scheiner X-ray powder camera; complete petrographic and incident-light microscopy equipment; hydrothermal apparatus for experimental mineralogy; a sediment-core laboratory with a computer-assisted Multi-Sensor Core Logger measuring sonic velocity, gamma-ray attenuation (bulk density), and magnetic susceptibility, a cold storage room, and a transportable Mackereth corer; floating plankton laboratory; complete laboratory for noble-gas and fission-track geochronology, including a low-blank, high vacuum furnace, and a VG Isotopes model 3600 mass spectrometer; Finnigan MAT model 252 isotope ratio mass spectrometer and high-vacuum extraction lines for O, H, C, S, and N isotope analyses; paleomagnetism laboratory with a Molspin spinner magnetometer, a 2-Axis CTF Cryogenic Rock Magnetometer, a Schonstedt tumbling AF demagnetizer, and a Schonstedt thermal demagnetizer; reflection seismology laboratory with Apollo computer workstation for seismic processing and Bison DIFP multichannel x-seismograph; sedimentation laboratory equipped with Particle Data computer-based particle-size analyzer and rapid sediment analyzer; field geophysical equipment including Bison shallow refraction seismic unit and Bison shallow resistivity apparatus, master Wordon gravimeter, Geomatics portable proton precession magnetometer; Kek borehole logging equipment including caliper, natural gamma, electrical resistivity, and self-potential probes; downhole geochemical sampling equipment; Waters computer- assisted ion chromatography; ARL 3400X inductively-coupled plasma atomic emission spectrometer (ICP/AES); NETZSZCH DTA/tga analyzer; Sun and IBM workstations which support CADD, mapping/contouring software, and ARC/INFO geographic information system; standard equipment for field mapping.

Three wells are also located on campus completed by a water and greenhouse. Students perform a variety of pump tests, geophysical sampling, and down-hole geophysical determinations at this facility.

The following major analytical facilities are available on campus to students and staff of the Department: fully automated JEOL 733 electron microscope, Philips 300 electron microscope completely equipped for transmission and diffraction, ETEC scanning microscope completely equipped for quantitative X-ray microanalysis and electron energy-loss spectroscopy, JEOL 6300F field-emission digital SEM with backscattered electron detector and image analysis, SCIENTA ESCA 300 x-ray photoelectron spectrometer, and Perkin Elmer double-beam infrared spectrophotometer.

Equipment to conduct environmental biology research is also available in the Department. This includes, but is not limited to, computers, microscopes, environmental chambers, centrifuges, sampling nets, current meters, incubators, and autoclaves. A remotely operated vehicle (ROV) equipped with a video camera can be used to monitor plankton behavior and dynamics in aquatic environments. The Department also has the Pocono Comparative Lakes Program (PCLP), an interactive research and educational program, to study lake systems through multidisciplinary research and to provide training for undergraduate and graduate students. The program is centered at the Lacawac Sanctuary in the Poconos and focuses on the core lakes that serve as model systems for experimental and comparative studies on aquatic communities and ecosystems. For more information about the PCLP, please contact Prof. Williamson (610-758-3660).

405. Paleoclimate and Environmental Magnetism (3)
Topics in paleomagnetism and environmental magnetism. Class will be designed and conducted as a research project, read the relevant literature and write a research paper. May be repeated for credit. Prerequisite: EES 309 or consent of course instructor. Koda (spring every year)

407. Seismology (3)
Seminar on advanced topics in seismology, review of classic and current literature. Topics include but are not limited to: wave propagation in ideal media and earth materials, seismic imaging of complex structures, tomography, modeling, and high-resolution seismic imaging. May be repeated for credit. Prerequisite: an introductory geophysics course. Melzer

414. Glacial and Quaternary Geology (3)
Study of the origin, distribution, and movement of present and past glaciers. Special emphasis on glacial land forms and deposits, quaternary stratigraphy and dating techniques, periglacial phenomena, and Pleistocene environments. Lectures and required field trips. Prerequisite: Consent of instructor. Evenson

415. Paleoclimatology (3)
Principles of physical climatology and the methods of reconstructing past climatic variation from a variety of records including stable isotopes. Emphasis is on the Quaternary. Issues related to linking climate variation to tectonic processes, chemical composition of the atmosphere and biogeochemical cycles, ocean-atmosphere interactions, and variations in the parameters of Earth’s orbit. Prerequisite: graduate standing in EES. Carson and Moses

418. Advanced Glacial and Quaternary Geology (3)
Lectures and seminars on selected contemporary topics. Topics include glaciology, ice cores, modern and ancient glacial environments and deposits. Required field trips. May be repeated for credit. Prerequisite: EES 414 or consent of course instructor. Evenson (fall odd years)

426. Tectonic Processes (3)
Current models of tectonic processes in intraplate settings and at plate boundaries. Critical evaluations by the class of the geological,
Economics

427. Orogenic Belts (3)
Geometry, kinematics, and mechanics of compressional orogenic belts. Course will emphasize deformational, depositional, and metamorphic processes in forearc and backarc regions. Lectures, seminars, and field trips. Prerequisites: EES 123, EES 131, and EES 213 or equivalents. Anstattos [fall every year].

428. Stress and Strain in Rocks (3)
Theory of continuum mechanics and application to analytical methods of geological strain analysis; rock material properties and micro-mechanisms of rock deformation; tectonic fabric development; kinematic analysis. Lectures and laboratories. Prerequisite: EES 123 or equivalent. Anstattos

429. Methods and Applications of Geochronology (3)
Examination of isotopic techniques used to measure geologic time, and their applications. Lectures, laboratories, research projects, field trips. Prerequisite: graduate standing in EES. May be repeated for credit. Zeitler [fall odd years].

438. Petrogenetic Processes (3)
Metamorphism, melting, and magmatism in the Earth's crust and mantle. Tectonic evolution, crust-mantle heat and mass transfer, fluid-rock interactions, and rate processes. Varying combinations of lecture and seminar formats. May be repeated for credit when topics differ. May include laboratory and field experience and computational exercises. Prerequisite: consent of course instructor. Bebout [spring even years].

451. Advanced Topics in Limnology and Paleolimnology (3)
In-depth discussion of current issues in the fields of limnology and paleolimnology. Consideration of both the modern behavior of lake ecosystems, as well as lacustrine dynamics in the past based on interpretation of the fossil record. Topics may range from the interaction of lakes with their watersheds and the atmosphere to the dynamics of algal communities. Prerequisite: EES 351 or equivalent. Fritz [spring odd years].

453. Advanced Topics in Microbial Ecology (3)
Lectures and seminars will focus on topics of current interest in the microbial ecology of pelagic (freshwater and marine), sediment, and/or soil environments. Emphasis will be placed on the role of microbes in ecosystems level processes such as energy transformations and elemental cycling. May include laboratory and field exercises. Prerequisite: graduate standing or consent of course instructor. Morris [spring even years].

458. Advanced Ecology (3)
Seminars, conferences and directed field work with emphasis on theoretical models and their application to real biological systems. May be taken more than once for credit. Prerequisite: EES 251 or equivalent. Williamson

471. Stable Isotope Chemistry - Theory, Techniques, and Applications in the Earth and Environmental Sciences (3)
Distributions of stable isotopes (primarily of O, H, C, S, and N) in the lithosphere, hydrosphere, biosphere, and atmosphere. Topics include mechanisms of fractionation and mixing, advancements in techniques for extractions and mass spectrometry, and recent applications of stable isotopes in the earth and environmental sciences. Lectures, seminars, laboratory sessions. Prerequisite: consent of instructor. Bebout

473. Aqueous Geochemistry (3) spring (alternate even years)
Advanced study of physical and inorganic aqueous geochemistry, including homogeneous and heterogeneous equilibria, kinetics, and surface processes in water-rock systems. Computational modeling of water-rock systems. Prerequisites: EES 376 or equivalent, computer programming (C, Pascal, or Fortran), and consent of instructor. Moses

484. Aquatic Ecosystems (3) fall (alternate even years)
Theoretical and experimental approaches to understanding physical and chemical influences in aquatic environments on organisms and their community, population, and ecosystem ecology. Field trip. Prerequisite: graduate standing in EES. Staff

487. Advanced Topics in Bio-Optics (3)
Bio-optics includes the ecosystem role and fate of solar radiation and the optical properties of biotic and abiotic components of ecosystems. This course will explore advanced topics through selected readings, data analysis, and modeling. Topics will focus on aquatic ecosystems and may include optical models, atmospheric factors, inherent and apparent optical properties, algal fluorescence, light adaptation and photodamage, ultraviolet radiation, and optical stratification. Prerequisite: EES 484 or consent of course instructor. Hawege [fall, 1992].

490. Thesis Research (1-6)
Masters' thesis research directed by a research committee. 3-6 credits required for EES MS programs. May be repeated for credit. Prerequisite: Permission of research adviser.

491. Investigations in Earth and Environmental Sciences (1-6)
Research on a special problem; field, laboratory, or library study; report required. Credit above three hours granted only when a different problem is undertaken.

492. Advanced Topics in Modern and Quaternary Processes (1-6)
Intensive study of topics in modern and Quaternary geology not covered in more general courses. May be repeated for credit.

493. Advanced Topics in Tectonics (1-6)
Intensive study of tectonic processes and products not covered in more general courses. May be repeated for credit.

494. Advanced Topics in Aquatic Ecosystems (1-6)
Intensive study of aquatic ecosystems not covered in more general courses. May be repeated for credit.

499. Dissertation Research (1-15)
PhD dissertation research directed by a research committee. May be repeated for credit. Prerequisite: Permission of research adviser.

Economics

Professors. J. Richard Aronson, Ph.D. (Clark), Clayton Professor; Thomas J. Hickey, Ph.D. (Notre Dame); Jon T. Innes, Ph.D. (Oregon); Arthur E. King, Ph.D. (Ohio State); John R. McNamara, Ph.D. (Rensselaer); Vincent G. Munley, Ph.D. (SUNY); chairman; Larry W. Taylor, Ph.D. (North Carolina); Robert J. Thornton, Ph.D. (Illinois); MacFarlane Professor.

Associate professors. Colleen M. Callahan, Ph.D. (North Carolina), major advisor and curriculum director; James Dearden, Ph.D. (Perm State); Mary A. Delly, Ph.D. (Harvard); Frank R. Gunter, Ph.D. (John Hopkins); Judith McDonald, Ph.D. (Princeton); Anthony P. O'Brien, Ph.D. (Berkeley).

Assistant professors. Darlene Chisholm, Ph.D. (Washington); Todd Watkins, Ph.D., (Harvard).

Instructor. J. Roi Thomas (M.B.A., Stanford; ABD, UC-San Diego)
Active emeriti. Nicholas W. Balabkins, Ph.D. (Rutgers); Alvin Cohen, Ph.D. (Florida); Eli Schwartz, Ph.D. (Brown).
Though economics is variously defined, modern-day definitions generally suggest that it is the study of the principles that govern the efficient allocation of resources. One of the greatest of the 19th century economists who did much to uncover these principles suggested a broader definition. Alfred Marshall described economics as "a study of mankind in the ordinary business of life... a part of the study of man." This dual nature of economics, technical and humanistic, is reflected in the fact that at Lehigh the economics major is available to students in the College of Arts and Science as well as in the College of Business and Economics.

As the description below suggests, the economics program is exceptionally flexible once one moves beyond the sophomore year. This flexibility allows the major to be adapted easily to the needs of students with widely varying goals. Although many students choose the economics major in order to secure a firm foundation in economics and finance before entering the business world, many others choose it in preparation for law school or as a complement to their major in political science, history, international relations, journalism, mathematics, urban studies or other disciplines. Naturally, many students who major in economics do so with the intent of pursuing graduate work at the master's or doctor of philosophy levels; others simply want to become "economically literate" in a world where such literacy is increasingly in demand.

At the same time that the program provides flexibility, it also consists of a substantial core of economic theory and related courses. This assures that the student who is uncertain concerning career goals will obtain a broad education in economics and business no matter what upper-level courses are chosen.

Students who are interested in designing a major program in economics suitable to their needs should consult with the major advisor and curriculum director.

Major in College of Business and Economics

Students in the College of Business and Economics electing to major in economics must take the College core courses as listed in the College of Business and Economics section of this catalog. They must also take Econ 119 and at least 12 credit hours of 200 and 300-level economics courses beyond the core requirements. These courses may be chosen so as to form an area of specialization or to provide a broad exposure to the various aspects of the discipline. In any case, students should consult with the major advisor (Prof. Colleen Callahan) in forming their programs.

Major in College of Arts and Science

The study of economics leads to many possibilities, some of which involve formal education beyond a bachelor's degree, and others in which one immediately begins a career after graduation. The department of economics has established the following four tracks to meet the different needs of students who select economics as a major.

The tracks available to economics majors are:

I. Business/Consulting/Financial Markets

II. Political Economy and Public Policy

III. International Economics and Global Markets

IV. Graduate Study in Economics

The four tracks have in common a core set of courses in economics, a core collateral course and four elective courses in economics. The common requirements are listed below. In addition, each of the four tracks are differentiated by additional requirements tailored to the need of the students in each track. The complete requirements for each track are described below.

ECONOMICS CORE COURSES (17 credits, required of all economics majors)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economics 1</td>
<td>Principles of Economics</td>
<td>4</td>
</tr>
<tr>
<td>Economics 115</td>
<td>Applied Microeconomics</td>
<td>3</td>
</tr>
<tr>
<td>Economics 119</td>
<td>Intermediate Macroeconomics</td>
<td>3</td>
</tr>
<tr>
<td>Economics 129</td>
<td>Money and Banking</td>
<td>3</td>
</tr>
<tr>
<td>Economics 145</td>
<td>Statistical Methods</td>
<td>4</td>
</tr>
</tbody>
</table>

CORE COLLATERAL COURSE (4 credits, required of all economics majors)

Mathematics 51 Survey of Calculus I (4)

(Students may substitute Math 21 for this course. Also see the additional requirements within each of the four tracks as listed below.)

ELECTIVE COURSES (12 credits, required of all economics majors)

Four upper-level (numbered at 200-level or beyond) economics courses.

(See information below on specific requirements by track.)

SUMMARY OF REQUIREMENTS FOR EACH TRACK

I. Business/Consulting/Financial Markets (41 credits)

Description. Especially intended for students who want to build a strong academic background in economics for immediate application to the world of business, consulting and financial markets. Excellent preparation for an MBA.

Required economics courses. Economics CORE courses and ELECTIVE courses, to be selected in consultation with the major advisor.

Required collateral courses. (a) CORE collateral course (Mathematics 51), (b) Mathematics 61, (c) Accounting 151 and (d) Finance 225.

Recommended additional collateral courses. Accounting 152 and Marketing 211.

II. Political Economy and Public Policy (43 credits)

Description. Especially intended for students who are interested in economics with a liberal arts emphasis, public policy analysis or law school.

Required economics courses. Economics CORE and ELECTIVE courses, to be selected in consultation with the major advisor.

Required collateral courses. (a) CORE collateral course (Mathematics 51), (b) One course in each of the following areas: (i) history, (ii) political science and (iii) anthropology or sociology.

Recommended additional collateral courses. Courses in philosophy, especially Philosophy 128, 131, 133, 135 or 139.

III. International Economics and Global Markets (39 credits)

Description. Especially intended for students who are interested in careers in the international sphere, including multinational firms, and who desire a broad background in international economics and global markets.

Required economics courses. Economics CORE courses and ELECTIVE courses, including at least two of the following: Economics 209, 303, 305, 339, 340 or 343. These are to be selected in consultation with the major advisor.

Required collateral courses. (a) CORE collateral course (Mathematics 51), (b) a course in non-US history and (c) a course in international relations.

Recommended additional collateral courses. Two or more semesters of foreign language study would be of great benefit. Students interested in international business would be well-served by a course in international marketing or multinational business finance, and should consult the catalog for prerequisites for such courses.

IV. Graduate Study in Economics (36 credits)

Description. Especially designed for students who intend to pursue a master's degree or doctorate in economics.

Required economics courses. Economics CORE and ELECTIVE
courses, plus either Mathematical Economics (Eco 351) or Econometrics (Eco 415), to be selected in consultation with the major advisor.

**Required collateral courses.** (a) CORE collateral course (Mathematics 51) and Mathematics 52. The following mathematics sequences may be substituted for Math 51 and 52: Mathematics 21, 22 and 23, or Mathematics 31, 32 and 33 (honors calculus).

**Recommended additional collateral courses.** (a) Mathematics 205 and (b) Mathematics 231 or 309. Students may substitute Math 231 for Eco 145. Interested students should consult the major advisor for a list of other useful mathematics courses.

**HONORS IN ECONOMICS**
Departmental honors will be awarded to graduating economics majors who have completed at least 15 credits of upper-level economics courses, or approved substitutes, and earned a major GPA of at least 3.25. One of the upper-level courses must be a senior honors project conducted under the supervision of a team of department faculty. Students interested in departmental honors should consult with the major advisor by the end of their junior year.

Note: For the purposes of department honors, the major GPA will be computed with respect to all economics courses, or approved substitutes, beyond Economics 1 and 145.

**Minor in Economics**
A minor in economics consists of 12 credit hours beyond Economics 1. Required courses in the minor are: Economics 115, 119 or 129, and two elective courses. Elective courses must be chosen from among the 200 and 300-level economics offerings. This minor is available only to students in the College of Arts and Science and in the College of Engineering and Applied Science. Interested students should contact Prof. Vincent Munley.

**Undergraduate Courses**

1. **Economics (4)**
A one-semester course in the principles of economics. General topics covered are: the determination of national income; the determination of relative prices; money and banking; monetary and fiscal policy; government finance. (Not available for credit to students who have taken Eco 11 or 12.) (SS)

11. **Principles of Microeconomics (3)**
This course is an introduction to basic economic concepts, theory, and institutions. It emphasizes the application of economic analysis to a variety of problems. Topics include supply and demand; consumer choice and behavior; pricing and production decisions of firms; the role of government in the economy; labor markets and unions. (Not available for credit to students who have taken Eco 1.) (SS)

12. **Principles of Macroeconomics (3)**
This course extends the application of economic analysis to the macroeconomy. Topics include the measurement and determination of national output; the banking system and money supply; monetary and fiscal policy; unemployment and inflation; international trade and the balance of payments. (Not available for credit to students who have taken Eco 1.) (SS)

101. **(Mgt 101) Introduction to Quantitative Methods (3)**
Mathematical concepts within a business and economics framework: linear algebra, partial derivatives, constrained optimization, and integral calculus. Meets mathematics prerequisite for entering students in the master of business administration program. Not available for credit to undergraduates. Prerequisite: Eco 1 or Eco 11 and 12. (ND)

105. **Intermediate Microeconomic Analysis (3)**
Determination of prices in terms of the equilibrium of the business enterprise and consumer choice in markets of varying degrees of competition; analysis of market structures; determination of wages, rent, interest and profits. Prerequisite: Eco 1 or Eco 11 and 12. (Not available for credit to students who have taken Eco 115.) (SS)

115. **Applied Microeconomic Analysis (3)**
The application of economic analysis to managerial and public policy decision making. Prerequisite: Eco 1 or Eco 11 and 12. (Not available for credit to students who have taken Eco 105.) (SS)

119. **Intermediate Macroeconomic Analysis (3)**
Macroeconomic measurement, theory and policy. The use of alternative macroeconomic models to analyze the level of national income, inflation, unemployment, economic growth; the balance of payments, and exchange rate determination. Prerequisite: Eco 1 or Eco 11 and 12. (SS)

129. **Money and Banking (3)**
A course dealing with the nature and functions of money, money markets, and commercial and central banking. Effects of the interest rate and money supply on economic activity. Examination and evaluation of current and past monetary policies. Prerequisite: Eco 1 or Eco 11 and 12. (SS)

130. **Economics of Race and Gender (2)**
The question of the role of race and gender in economic decision-making is explored. Various sorts of discrimination are discussed in an economic framework and possible remedies are evaluated. The historical role of race and gender in the economy is also discussed. Prerequisite: Eco 1 or Eco 11 and 12. (SS)

131. **The Canadian Economy (2)**
This course analyzes the economic challenges facing the Canadian economy. Some of the issues include: Canada’s record on inflation and unemployment; the distribution of income; the role of natural resources; and Canada’s health-care and educational systems. Canada’s monetary and fiscal policies, and Canada’s performance in the international economy will also be examined. Prerequisite: Eco 1 or Eco 11 and 12. McDonald (SS)

145. **Statistical Methods (4)**
Descriptive statistics, probability and probability distributions, sampling, estimation, hypothesis testing, regression and correlation, analysis of variance, nonparametric tests, and index numbers. (ND)

For Advanced Undergraduates And Graduate Students

209. **Comparative Economic Systems (3)**
An analysis of the micro- and macro-economic, institutional and political dimensions of various economic systems, with particular emphasis on former centrally planned economies in their transition to a market orientation. Prerequisite: Eco 1 or Eco 11 and 12. King (SS)

210. **Economic Evolution (3)**
Structural changes, social transformation, and sources of the long-term growth of the U.S. economy. Prerequisite: Eco 1 or Eco 11 and 12. O’Brien (SS)

231. **Business History (3)**
The historical context of the development of the modern business firm in the United States. The roles of entrepreneurship, economic structure, technology, and government policy in the shaping of current business practices. Prerequisite: Eco 1 or Eco 11 and 12. (Eco 145 is recommended). O’Brien (SS)

234. **Labor-Management Relations (3)**
An analytical study of the U.S. system of industrial relations, including the evolution of the labor movement, worker choice on the issue of union representation, the process of collective bargaining and the impact of collective bargaining on the management of the firm. Prerequisite: Eco 1 or Eco 11 and 12. Hycak (SS)
235. Labor Economics (3)
The economic analysis of labor markets, with emphasis on labor supply and demand, wage and employment theory, and the economics of unionism and other labor market institutions. Prerequisite: Eco 1 or Eco 11 and 12. Thornton (SS)

237. Transportation Economics (3)
The principles of transportation in theory and practice. Transport models and their relationship to economic activity. Analysis and evaluation of transportation policies, industry structure and performance. Prerequisite: Eco 1 or Eco 11 and 12. Barsness (SS)

246. Business Cycles and Forecasting (3)
A study of short-term business fluctuations, growth, forecasting and stabilization. Prerequisites: Eco 1 or Eco 11 and 12 and a course in statistics. (ND)

303. Economic Development (3)
The principal determinants of economic development theories are examined. Most of the theories are applicable to both the advanced industrial societies and to the poorer nations, but the emphasis is on the developmental process of the countries of the Third World. Prerequisite: Eco 115. Cohen (SS)

305. The Economic Development of Latin America (3)
The course examines the forces at work in the development process in Latin America. Variables considered include the social and political as well as the economic ones. Theories are presented along with their application via the examination of country case studies. Prerequisite: Eco 115. Cohen (SS)

311. Environmental Economics (3)
Resource allocation implications of environmental degradation. Analysis of the benefits and costs associated with alternative pollution control programs and strategies. Prerequisite: Eco 115. Munley (SS)

312. Urban Economics (3)
The analysis of economic problems related to urban areas; the nature and function of cities; the economic and spatial characteristics of urban activity. Prerequisite: Eco 115. Hyelak (SS)

313. History of Economic Thought (3)
A survey of the important historical writings that form the foundation of today's mainstream economic theory. Emphasis is on the period from 1750 to 1950 and on such notable economists as Smith, Ricardo, Walras, Marshall and Keynes. Prerequisite: Eco 115 or 119. Innes (SS)

314. Energy Economics (3)
The economic theory of natural resource allocation over time. Economics of exhaustible and renewable resources. Environmental effects of energy production and consumption. Government regulation of the energy industry. Computer models for energy system forecasting and planning. Prerequisite: Eco 115. McNamara (SS)

315. Industrial Organization (3)
Structure of American industry. Development of economic models to describe behavior in markets with varying degrees of competition. Technological innovation, relationship between industry concentration and rates of return on capital, role of information and advertising, dynamics of monopoly and oligopoly pricing. Prerequisite: Eco 115. Chisholm (SS)

332. (Fin 332) Monetary-Fiscal Policy (3)
Monetary, credit and fiscal policies of governments and central banks with particular reference to the policies of the United States Treasury and the Federal Reserve System. Prerequisite: Eco 119 or 129 or 229. Innes (SS)

333. Managerial Economics (3)
Models of managerial decision-making. Emphasis on the application of economic theory to a variety of business problems. Case studies are employed. Prerequisites: Eco 115 and 145 and a calculus course or consent of instructor. McNamara (SS)

336. Business and Government (3)
Analysis of government involvement in the private sector. The problems of monopoly, oligopoly, and externalities in production and consumption. Optimum responses to market failure and analysis of the performance of actual government policies. Prerequisite: Eco 115. Deily (SS)

339. International Trade (3)
The theory of international trade; the theory of tariffs; United States commercial policies; the impact of growth and development of the world economy. Prerequisite: Eco 115. McDonald (SS)

340. (Fin 340) International Finance (3)
Analysis of balance of payments and disturbances and adjustment in the international economy; international monetary policies. Prerequisite: Eco 129 or 229. Callahan (SS)

343. European Economic Integration (3)
Study of the problems of economic integration throughout Europe, especially in the Post-Cold War era among Western, Central and Eastern European nations. Prerequisite: Eco 209 (may be taken concurrently with permission of instructor). King (SS)

351. Introduction to Mathematical Economics (3)
Application of mathematical techniques to economic problems of optimization and to economic models. Prerequisites: Eco 115 and 119 and a calculus course. Chisholm (ND)

352. Advanced Statistical Methods (3)
Advanced probability theory, probability and sampling distributions, and classical statistical inference. Index numbers, multiple regression, correlation, and analysis of variance. Spectral analysis, Box-Jenkins auto-regressive and moving average stochastic processes. Prerequisites: Eco 115 and a course in statistics. Taylor (ND)

353. (Fin 353) Public Economics and Government Finance: Federal (3)
A course dealing with the expenditures and revenues of the Federal government. Major topics include public choice theory, benefit-cost analysis, the theory of public goods, the economics of taxation and the design of tax structures. Prerequisite: Eco 115. Aronson (SS)

354. (Fin 354) Public Economics and Government Finance: State and Local (3)
A course dealing with the expenditures and revenues of state and local governments. Major topics include the theory of fiscal federalism, intergovernmental fiscal transfers, the design of state and local tax structures, capital budgeting and debt finance, pension funds and school finance. Prerequisite: Eco 115. Aronson, Munley (SS)

357. Econometrics (3)
Problems in construction, evaluation and use of econometric models. Applications based on research and case studies. Prerequisites: Eco 115 or 119, and a course in statistics. King (ND)

358. Game Theory (3)
A mathematical analysis of how people interact in strategic situations. Applications include strategic pricing, negotiations, voting, contracts and economic incentives, and environmental issues. Prerequisites: Eco 115 and a calculus course. Dearden (SS)

361. Senior Seminar (3)
Intensive study and discussion of significant topics in economic policy and theory. Prerequisite: senior standing as economics major or consent of department chairman. (SS)
362. Martindale Research Seminar (1-3 hrs.)
This course prepares students to undertake research on various topics in business and/or economics. Admission to this course is limited to student associates of the Martindale Center for the Study of Private Enterprise. Consent of the instructor is required. Course may be repeated for credit up to a maximum total number of 3 hours credit. (ND)

368. Health Economics (3)
Supply and demand in the health service markets for the U.S. and Canada. Unique features of health care which interfere with competitive market allocation and pricing. Overview of insurance systems and other payment methods. Prerequisites: Eco 115 and a course in statistics. King (SS)

371. Special Topics in Economics (1-3)
Study in various fields of economics, designed for the student who has a special interest in some field of economics not covered by the regularly scheduled courses. Prerequisite: preparation in economics acceptable to the department chairman. (ND)

372. Special Topics in Economics (1-3)
Continuation of Eco 371.

Graduate Courses (Economics)

GECO 401. Basic Statistics for Business and Economics (3)
Descriptive statistics, probability and probability distributions, estimation, hypothesis testing, correlation and regression, chi-square analysis, and analysis of variance. Computer applications.

GECO 402. Managerial Economics (3)

GECO 403. Money, Banking, and Macroeconomic Analysis (3)
The monetary process and the determination of macroeconomic variables: income, output, employment, and prices. Money and capital markets, interest rates, functions of financial intermediaries, monetary and fiscal policy, and recent macroeconomic issues. Prerequisite: GECO 402 (or concurrently).

GECO 404. Technology Trade and Economics Growth (1)
Overview of the role of technology in economics systems: productivity and growth effects, relationships to industry structure, impacts on international trade and competitiveness. Prerequisite: intended to be taken concurrently with GECO 402, Managerial Economics. Watkins

GECO 411. History of Economic Thought (3)
Selected topics in the history of economic thought, with special attention to the origins of modern economic theory. Prerequisite: a graduate course in economic theory. Innes

GECO 412. Mathematical Economics (3)
Applications of various mathematical techniques in the formulation and development of economic concepts and theories. Prerequisite: consent of the department chairman. Chisholm

GECO 413. Advanced Microeconomic Analysis (3)
A survey of methods of decision-making at the microeconomic level; price theory and econometric applications. Prerequisite: Intermediate microeconomic theory. Dearden

GECO 414. Advanced Topics in Microeconomics (3)
Resource allocation and price determination. Theories of choice of consumers, firms and resource owners under various market forms. Prerequisite: GECO 413 and GECO 401 or equivalents. Dearden

GECO 415. Econometrics I (3)
Computer applications of standard econometric techniques using regression analysis in a single equation context. Discussion of problems of multicollinearity, heteroscedasticity and autocorrelation. An introduction to simultaneous equation models, identification and estimation problems. Prerequisite: a course in basic statistics. King

GECO 416. Econometrics II (3)
Mathematical and statistical specification of economic models. Statistical estimation and tests of parameters in single and multiple equation models. Prediction and tests of structural changes. Prerequisites: GECO 401, 412 and 415 or equivalent background in statistics, calculus and matrix algebra. Taylor

GECO 417. Advanced Macroeconomic Analysis (3)
Macroeconomic theory and policy. Primary emphasis on theoretical models and policy implications. Prerequisite: GECO 419 or equivalent. McDonald

GECO 418. Advanced Topics in Macroeconomics (3)
Models of employment, income, and growth in monetary economies. Policies for economic stability and growth. Prerequisite: GECO 417 or equivalent. Thomas

GECO 423. (GBUS 423) Valuation Seminar (3)
Determinants of financial asset values. The role of uncertainty, imprecise forecasts, risk preferences, inflation, and market conditions. Prerequisite: GBUS 406. Beidler, Buell

GECO 427. (GBUS 427) Banking and Monetary Policy (3)
Analysis of the U.S. monetary and banking systems. Financial markets. Central bank controls, monetary theory and policy. Prerequisite: a course in money and banking. Innes, Schwartz

GECO 428. (GBUS 428) Capital and Interest Theory (3)
Theories of interest and capital. Annuities; applications of present value theory; investment valuation under uncertainty and risk; term structure of interest rates; the theory of savings, cost of capital and capital formation. Prerequisite: a course in finance. Schwartz

GECO 429. (GBUS 429) Monetary Theory (3)
The role of money in the economy from theoretical and empirical perspectives. The influence of money and prices, interest rates, output and employment. Prerequisite: GECO/GBUS 427 or equivalent. Gunter

GECO 430. (GBUS 430) Public Finance (3)
The economics of public spending and taxation; principles of government debt management; theories of budgeting and cost-benefit analysis and public choice. Aronson, Munley

GECO 436. Economic History of the United States (3)
Analysis of the colonial economy, transition to industrialization, and role of trade and transportation in America's development. A consideration of the importance of slavery to the 19th century American and other New World economies. Origin and development of banking and financial markets. Prerequisites: intermediate microeconomic theory and basic statistics. O'Brien

GECO 440. Labor Economics (3)
The economics of labor markets and various labor market institutions with emphasis on current theoretical and empirical research. Prerequisites: GECO 402 and GECO 401 or equivalents. Thornton

GECO 450. Energy Economics (3)
The economics of energy production and consumption. Energy system modeling for forecasting and planning. Theoretical models of resource exploitation over time. Regulation of the energy industry. Prerequisites: GECO 402 and GBUS 403 or equivalents. McNamara
GEKO 451. Urban Economics (3)
The application of traditional and spatial economics to the location of economic activity focusing on the urban economic problems of business location, housing, land value, land use and intra-urban transportation.

GEKO 452. Regional Science-Metropolitan Analysis (3)
A study of the methodology of regional science with emphasis on metropolitan area analysis. A survey of the applications of this methodology to the economic problems of regions and metropolitan areas.

GEKO 453. Government Regulation of Business (3)
Analysis of the economic justification for government regulation of private enterprise. Topics include antitrust policy, utilities, and health, safety and environmental regulation. Prerequisite: a course in intermediate microeconomic theory, Deily

GEKO 454. Economics of Environmental Management (3)
The effect of environmental policies on resource allocation. Survey of the major pollution control programs currently in place in the U.S. Prerequisite: GEKO 402. Mulney

GEKO 455. Health Economics (3)
Economic theory of health care delivery systems. Financing health care services. Case studies of specific economic/financing problems and/or international comparisons of health care delivery. Prerequisites: GEKO 401 and GEKO 421, or permission of the instructor. King

GEKO 456. Industrial Organization (3)
Theoretical and empirical analysis of how the structure, organization, and behavior of firms and industries affect economic performance and economic welfare. Prerequisite: GEKO 402 or equivalent. Chisholm

GEKO 460. Index Numbers and Time Series Analysis (3)
Classical decomposition of time series, trend analysis, exponential smoothing, spectral analysis and Box-Jenkins autoregressive and moving average methods. Taylor

GEKO 461. Forecasting (3)
Methods of economic and business forecasting. Taylor

GEKO 462. Advanced Statistics for Business and Economics (3)
An expanded development of statistical concepts necessary for business and economic research. Topics include probability theory, sets, density functions and distributions, sampling distributions, point estimation, moment generating functions, maximum likelihood, classical statistical inference, power functions, likelihood ratio tests and non-parametric tests. Prerequisites: A calculus course. Taylor

GEKO 463. Topics in Game Theory (3)
A mathematical analysis of how people interact in strategic situations. Topics include normal-form and extensive-form representations of games, various types of equilibrium requirements, the existence and characterization of equilibria, and mechanism design. The analysis is applied to microeconomic problems including industrial organization, international trade, and finance. Prerequisites: Two semesters of calculus, GEKO 412 and GEKO 414 (or permission of the instructor). Dearden

GEKO 464. Methodology in Theory and Research (3)
Foundations of theory construction and empirical research in economics.

GEKO 470. International Financial Economics (3)
Analysis of the structure and functioning of the international monetary system, international capital markets, Eurocurrency markets, fixed and floating exchange rates, and the role of international monetary institutions in foreign exchange risk management. Gunter

GEKO 471. International Economic Development (3)
An introduction to the basic theoretical concepts in international economic development and an evaluation of their application by means of a representative sample of the literature. Cohen

GEKO 472. International Trade Theory (3)
Theories of comparative advantage, factor price equalization, trade and welfare, tariffs, trade and factor movements. Prerequisite: GEKO 413 or consent of the chairman. Gunter

GEKO 473. International Monetary Economics (3)
Theory of the balance of payments, the microeconomics of international finance, various approaches to balance-of-payments adjustments, theories of foreign exchange rate determination and macroeconomic policy under fixed and flexible exchange rates. Prerequisite: GEKO 417 or consent of the chairman. McDonald

GEKO 480. Economics of Technical Change (3)
Explores theoretical models and empirical evidence on the economics of innovation and technical change. Includes examination of: the role of technology in competitiveness, industrial structure, and economic growth; alternative models of the innovative process; incentives for and other conditions affecting research and development; and evaluation of the justifications for government support of R&D. Prerequisites: GEKO 402. Watkins

GEKO 490. Thesis

GEKO 492. Special Topics in Economics (1-3)
Extended study of an approved topic not covered in scheduled courses.

GEKO 493. Special Topics in Economics (1-3)
Continuation of GEKO 492.

GEKO 495. Directed Readings

GEKO 499. Dissertation in Economics and Business

Education, College of

The College of Education has one academic department, the Department of Education and Human Services. The department faculty and program offerings are listed below followed by descriptions of course offerings. More details on specific degree requirements and on University Graduate School regulations can be found in the section Advanced Study and Research.

Department of Education and Human Services

Professors. Raymond Bell, Ed.D. (Lehigh); chairperson; Mark H. Bickhard, Ph.D. (Chicago); Diane M. Browder, Ph.D. (Virginia); Marvin Charles, Ph.D. (Brooklyn Polytechnic); Joseph P. Kender, Ed.D. (Pennsylvania); J. Gary Lutz, Ed.D. (Lehigh); Alden J.Mo, Ph.D. (Minnesota); Edward S. Shapiro, Ph.D. (Pittsburgh); Arnold R. Spokane, Ph.D. (Ohio State); LeRoy J. Tuscher, Ph.D. (Florida State); Perry A. Zirkel, J.D. Ph.D. (Connecticut), L.L.M. (Yale). Iacocca Professor of Education and Law.

Associate professors. Linda M. Barsa, Ed.D. (Vanderbilt); Judith A. Bazler, Ed.D. (Montana); Ward M. Bates, Ed.D. (Duke); Christine L. Cole, Ph.D. (Wisconsin-Madison); H. Lynn Colomba, Ed.D. (Louisville); George J. DaPaul, Ph.D. (Rhode Island); Francis A. Harvey, Ed.D. (Harvard); Warren R. Heydenreich, Ed.D. (Colorado); Asha K. Jitendra, Ph.D. (Oregon); April E. Metzler, Ph.D. (Florida); Tina Q. Richardson, Ph.D. (Maryland); George P. White, Ed.D. (Peabody College of Vanderbilt Univ.).

Lecturer: Juan R. Baughn, Ed.D. (Temple).

Adjunct faculty: Joseph I. Abraham, Ed.D. (Lehigh); Mary B. Austin, M.S. (SUNY-Buffalo); William E. Ayers, Ed.D. (Temple); David Babh, Ph.D. (American); James E. Barnes, M.M. (Juilliard); Eileen Bauer, Ph.D. (Lehigh); Ian T. Birky, Ph.D. (Oklahoma State); Patricia Budd, Ph.D. (Lehigh); Mary Rita Colarusso, Ed.D. (Lehigh); Charlotte Collier, Ph.D. (Leigh); Karena Cooper, M.Ed. (Leigh); Brad K. Creaseman, Ed.D. (Leigh); Fred J. Croop, MBA (Wilkes); Leigh Cundari, Ed.D. (Leigh); Frank M. Dattilio, Ph.D. (Temple); Jeannette Gallagher, Ph.D. (Loyola); Scott Garrigan, Ed.D. (Leigh); Beth R. Golden, Ph.D. (Virginia Commonwealth); Francis L. Guenther, Ph.D. (Temple); Karen L. Laudenslager, M.S. (Florida State); Robert L. Leight, Ed.D. (Leigh); Michael McAllister, Ph.D. (Oregon); Rosa McAllister, M.Ed. (Temple); John D. McAndrew, Ed.D. (Leigh); Gary P. McCarty, Ed.D. (Temple); Kathleen McQuillan, Ed.S. (Leigh); Ann Miniati, Ph.D. (Wayne State); Harry W. Morgan, Ed.D. (Leigh); Ingrid H. Parson, Ed.D. (Leigh); Joseph Petraglia, M.Ed. (Leigh); Gary C. Powell, Ed.D. (Georgia); Joanne Regina, Ph.D. (Detroit); Carol M. Richman, Ph.D. (Virginia Commonwealth); Annie M. Sainz, M.S. (Leigh); Bruce S. Shankin, Ph.D. (Maryland); David R. Snyder, Ed.D. (Leigh); Wanda Suchanski, M.S. (Leigh); Sheryl S. Solow, Ed.D. (Leigh); Melvin R. Sonier, Ed.D. (Leigh).

The department offers master's degrees and/or professional certification in Counseling and Human Services, Educational Technology, Educational Leadership, Elementary and Secondary Education, School Counseling, and Special Education as well as the Ed.S. degree and professional certification in School Psychology and Special Education. Ed.D. degree programs are offered in Curriculum and Instruction, Educational Leadership, Educational Technology, and Elementary Education. Ph.D. degrees are offered in Counseling Psychology, School Psychology, and Special Education. While general courses are listed separately, the courses pertinent to each program are listed below.

Education

Educ 312. Classroom Practice (1-3)
Experience in elementary and secondary classrooms as related to theories of child and adolescent development, classroom didactics, and philosophies of education. Problem-centered discussion and observations. Prerequisite: consent of the program director.

Educ 313. Intern Teaching (3-6)
Intensive practice in the application of the principles of teaching. Supervision is provided by the cooperating school and by the university. Prerequisite: consent of the program director.

Educ 314. Seminar in Elementary and Secondary Education (1-3)
Critical analysis and discussion of classroom instructional practices based on experiences of participants as they engage in teaching experiences. Prerequisite: consent of the program director.

Educ 321. The Writing Process (3)
Developmental characteristics of children's writing and relationships among writing, spelling and reading. Predictors of writing achievement, teaching strategies and activities, and evaluation schemes will be emphasized. K-12.

Educ 343. The Disadvantaged Student (3)
Philosophical analyses of disadvantage and relevant educational theories. Applications and evaluations of special methods and techniques.

Educ 388. Statistical Computing (3)
Use of one or more major statistical software packages. Principles of data coding, editing, integrity checking, and management. Emphasis on link between personal computers, mainframes, and other software. Prerequisite: Educ 408 or consent of instructor.

Educ 391.2. Workshops (1-3)
Cooperative study of current educational problems. Provides elementary, secondary, and special education teachers an opportunity to work at their own teaching levels and in their own fields. Limited to six credits during a summer session but the student may register for more than one workshop provided there is no duplication in subject matter.

Educ 394. Special Topics in Education: (with subtitle) (3)
Examination of a topic of research or professional interest in Education. Subtitle will vary. May be repeated for credit as subtitle varies.

Educ 401. Sociological Foundations of Education (3)
The American school as a social institution, its cultural heritage, its purposes and processes in relation to social change and educational leadership; its role in socialization and its responsibilities for relevance to social issues and to subcultural needs.

Educ 403. Research (3)
Basic principles of research; techniques of gathering and analyzing data; design of studies in education. Emphasis on critical reviews of research reports representing various methodologies. Research report required.

Educ 404. Introduction to Testing and Evaluation (3)
Construction and evaluation of the teacher-made test. Selection of published tests and interpretation of individual and group results. Use and misuse of tests in assessing achievement.

Educ 405. Comparative Education (3)

Educ 406. Historical Foundations of Education (3)
Development of primary, secondary, and higher education; aims, curricula, methods, and systems of schooling in America from colonial time to present, in relation to social conditions.

Educ 407. Philosophical Foundations of Education (3)
Comparative philosophical analysis of educational aims, practices, and institutions. Major philosophical theorists whose work has influenced educational thought.

Educ 408. Introduction to Statistics (3)
Organization and description of data. Principles of statistical inference-including hypothesis testing, interval estimation, and inferential error control. Emphasis on application.

Educ 409. Analysis of Experimental Data (3)
Emphasis on analysis of variance designs including one-way, factorial, nested, and repeated measures designs. Introduction to multiple regression and the analysis of covariance. Prerequisite: Educ 408 or consent of instructor.

Educ 410. Univariate Statistical Models (3)
The univariate general linear model. Principles of expressing models and hypotheses about those models. Emphasis on similarity among the analysis of variance, multiple regression, and the analysis of covariance. Examples of non-standard models and generalization to complex designs. Prerequisite: Educ 409 or consent of the instructor.

Educ 411. Multivariate Statistical Models (3)
The multivariate general linear model. Principles of expressing multivariate models and hypotheses about those models. Emphasis on similarity among the multivariate analysis of variance, multiple regression, and the analysis of covariance. Examples of non-standard models and generalization to complex designs. Prerequisite: Educ 410 or consent of the instructor.
Educ 412. Advanced Applications of Psychometric Principles (3)
Conceptual examination of exploratory and confirmatory factor analysis, cluster analysis, latent-trait modeling, and other advanced psychometric topics. Prerequisites: Educ 409 or equivalent, SchP/CPsy 427 or SpEd 405.

Educ 413. Intern Teaching (3-6)
Intensive practice in the application of principles of teaching. Supervision is provided by the cooperating school and by the university. Prerequisite: consent of the program director.

Educ 414. Intern Teaching Seminar (3)
Critical analysis and discussion of classroom instructional practices. Discussion and illustration based on experience of participants as they engage in intern teaching. Prerequisite: consent of the program director.

Educ 415. Classroom Didactics (3)
Initial preparation of interns for classroom teaching. Secondary interns are trained in teaching methods in subject fields and the reading problems of secondary students. Elementary interns study teaching methods in the elementary school. Open to teaching interns only.

Educ 416. (SR 416) Quasi-Experimentation and Program Evaluation (3)
Social science research methods for non-laboratory settings. Detailed examination of a dozen quasi-experimental research designs, three dozen threats to validity, possible controls, and uses in social program evaluation. Nonmathematical presentation.

Educ 417. Participation in Teaching (3)
Study, directed observation of, and initial practice in the various phases of teaching in a laboratory-demonstration school or in area elementary and secondary schools. Prerequisite: consent of the program director.

Educ 418. Science in Elementary Education (3)
Principles of the elementary science program. Demonstrations and discussions of appropriate materials and techniques for teaching science concepts to elementary school students.

Educ 419. Mathematics in Elementary Education (3)
Mathematical skills and concepts for the elementary school program. Sets, systems of numeration, experience with numbers, operations with numbers, number concepts and numerals, and elements of geometry.

Educ 421. Materials in Reading (3)
Provides examination and critical analysis of published and unpublished reading materials used in instruction from kindergarten through adult levels. Prerequisite: Educ 426 or consent of the program director.

Educ 422. Language Development of Children (3)
The nature of language and its relation to the development of communication skills. Critical analysis of related research. Implications for the elementary school.

Educ 423. Curriculum and Instruction in Social Studies (3)
Curriculum, content, teaching strategies, and instructional materials of the social studies field. Emphasis will be placed on organizing content, using appropriate methods, testing and evaluation, and innovations for social studies at the elementary, middle, and high school levels. Attention will be given to examining textbooks, courses of study, and teacher-made materials.

Educ 424. Developmental Reading (3)
Introductory course spanning the elementary and secondary levels. Reading methods, materials, the disadvantaged and gifted reader, procedures for individualized reading instruction.

Educ 426. Diagnosis and Adjustment of Reading Difficulties (3-6)
Psychology of reading related to learning difficulties; measurement and diagnosis of reading difficulties; development of informal tests; materials for corrective and remedial instruction. Prerequisite: Educ 424 or consent of the program director.

Educ 427. Children’s Literature in Reading Instruction (3)
Role of literature in the instructional program of the elementary schools. Use of trade books for individual instruction in reading.

Educ 428. Reading in the Content Areas (3)
Focuses on expository reading development in content areas such as language arts, mathematics, science and social studies. Practical teaching strategies in critical areas, such as comprehension and study skills. Review of research and methods for improving the reading development of students.

Educ 429. Child Development (3)
A study of physical, intellectual, emotional and social aspects of child development as they relate to the elementary schools.

Educ 430. Advanced Topics in Reading (3)
Theory and research in historical background of reading instruction; cognitive, affective, and linguistic aspects of reading; implications for the disadvantaged and gifted reader. Field experience required. Prerequisite: Educ 424 or consent of the program director.

Educ 431. Critical Thinking in Reading (3)
An understanding of the reading/thinking process and its relationship to logic, leading to the ability to analyze, criticize and advocate ideas and to reach factual or judgmental conclusions based on inferences drawn from the printed word. Implications and methods for teaching elementary through college level students will be addressed.

Educ 432. Reading Specialists Clinic (6)
Concentrates on diagnosis of reading problems and disabilities and the remediation of the deficits in children. Requires the graduate student to work with reading-disabled children for 125 clock hours.

Educ 433. Mathematics in Middle Level and High School Education (3)
Curricula, instructional activities, and manipulative aids applicable to mathematics courses in middle level and high schools. Teaching strategies and materials appropriate for teaching mathematics will be emphasized. Permission of the instructor.

Educ 434. Seminar in Reading Research (3)
An advanced course dealing with critical appraisal and discussion of classical and current studies in reading.

Educ 435. Adult Literacy (3)
The magnitude of illiteracy in the United States and its implications will be covered. Characteristics of the adult learner will be addressed as well as appropriate assessment strategies and instruments, methods of instruction, materials and programs. Program funding and development will be explored.

Educ 436. Practicum in Supervision of Reading Program (3)
For candidates for supervisor’s certificate in reading. Organization of the instructional processes in reading programs. Participants in supervisory activities.

Educ 437. Science in Middle Level and High School Education (3)
Curriculum, philosophy, methodology, strategies and safety in teaching of middle and high school science. Emphasis on laboratory and instructional technology, at-risk and underrepresented students and current models of science education. Permission of the instructor.

Educ 438. Programs for Gifted and Talented (3)
Characteristics of gifted children; teaching gifted children; programs for the gifted in elementary and secondary schools.
Educ 441. Youth in Society (3)
Social development, characteristics, and problems of adolescents and young adults. Impact of relationships with sibling, peers, adults, subcultures, in the context of changing institutions and values.

Educ 442. Introduction to Bilingual/Bicultural Education (3)
An overview of the social, political, and legal contexts influencing the development and implementation of a bilingual education. Programs, methods, and empirical research in the field of bilingual education will be explored as will the development and implementation of and education that is authenically bilingual and bicultural.

Educ 443. Bilingual/Bicultural Families as Educators (3)
Research knowledge, experiential learning and related applications realities of growing up bilingual in our society. Emphasis is placed upon a nondeficit philosophy, exploring the strengths and unique contributions of bilingual families in the cognitive and social development of children.

Educ 444. Program Design in Bilingual/Bicultural Education (3)
Knowledge, competencies, and understandings relating to programmatic (curricular, instructional) design of bilingual programs will be explored. Innovative empirically based integrative bilingual/bicultural education models will be designed.

Educ 447. Assessment Principles for Bilingual/Bicultural Learners (3)
Research and practical knowledge regarding optimal methods of assessment for bilingual learners. Educational issues faced by bilingual learners resulting from assessment strategies and alternate paradigms will be the major focus.

Educ 448. Qualitative Research Practicum in Bilingual/Bicultural Settings (3)
Research knowledge, competencies, and understandings relating to qualitative research with bilingual, bicultural populations. Practical applications, appraisal of the current state of the art, and exploration of innovative designs will be emphasized.

Educ 450. Curriculum Construction (3)
Theoretical models of curriculum design and evaluation. Scope, sequence, articulation, continuity, and balance in designs. Organizing for curriculum planning, development, implementation and change. K-12.

Educ 451. (Psy 451) Theories of Learning (3)
In-depth study of major classical and contemporary learning theories. Review of experimental research relevant to theories.

Educ 456. School Curriculum (3)
Curricular innovations. Applications of curricular designs K-12. Subject matter and course design. Integration and importance of the fine arts and physical education in the curriculum.

Educ 460. Program Evaluation (3)
The historical background, theory, methodology, and current practices of program evaluation in the human services area. Emphasis will be placed on conducting evaluations of educational programs. Current research will be conducted and an examination of on-going program evaluations will be conducted.

Educ 461. Single-Subject Research Design (3)
Experimental designs for use with small N's. Topics include design theory and application, experimental validity (internal, external, statistical conclusions and construct validity) and an overview of data analysis procedures.

Educ 471. (CPS 471) Multicultural Issues (3)
Examination of the influence of culture, gender, and disabilities on behavior and attitudes. Historical and current perspectives on race, culture, gender, and minority group issues in education and psychology. Lecture/small group discussion.

Educ 473. (SR 473) Social Basis of Human Behavior (3)
Development of human behavior from a social psychological perspective. Emphasis placed on the impact of society upon school-age children and adolescents.

Educ 474. (Psy 474) Psychological Development in Childhood (3)
Topics selected from such areas as socialization and the parent-child interaction, personality disorders in childhood, moral development and cognitive development. May be repeated for credit.

Educ 491, 2. Advanced Seminars: (with subtitle) (1-6)
Intensive study and discussion of a specialized area. Title will vary. May be repeated for credit as title varies.

Educ 493. Internship in: (with subtitle) (3)
Opportunity for advanced students to obtain practical experience. Conference hours for students and staff members devoted to discussion of work and problems encountered in the schools. Prerequisite: consent of the program director.

Educ 494. Field Work in: (with subtitle) (3)
Identification of significant problems in an educational environment, review of the literature, and development of appropriate research plans.

Educ 495. Independent Study in: (with subtitle) (1-6)
Individual or small group study in the field of specialization. Approved and supervised by the major adviser. May be repeated.

Educ 496. Doctoral Research Seminar (3)
For doctoral students. Research design and application to various kinds of educational problems; data collection and analysis. Criticism and evaluation of student proposals. May be repeated for a maximum of nine credits.

Educ 497. Advanced Doctoral Seminar in Curriculum and Instruction (with subtitle) (3)
Seminar on special topics such as curriculum management, integration of curriculum, middle school curriculum, etc. May be repeated for credit. For doctoral students or with the consent of the instructor.

Counseling Psychology
CPsy 427. (SchP 427) Standardized Tests, Measurement and Appraisal (3)
CPsy 429. Diagnostic Interview Laboratory (1)
Principles of psychological measurement (e.g., tests construction, technology, validity, reliability, functional utility). Ethical, legal, and cultural issues in the administration and interpretation of psychological tests. Case conceptualization, reporting and presentation. One-credit diagnostic laboratory is mandatory for counseling majors but optional for students from other programs. Lab covers diagnostic interviewing and systems for the identification and classification of behavioral and psychological disorders.

CPsy 430. Professional Seminar (4)
Professional, ethical, and legal issues in counseling. Management and delivery of counseling services in a culturally diverse society. Professional development, certification, licensure, and role identification. A required one-credit laboratory extends counseling skill acquisition and examines ethical and legal issues in counseling cases.

CPsy 436. Career Development (3)
Examination of the career development process for children, adolescents, and adults. Study of theories, vocational assessment process, and occupational and psychological information systems.
CPs 439. Theory and Practice of Group Counseling (3)
Introduction to the process of group counseling and therapy. Selection of group members; group rules; group procedures with children, adolescents and adults; ethical considerations with groups. Study of research on group processes, group therapy, and group leadership. Prerequisite(s): permission of the program coordinator required.

CPs 440. Introduction to Family Counseling (3)
Research and current trends in the practice of family counseling. Overview and analysis of major theoretical approaches of family therapy.

CPs 442. Counseling and Therapeutic Approaches (4)
Theory, research, and technique of counseling and psychotherapy within a cultural context. Contains a one-credit laboratory experience on basic counseling skills and requiring role plays, audio and/or videotaping of client sessions. Prerequisite(s): Admission to CPs master's program, CPs 430, or permission of counseling psychology program coordinator.

CPs 445. Elementary School Counseling and Guidance (3)
Emphasizes professional concerns of the elementary school counselor in working with teachers, parents, administrators, and other specialists. Policies, practices, and curriculum concerns, as they affect the development of the child. Prerequisite: CPs 430.

CPs 448. Secondary School Counseling and Guidance (3)
Establishing an effective secondary counseling and guidance program within the framework of the school setting. Policies, procedures, and curriculum concerns as they affect the student. Professional approaches to involve students, teachers, administrators, and parents in the counseling and guidance activities of the secondary school. Prerequisite: CPs 430.

CPs 460. (Psy 475) Theories of Psychological Counseling (3)
Analysis and synthesis of concepts drawn from counseling theorists. Research and current trends in counseling concerning educational, social and vocational problems. Prerequisites: admission to the Ph.D. program in counseling psychology or permission of the counseling psychology program coordinator.

CPs 461. Assessment of Adult Intellectual Functioning (3)
Administration and interpretation of individual tests/batteries of adult intelligence and neuropsychological functioning. Consideration of psychological and cross-cultural issues in intellectual assessment. Preparation of psychological reports. Prerequisite: CPs 427 and permission of the instructor.

CPs 462. Assessment of Personality (3)
Consideration of issues and methods of personality assessment, including ethical and legal issues, and cross-cultural issues. Practice in the administration of instruments used for personality assessment. Supervised experience and report writing. Prerequisites: CPs 427 and admission to the Ph.D. program in counseling psychology.

CPs 466. Current Issues in Counseling and Therapy (1-6)
Examination of an area of counseling or therapy that is of topical interest to students and faculty. Permission of program director required. May be repeated for credit.

CPs 470. Independent Study and Research (1-6)
Individual or small group study in the field of counseling. Approved and supervised by the major adviser. May be repeated for credit.

CPs 471. (Ed 471) Multicultural Issues (3)
Examination of the influence of culture, gender, and disabilities on behavior and attitudes. Historical and current perspectives on race, culture, gender, and minority group issues in education and psychology. Lecture/small group discussion.

CPs 472. Human Development Across the Lifespan (3)
An examination of prevailing theories of human growth and development across the lifespan. Examination of the interactive effect of various age groups upon one another. Particular emphasis on the helping relationships.

CPs 473. Research Seminar in Counseling (1-3)
For doctoral students in counseling psychology. Issues and methods in research design, data collection, and data analysis, criticism and evaluation of student proposals. Admission to the Ph.D. program in counseling psychology or permission of the counseling psychology program coordinator.

CPs 476. Supervision of Counseling (1-6)
For candidates for supervisor's certificate or doctorate in counseling. Observation and supervision of counseling practicum students. Prerequisites: CPs 480 and permission of instructor.

CPs 480. Practicum (1-4)
Twenty hours of weekly supervised practicum training for advanced graduate students in individual, group, and family counseling and therapy. Prerequisites: CPs 442, CPs 451, CPs 475, and permission of instructor. May be repeated for credit.

CPs 481. Advanced Multicultural Counseling (3)
This course covers models and theories of multicultural counseling and intervention. Students should be actively engaging in practice with multicultural clients in a practicum or field site, and these cases will form part of the basis of course discussions. Prerequisites: CPs 471, admission to the doctoral program in counseling psychology, and permission of the counseling psychology program coordinator.

CPs 483. Field Work in Counseling (3-6)
Twenty hours of weekly supervised professional practice in a school or agency setting as an extension of CPs 480, Practicum. On-site supervision, audio and/or video recordings and case presentations required. Prerequisites: CPs 480 and permission of the counseling psychology program coordinator.

CPs 485. Advanced Psychopathology (3)
This course will cover etiology, assessment, interviewing techniques, establishing a therapeutic alliance, and treatment planning in adult mental disorders. In depth coverage will be given to Axis II disorders. The diagnosis and classification of abnormal behavior using DSM-IV-R and medical model will be emphasized. Alternate theories of abnormal psychology will also be discussed. Prerequisite: Psyc 435, Abnormal Psychology.

CPs 486. Family Counseling Clinic (3-6)
Supervised practicum training for advanced graduate students in family counseling and therapy. Techniques and methods of conducting family counseling and therapy. Prerequisites: CPs 480 and CPs 440.

CPs 487. Advanced Practicum I (3)
Supervised clinical experience for entry-level doctoral students. Emphasis on intake and assessment procedures. Audio and video recording, staffing, and individual and group supervision. Prerequisite: admission to the Ph.D. program in counseling psychology and permission of the counseling psychology program coordinator.

CPs 488. Advanced Practicum II (3)
Supervised clinical experience with emphasis on the development of intervention skills. Audio and video recording, staffing, and case presentations are required. Individual and group supervision. Prerequisite: CPs 487. Admission to the Ph.D. program in counseling psychology and permission of the counseling psychology program coordinator.
CPsy 489. Advanced Practicum III (3)
Supervised experience in counseling and therapeutic settings for doctoral students. Use of audio and video recordings, small group supervision, and individual supervision, case presentations required. Prerequisites: CPsy 488, admission to the Ph.D. program in counseling psychology, and permission of the counseling psychology program coordinator.

CPsy 491. Advanced Practicum IV (3)
Supervised experience in counseling and therapeutic settings for doctoral students. Use of audio and video recordings with emphasis on a blend of individual and group counseling, consultation, training and supervision. Case presentations, small group supervision and individual supervision are required. Prerequisites: CPsy 489 and permission of the counseling psychology program coordinator.

CPsy 498. Counseling Psychology Doctoral Internship (1)
A one year full-time or two year half-time supervised internship in professional psychology. Student functions as regular staff member. Regular contact with academic advisor required in addition to end of semester evaluation by the internship site and the student. Prerequisite: CPsy 491 and permission of the counseling psychology program coordinator. (Repeatable for a total of 3 credits).

Educational Leadership

EdL 400. Introduction to Organizational Leadership: Theory and Practice (3)
Development of theories of administration and applications in educational institutions. Administrative behavior in organizational settings; administrator’s leadership role in decision-making, evaluation, and conflict resolution.

EdL 405. The Principalship (3)
Major problems of organization and administration of schools, types of organization, pupil promotion, program of studies, teaching staff, pupil personnel, contract management, time allotment, plant and equipment, and community relations. Prerequisite: EdL 400.

EdL 406. School Principals Clinic (1-6)
Simulated materials workshop on administrative decision making open to practicing and prospective elementary and secondary school administrators.

EdL 457. Performance Appraisal (3)
Essential elements for the evaluation of school teachers, principals and superintendents. Research-based constructs as well as practical applications. The course is intended primarily for future and practicing school administrators.

EdL 466. Supervision of Instruction (3)
Analysis of the principles underlying the organization and supervision of instruction; application to specific teaching situations K-12.

EdL 469. Advanced Instructional Supervision (3)
A staff development approach to supervision designed to extend the supervisor’s knowledge of and skills in applying clinical techniques to instructional supervision.

EdL 470. Special Topics in Educational Leadership: (with subtitle) (1-6)
Intensive study and discussion of a specialized area. Title will vary. May be repeated for credit as title varies.

EdL 473. Human Resources Management (3)
Overview of the effective utilization of the human resources of educational organizations. Trends in human resource planning, recruitment, selection, development, evaluation, compensation and contract administration.

EdL 476. School Financial Management (3)
Theoretical and practical foundation in financial management emphasizing the economics of education, financing and distribution of funds, and the management of funds at the school and district level.

EdL 477. Seminar in School-Community Relations (3)
Analysis and development of the communication and public relations skills needed by educators in dealing with the public.

EdL 478. Collective Bargaining in the Schools (3)
Contract negotiations, grievance, mediation, and arbitration for both professional and classified employees in education.

EdL 479. School Law (3)
Effect of school law on administration of public school systems; analysis and synthesis of judicial interpretations of the constitutions, statutes, rules, regulations, and common law relating to educational issues.

EdL 481. Policy and Politics in Public Education (3)
Analysis of the forces, factors, agencies, formal governmental systems and informal subsystems that influence educational policy in local districts and state and national governments.

EdL 485. The Superintendency (3)
A theoretical and historical examination of superintendents’ leadership, school board/superintendent relations, and the array of duties and demands upon the superintendency.

EdL 489. Doctoral Seminar in School Administration (3)
Analysis of the theoretical, empirical, and conceptual aspects of contemporary issues in educational administration and their implications for policy formulation and implementation in educational institutions. Prerequisite: Official standing as a doctoral student in educational leadership.

Educational Technology

EdT 404. Interactive Multimedia Programming (3)
Introduction to programming interactive multimedia applications in education and training. Emphasis on using event-driven, object-oriented programming to design and create applications utilizing sound, video, graphics and computer animation. Must be taken with accompanying laboratory (EdT 414).

EdT 405. Hypermedia Theory and Applications (3)
Analysis of the theory of hypermedia and multimedia. Emphasis on the examination of current practices and research in hypermedia. Complementary course to courses on multimedia programming. Must be taken with accompanying practicum (EdT 415).

EdT 406. Advanced Multimedia Design and Programming (3)
Advanced hypermedia programming techniques applied to the design and delivery of technology-based instruction. Application and design of 3-D animation, digital audio and video. Must be taken with accompanying laboratory (EdT 416). Prerequisite: EdT 404 or consent of instructor.

EdT 407. Foundations of Educational Technology (2)
Events, philosophies, and practices instrumental in the evolution of the field of educational technology. Current and projected trends in the use of technology in education and training. Topics such as technology-based school restructuring, computer-based cognitive science for instructional design and technology use, and information infrastructure technologies. Must be taken with accompanying practicum (EdT 417).

EdT 414. Interactive Multimedia Laboratory (1)
Laboratory for location and production of multimedia resources. Must be taken with EdT 404, Interactive Multimedia Programming.
EdT 415. Practicum in Hypermedia/Multimedia Learning (1)
Exploration of learning with hypermedia/multimedia. Must be taken with EdT 405, Hypermedia Theory and Applications.

EdT 416. Advanced Interactive Multimedia Laboratory (1)
Advanced laboratory for the location and production of multimedia resources. Must be taken with EdT 406, Advanced Multimedia Design and Programming.

EdT 417. Practicum in Educational Technology Foundations (1-2)
Complementary learning activities and exercises in the use of technology-based learning materials. Must be taken with EdT 407, Foundations of Educational Technology. May be taken for one or two hours of credit.

EdT 418. Desktop Publishing (3)
This course emphasizes the application of visual design technologies required to create and publish electronically prepared documents. The creation of high quality text and special graphics effects will be examined. Advanced technologies related to desktop publishing such as optical character recognition, color printing theory and digital video will be included.

EdT 420. Media Production for Instructional Programming (3)
Applications in the design, production, editing, and evaluation of educational video tapes. Students will gain hands-on experience designing, filming, editing, and producing educational learning materials in a studio production center.

EdT 428. Advanced Interactive Computing and Telecommunications (4)
Integration of object-oriented programming and emerging telecommunication networks for interactive distributed learning. Conceptual orientation, policy issues, and emphasizing interactive instruction and training delivered over enterprise and wide area networks. Special attention to the construction of applications for satellite delivery, the Internet, and desktop-conferencing systems. Prerequisite: EdT 404 or consent of instructor.

EdT 433. Introduction to Instructional Design (3)
The systematic design of instruction. Emphasis on the use of instructional design models, both behavioral and cognitive, to create effective instruction. Models and processes used in education and industry. Design of instructional materials employing models used in education and industry. Must be taken with accompanying practicum in instructional design (EdT 434).

EdT 434. Practicum in Instructional Design (1)
Technology-based activities to enhance instructional design skills. Must be taken with EdT 433, Introduction to Instructional Design.

EdT 443. Principles of Instructional Interface Design (3)
Design principles applied specifically to the creation of technology-based instructional programs. Topics include learner versus program control, interface consistency, principles of screen layout, and attentiongetting and retention-enhancing techniques. Special emphasis on multimedia and graphical user interfaces in education and training. Students design—but do not code—technology-based lessons. Must be taken with accompanying practicum in interface design (EdT 444).

EdT 444. Practicum in Interface Design (1)
Use of technology-based learning to acquire additional interface design skills. Application of interface design skills to realistic design projects. Must be taken with EdT 443, Principles of Instructional Interface Design.

EdT 453. Advanced Instructional Design (3)
Advanced instructional design and interface issues. Design of instructional environments, selection of instructional metaphors, the impact of the interface on the user, and demands of designing for newer learning technologies. Must be taken with the accompanying advanced practicum in instructional design (EdT 454). Prerequisite: EdT 433 or consent of instructor.

EdT 454. Advanced Practicum in Instructional Design (1)
Use of technology-based learning to acquire additional instructional design skills. Application of instructional design skills to realistic design projects. Must be taken with EdT 453, Advanced Instructional Design.

EdT 455. Vygotsky’s Theories Applied to Educational Technology (3)
Advanced seminar examining historical and theoretical issues related to Vygotsky’s theories of socio-historical psychology. Vygotsky’s theories applied specifically to the design and use of technology-based instructional materials.

EdT 458. Integrating Experience in Educational Technology (3-8)
Pursuit of independent topics of interest through directed research, participation in internal or external project work or internships, or development of portfolio materials. Individual or team work under the direction of a faculty member. May be repeated for up to 8 hours of credit. Prerequisites: Educ 403, EdT 404, EdT 405, EdT 407, and EdT 433.

EdT 471. Evaluation of Technology-Based Instructional Systems (3)
Examination of current issues and practices related to the design and evaluation of instructional systems with special consideration to the delivery and management of instruction utilizing educational technology. A case study approach will be used to study both instructional systems and the evaluation of individual learning in technology-based curricula.

EdT 477. Research Topics in Educational Technology (3)
Current issues and practices related to the use or adoption of educational technology. Topics will vary (for example, The Role of Educational Technology in Teaching Persons with Special Needs; Educational Technology in the Workplace; Educational Technology and School Restructuring). May be repeated for credit as topic varies.

Approaches and techniques applicable to empirical research studies in educational technology, both quantitative and qualitative. Students design and carry out small-scale investigations of research questions and hypotheses related to educational technology and write up research reports of their findings and conclusions. Prerequisite: Educ 403.

School Psychology

SchP 402. (SpEd 402, Psy 402) Applied Behavior Analysis (3)
Theory and application of behavior modification methods in classroom and clinical settings. Topics include behavior analysis, outcome research, task utilization, and single case research.

SchP 404. Historical and Contemporary Issues in School Psychology (3)
History of Psychology, Education, and School Psychology. Roles and function of school psychologist; legal and ethical aspects of school psychology.

SchP 412. Consultation Procedures (2)
Observational methodology utilized in consultation; rationale, theory and methods of consultation; individual, group and parent consulting. Study of research on the consultation process. Students must also register for 1 credit of SchP 431.

SchP 413. Advanced Research Methodology Seminar-I (1)
First of two semester courses covering advanced topics in research design, methodology, and analysis. Prerequisite: admission to doctoral program.
SchP 414. Advanced Research Methodology Seminar-II (1)
Continuation of SchP 413. Prerequisite: admission to doctoral program and SchP 413.

SchP 422. Assessment of Intelligence (3)
Administration and interpretation of individual tests of intelligence used in school evaluation and preparation of psychological reports. Prerequisite: permission of instructor.

SchP 423. Behavioral Assessment (3)
Techniques of behavioral assessment including direct observation, interviews, checklists, rating scales, self-monitoring and role-play tests. Prerequisite: permission of instructor.

SchP 425. Assessment and Intervention in Educational Consultation (3)
Collection and use of data in designing classroom interventions. Curriculum based assessment, direct behavioral assessment, and structured interviews, and the interrelationship with diagnoses are emphasized within the behavioral consultation model. Utilization of data from actual case studies. Prerequisites: SchP 402, SchP 423.

SchP 426. Advanced Child Behavior Therapy (3)
Techniques of child behavior therapy applied in classrooms and clinical settings. Particular emphasis on self-control procedures, such as social skills training, self-instruction training, and cognitive behavior therapy. Course covers both the theoretical and practical components of procedures. Prerequisite: SchP 402.

SchP 427. (CPsy 427) Standardized Tests, Measurement and Appraisal (3)
Principles of psychological measurement (e.g., tests construction, technology, validity, reliability, functional utility). Ethical, legal, and cultural issues in the administration and interpretation of psychological tests. Case conceptualization, reporting, and presentation.

SchP 429. Special Topics in School Psychology (with subtitle) (1-3)
SchP 431. Practicum in Consultation Procedures (1-3)
Supervised experience in conducting school-based consultations. Co-requisite, SchP 412.

SchP 432. Practicum in Assessment of Intelligence (1-3)
Supervised experience in the administration and interpretation of intelligence tests. Co-requisite, SchP 422.

SchP 433. Practicum in Behavioral Assessment (1-3)
Supervised experience in conducting behavioral assessments in school settings. Co-requisite, SchP 423.

SchP 434. (SpEd 434) Applied Research Practicum (1-3)
Designing and conducting research projects in applied settings.

SchP 435. Practicum in Assessment & Intervention in Educational Consultation (1-3)

SchP 436. Practicum in Interventions for Students with Behavior Disorders (1-3)
Supervised experience in designing and implementing interventions in classrooms for students with behavior disorders. Permission of instructor required.

SchP 437. Advanced Child Psychopathology (3)
Advanced training in the definition, classification, etiology, long-term outcome, and treatment of children and adolescents with various psychopathological disorders. Emphasis is placed upon the assessment and treatment of child and adolescent psychopathology in school settings. Prereq. admission to doctoral program or by permission of instructor.

SchP 442. Doctoral Practicum in School Psychology (1-6)
Field-based experience in providing psychological services in school and/or clinical settings. Prerequisite: admission to doctoral program. May be repeated for credit.

SchP 443. Certification Internship (1-6)
Full-time experience in clinical/educational settings. Student must complete a minimum of 1,200 clock hours under joint supervision of faculty and field supervisor. May be repeated for credit.

SchP 444. Doctoral Internship (1-6)
Full-time experience in clinical/educational settings. Student must complete a minimum of 1,500 clock hours under joint supervision of faculty and field supervisor. May be repeated for credit.

SchP 496. Doctoral Seminar in School Psychology (with subtitle) (3)
Selected topics in school psychology (titles will vary) including professional issues, assessment and intervention in school settings, and supervision of school psychology services. May be repeated for credit. Prerequisite: admission to doctoral program.

Special Education

SpEd 322. Integration (3)
Theory and application of the basic concepts on integration. Emphasis on educating students with special needs in regular school and classroom environments.

SpEd 323. Introduction to Mild Disabilities (3)
An intensive introduction to direct instruction, behavioral interventions, social skills training, curriculum based assessment, IEPs, classroom structure for those who need emotional and learning support (e.g., learning disabilities, serious emotional disturbances and mild mental retardation).

SpEd 324. Introduction to Severe Disabilities (3)
An intensive introduction to a life skills approach to curriculum, including systematic instruction, data based decisions, community based instruction, behavior management, integration and IEPs or IHPs for students who need a life skills approach (e.g., autism, severe/profound mental retardation, cerebral palsy, multihandicaps).

SpEd 330. Special Topics in Special Education: (with subtitle) (1-3)
Current issues in the education of individuals with special needs. Titles vary. May be repeated for credit as title varies.

SpEd 331. (Psy 352) Emotional and Behavioral Disorders of Children (3)
Definition, classification, etiology, treatment, and historical perspective of children and adolescent disorders.

SpEd 332. Education of Individuals with Special Needs (3)
Legal, educational, and social issues related to the special education of people with mental retardation, physical handicaps, emotional/behavior disorders, learning disabilities, visual and hearing impairments, health impairments and those who are intellectually gifted.

SpEd 333. Physical Handicaps and Developmental Disabilities (3)
Definition, classification, etiology, treatment and historical perspectives of individuals with mental retardation, autism, cerebral palsy, and other severe disabilities (e.g., deaf/blind). Remediation of movement difficulties, physical and occupational therapy interventions.
SpEd 339. Learning Disabilities (3)
Definition, classification, etiology, treatment, and historical perspective of individuals with learning disabilities.

SpEd 402. (SchP 402, Psy 402) Applied Behavior Analysis (3)
Theory and application of behavior modification methods in classroom and clinical settings. Topics include behavior analysis, outcome research, task utilization, and single case research.

SpEd 405. Assessment of Individuals with Mild Disabilities (3)
Educational assessment procedures used with individuals with special needs. Understanding and applying information from formal education assessment and interviews. Utilization of curriculum based assessment.

SpEd 418. Teaching Individuals with Severe Disabilities (3)
Curriculum and methods for life skills instruction—self care, daily living, community based instruction, communication, social integration, vocational training, functional academics.

SpEd 419. Teaching Individuals with Mild Disabilities (3)
Emphasis on effective teaching techniques for academic and social skills. Emphasis on curriculum development and instructional strategies in language arts, math, and other academic content areas.

SpEd 420. Intern Teaching: Certification (3)
Competency based practice in application of procedures for teaching a broad spectrum of individuals with special needs in preparation for Level I Certification as a Teacher of the Mentally or Physically Handicapped. Prerequisite: consent of program coordinator one semester before registering for this course.

SpEd 424. Assessment of Individuals with Severe Disabilities (3)
Curriculum based assessment and program development for individuals whose disabilities preclude traditional academic or psychological assessment. Emphasis on life skills assessment.

SpEd 425. Specialization Internship (3)
Competency based practice to develop specific expertise in Behavior Disorders, Severe Disabilities, Consulting Teacher or Early-childhood. May be repeated for credit in more than one specialty. Prerequisite: consent of program coordinator one semester before registering.

SpEd 428. Advanced Behavior Management for Individuals with Severe Disabilities (3)
This course will develop skills in long-term remediation of problem behaviors characteristic of persons with severe disabilities through functional assessments, positive procedures, and lifestyle interventions.

SpEd 429. Professional Seminar (3)
Master’s seminar on current issues in the area of special education and research design. Prerequisite is 18 graduate credits in special education.

SpEd 430. Advanced Seminar in Special Education (3)
Advanced issues relating to the field of special education. Titles will vary.

SpEd 432. Supervision of Special Education (3)
Advanced knowledge of teaching research with individuals with special needs. Teacher supervision models.

SpEd 434. (SchP 434) Applied Research Practicum (1-3)
Designing and conducting research projects in applied settings.

SpEd 435. Internship: Supervision of Special Education (3)
Advanced students receive competency based practice in staff supervision in preparation for certification as a Supervisor of Special Education. Prerequisite: consent of program coordinator one semester before registering for the course.

SpEd 490. Doctoral Seminar in Special Education (3)
Advanced knowledge of issues and research in the education of individuals with special needs. Topics will vary. May be repeated for credit. Prerequisite: admitted for doctoral studies.

Educational Technology

See listings under Education.

Electrical Engineering and Computer Science

Alastair D. McAulay, Ph.D. (Carnegie Mellon), chair and Chandler-Weaver professor; Frank H. Hielscher, Ph.D. (Illinois) associate chair; Donald J. Hillman, Ph.D. (Cambridge, England), head of computer science division; D. Richard Decker, Ph.D. (Lehigh), head of electrical engineering division; Bruce D. Fritchman, Ph.D. (Lehigh); Samuel L. Gulden, M.A. (Princeton); Miltiadis Hatalis, Ph.D. (Carnegie Mellon); Carl S. Holzinger, Ph.D. (Lehigh); James C. M. Hwang, Ph.D. (Cornell); Edwin J. Kay, Ph.D. (Lehigh); Roger N. Nagel, Ph.D. (Maryland); Harvey E. Wagner professor of manufacturing systems engineering; Kenneth K. Tseng, Ph.D. (Illinois); Marvin H. White, Ph.D. (Ohio State); Sherman Fairchild professor of electrical engineering.

Associate professors. Glenn D. Blank, Ph.D. (Wisconsin-Madison); Terrance E. Boutil, Ph.D. (Columbia); Dragana Brezakovic, Ph.D. (Florida); Demetrius Chistoudlou, Ph.D. (Johns Hopkins); Douglas R. Frey, Ph.D. (Lehigh); Weiping Li, Ph.D. (Stanford); Karl H. Nioran, Ph.D. (Imperial College, London); Patti T. Ota, Ph.D. (Pennsylvania), viceprovost for academic administration; Meghanad D. Wagh, Ph.D. (I.I.T., Bombay), head of computer engineering division.

Assistant professors. Richard Beigl, Ph.D. (Stanford); Rick S. Blum, Ph.D. (Pennsylvania); Eunice Santos, Ph. D. (Berkeley); Michael J. Schulte, Ph.D. (U. of Texas at Austin).


The department of electrical engineering and computer science (EECS) offers undergraduate and graduate programs of study along with supporting research for students interested in the fields of electrical engineering, computer engineering, and computer science. Lehigh University offers a bachelor of science degree from the College of Engineering and Applied Science in electrical engineering, computer engineering, and computer science, and it offers the bachelor of science and bachelor of arts degree with a major in computer science from the College of Arts and Science. A minor in computer science is available except for students in the department.

Graduate study leads to the degree of master of science, master of engineering, and doctor of philosophy in electrical engineering, the master of science in computer engineering, and the degree of master of science and doctor of philosophy in computer science.

While each of the programs has its unique attributes, Lehigh’s programs exploit the growing interrelationship among electrical engineering, computer engineering, and computer science. For example, a new computer system which may encompass fundamental algorithmic development, innovative architecture and logic design, and very large scale integrated circuit design and fabrication requires the expertise of individuals knowledgeable across the spectrum.

The undergraduate programs emphasize the fundamental aspects of their respective areas. Engineering design concepts are introduced early in the curriculum, and required instructional laboratories introduce design as a hands-on activity. Electives permit the student to tailor his program according to his interests and goals, whether they be in preparation for graduate study or entry into industry. Students are free
to select courses offered by other departments and are encouraged to do so when appropriate. In this way they can prepare themselves for activities which straddle departmental boundaries or for entry into professional schools such as medicine or management. Students have the opportunity to synthesize and apply their knowledge in a senior design project. Students may use the senior design project as a way to participate in the various research projects of the department.

The department maintains a number of laboratories in support of its curricular programs. These laboratories include the sophomore laboratory, junior electronics circuits laboratory, microcomputer laboratory, electromechanics laboratory, laboratory, digital signal processing laboratory, parallel computing laboratory, and the digital systems laboratory. The department has research laboratories in artificial intelligence, computer architectures; design and computing systems; electron device physics; microelectronics fabrication; microwave monolithic circuits; microwave and VLSI measurements.

These laboratories are described more completely in the departmental graduate brochure. These laboratories, among others, are available for undergraduate projects.

The graduate programs allow students to deepen their professional knowledge, understanding, and capability within their specialties. The thesis is regarded as an essential and important ingredient of these programs. Each graduate student develops a program of study in consultation with his or her graduate advisor. Key research thrust areas in the department include:

1. Silicon and gallium arsenide microelectronics, VLSI architectures, optoelectronics.
2. Signal processing, optical data communication and networking, error-control coding.
3. Computer vision, object oriented software, multimedia, AI and natural languages, parallel and distributed processing.

Graduate research is encouraged in these and other areas.

Computers and computer usage are an essential part of the student's environment. The university provides a distributed network of more than 125 BM RS/6000 high-performance workstations and over 300 PC-compatible workstations in the computer center (L.U.C.C) systems. The primary department resource is a network of more than 30 Sun Sparc workstations, file servers, and computer servers, running the Unix operating system. With over 30 gigabytes of storage, CD-ROM drives, tape drives, and other peripherals, these systems provide the array of software tools for our students and researchers including programming languages (C, C++, Pascal, FORTRAN), software development tools, software and hardware simulators, and other computer aided design packages. In addition to the workstations, the department maintains a collection of PC compatible workstations for EECS students, including a set of machines which can be dedicated to hardware/software projects. The department also provides various application specific systems, including multimedia stations with sound and video capture and generation capabilities, Silicon Graphics workstations for image processing and visualization, and a 64 node multiprocessor computer for parallel processing and instruction. The workstations and microcomputers are connected via multiple high-speed ethernet and fiber optic networks, which are in turn connected to the university's backbone network, the Pennsylvania Research and Economic Partnership Network (PREPNET), and the Internet. Students are not required by the department nor the university to own a personal computer, but many find such a tool a valuable asset.

A detailed description of the curricular programs follows with a listing of the required courses and with a listing of the departmental course offerings. The departmental courses carry the prefixes CSE for computer science and ECE for electrical and computer engineering. The student is urged to search in both listings for courses appropriate to his/her career goal.

**Undergraduate Programs**

**Bachelor of Science in Electrical Engineering**

The required courses for this degree contain the fundamentals of linear circuits, systems and control theory, electronic circuits, signal theory, physical electronics, electromagnetic theory, energy conversion, digital systems, and computing techniques. A strong foundation in the physical sciences and in mathematics is required. Approved electives, chosen with the advisor's consent, are selected in preparation for graduate study or entry into industry according to individual interests.

The program totals 136 credit hours. The recommended sequence of courses follows:

**See freshman year requirements, section III.**

**sophomore year, first semester (17 credit hours)**
- ECE 33 Introduction to Computer Engineering (4)
- ECE 81 Principles of Electrical Engineering (4)
- Phy 21, 22 Introductory Physics II and Laboratory II (5)
- Math 23 Analytic Geometry and Calculus III (4)

**sophomore year, second semester (18 credit hours)**
- ECE 82 Sophomore Laboratory (1)
- ECE 108 Signals and Systems (4)
- ECE 126 Fundamentals of Semiconductor Devices (3)
- Math 205 Linear Methods (3)
- Eco 1 Economics (4)

**junior year, first semester (17 credit hours)**
- ECE 121 Electronic Circuits Laboratory (2)
- ECE 123 Electronic Circuits (3)
- ECE 202 Introduction to Electromagnetics (3)
- Math 208 Complex Variables (3)
- HSS elective (3)

**junior year, second semester (17 credit hours)**
- ECE 125 Circuits and Systems (3)
- ECE 138 Digital Systems Laboratory (2)
- ECE 203 Introduction to Electromagnetic Waves (3)
- Math 231 Probability and Statistics (3)
- approved technical elective* (3)

**senior year, first semester (18 credit hours)**
- ECE 111 Proseminar (1)
- ECE 136 Electromechanics (3)
- ECE 251 Senior Project 1(2)
- approved technical electives* (6)

**senior year, second semester (18 credit hours)**
- approved technical electives* (1.2)
- HSS elective (3)
- free elective (3)

Approved technical electives are subjects in the area of science and technology. Students must select a minimum of four courses from the following list, with a minimum of two courses in each of two technical areas described in this list. Students must also choose at least one Engineering elective in either materials, mechanics, thermodynamics, fluid mechanics or physical chemistry, and at least one Science elective in physics, chemistry or biology. For students interested in solid-state electronics, quantum mechanics is recommended for the Science elective.
Approved Technical Electives for Electrical Engineering

Breadth Requirement: Minimum of 4 ECE or CSc elective courses

Depth Requirement: Minimum of 2 courses in one of the technical areas described below

A. Solid State Circuits
ECE 308 Physics and Models of Electronic Devices (3)
ECE 332 Design of Linear Electronic Circuits (3)
ECE 333 Medical Electronics (3)
ECE 351 Microwaves and Antennas (3)
ECE 355 Introduction to VLSI Technology (3)
ECE 361 Introduction to VLSI Circuits (3)
ECE 362 Introduction to VLSI System Design (3)

B. Signal Processing and Communications
ECE 340 Adaptive Signal Processing (3)
ECE 342 Communication Theory (3)
ECE 343 Digital Signal Processing (3)
ECE 344 Statistical Signal Processing (3)
ECE 345 Speech Synthesis and Recognition (3)
ECE 375 Computer Vision (3)
ECE 387 Digital Control (3)
ECE 389 Control Systems Laboratory (3)

C. Microwaves and Lightwaves
ECE 254 Microwave-Lightwave Laboratory (2)
ECE 346 Microwave Circuits and Techniques (3)
ECE 347 Introduction to Integrated Optics (3)
ECE 348 Lightwave Technology (3)
ECE 372 Optical Information Processing (3)
ECE 372 Optical Networks (3)

D. Computers
CSc 305 Any CSc course except CSc 111
ECE 216 Software Engineering (3)
ECE 316 Microcomputer System Design (3)
CSc 308 Digital System Design (3)

Note: ECE 350 Special Topics (3) (The area of each course must be evaluated individually)

Bachelor of Science in Computer Science

The required courses for this degree contain the fundamentals of electronic circuits, signal theory, logic design, computer architecture, structured programming, data structures, software engineering, discrete mathematics, and numerical analysis. A strong foundation in the physical sciences and mathematics is required. Approved technical electives, chosen with the advisor's consent, are selected for preparation for graduate study or entry into industry according to individual interests. The program totals 137 credit hours. The recommended sequence of courses follows:

See freshman year requirements, section III.

sophomore year, first semester (17 credit hours)
ECE 81 Introduction to Electrical Engineering (4)
ECE 33 Introduction to Computer Engineering (4)
Phy 21, 22 Introductory Physics II and Laboratory II (5)
Math 23 Analytic Geometry and Calculus III (4)

sophomore year, second semester (19 credit hours)
CSc 17 Structured Programming and Data Structures (4)
ECE 82 Sophomore Laboratory (1)
ECE 108 Signals and Systems (4)
Eco 108 Economics (4)
Math 205 Linear Methods (3)

HSS elective (3)

junior year, first semester (17 credit hours)
ECE 121 Electronic Circuits Laboratory (2)
ECE 123 Electronic Circuits (3)
CSc 262 Programming Languages (3)
Math 231 Probability and Statistics (3) or Math 309 Theory of Probability (3)
approved technical elective* (3) free elective (3)

junior year, second semester (17 credit hours)
ECE 216 Software Engineering (3)
ECE 138 Digital Systems Laboratory (2)
ECE 201 Computer Architecture (3)
CSc 261 Discrete Structures (3)
free elective (3)
HSS elective (3)

senior year, first semester (18 credit hours)
ECE 111 Proseminar (1)
ECE 251 Senior Project I (2)
ECE 319 Digital System Design (3)
CSc 303 Operating System Design (3)
HSS elective (3)
approved technical elective* (3)
free elective (3)

senior year, second semester (18 credit hours)
approved technical electives* (12)
HSS elective (3)
free elective (3)

*Approved technical electives are subjects in the area of science and technology. They are not restricted to offerings in the department of computer science and electrical engineering. One elective must be an engineering science elective from another department.

Bachelor of Science in Computer Science

Two degree programs are available to students through either the College of Arts and Science or the College of Engineering and Applied Science. The program offered by the College of Engineering and Applied Science is accredited by the Computer Science Accreditation Board, Inc. The two programs are identical in the fundamental requirements in mathematics and computer science, and the programs are appropriate for entry into management or industrial positions and for continued graduate study. The programs differ in that the students must fulfill the distribution requirements of the respective college. The result of this difference is that the Arts and Science program requires 127 credit hours whereas the College of Engineering and Applied Science program requires 134 credit hours. Students with interests in management, finance, data processing, and information handling may find the Arts and Science College program more appropriate and students with interests in engineering and science applications may find the Engineering and Applied Science College program more appropriate.

The required courses for the degrees contain the fundamentals of discrete mathematics, structured programming, algorithms, computer architectures, compiler design, operating systems, and programming languages. A strong foundation in mathematics is required. The recommended sequence of courses is as follows:

College of Arts and Sciences

See the distribution requirements of the College of Arts & Sciences, section 111.

freshman year, first semester (17 credit hours)
Engl 1 Composition and Literature (3)
Math 21 Analytic Geometry and Calculus I (4)
CSc 11 Introduction to Computing (4)

distribution (6)
### College of Engineering and Applied Science

**See freshman year requirements, section III.**

#### Freshman Year

**Second Semester (17 credit hours)**
- Engl 2: Composition and Literature: Fiction, Drama, Poetry (3)
- Math 22: Analytic Geometry and Calculus II (4)
- Csc 17: Structured Programming and Data Structures (4)
  
**Sophomore Year

**First Semester (17 credit hours)**
- Math 23: Analytic Geometry and Calculus III (4)
- ECE 33: Introduction to Computer Engineering (4)

**Second Semester (15 credit hours)**
- Csc 109: Systems Programming (3)
- Csc 262: Programming Languages (3)
- Math 205: Linear Methods (3)

**Junior Year

**First Semester (15 credit hours)**
- Csc 209: Assembly Language Programming (3)
- Csc 261: Discrete Structures (3)
- Math 231: Probability and Statistics (3)

**Second Semester (15 credit hours)**
- Csc 340: Design and Analysis of Algorithms (3)
- ECE 201: Computer Architecture (3)
- ECE 216: Software Engineering (3)

**Senior Year

**First Semester (16 credit hours)**
- Csc 303: Operating System Design (3)
- Csc 318: Automata & Formal Grammars (3)
- ECE 111: Proseminar (1)
- Math 230: Numerical Methods (3)

**Second Semester (15 credit hours)**
- Csc 302: Compiler Design (3)

**Approved technical electives are chosen by the student, with the approval of the major advisor, to support the professional objectives of the student. The approved elective choices must include: a two semester sequence of laboratory science courses acceptable for majors in the field of the courses selected.**

### Bachelor of Arts in Computer Science

This program of 121 credit hours is for students who desire a strong liberal arts program with a concentration in computer science. The program contains the fundamentals of computer science which include discrete mathematics, structured programming, data structures, programming languages, computer organization, compiler design, and operating systems. The recommended course sequence is as follows:

See the distribution requirements of the College of Arts & Sciences, section III.

#### Freshman Year

**First Semester (14 credit hours)**
- Engl 1: Composition and Literature (3)
- Math 21: Analytic Geometry and Calculus I (4)
- Csc 11: Introduction to Computing (4)

**Second Semester (14 credit hours)**
- Engl 2: Composition and Literature: Fiction, Drama, Poetry (3)
- Math 22: Analytic Geometry and Calculus II (4)
- Csc 17: Structured Programming and Data Structures (4)

**Sophomore Year

**First Semester (16 credit hours)**
- Csc 261: Discrete Structures (3)
- Math 243: Algebra (3)
- ECE 33: Introduction to Computer Engineering (4)
sophomore year, second semester (15 credit hours)
  Math 43  BMSS Linear Algebra (3)
  CSc 109  Systems Programming (3)
  ECE 201  Computer Architecture (3) distribution (6)

junior year, first semester (15 credit hours)
  CSc 209  Advanced Programming (3)
  CSc 262  Programming Languages (3) distribution (6)
          free electives (3)

junior year, second semester (15 credit hours)
          distribution (6)
          free electives (9)

senior year, first semester (16 credit hours)
  CSc 303  Operating System Design (3)
  CSc 318  Automata and Formal Grammars (3) distribution (3)
          free electives (7)

senior year, second semester (16 credit hours)
  CSc 302  Compiler Design (3) distribution (6)
          free electives (7)

Minor in Computer Science
  The minor in computer science provides a concentration which includes software development and programming, and computer organization, and essential elements of computer science. This minor is not available to students of the Department. The minor is as follows:
  CSc 11  Introduction to Computing (4)
  CSc 17  Structured Programming and Data Structures (4)
  ECE 33  Introduction to Computer Engineering (4)
  Two CS electives from the following list:
     CSc 109  Systems Programming (3) or
     CSc 216  Software Engineering (3) or
     CSc 241  Data Base Systems (3) or
     CSc 261  Discrete Structures (3) or
     CSc 271  Programming in C and the Unix Environment (3) or
     CSc 262  Programming Languages (3) or
     CSc 327  Artificial Intelligence Theory and Practice (3) or
    CSc 340  Analysis of Algorithms (3)
          (18 credit hours)

Graduate Programs
  Graduate programs of study provide a balance between formal classroom instruction and research and are tailored to the individual student’s professional goals. The programs appeal to individuals with backgrounds in electrical or computer engineering, computer or information science, mathematics, or the physical sciences. Research is an essential part of the graduate program. Major research areas include:

  Compound Semiconductor Microwave & Quantum Electronics

Microelectronics - Devices, Integrated Circuits, VLSI Design
  Silicon integrated circuit technology, processing, fabrication and testing. Semiconductor device physics, small geometry devices, CMOS VLSI logic design and verification, computer-aided design (CAD), VLSI chip architectures. Non-linear circuit design.

Information and Computer Engineering
  Networking and distributed computing; architecture, distributed processing, error control, security and protection; real-time processing; pipelining and scheduling, signal processing algorithms, VLSI architectures, speech compression and recognition, concurrent processing; fault tolerant computing; hardware/software redundancy, coding theory; use of optics in fiber optic communications, networks, and computers.

Software and Artificial Intelligence
  Expert systems; knowledge-based systems in design, electronics packaging, manufacturing, and construction; natural language processing; AI programming languages; learning systems and mechanisms; data models and object-oriented systems; user interfaces; decision-support systems; database interfaces; computer vision, including use of color and polarization, object oriented software and parallel/distributed systems.

  The Master of Science degree requires the completion of 30 credit hours of work which may include a six credit hours thesis for the E.E. and CompE. degrees and a three credit hour thesis for the C.S. degree. Special topics courses are restricted to six credit hours. The C.S. degree requires CSc 302 Compiler Design, CSc 411 Advanced Programming Techniques, and CSc 403 Theory of Operating Systems. A program of study must be submitted in compliance with the graduate school regulations. An oral presentation of the thesis is required.

  The Master of Engineering degree requires the completion of 30 credit hours of work, which includes design oriented courses and an engineering project. A program of study must be submitted in compliance with the graduate school rules. An oral presentation of the project is required.

  The Ph.D. degree in Electrical Engineering and the Ph.D. degree in Computer Science require the completion of 42 credit hours of work (including the dissertation) beyond the master’s degree (48 hours if the master’s degree is non-Lehigh), the passing of a departmental qualifying examination appropriate to each degree within one year after entrance into the degree program, the passing of a general examination in the candidate’s area of specialization, the admission into candidacy, and the writing and defense of a dissertation. Competence in a foreign language is not required.

  Additional graduate program information may be obtained from the department’s graduate coordinator.

Departmental Courses
  Courses are listed under the prefixes CSc and ECE. Generally, electrical engineering courses carry the ECE prefix and computer science courses carry the CSc prefix. Computer Engineering courses are found under either prefix. The reader should consult both listings.

Computer Science (CSc)

For Undergraduate Students
  CSc 11. Introduction to Computing (4) fall
  Problem solving and programming in C++. Survey of great ideas in computer science. Multi-media computer laboratory. No prerequisites. (ES 2) (ED 2) Blank.

  CSc 17. Structured Programming and Data Structures (4)
  Algorithmic design and implementation in high level, block-structured, procedure-oriented languages. Recursion, lexical programs, pointers, data structures, and their applications. Previous experience with programming required. (ES 3) (ED 1)

  CSc 109. Systems Programming (3)
  Advanced data structures: hash tables, B-trees, disk files. Design of assemblers, macro-processors, loaders, interpreters, translators, communication protocols. Use of a high-level language to implement sample systems. Prerequisites: CSc 17 and ECE 33. (ES 1.5), (ED 1.5)
CSc 190. Special Topics (1-3)  
Supervised reading and research. Prerequisite: consent of the division head.

CSc 209. Assembly Language Programming (3)  
Design and development of assembly language programs for computer systems. Interactive input-output, handling interrupts, system architecture, hardware-software tradeoffs. Evaluation of program efficiency. Prerequisite: CSc 109. (ES 1), (ED 2)

CSc 241. Data Base Systems (3) spring  
Data base concepts in terms of formal logic. Knowledge representation and deduction. Data base integrity. Query languages. Prerequisite: CSc 11 or approval of the division head. (ES 1), (ED 1.5)

CSc 252. Computers and Society (3)  
A general nontechnical survey of the impact of computers on modern society. Special attention is given to the use of large-scale data banks and retrieval systems, the problems of privacy and file security, and the impact of automation on everyday life.

CSc 261. (Math 261) Discrete Structures (3)  
Topics in discrete structures chosen for their applicability to computer science and engineering. Sets, propositions, induction, recursion; combinatorics; binary relations and functions; ordering, lattices and Boolean algebra; graphs and trees; groups and homomorphisms. Various applications. Prerequisites: Math 21 and either CSc 11 or Engr 1. (ES 2), (ED 1)

CSc 262. Programming Languages (3) fall and spring  
Use, structure and implementation of several programming languages. Prerequisite: CSc 17. (ES 1.5), (ED 1.5)

CSc 271. Programming in C and the Unix Environment (3)  
C language syntax and structure. C programming techniques. Emphasis on structured design for medium to large programs. Unix operating system fundamentals. Unix utilities for program development, text processing, and communications. Prerequisites: ECE 33 and either CSc 17. (ES 2), (ED 1)

CSc 302. Compiler Design (3) spring  
Principles of artificial language description and design. Sentence parsing techniques, including operator precedence, bounded-context, and syntax-directed recognizer schemes. The semantic problem as it relates to interpreters and compilers. Dynamic storage allocation, table grammars, code optimization, compiler-writing languages. Prerequisites: CSc 109 and CSc 318. (ES 1.5), (ED 1.5)

CSc 303. Operating System Design (3) fall  
Assemblers, executive systems, multiprocessing, time sharing. Concurrent tasks, deadlocks, resource sharing. Construction of a small operating system. Prerequisites: ECE 201 and CSc 109 or ECE 216. (ES 1.5), (ED 1.5)

CSc 313. Computer Graphics (3)  
General principles; algorithms; display devices and organization; methods of interaction; design of visual interactive systems. Prerequisite: CSc 109. (ES 1.5), (ED 1.5)

CSc 318. Automata and Formal Grammars (3)  
Formal languages, finite automata, context-free grammars, Turing machines, complexity theory, undecidability. Prerequisite: CSc 261. (ES 3)Y (ED 0)

CSc 327. Artificial Intelligence Theory and Practice (3)  
Survey of foundations: heuristic search, knowledge representation, general problem solvers, probabilistic reasoning, connectionism. Survey of applications and research issues, such as knowledge engineering, natural language processing, intelligent robots, cognitive science. Use of expert system and neural net software to develop rule-based and connectionist systems. (ES 2), (ED 1)

CSc 330. Advanced Software Engineering Tools (3)  
CASE tools; portability and reusability of software; experimental methods in software engineering; automatic programming. Prerequisite: ECE 216. (ES 1), (ED 2)

CSc 340. (Math 340) Design and Analysis of Algorithms (3)  
Algorithms for searching, sorting, counting, graph and tree manipulation, matrix multiplication, scheduling, pattern matching, fast Fourier transform. Minimum time and space requirements are established, leading to the notion of abstract complexity measures and the intrinsic complexity of algorithms and problems, in terms of asymptotic behavior. The question of the correctness of algorithms is also treated. Prerequisite: Math 22 and CSc 261. (Math 261). (ES 3), (ED 0)

CSc 350. Special Topics (3)  
Selected topics in the field of computer science not included in other courses. May be repeated for credit.

CSc 365. Natural Language Processing (3)  
Computer analysis of human languages, such as English. Syntactic parsing and semantic interpretation of sentences; morphological recognition of words and idioms. Applications of natural language processing such as database queries. Prerequisite: CSc 262 or equivalent familiarity with Prolog, Lisp. (ES 2), (ED 1)

CSc 368. Artificial Intelligence Programming (3) spring  
The use of LISP and related languages to simulate intelligence on computers. Prerequisite: CSc 262 or approval of the division head. (ES 2), (ED 1)

CSc 375. Hardware & Software Topics in Parallel Computing (3)  
Introduction to parallel computing, covering both hardware and software topics such as interconnection networks, SIMD, MIMD, and hybrid parallel architectures, parallel languages, parallelizing compiler techniques and operating systems for parallel computers. Prerequisite: ECE 201 and CSc 303 previously or concurrently, or consent of the instructor. (ES 1.5), (ED 1.5)

CSc 376. Parallel Algorithms (3)  
Parallel algorithms for searching, sorting, matrix processing, network optimization, and selected graph problems. Implementation and efficiency measures of parallel algorithms also considered. Prerequisite: CSc 375 or CSc 340 or consent of instructor. (ES 1), (ED 2)

CSc 392. Independent Study (1-3)  
An intensive study, with report, of a topic in computer science which is not treated in other courses. May be repeated for credit. Prerequisite: Consent of instructor.

For Graduate Students
CSc 403. Theory of Operating Systems (3)  
Principles of operating systems with emphasis on hardware and software requirements and design methodologies for multi-processing systems. Global topics include the related areas of process management, resource management, and file systems. Prerequisite: CSc 303 or equivalent.

CSc 409. Theory of Automata and Formal Grammars (3)  
Finite automata. Pushdown automata. Relationship to definition and parsing of formal grammars. Prerequisite: CSc 318.

CSc 411. Advanced Programming Techniques (3) spring  
Deeper study of structured programming, data structures, back-tracking, recursion. Applications of basic concepts of automata theory and formal language theory. Fundamental principles of "large program" design. Several major programming assignments using Pascal. Prerequisite: 17 or consent of the division head. Gulden
CSc 412. Object Oriented Programming (3)
Objects, messages, classes and inheritance, the model-view-controller paradigm. Prototyping the user interface. Kay

CSc 413. Robotics and Intelligent Machines (3)
Software aspects of robot and intelligent machine controls. Fundamental control issues through language and artificial intelligence implementations.

CSc 414. Expert Systems (3)

CSc 415. Database Topics (3)
Design issues in integrated database systems. Database entities and their relationships. Prerequisite: CSc 241 or equivalent.

CSc 416. Advanced Issues in Knowledge-based Systems (3)
Advanced techniques and current applications of knowledge-based systems. Emphasis on knowledge engineering techniques through the development of a substantial system. Prerequisite: CSc 444. Hillman and Blank

CSc 417. Topics in Information Retrieval (3)
Selected topics in the design of advanced retrieval systems. Prerequisite: CSc 241 or equivalent.

CSc 418. Uncertainty in Knowledge Based Systems (3)
Basic problems and possibilities for probable inference by expert systems are discussed. In this light, Bayesian inference, certainty factors, Dempster-Shafer evidence theory, and fuzzy logic are described and critiqued. Various related topics are also discussed.

CSc 422. Advanced Topics in Compiling (3)
Topics from general parsers, attributed translation, attribute grammars, two-level grammars, expression optimization, data flow, code optimization, compiler compilation, implementation languages, multi-tasking languages. Prerequisite: CSc 302 or consent of the division head. Gulden

CSc 432. Object-Oriented Software Engineering (3)
Design and construction of modular, reusable, extendable and portable software using statically typed object-oriented programming languages (Eiffel, C++, Objective C). Abstract data types; generativity; multiple inheritance; use and design of software libraries; persistence and object-oriented databases; impact of object-oriented programming on the software life cycle.

CSc 437. Program Semantics (3)
Theories and techniques of program semantics and program verification. Topics may be chosen from denotational semantics, operational semantics, Floyd-Hoare semantics, temporal logic, dynamic logic, algebraic semantics, continuous semantics, recursive function theory or a current semantic theory. Gulden

CSc 440. Graph Theory and Application (3)
Fundamental concepts and algorithms for graphs, including: connectivity, planarity, network flows, matchings, colorings, traversals, duality, intractability and applications. Prerequisite: CSc 340 or consent of instructor.

CSc 450. Special Topics (3)
Selected topics in computer science not included in other courses. May be repeated for credit.

CSc 463. Advanced Issues in Natural Language Processing (3)
Advanced techniques and current applications of natural language systems. Complex syntax and semantics, discourse coherence and planning, natural language interfaces and other applications. Prerequisite: CSc 365 or CSc 465. Blank

CSc 465. Seminar in Natural Language Processing (3)
Writing and presenting reviews of research issues in natural language, knowledge representation, speech processing and other applications. Requires concurrent attendance in CSc 365: Natural Language Processing.

CSc 491. Research Seminar (1-3)
Regular meetings focused on specific topics related to the research interests of department faculty. Current research will be discussed. Students may be required to present and review relevant publications. May be repeated for credit up to a maximum of three (3) credits. Prerequisite: Consent of instructor.

CSc 492. Independent Study (1-3)
An intensive study, with report of a topic in computer science which is not treated in other courses. May be repeated for credit. Prerequisite: Consent of instructor.

Electrical and Computer Engineering (ECE)

For Undergraduate Students

ECE 33. Introduction to Computer Engineering (4) fall
Analysis, design and implementation of small digital circuits. Boolean algebra. Minimization techniques, synchronous sequential circuit design, number systems and arithmetic. Microcomputer architecture and assembly level programming. Prerequisite: Engr 1 or CSc 17. (ES 2), (ED 2)

ECE 81. Principles of Electrical Engineering (4) fall and spring

ECE 82. Sophomore Lab (1) spring
An introduction to the fundamental laboratory instrumentation and measurement techniques of electrical and computer engineering. Five or six experiments based on the fundamental concepts discussed in the prerequisite courses. Introduction to PSPICE and application of various computer aids to design and documentation. Discussions of electrical components and laboratory safety. Use of engineering notebooks and report writing. One 3-hour laboratory per week. Prerequisites: ECE 33 and ECE 81, previously. (ES 0), (ED 1)

ECE 108. Signals and Systems (4) spring
Continuous and discrete signal and system descriptions using signal space and transform representations. Includes Fourier series, continuous and discrete Fourier transforms, Laplace transforms, and z-transforms. Introduction to sampling. Prerequisite: ECE 81. (ES 4), (ED 0)

ECE 111. Proseminar (1) fall
A weekly seminar to acquaint students with current topics in electrical and computer engineering. Students prepare and present oral and written reports that are judged on quality and presentation as well as technical content. Prerequisite: senior standing. (ES 0.5), (ED 0.5)

ECE 121. Electronic Circuits Laboratory (2) fall
One lecture and one laboratory per week. Experiments illustrating the principles of operation of electronic devices and their circuit applications. Basic electronic instrumentation and measurement techniques. Corequisite: ECE 123. (ES 0.5), (ED 1.5)

ECE 123. Electronic Circuits (3) fall
Methods for analyzing and designing circuits containing electronic devices. Topics include device models, basic amplifier configurations, operating point stabilization, frequency response analysis, and computer-aided analysis of active circuits. Prerequisite: ECE 108. (ES 1.5), (ED 1.5)
ECE 125. Circuits and Systems (3) fall
Formulation of linear circuit equations in the time and frequency domain. Complete solutions of difference and differential equations. Network theorems. Basic stability and feedback concepts. Modulation theory, sampling theory and basic digital signal processing ideas. Prerequisite: ECE 108. (ES 2.5), (ED 0.5)

ECE 126. Fundamentals of Semiconductor Devices (3) spring
Introduction to the physics of semiconductors in terms of atomic bonding and electron energy bands in solids. Charge carriers in semiconductors and carrier concentration at thermal equilibrium. Principles of electron and hole transport, drift and diffusion currents, generation and recombination processes, continuity. Treatment of semiconductor devices including p-n junctions, bipolar junction transistors and field effect transistors. Prerequisite ECE 81. (ES 2.5), (ED 0.5)

ECE 136. Electromechanics (3) spring
Two lectures and one laboratory per week. An experimental introduction to electromechanical energy conversion. Basic concepts of magnetic fields and forces and their application to electrical apparatus including electromechanical transducers, transformers, AC and DC machines. Prerequisite: ECE 81. (ES 2), (ED 1)

ECE 138. Digital Systems Laboratory (2) spring
Implementation issues and techniques for digital logic design. Combinational and sequential logic design using standard integrated circuits. I/O and interrupt processing. Design and implementation of real-time complex digital logic using microprocessor systems. Prerequisite: ECE 33. (ES 0.5), (ED 1.5)

ECE 162. Electrical Laboratory (1) spring
Experiments on circuits, machines, and electronic devices. Elementary network theory. Survey laboratory for students not majoring in electrical or computer engineering. Prerequisite: ECE 81. (ES 1), (ED 0)

ECE 201. Computer Architecture (3) spring
Structure and function of digital computers. Computer components and their operations. Computer interconnection structures. Memory system and cache memory. Interrupt driven input/output and direct memory access. Instruction sets and addressing modes. Instruction pipelining. Floating-point representation and arithmetic. Alternative architectures: RISC vs. CISC and introduction to parallel architectures. Prerequisite: ECE 33. (ES 1.5), (ED 1.5)

ECE 202. Introduction to Electromagnetics (3) spring
Elements of vector analysis, Coulomb’s law, Biot-Savart’s and Ampere’s laws, Lorentz Forces, Laplace’s and, Maxwell’s equations, boundary conditions, methods of solution in static electric and magnetic fields, including finite element numerical approach. Quasistationary fields, inductance. Prerequisite: Math 205, Phys. 21. (ES 3), (ED 0)

ECE 203. Introduction to Electromagnetic Waves (3) fall
Uniform plane waves in free space and in materials, skin effect. Waves in transmission lines and waveguides, including optical fibers. Energy and power flow, Poynting’s theorem. Reflection and refraction. Resonators. Radiation and diffraction. Prerequisite: ECE 202. (ES 2.5), (ED 0.5)

ECE 212. Control Theory (3)

ECE 216. Software Engineering (3) spring
The software life-cycle; life-cycle models; software planning; testing; specification methods; maintenance. Emphasis on team work and large-scale software systems, including oral presentations and written reports. Prerequisite: Cse 17 and Cse 262. (ES 1.5), (ED 1.5)

ECE 251. Senior Project I (2) fall
This capstone course integrates the knowledge and experience acquired in previous and concurrent courses. Emphasis is on design, implementation, test and evaluation of an engineering project in any of the diverse areas of electrical and computer engineering and computer science consistent with the abilities of the student and departmental resources. A written project proposal, periodic progress reports, a final project report, and a project demonstration are required. Prerequisite: Senior standing. (ES 0.5), (ED 1.5)

ECE 252. Senior Project II (2) spring
Same as ECE 251. May be used to substitute for ECE 251 for those students not following the normal schedule. Also serves as a continuation for those projects beyond the scope of a one semester course. Two-three hour sessions per week. Prerequisite: Senior standing. (ES 0.5), (ED 1.5)

ECE 254. Microwave-Lightwave Laboratory (2) spring
Basic microwave and optical measurement techniques, design procedures and practical concepts. Practical aspects of fiber optics, optical transmission, and modulation. Two-three hour sessions per week. Corequisite: ECE 346. (ES 1), (ED 1)

ECE 256. Honors Project (1) spring
Open by invitation only to students who have completed ECE 251 Senior Project. Selection is based upon the quality of the senior project with regard to ingenuity, design approach and completeness. The objective of this course is to carry the successful senior projects forward to completion of a technical paper suitable for publication or submission to a technical conference. A written paper and oral presentation are required by mid-semester. Oral presentations will be made before an appropriate public forum. Enrollment limited. (ES 0), (ED 0)

ECE 308. Physics and Models of Electronic Devices (3)
Physics of metal-semiconductor junction, p-n junctions, and MOS capacitors. Models of Schottky barrier and p-n junction diodes, JFET, MOSFET, and bipolar transistors. Prerequisite: ECE 126. (ES 2), (ED 1)

ECE 316. Microcomputer System Design (3) spring
Content is primarily hardware oriented, but software issues are covered where required. Includes performance characteristics of the more popular devices on the market today. Specific topics include: basic microcomputer structure, bus interconnections, memory systems, serial and parallel interfacing, CRT controllers, interrupt structures, DMA. Prerequisite: ECE 33. Holzinger. (ES 0.5), (ED 2.5)

ECE 319. Digital System Design (3) fall
Design techniques at the register transfer level. Control strategies for hardware architectures. Implementation of microprogramming, internsystem communication and peripheral interfacing. Hardware design languages and their use in design specification, verification and simulation. Prerequisite: ECE 138. (ES 0), (ED 3)

ECE 320. Logic Design (3) spring
Review of basic switching theory, vector boolean algebra, canonical implementations of medium size circuits, threshold logic, fault detection in combinational and sequential logic, Multivalued and Fuzzy logic, regular expressions, nondeterministic sequential machines. Prerequisite: ECE 33. (ES 1.5), (ED 1.5)

ECE 332. Design of Linear Electronic Circuits (3) spring
Introduction to a variety of linear design concepts and topologies, with contemporary audio networks providing many of the concrete examples. Topics include low and high-level preamps; equalizers and
filters; mixers; voltage controlled amplifiers; input and output stage modifications; power amplifiers; analog switching and digital interface circuitry. Prerequisite: ECE 125 and ECE 355. Frey. (ES 1), (ED 2)

ECE 333. Medical Electronics (3) fall
Bioelectric events and electrical methods used to study and influence them in medicine, electrically excitable membranes, action potentials, electrical activity of muscle, the heart and brain, bioamplifiers, pulse circuits and their applications. Prerequisite: ECE 123 or equivalent. Norian. (ES 2.5), (ED 0.5)

ECE 340. Adaptive Signal Processing (3) spring
Introduction to the uses and practice of modern adaptive signal processing. Theory and design of discrete-time optimum linear filters and adaptive filters. AR, MA, and ARMA processes are introduced. Common adaptive filtering algorithms are derived and discussed for transversal and ladder structures, including, LMS, Least Squares, and RLS algorithms. Kalman filtering is introduced with some applications. Some programming will be required, using preferably Maple or Matlab. Prerequisites: ECE 125, and Math 231 or Math 309. Frey. (ES 2.5), (ED 0.5)

ECE 342. Communication Theory (3) spring
Theory and application of analog and digital modulation. Sampling theory with application to analog-to-digital and digital-to-analog conversion techniques. Time and frequency division multiplexing. Introduction to random processes including filtering and noise problems. Introduction to statistical communication theory with primary emphasis on optimum receiver principles. Prerequisites: ECE 125 and Math 309 or Math 231. (ES 2.5), (ED 0.5)

ECE 343. Digital Signal Processing (3) fall
Study of orthogonal signal expansions and their discrete representations, including the Discrete Fourier Transform and Walsh-Hadamard Transform. Development of fast algorithms to compute these, with applications to speech processing and communication. Introduction to the z-transform representation of numerical sequences with applications to input/output analysis of discrete systems and the design of digital filters. Analysis of the internal behavior of discrete systems using state variables for the study of stability, observability and controllability. Prerequisite: ECE 108. (ES 2.5), (ED 0.5)

ECE 344. Statistical Signal Processing (3) fall
Introduction to random processes, covariance and spectral density, time average, stationarity, and ergodicity. Response of systems to random inputs. Sampling and quantization of random signals. Optimum filtering, estimation, and hypothesis testing. Prerequisite: Math 231 or Math 309, and ECE 108. Blum. (ES 2.5), (ED 0.5)

ECE 345. Speech Synthesis and Recognition (3) spring
Application of digital technology to generation and recognition of speech by machines. The analytical tools required for digitizing and encoding speech signals; the methods currently used for synthesizing and recognizing speech; various hardware products available to perform these tasks. Prerequisite: ECE 108. Holzinger. (ES 1), (ED 2)

ECE 346. Microwave Circuits and Techniques (3) spring
Impedance transformation along waveguides. Matching techniques. Applications of Smith Chart. Resonators as circuit elements. Scattering and transfer matrices. S-parameter design of transistor amplifiers. Stability,Noise. Reflection type amplifiers. Prerequisite: ECE 203 or equivalent. (ES 1), (ED 2)

ECE 347. Introduction to Integrated Optics (3) fall
Theory of dielectric waveguides (ray and wave approach). Modes in planar slab optical guides and in waveguides with graded index profiles. Coupled-mode formalism and periodic structures. Coupling of optical beams to planar structures. Switching and modulation of light in dielectric guides: phase, frequency and polarization modulators; electro-optic, acousto-optic and magneto-optic modulators. Semiconductor lasers. Fabrication of semiconductor components. Recent advances. Prerequisites: ECE 202 and ECE 203. Christodoulides. (ES 3), (ED 0)

ECE 346. Introduction to Integrated Optics (3) fall
Theory of dielectric waveguides (ray and wave approach). Modes in planar slab optical guides and in waveguides with graded index profiles. Coupled-mode formalism and periodic structures. Coupling of optical beams to planar structures. Switching and modulation of light in dielectric guides: phase, frequency and polarization modulators; electro-optic, acousto-optic and magneto-optic modulators. Semiconductor lasers. Fabrication of semiconductor components. Recent advances. Prerequisites: ECE 202 and ECE 203. Christodoulides. (ES 3), (ED 0)

ECE 348. Lightwave Technology (3) spring
Overview of optical fiber communications. Optical fibers, structures and waveguiding fundamentals. Signal degradation in fibers arising from attenuation, intramodal and intermodal dispersion. Optical sources, semiconductor lasers and LEDs. Rate equations and frequency characteristics of a semiconductor laser. Coupling efficiency of laser diodes and LEDs to single-mode and multimode fibers. PIN and avalanche photodetectors. Optical receiver design. Transmission link analysis. Prerequisite: ECE 203. Christodoulides. (ES 2), (ED 1)

ECE 350. Special Topics (3)
Selected topics in the field of electrical and computer engineering not included in other courses. May be repeated for credit.

ECE 351. Microelectronics Technology (3) fall
Technology of semiconductor devices and of integrated circuits, including crystal growth and doping, phase diagrams, diffusion, epitaxy, thermal oxidation and oxide masking, lithography. The major emphasis will be on silicon technology, with additional lectures on GaAs technology. Prerequisites: ECE 126 and Phys 31. (ES 2) (ED 1)

ECE 355. Applied Integrated Circuits (3) fall
Emphasis on understanding of terminal characteristics of integrated circuits with excursion into internal structure only as necessary to assure proper utilization in system design. Classes of devices studied include operational amplifiers, digital-to-analog and analog-to-digital converters, linear multipliers, modulators, and phase-locked loops. Prerequisites: ECE 108 and 123. Holzinger. (ES 0.5), (ED 2.5)

ECE 361. Introduction to VLSI Circuits (3) fall
The design of Very Large Scale Integrated Circuits, with emphasis on CMOS Standard Cell design. Topics include MOS transistor physics, device behavior and device modeling, MOS technology and physical layout, design of combinational and sequential circuits, static and dynamic memories, and VLSI chip organization. The course includes a design project using CAE tools for layout, design rule checking, parameter extraction, and SPICE simulations for performance prediction. Two one-hour lectures and three hours of laboratory per week. Prerequisite: ECE 123. Hielsher. (ES 1.5), (ED 1.5)

ECE 362. Introduction to VLSI System Design (3) spring
Structured hierarchical approach to the design of digital VLSI circuits and systems. Use of CAE tools for design and verification. Topics include: systems aspects of VLSI design, design methodologies, schematic capture, functional verification, timing simulation, use of a CMOS standard cell library and of a silicon compiler. The course includes a semester-long design project, with the design to be fabricated by a foundry. Two one-hour lectures and three hours of design laboratory per week. Prerequisite: ECE 138. Hielsher. (ES 0.5), (ED 2.5)

ECE 371. Optical Information Processing (3) spring
Introduction to optical information processing and applications. Interference and diffraction of optical waves. 2D optical matched filters that use lenses for Fourier transforms. Methods and devices for modulating light beams for information processing, communications, and optical computing. Construction and application of holograms for optical memory and interconnections. Prerequisite: ECE 108. McAulay. (ES 2.5), (ED 0.5)

ECE 372. Optical Networks (3) spring
Study the design of optical fiber local, metropolitan, and wide area networks. Topics include: passive and active photonics components for optical switching, tuning, modulation and amplification; optical interconnection switches and buffering; hardware and software
architectures for packet switching and wavelength division multiaccess systems. The class is supported with a laboratory. Prerequisite ECE 81. Mcaulay (ES 2), (ED 1)

ECE 375. Computer Vision (3) fall
Acquisition and processing of digital images. Interpretation of vision modalities. Intermediate level vision, including segmentation, texture, and shape representation. Three-dimensional scene understanding from stereo, texture, shading and photometric stereo. Basics of high level vision. Prerequisite: ECE 108 or equivalent or consent of instructor. Bzrakov. (ES 2), (ED 1)

ECE 387. (ChE 387, ME 387) Digital Control (3) spring
Sampled-data systems; z-transforms; pulse transfer functions; stability in the z-plane; root locus and frequency response design methods; minimal prototype design; digital control hardware; discrete state variables; state transition matrix; Liapunov stability; state feedback control. Prerequisite: ChE 386 or ECE 212 or ME 342 or consent of instructor. (ES 3), (ED 0)

ECE 389. (ChE 389, ME 389) Control Systems Laboratory (2)
Experiments on a variety of mechanical, electrical and chemical dynamic control systems. Exposure to state-of-the-art control instrumentation: sensors, transmitters, control valves, analog and digital controllers. Emphasis on comparison of theoretical control system predictions with actual experimental data. Lab teams will be interdisciplinary. Prerequisite: ChE 386, ME 343, ECE 212. (ES 1), (ED 1)

ECE 392. Independent Study (1-3)
An intensive study, with report of a topic in electrical and computer engineering which is not treated in other courses. May be repeated for credit. Prerequisite: Consent of instructor.

For Graduate Students

ECE 401. Advanced Computer Architecture (3)
Design, analysis and performance of computer architectures; high speed memory systems; cache design and analysis; modeling cache performance; principle of pipeline processing, performance of pipelined computers; scheduling and control of a pipeline; classification of parallel architectures; systolic and data flow architectures; multiprocessor performance; multiprocessor interconnections and cache coherence. Prerequisite: ECE 201 or equivalent.

ECE 404. Computer Networks (3)
Study of architecture and protocols of computer networks. The ISO model; network topology; data-communication principles, including circuit switching, packet switching and error control techniques; sliding window protocols, protocol analysis and verification; routing and flow control; local area networks; network interconnection; topics in security and privacy. Tzeng

ECE 407. Linear and Nonlinear Optics (3)
Diffraction theory, Gaussian beams. Optical resonators and waveguides. Crystal optics, second harmonic generation, parametric amplification. Third order nonlinearities and associated phenomena such as phase conjugation, optical bistability, self-focusing, optical switching, solutions, etc. Photorefractive effect. Brillouin and Raman scattering. Christodoulides

ECE 411. Information Theory (3)
Introduction to information theory. Topics covered include: development of information measures for discrete and continuous spaces of data; information theory and source coding theorems, information theory and source coding theorems, development of noisy channel coding theorems. Fritchman

ECE 412. Advanced Digital Signal Processing (3)
Design and analysis of signal processing algorithms. Number theoretic foundations of algorithm design, bilinear algorithms, computational techniques for digital filtering and convolution, Fourier transform and its algorithms, number theoretic transforms and applications to digital filtering, general and special purpose signal processor designs, application specific techniques in signal processing. Prerequisite: ECE 343 or consent of the department chairman. Wagh

ECE 414. Signal Detection and Estimation (3) spring
Brief review of probability and random process theory. Hypothesis testing as applied to signal detection. Various optimality criterion including Bayes and Neyman-Pearson and their applications in digital communications, radar, and sonar systems. Optimum and locally optimum detection schemes for Gaussian and non-Gaussian noise. Estimation of unknown signal parameters. Topics of current interest including, distributed signal detection, robust signal detections and quantization for detection as time permits. Prerequisites: ECE 108, and Math 231 or Math 309. Blum

ECE 415. Numerical Processors (3)
Design strategies for numerical processors, cellular array adders and multipliers, conditional sum and carry-save asynchronous processors, data encoding and Booth's algorithms, use of alternate numerical bases, CORDIC trigonometric calculator, accumulator orientations, bit slice and bit-sequential processors, pipelining and parallel processing considerations. Prerequisite: ECE 201. Wagh

ECE 416. VLSI Signal Processing (3)
The fundamentals of performance-driven VLSI systems for signal processing. Analysis of signal processing algorithms and architectures in terms of VLSI implementation. VLSI design methodology. Includes a design project which requires use of a set of tools installed on SUN workstations for behavioral simulation, structural simulation, circuit simulation, layout, functional simulation, timing and critical path analysis, functional testing, and performance measurement. Prerequisite: ECE 361, ECE 343, or equivalent. Li

ECE 417. Pattern Recognition (3)

ECE 423. Digital Image Processing (3)
Fundamentals of imaging acquisition and geometry, Fourier, Hadamard, Walsh and Wavelet Transforms and their usage in image segmentation and understanding. High-pass and low-pass filtering in frequency and spatial domains. Multiresolution analysis and spatial scale filtering. Shape and texture representation and recognition. Prerequisite: ECE 343 or equivalent. Bzrakov

ECE 424. Advanced Circuits and Systems (3)
Review of linear circuit and system analysis including time domain and frequency domain solution techniques. Overview of contemporary mathematical and circuit-theoretic techniques applied to the solution of linear circuits— including, fundamental loop and cutset equations, generalized nodal, modified nodal, tableau, and mesh equation formulation, hybrid N-port network description and state equation formulation, and selected matrix and linear operator theory relevant to the solution of system equations. Discretization and computer based circuit analysis will be a fundamental theme of the course. Nonlinear and time varying networks will be discussed in this context. Frey

ECE 431. Topics in Switching Theory (3)
Emphasis on structural concepts motivated by recent advances in integrated circuit technology. Major topics include: logical completeness, decomposition techniques, synthesis with assumed network forms,
systolic architectures, systolic lemma and its applications, bit serial architectures. Prerequisite: ECE 320 or equivalent. Wagh

ECE 433. (ChE 433, ME 433) State Space Control (3)
State-space methods of feedback control system design and design optimization for invariant and time-varying deterministic, continuous systems; pole positioning, observability, controllability, modal control, observer design, the theory of optimal processes and Pontryagin’s Maximum Principle, the linear quadratic optimal regulator problem, Lyapunov functions and stability theorems, linear optimal open loop control; introduction to the calculus of variations; introduction to the control of distributed parameter systems. Intended for engineers with a variety of backgrounds. Examples will be drawn from mechanical, electrical and chemical engineering applications. Prerequisite: ME 343 or ECE 212 or ChE 386 or consent of instructor.

ECE 434. (ChE 434, ME 434) Multivariable Process Control (3)
A state-of-the-art review of multivariable methods of interest to process control applications. Design techniques examined include loop interaction analysis, frequency domain methods (Inverse Nyquist Array, Characteristic Loci and Singular Value Decomposition) feed forward control, internal model control and dynamic matrix control. Special attention is placed on the interaction of process design and process control. Most of the above methods are used to compare the relative performance of intensive and extensive variable control structures. Prerequisite: ChE 433 or ME 433 or ECE 433 or consent of instructor.

ECE 435. Error-Correcting Codes (3)
Error-correcting codes for digital computer and communication systems. Review of modern algebra concentrating on groups and finite fields. Structure and properties of linear and cyclic codes for random or burst error correction covering Hamming, Golay, Reed-Muller, BCH and Reed-Solomon codes. Decoding algorithms and implementation of decoders. Prerequisite: CSc 261 or equivalent. Tzeng.

ECE 436. (ChE 436, ME 436) Systems Identification (3)
The determination of model parameters from time-history and frequency response data by graphical, deterministic and stochastic methods. Examples and exercises taken from fast process industries, communications and aerospace testing. Regression, quasilinearization and invariant-embedding techniques for linear system parameter identification included. Prerequisite: ChE 433 or ME 433 or ECE 433 or consent of instructor.

ECE 437. (ChE 437, ME 437) Stochastic Control (3)
Linear and nonlinear models for stochastic systems. Controllability and observability. Minimum variance state estimation. Linear quadratic Gaussian control problem. Computational considerations. Nonlinear control problem in stochastic systems. Prerequisite: ChE 433 or ME 433 or ECE 433 or consent of instructor.

ECE 447. Nonlinear Phenomena (3)
Investigation of nonlinear effects in active and passive lumped and distributed circuits with emphasis on methods of analysis as well as physical understanding of jump phenomena, van der Pol’s theory, stability criteria, phase locking, Transmission line and optical waves in nonlinear media; shock waves, harmonic generation and optical parametric amplification.

ECE 450. Special Topics (3)
Selected topics in electrical and computer engineering not covered in other courses. May be repeated for credit.

ECE 451. Physics of Semiconductor Devices (3)
Crystal structure and space lattices, crystal binding, lattice waves and vibrations, electrons and atoms in crystal lattices. Quantum mechanics and energy band theory, carrier statistics, Boltzmann transport theory, interaction of carriers with scattering centers, electronic and thermal conduction. Magnetic effects. Generation and recombination theory. Application to p-n junctions. Prerequisites: Phys 31 and ECE 126 or equivalent. Decker or White.

ECE 452. Advanced Semiconductor Diode and Transport Theory (3)
Properties of metal-semiconductor contacts, Schottky barriers, ohmic contacts, hot electron transport, intervalley scattering, velocity saturation, secondary ionization, avalanche breakdown. Application of microwave devices such as avalanche and Gunn diodes, Schottky barrier diodes, tunnel diodes and PIN diodes. Prerequisite: ECE 451. Decker.

ECE 455. Theory of Metal Semiconductor and Heterojunction Transistors (3)

ECE 460. Engineering Project (3-6)
Project work in an area of student and faculty interest. Selection and direction of the project may involve interaction with industry. Prerequisite: consent of department chairperson.

ECE 461. Theory of Electrical Noise (3)

ECE 463. Design of Microwave Solid State Circuits (3)
Equivalent circuit modeling and characterization of microwave semiconductor devices, principles of impedance matching, noise properties and circuit interaction, introduction to the design of high power and non-linear circuits. Decker.

ECE 467. Semiconductor Material and Device Characterization (3)
This course covers the main characterization techniques used in semiconductor industry. Emphasis is given to the electrical characterization methods although some optical and physical analytical techniques are reviewed. The principles and the experimental set up for measuring the following parameters are covered: resistivity; carrier and doping concentration; contact resistance and Schottky barrier height; device series resistance; MOSFET’s channel length and threshold voltage; carrier mobility; oxide and interface trapped charge; and carrier lifetime. Laboratory sessions provide hands-on experience on some of the above methods. Prerequisites: ECE 126 and ECE 308, or equivalent. Hatals.

ECE 469. Process Modeling for Semiconductor Devices (3)
Students will design and "manufacture" a Si or GaAs transistor through process simulation of ion implantation, epitaxial growth, diffusion and contact formation, etc. I-V characteristics and small signal parameters, suitable for digital and microwave circuit simulation programs, will be derived. Complementary to ECE 463 and 471. Prerequisite: ECE 308 or 351. Hwang.

ECE 474. Analog CMOS VLSI Design (3)
The fundamentals of analog circuit design with CMOS linear IC techniques. Discrete Analog Signal Processing (DASP) is accomplished with switched-capacitor CMOS circuits. Analog building blocks include operational amplifiers, S/H circuits, comparators and voltage references, oscillators, filters, modulators, phase detectors/shifters, charge transfer devices, etc. Analog sub-system applications are phase-locked loops (PLL’s), A/D and D/A converters, modems, sensors, adaptive filters and equalizers, etc. The emphasis is on the physical operation of analog CMOS integration circuits and the design process. Prerequisite: ECE 355 or equivalent. White.
ECE 476. Analysis and Design of Analog Integrated Circuits (3)
Device and circuit models of bipolar and field effect transistors; bipolar and MOS integrated circuit technology; passive components; parasitic and distributed elements; amplifier gain stages; subthreshold gain stages; current sources and active loads; temperature and supply independent biasing; output stage design; frequency response and slew rate limitation; operational amplifier and analog multiplier design. Circuit simulation using SPICE. Prerequisite: ECE 308 or equivalent. Hielscher

Large signal models and transient behavior of MOS and bipolar transistors. Basic inverter and logic gate circuits. Noise margins, operating speed, and power consumption of various logic families, including MOS, CMOS, saturated logic TTL, ECL, and IHL.
Regenerative logic circuits and digital memories. Circuit design and computer aided circuit analysis for LSI and VLSI circuits. Prerequisite: ECE 308 or equivalent. Hielscher

ECE 479. Advanced MOS VLSI Design (3)
The design of very large scale NMOS and CMOS integrated circuits. Strong emphasis on device physics, and on novel circuit design approaches for VLSI implementation. Examination of second-order effects involved in designing high performance MOS digital integrated circuits, with the goal of pushing the design process to the limits determined by our current understanding of semiconductor device physics and of the currently available technologies. The topics include device physics (subthreshold conduction, short channel effects), important circuit innovations (substrate bias generators, sense amplifiers), systems aspects (clocking, timing, array structures), as well as static and dynamic circuit implementations. Design project, using VLSI design automation tools. Prerequisites: ECE 308 (or equivalent) and ECE 361. Hielscher

ECE 483. Advanced Semiconductor Devices for VLSI Circuits (3)
Theory of small geometry devices for VLSI circuits. Emphasis on MOS bipolar device static and dynamic electrical characteristics. Carrier injection, transport, storage, and detection in bulk and interfacial regions. Limitations of physical scaling theory for VLSI submicron device structures. MOS physics and technology, test pattern design, charge-coupled devices, MINOS nonvolatile memory devices, and measurement techniques for device and process characterization. The influence of defects on device electrical properties. Prerequisite: ECE 451. White

ECE 485. Heterojunction Materials and Devices (3)
Material properties of compound semiconductor heterojunctions, quantum wells and superlattices. Strained layer epitaxy and band-gap engineering. Theory and performance of novel devices such as quantum well lasers, resonant tunneling diodes, high electron mobility transistors, and heterostructure bipolar transistors. Complementary to ECE 452. Prerequisite: ECE 451. Hwang

ECE 486. Integrated Solid-state Sensors (3)
The physical operation of sensor-based, custom integrated circuits. Emphasis on the integration of sensors, analog, and digital circuits on a silicon chip with CMOS technology. Sensors include photodetectors, electrochemical transducers, strain gauges, temperature detectors, vibration and velocity sensors, etc. Analysis of sensor-circuit performance limits including signal-to-noise, frequency response, temperature sensitivity, etc. Examples of sensor-based, custom IC's are discussed and analyzed with CAD modeling and layout. Prerequisite: ECE 451. White

ECE 491. Research Seminar (1-3)
Regular meetings focused on specific topics related to the research interests of department faculty. Current research will be discussed. Students may be required to present and review relevant publications. May be repeated for credit up to a maximum of three (3) credits. Prerequisite: Consent of instructor.

ECE 492. Independent Study (1-3)
An intensive study, with report, of a topic in electrical and computer engineering which is not treated in other courses. May be repeated for credit. Prerequisite: Consent of instructor.

ECE 493. Solid State Electronics Seminar (3)
Discussion of current topics in solid-state electronics. Topics selected depend upon the interests of the staff and students and are allied to the research programs of the Sherman Fairchild Laboratory for Solid State Studies. Student participation via presentation of current research papers and experimental work. Prerequisite: consent of instructor. May be repeated for credit.

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Electrical Engineering

See listings under Electrical Engineering and Computer Science.

Electrical Engineering and Engineering Physics

This dual-degree curriculum is particularly well suited for students seeking thorough preparation in the field of electronic device physics. It is a combination of the basic electrical engineering and engineering physics curriculums and requires 162 credit hours, distributed over five years. The student will earn two degrees: B.S. in electrical engineering and B.S. in engineering physics.

Two alternative course sequences are listed below. Students who follow the course sequence in the column on the left will complete 134 credit hours, including all of the required electrical engineering courses, by the end of the fourth year and the rest of 162 credit hours at the end of the fifth year. Since the electrical engineering degree requires 135 credit hours, students normally will complete the requirements for that degree at the end of the ninth semester. It is possible for a student to earn the electrical engineering degree at the end of the eighth semester by accumulating the extra credit hour through advanced placement and/or overload credits.

In the alternate course sequence in the column on the right, the student completes 132 credit hours by the end of the fourth year, including all the required physics courses, and the rest of the 162 credits at the end of the fifth year. Since 131 credit hours are required for the engineering physics degree, the student will complete the requirements for that degree at the end of the fourth year, and the requirements for the electrical engineering degree at the end of the fifth year.

Students interested in a dual-degree program combining physics (rather than engineering physics) and electrical engineering should consult the Physics section of this catalog. That program allows the student to earn the B.S. in physics and the B.S. in electrical engineering.

Students interested in either dual-degree program should contact Prof. S. H. Radin, department of physics.

The recommended sequences of courses for the two different EEEP sequences are:

Freshman year (see Section 111)
### Engineering

Engr 1 and Engr 2 are required of all engineering and applied science majors and is taken in the recommended freshman year.

1. **Engineering Computations (3) fall-spring**
   
   Introduction to the solution of engineering problems through the use of the computer. Elementary computer programming in FORTRAN is taught and illustrated by means of several topics in computational mathematics such as roots of equations, matrices, least squares analysis, numerical integration, and others. No previous knowledge of computer programming is assumed. Prerequisite: Math 21 or 31, previously or concurrently. ES (1)

2. **Introduction to Engineering (1) fall-spring**
   
   Introduction to the engineering profession through a series of lectures and demonstrations. Emphasis is on describing the diversity of engineering career opportunities and the associated curricular choices. To be rostered by junior students in the College of Engineering and Applied Science in the semester opposite that in which ENGR 1 is rostered. Pass-fail grading.

3. **Freshman Design Experience (2) fall-spring**
   
   This course is designed to introduce students to the process of design through a series of lectures and the experience of working on a project design team. Small groups of students will work closely with a faculty member supervising a design project. Lectures will supply information about different aspects of design. Laboratory experiences will assist the student in developing the project design. All students will be required to participate in written and oral presentations.

4. **Integrated Product Development (IPD) Projects (3) spring**
   
   Business and engineering students work in cross-disciplinary teams of 4-6 students on marketing, financial, and economic planning, economic and technical feasibility of new product concepts. Teams work on industry projects with faculty advisors. Oral presentations and written reports. Open to junior or senior students in Business, Economics or Arts.

5. **Undergraduate students who are officially enrolled in the College’s Co-op program are eligible for 1-6 credits of free electives. These credits will be taken P/F. Typically, students will take 3 credits of Engr 200 for the fall semester of junior year work experience and another 3 credits for the following summer.**

6. **Computer Modeling of Scientific and Engineering Systems (3) fall**
   
   Introduction to the mathematical modeling of scientific engineering systems, with emphasis on higher-order nonlinear models for which analytical methods are precluded. Solution of the model equations by computer-based numerical algorithms. Introduction to numerical
methods for linear and nonlinear algebraic systems, ordinary and partial
differential equations, error analysis and control, stability and
numerical calculation in various applications. Prerequisites: Engr 1; Math 205,
previously or concurrently. ES (1) ED (1)

400. Engineering Co-op for Graduate Students (3) P/F
Supervised cooperative work assignment to obtain practical experience
in field of study. Requires consent of department chairperson. When
on a cooperative assignment, the student must register for this course to
maintain continuous student status. Limit to one semester per 2 years
of matriculation. This course will not count toward completion of the
Masters degree.

475. Research (1)
Projects conducted under the supervision of a faculty advisor. Includes
analytical, computational or experimental work, literature searches,
assigned readings. Regular meetings with the advisor to consider
progress made and future direction are required. The course is open only
to graduate students and may be repeated for credit. Prerequisite:
Graduate standing and departmental approval.

Engineering Mathematics

Professors. Philip A. Blythe, Ph.D. (Manchester, England) head; Terry
J. Delph, Ph.D. (Stanford); Fazil Erdogan, Ph.D. (Lehigh); D. Gary
Harlow, Ph.D. (Cornell); Stanley H. Johnson, Ph.D. (Berkeley); Arturs
Kalnins, Ph.D. (Michigan); Jacob Y. Kazakia, Ph.D. (Lehigh); Alistair
K. Macpherson, Ph.D. (Sydney); Herman F. Nied (Lehigh); Kenneth N.
Sawyers, Ph.D. (Brown); Eric Varley, Ph.D. (Brown); J. David A.
Walker, Ph.D. (Western Ontario).

Associate professors. Antonios Liakopoulos (Florida).

Assistant professors. Alparsan Oztok (Illinois).

The Division of Engineering Mathematics was established within the
Department of Mechanical Engineering and Mechanics to foster
interdisciplinary research in the application of mathematics to the
engineering and physical sciences. Interaction with industry is actively
encouraged, and appropriate programs are designed for part-time
students. Program content for all students is developed through close
consultation with Division faculty.

For a description of the graduate programs in Applied Mathematics
see the discussion under Interdisciplinary Graduate Programs.

Engineering Mathematics courses are listed under Mechanical
Engineering and Mechanics.

English

Professors. Barbara H. Traister, Ph.D. (Yale), chairperson; Rosemarie
A. Arbur, Ph.D. (Illinois); Peter G. Beidler, Ph.D. (Lehigh); Lucy G.
Moses Distinguished Professor; Addison C. Brass, Ph.D. (Louisiana
State); Jack A. De Bellis, Ph.D. (UCLA); Jan S. Fergus, Ph.D.
(C.U.N.Y.); Elizabeth N. Fifer, Ph.D. (Michigan); James R. Frakes,
Ph.D. (Pennsylvania); Edmund W. Fairchild Professor of American
Studies; Edward J. Gallagher, Ph.D. (Notre Dame); Barry M. Kroll,
Ph.D. (Michigan); Robert D. Rodale Professor of Writing; Rosemary J.
Mundhenk, Ph.D. (UCLA).

Associate professors. Alexander M. Doty, Ph.D. (Illinois); Edward E.
Lotto, Ph.D. (Indiana) director, 110 Brown; Barbara Pavloch, Ph.D.
(Cornell).

Assistant professors. Scott P. Gordon, Ph.D. (Harvard); David Hawkes,
Ph.D. (Columbia); Patricia C. Ingham, Ph.D. (UC Santa Barbara).

"Nature is a Haunted House," Emily Dickinson wrote to a friend in
1876, "but Art—a House that tries to be haunted." In the Department of
English we try to tease forward the spirits that give life to houses built
of words.

Undergraduate Major in English
The major in English is designed to give students experience in reading,
analyzing, and formulating thoughts about people and ideas that matter;
an understanding of how literary artists find the appropriate words to
express their thoughts and feelings; and a basic knowledge of the
historical development of British, American and world literature.

Students who major in English go on to careers in teaching, writing,
law, business, science, medicine, engineering—and many others. The
analytical and communication skills acquired in the study of literature
and writing will be of use in almost any profession or human activity.
Depending on their interests, abilities, and career plans, students who
major in English are encouraged to consider double majors or one or two
minors in other fields. The major in English is flexible enough to allow
cross-disciplinary study with ease.

The student majoring in English chooses from an extensive list of
courses. To ensure breadth of coverage and a deeper study of two major
writers, each English major is required to take the following courses:

Engl 123 American Literature I, or
Engl 124 American Literature II
Engl 125 British Literature I, and
Engl 126 British Literature II;
Engl 327 Chaucer or
Engl 328 Shakespeare or
Engl 331 Milton
Engl 290 Senior Seminar

In addition, each English major elects at least three more courses in
literature or film distributed as follows:

at least three courses at the 300-level, and
one course may be numbered below 300

These eight courses are the minimum for the major. Many of our
students will elect to take more, depending on their career plans, their
other majors and minors, their plans to study abroad, and so on. Each
major has a departmental advisor to assist in selecting courses and to
offer counsel about career plans.

The department strongly recommends that any student
complaining the possibility of advanced study of literature at the
graduate level should work toward departmental honors.

Departmental Honors in English
In order to receive departmental honors the English major must attain
a 3.3 grade-point average in courses presented for the major and must
complete a 12 credit hours of course work in English (beyond
English 1 and 2). For the additional credits beyond the 32 required of all
English majors, honors students must take one of the following three
courses:

Engl 248, Introduction to the English Language, or
Engl 387, Film History and Criticism, or
Engl 390, Interpretive Approaches to Literature;
and either
Engl 307 (or 308), Thesis, or
Engl 4—, a graduate seminar, by petition.

Because most graduate schools require language examinations, the
department also strongly recommends that students going for honors
achieve at least second-year college competency in at least one foreign
language. Students who complete the courses required for departmental
honors but who do not achieve the necessary grade-point average will
receive the bachelor of arts degree with a major in English.

Minors in English
The Department of English offers three minors, each requiring sixteen
hours of course work beyond English 1 and 2. Students’ major advisors
monitor the minor programs, but students should consult the minor
advisor in the Department of English when setting up a minor program.
To minor in British literature, students take Engl 125, Engl 126, and two more courses in British literature, at least one of them at the 300-level.

To minor in American literature, students take Engl 123, Engl 124, and two more courses in American literature, at least one of them at the 300-level.

To minor in writing, students take Engl 171 and one of these two courses: Engl 347 or Engl 373. They must also take two more courses chosen from Engl 173, 174, 201, 248, 281, Journ 11, 12, 123.

**Graduate Work in English**

We prepare our students to meet contemporary demands for faculty who value excellence in teaching and scholarship.

**The Master of Arts Program**

Applicants for the M.A. program should have an undergraduate English major. Students who did not major in English may be admitted but will need to supplement their undergraduate training in English.

Candidates for the master’s degree must complete at least thirty credit hours. Students take at least seven of the required courses (including “thesis papers”) at the 400 level but may select the balance of their curricula from 300-level course offerings. Course work for the M.A. must include two courses in literature before 1660; two courses in the period between 1660 and 1900; two courses from 1900 to the present; and one course in literary theory. At least two of these courses must be in American literature and at least four in British literature. Up to six hours of collateral work in other departments may be included in a master’s program.

Instead of writing the traditional “thesis,” M.A. candidates write two or three shorter “thesis papers” certified by faculty advisors as ready for submission to a session organizer as a conference presentation or to a professional journal for possible publication.

**The Doctor of Philosophy Program**

The department admits to its doctoral program only students of proven competence and scholarly promise. An average of 3.5 in M.A. course work and strong endorsements from graduate instructors are minimum requirements for acceptance.

Doctoral candidates with a Lehigh master’s degree are required to take eight courses and register for 42 credit hours beyond the M.A. Those entering the doctoral program with a master’s from another institution are required to take nine courses and register for 48 credit hours. All candidates take at least one course from the following sequence: English 421 (History of the English Language), English 423 (Old English), and English 424 (Beowulf). Candidates must also demonstrate a reading knowledge of one or two foreign languages after having agreed on choices with the Director of Graduate Studies.

No later than six months after completing their course work, candidates will write and oral examinations in one major field and two minor fields.

Candidates write their dissertations after having their dissertation proposals approved by the department and being admitted to candidacy by the Graduate School.

**Freshman Composition Requirement**

With the two exceptions noted below, all undergraduate students take six credit hours of freshman English courses: English 1 and one of the five options for the second semester, Engl 2, 4, 6, 8, 10. The exceptions are:

1. Advanced placement and six hours of Lehigh credit for freshman English are given to students who earn a score of 5 on the College Board Advanced Placement Test in English. Students who receive a grade of 4 on the Advanced Placement Test in English or who have a score of 700 or higher on the SAT Verbal Aptitude Test or the English Composition Achievement Test will receive three hours of credit in freshman English; these students will complete the six-hour requirement by taking an English course suggested by the department. Students who have an SAT Verbal Aptitude Test or English Composition Achievement Test score between 650 and 699 or who have received a grade of 3 on the College Board Advanced Placement Test in English may apply to the department for a special examination given during orientation, which, if completed successfully, will result in three hours of credit and exemption from Engl 1.

2. Students with English as a Second Language. Categories include students on non-immigrant visas, students on immigrant visas, registered aliens, and citizens either by birth or by naturalization. Students in all these categories for whom English is not the first language may petition for special instruction through the program in English as a Second Language.

At matriculation, all foreign students take an English language competence test to determine the kind of instruction best suited to their needs. Matriculating freshmen judged to be qualified will receive credit for one of the following: Engl 1, followed by Engl 2, 4, 6, 8, or 10. Others will be enrolled in Engl 3, followed by Engl 5 (or 2, 4, 6, 8, or 10).

Students enrolled in the English as a Second Language program are expected to reach a level of competence comparable to those in the usual freshman program. The form of instruction, however, will differ in the ESL program by taking into account the special problems of non-native speakers.

Matriculating students in all the above categories who are entering at a level above the freshman year, but who need composition credit, should consult the department for advice.

**Freshman Courses**

1. Composition and Literature (3)
The art of expository writing. Appropriate collateral reading.

2. Composition and Literature: Multicultural American Voices (3) spring

3. English as a Second Language (3)
Idiomatic English both oral and written, with a strong emphasis on producing well-organized, coherent essays. Enrollment limited to non-native speakers; placement is determined after testing by the Department of English.

4. Composition and Literature: Cultural Issues in Literature (3)
Continuation of Engl 1. Writing about a variety of cultural issues. Emphasis on critical reading, thinking, and writing. Texts chosen from literature, film, and other media. Prerequisite: Engl 1.

5. English as Second Language II (3)
Continuation of English 3.

6. Composition and Literature: Reading Nature (3) spring
Continuation of Engl 1. Writing about nature’s role in our culture. Emphasis on critical reading, thinking, and writing. Texts chosen from literature, film, and other media. Prerequisite: Engl 1.

7. Composition and Literature: Fiction, Poetry, Drama (3) spring

8. Composition and Literature: Experimental Topic (3) spring
Continuation of Engl 1. Writing about an important cultural issue. Emphasis on critical reading, thinking, and writing. Texts chosen from literature, film, and other media. Topic varies from year to year. Prerequisite: Engl 1.

9. Literature Seminar for Freshmen (3)
Discussion of and writing about selected masterworks of literature. Open as an elective to any freshman exempt from the regular freshman English requirement.
Undergraduate Courses

English 52, 54, 56, and 58 are open to all undergraduates, including first-year students also taking freshman English. Courses numbered at the 100-level are open to students who have completed or who are exempt from the required six hours of freshman English. First-year students who have completed English 1 with a grade of A or A– may roster one of the 100-level courses as a second English course to be taken concurrently with the second-semester English composition requirement.

Prerequisites. Each course is self-contained unit. None has any other prerequisite than two semesters of freshman English. Thus, students may roster English 126 whether or not they have had, or ever plan to take, English 125. For all courses above 200, it is understood that students will have completed six hours of freshman English, even though that is not specified in the course description.

38. (AAS 38) Introduction to African Literature (3)
Sub-Saharan African literary themes and styles; historical and social contexts. African folktales, oral poetry, colonial protest literature, postcolonial writing, and films on contemporary Africa. Scott. (HU)

52. (CIS 52) Classical Epic (3)
Study of major epic poems from Greece and Rome. Works include Homer’s Iliad and Odyssey, Apollonius’ Argonautica, Vergil’s Aeneid, and Ovid’s Metamorphoses. Pavlock. (HU)

54. (CIS 54) Greek Tragedy (3)
Aspects of Greek theatre and plays of Aeschylus, Sophocles, and Euripides in their social and intellectual contexts. Pavlock. (HU)

56. (CIS 56) The Ancient Novel (3)
Examination of the origins of the novel in Greece and Rome. Includes the picaresque novel. Pavlock. (HU)

58. (CIS 58) Greek and Roman Comedy (3)
Study of comedy as a social form through plays of Aristophanes, Menander, Plautus, and Terence. Pavlock. (HU).

91. Special Topics (1-4)
A topic, genre, or approach in literature or writing not covered in other courses. (HU)

120. Literature from Developing Nations (4)
Contemporary literature from Africa, Central and South America, and Asia. Prerequisite: six hours of freshman English. Fifer. (HU)

122. Speculative Fiction (4)
The study of “hard” science fiction and mythic fantasy from philosophical and scientific as well as aesthetic and literary perspectives. Prerequisite: six hours of freshman English. Arbur. (HU)

123. American Literature I (4)
American literature works through the mid-19th century. Prerequisite: six hours of freshman English. (HU)

124. American Literature II (4)
American literature from the middle of the 19th century to the present. Prerequisite: six hours of freshman English. (HU)

125. British Literature I (4)
British literature and literary history from Beowulf through the Pre-Romantics. Prerequisite: six hours of freshman English. (HU)

126. British Literature II (4)
British literature and literary history from the Romantic period into the 20th Century. Prerequisite: six hours of freshman English. (HU)

127. (Thr 127) The Development of Theatre and Drama I (4)
Historical survey of western theatre and dramatic literature from their origins to the Renaissance. Hall-Karambe (HU)

128. (Thr 128) The Development of Theatre and Drama II (4)
Historical survey of western theatre and dramatic literature from the Renaissance to the modern era. Hall-Karambe (HU)

155. The Novel (4)
Selected novels, with attention to such matters as narrative, characterization, and cultural context. Prerequisite: six hours of freshman English. (HU)

157. Poetry (4)
Selected traditional and modern poetry, with attention to voice, form, and cultural context. Prerequisite: six hours of freshman English. (HU)

163. Topics in Film Studies (4)
History and aesthetics of narrative film. May be repeated for credit as subject varies. Prerequisite: six hours of freshman English. Doty. (HU)

171. Writing for Audiences (4)
Practice in and criticism of expository writing beyond the freshman level. Prerequisite: six hours of freshman English. (HU)

173. Personal Writing (4)
Practice in writing from immediate experience, with emphasis on accurate, persuasive descriptive writing. Prerequisite: six hours of freshman English. (HU)

174. Creative Writing Workshop (4)
Practice in and classroom criticism of creative writing done by students taking the course. Title may vary: Short Story; Drama; Poetry, etc. May be repeated for credit. Prerequisite: six hours of freshman English. (HU)

175. Individual Authors (4)
Intensive study of the works of one or more literary artists, such as Austen, Hemingway, and Kerouac. May be repeated for credit as authors and works vary. Prerequisite: six hours of freshman English. (HU)

177. Individual Works (4)
Intensive study of one or more literary works, such as Moby Dick and Stories of John Cheever. May be repeated for credit as works vary. Prerequisite: six hours of freshman English. (HU)

183. Independent Study (1-4)
Individually supervised study of a topic in literature, film, or writing not covered in regularly listed courses. Prerequisite: consent of the department chairperson. (HU)

187. Themes in Literature (4)
Study of a theme as it appears in several works of literature, such as Utopia and the quest. May be repeated for credit as titles and themes vary. Prerequisite: six hours of freshman English. (HU)

189. Popular Literature (4)
The form of literature that has been designated in one way or another as “popular,” such as folklore and detective fiction. May be repeated for credit as titles vary. Prerequisite: six hours of freshman English. (HU)

191. Special Topics (1-4)
A topic, genre, or approach in literature or writing not covered in other courses. Prerequisite: six hours of freshman English. (HU)

201. Special Topics in Writing (1-4)
Approaches not covered in other writing courses. Individual projects. May be repeated for credit. Prerequisite: Engl 171, or consent of department chair. (HU)

248. Introduction to the English Language (4)
Basic linguistic concepts together with a historical survey of the English language. Ingham. (HU)
281. Internship (1-4)
Projects on or off campus in business, professional, or government organizations. Projects approved by department committee on internships and supervised by department internship adviser. Project includes extensive writing that can be submitted for evaluation. Enrollment limited to juniors or seniors with a major or minor in English. May be repeated for credit. Prerequisite: consent of department chair. (ND)

290. Senior Seminar (4)
In-depth study of a problem, issue, question, or controversy. Enrollment limited to 15 students. Required Writing Intensive course for English majors. May be repeated for credit, space permitting, as title varies. DEPARTMENT APPROVAL REQUIRED. Prerequisite: senior English major standing. Staff (HU)

291. Special Topics (1-4)
A topic, genre, or approach in literature or writing not covered in other courses. (HU)

Graduate Students taking 300-level courses receive 3 credits.

301. Topics in Literature (4)
A topic, genre, or approach in literature, such as autobiography as literature and the gothic novel. May be repeated for credit as titles vary. (HU)

307. Undergraduate Thesis (3)
Open to advanced undergraduates who wish to submit theses in English. Prerequisite: consent of the department chairperson. (HU)

308. Undergraduate Thesis (3)
Open to advanced undergraduates who wish to submit theses in English. Prerequisite: consent of department chairperson. (HU)

311. (WS 311) Literature of Women (4)
Women's works about women. Besides re-reading familiar feminist's fiction, drama, and poetry, an introduction to contemporary and often experimental works by less famous writers. Arburg. (HU)

316. Native American Literature (4)
Fiction by modern American Indian writers like N. Scott Momaday, Leslie Marmon Silko, James Welch, Michael Dorris, and Louise Erdrich. Some attention given to the history of the relationships and conflicts between Native Americans and the federal government, white agricultural and business interests, and educational and religious interests. Beidler (HU)

327. Chaucer (4)
The Canterbury Tales, with some attention to other Chaucerian works and other works that may have provided source-materials for Chaucer's tales. Chaucer's language and the literary, intellectual, social, and historical backgrounds to his work. Beidler (HU)

328. Shakespeare (4)
An introduction to Shakespearean drama including comedies, histories, tragedies, and romances. Emphasis on textual study, cultural contexts, and performance strategies. Hawkes, Traister (HU)

331. Milton (4)
The poetry and prose of John Milton, in the context of the English Revolution. Particular attention to the intersection of theology and philosophy, and of the personal with the political. Hawkes. (HU)

347. The Essay (4)
Sustained work in writing and revising expository prose; classroom criticism in a workshop environment; grading by portfolio. (ND)

360. Middle English Literature (4)
Major literary works of the Middle English period by authors other than Chaucer. Emphasis on Piers Plowman, the Gawain/Pearl Poet, and the metrical romances. Ingham. (HU)

362. The Sixteenth Century (4)
Humanist, Petrarchan and dramatic traditions in the literature of Renaissance England. Readings from such authors as Erasmus, More, Wyatt, Sidney, Spenser, and Marlowe. Traister (HU)

364. The Seventeenth Century (4)
Literature of the seventeenth century, by such writers as Donne, Herbert, Jonson, Browne, Burton, Milton, Hobbes, Bunyan, and Locke, chronicling the unprecedented variety of aesthetic, political, and social innovations in this “century of revolution.” Hawkes, Traister. (HU)

366. The Restoration and Eighteenth Century (4)
Restoration and early eighteenth-century literature, with attention to the cultural forces that shaped the writers and their works. Readings will include Dryden, Behn, Rochester, Wycherley, Congreve, Swift, Finch, Pope, Addison and Steele. Gordon (HU)

367. The Eighteenth Century (4)
Poetry, drama and prose of the eighteenth century, with attention to cultural forces that shaped the writers, their works, and their position in the canon. Readings of Montagu, Burney, Wollstonecraft, Austen, Fielding, Richardson, Johnson, Sheridan, Sterne, in addition to a few earlier writers. Fergus, Gordon (HU)

369. British Romantic Literature (4)
Poetry and prose of Wordsworth, Coleridge, Byron, Shelley, and Keats within the contemporary, political, religious, and social context. (HU)

371. British Victorian Literature: Prose and Poetry (4)
Poetry and prose of Tennyson, Browning, Arnold, Swinburne, Carlyle, Mill, Newman, and Ruskin within the contemporary political, religious, and social contexts. Bross. (HU)

372. British Victorian Literature: Fiction (4)
Major fiction of the Victorian era by such writers as Dickens, Eliot, Thackeray, and Hardy within historical, social, and aesthetic contexts. Mundhenk. (HU)

373. Advanced Creative Writing Workshop (4)
Advanced practice in and classroom criticism of creative writing done by students taking the course. Emphasis may vary among: Fiction, Poetry, Creative Essay, Drama, etc. May be repeated for credit. Prerequisite: English 174, or permission of Writing Minor Advisor. (ND)

375. Major Authors (1-4)
The works of one or more major literary figures studied in depth. May be repeated for credit as titles and authors vary. (HU)

376. Early American Literature (4)
The literature of New England, the Middle Colonies, the South, and the Southwest from Columbus to the close of the eighteenth century, emphasizing our cultural and artistic diversity. Gallagher. (HU)

377. American Romanticism (4)
Emerson, Thoreau, Whitman, Hawthorne, Melville, Dickinson, Poe, and their contemporaries. Philosophical, historical, and social background, as well as the aesthetic study of romantic literary works. Arburg, DeBellas. (HU)

378. American Realism (4)
Theory and practice of realistic and naturalistic fiction from the Civil War to the early twentieth-century: Twain, Howells, James, Norris, Crane, Dreiser, Wharton, and regionalists. Frakes. (HU)

379. Twentieth-Century American Literature (4)
American literature before World War II. Lectures and class discussion of major fiction and poetry. DeBellas, Mundhenk. (HU)
430. Contemporary American Literature (4)
American literature since World War II. Lectures and class discussions of new writers and of recent works of established writers. DeBellis, Frakes. (HU)

382. Themes in American Literature (4)
Intensive study of one topic in American literature. Readings from the colonial period to the present. May be repeated for credit as title varies. (HU)

383. Modernism and Post-Modernism in Fiction (4)
The “anti-realistic” novel; time/space, point of view, narrative voice, structure as meaning. Kafka, Woolf, Beckett, Nabokov,Robbie-Grillet, Faulkner, Borges, Hawkes, Stein. Frakes. (HU)

384. Twentieth-Century World Literature (4)
World literature (Europe, Asia, South America, Africa) from 1900 to present. Fifer (HU)

385. Modern British and Continental Literature (4)
World English literature and continental literature before World War II. Lectures and class discussion of major fiction. Frakes. (HU)

386. Contemporary British and Continental Literature (4)
World English literature and continental literature after World War II. Fifer, Frakes (HU)

387. Film History, Theory, and Criticism (4)
Study of film with the focus on particular genres, directors, theories, periods, or topics. Weekly film screenings. May be repeated for credit as title varies. Doty. (HU)

388. Independent Study (1-4)
Individually supervised study of a topic in literature, film, or writing not covered in regularly listed courses. Prerequisite: consent of department chairperson. (HU)

390. Interpretation: Critical Theory and Practice (4)
Introduction to recent literary and cultural theory, such as New Criticism, Structuralism, Marxism, Psychoanalytic approaches, Reader-response Criticism, Deconstruction, Feminist Theory, New Historicism, and Cultural Criticism. Arbur, Bross, Gordon Mundhenk. (HU)

391. Special Topics (1-4)
A topic, genre, or approach in literature or writing not covered in other courses. (HU)

Graduate Courses in English
The following courses are seminars, ordinarily limited to no more than twelve graduate students, but undergraduate English majors who are planning to go on to graduate school in English and who have shown proficiency in the study of literature may petition to take one of these seminars in their senior year.

400. Supervised Teaching (1)
Practical experience in teaching through assisting a faculty teacher in conduct of a regularly scheduled undergraduate course. Open only to graduate students with at least one semester of graduate course work at Lehig University and a GPA of at least 3.5 Usually rostered in conjunction with 485. Prerequisite: Consent of the department chairperson.

421. History of the English Language (3)
The phonology, grammar, and lexicon of English from the beginnings to the present. Ingham

423. Anglo-Saxon Language and Literature (3)
An introductory study of the Anglo-Saxon culture through its language and literature. Special attention given to translation and interpretation of the epic poem Beowulf. Ingham

433. Middle English Literature (3)
Course may be repeated for credit as title varies. Possible offerings:
Arthurian Romance and History: An inquiry into medieval Arthurian literature from Celtic traditions to Malory's "Morte D'Arthur." Focus given to the confluences of these texts with fantasy and politics, and the problems of a literary history that understands "romance" and "history" as opposing terms. Ingham

Chaucer: A study of selected works by GeoCey Chaucer, with attention to his language, his sources, his cultural backgrounds that inform his poetry, and trends in modern criticism of his works. Beider

Insular Literary Cultures: A study of selected "British" works from a variety of cultures (Scots, Irish, Welsh, Middle-English, Anglo-Norman, Manx, Lollard, etc.) written (or popular) from 1300-1500. Careful attention given to reading texts in a larger cultural (and "multi-cultural") context. Ingham.

Origins of British Drama: A study of several medieval plays, like Everyman, the Second Shepherds' Play, and selected plays in one of the mystery play cycles. Brief consideration of the dramatic techniques of Chaucer's poetic fiction as a precursor to the drama that was to flourish centuries later. Beider

439. Sixteenth-Century British Literature (3)
Course may be repeated for credit as title varies. Possible offerings:

City and Court under Elizabeth and James: Study of how the City (London) and the Court under each monarch are represented in contemporary texts--drama, poetry, letters, sermons, and prose tracts. Traister

441. Seventeenth-Century British Literature (3)
Course may be repeated for credit as title varies. Possible offerings:

Theology and Interpretation in the Renaissance: Drawing on the hermeneutics of Luther and Calvin, the course will focus on how English writers of the sixteenth and seventeenth centuries elaborated a distinctively Protestant mode of signification. Writers studied will include Jonson, Donne, Herbert, Traherne, Browne, and Bunyan. Hawkes

442. Restoration and Early Eighteenth-Century British Literature (3)
Course may be repeated for credit as title varies. Possible offerings:
Restoration and Early Eighteenth-Century Drama: Examination of the drama written between 1660 and 1720 and of the culture shaping it and shaped by it. Cavendish, Philips, Dryden, Bohn, Wycherley, Etherege, Congreve, Shadwell, Steele will be among the writers we study. Gordon

Tory Feminism? Close investigation of the complex position of early modern women writers (including Cavendish, Philips, Bohn, Pix, Centlivre, Finch, Montagu); consideration of the conditions of authorship, for men and women, in late seventeenth-century Britain. Gordon

Frances Burney and Jane Austen: Major novels of Burney and the novels and juvenilia of Austen in their social and literary contexts. Examination of what it means to be a professional woman writer between 1770-1820. Fergus
445. Nineteenth-Century British Literature (3)
Course may be repeated as title varies. Possible offerings:
The Victorian Novel and Poststructural Theory: Intensive study of three or four Victorian novels, by writers such as Dickens, Eliot, Bronze, and Thackeray, through the lens of Feminist, Marxist, Psychoanalytical, Deconstructive, and Cultural theory. Mundhenk

The Problem of Knowledge in the Victorian Age: Given the new kinds of knowledge emerging in their time, such writers as Dickens, Carlyle, Mill, Marx, Eliot, Tennyson, Browning, Arnold, Ruskin, and Newman had to ponder the question: What notions—religious doctrines, for example, or scientific observations—should be considered "knowledge"? Bross

449. Twentieth-Century British Literature (3)
Course may be repeated as title varies. Possible offerings:
James Joyce: Close examination of the works of James Joyce, with special attention to style, narrative voices, and thematic complexity. Frakes

Modern British Fiction: Concentration on one or more major figures: Joyce, Conrad, Shaw, Forster, Woolf, Lawrence, Beckett. Revitalized "New Critical" approaches. Frakes

471. Early American Literature (3)
Course may be repeated as title varies. Possible offerings:
Benjamin Franklin and the American Character: In-depth study of Franklin's work, life, and career, as well as study of his influence and reputation through works written about him—something, some vicious—from John Adams to John Updike. Gallagher

Early American Literature: A broad survey of literature from Columbus to the end of the eighteenth century, focusing on important writers, geographical and cultural diversity, and diverse literary forms (history, sermon, poetry, autobiography, novel, travel narrative, political essay). Gallagher

473. Nineteenth-Century American Literature (3)
Course may be repeated as title varies. Possible offerings:
Emerson, Dickinson, Frost: Emerson's philosophy, literary theory, and poetry as the context in which we consider the poetry of Dickinson and Frost. Arbur

Literary Watersheds: Close reading, critical reputation, and contemporary approaches to four works that transformed and invented our national literature: Moby Dick; Uncle Tom's Cabin, Walden, and Leaves of Grass. Arbur

Henry James: Close Examination of the works of The Master: short stories, novellas, and major novels. Varied critical approaches. Frakes

Literary Realism and Naturalism: Selected fiction by one or more of the following pioneers in American literary realism and literary naturalism: Henry James, Mark Twain, Stephen Crane, William Dean Howells, Frank Norris, and Theodore Dreiser. Frakes

477. Modern American Literature (3)
Course may be repeated for credit as topic varies. Possible offerings:
Ernest Hemingway: Heightened "New Critical" approaches to the short stories and major novels of Ernest Hemingway. Frakes

Modern American Fiction: Heightened "New Critical" approaches to one or more major fiction writers from 1900 to 1950: Hemingway, Faulkner, Fitzgerald, Dos Passos, West, Porter. Frakes

Modern Southern Writers: Major Southern writers since 1920 from all regions including Styron, O'Connor, Williams, Faulkner, Welty, Percy, Porter, Ransom, Tate, and Warren. All genres, and some sub-genres like "Southern Gothic," will be studied, along with social and philosophical influences. DeBellis

Modern American Poetry: The significant poets from 1900 to 1960. The major emphasis falls upon Eliot, Pound, Stevens, and Williams, but other poets could include Cummings, Frost, Stein, Hughes, Lowell, Plath, Moore, Dickey, Roethke, and Warren. DeBellis


Contemporary American Drama: Drama from the 1950's to the 1990's. Such playwrights as Mamet, Shepard, Fornes, Wilson, Norman, Howe, Wasserstein, Durang and others. Fifer

Contemporary Native American Fiction: Short stories and novels by American Indian writers since the mid-1960's including Momaday, Silko, Welch, Dorris, and Erdrich. There will be special focus on the novels of Louise Erdrich. Beidler

480. Composition and Rhetoric (3)
Basic theories and works in composition and rhetoric, with some attention to classical rhetoric, but with primary emphasis on modern rhetoric and discourse theory, including Burke, Kinneavy, Moffett, and Britton, as well as theories of the writing process. Consideration of linguistics as it applies to teaching writing, and the history of teaching writing in America. Kroll, Lotto

481. Theory and Criticism (3)
Course may be repeated for credit as title varies. Possible offerings:
Theories of Authorship in Literature and Film: Material from Western Romanticism through theorists such as Derrida, Barthes, and Foucault. Focus on film auteurism and structuralist, post-structuralist, and feminist, Marxist, and gay/lesbian challenges to and reconceptualization of notions of authorship. Doty

The Ideology of the Aesthetic: Consideration of the aesthetic impulse and its relationship to rhetoric and literary criticism. Readings from Lentricchia, Eagleton, the Frankfurt School, Jameson, Burke, Bakhtin, and Bourdieu. Lotto


Advanced Critical Theory: Study of several important and influential recent theoretical texts. Emphasis on "pure" rather than "applied" theory: readings from Macherey, Derrida, Baudrillard, Kristeva, and Jameson. Hawkes

Feminist Theory: Culture, Gender, and Agency: A study of selected works of feminist theory with special emphasis on the interventions gender theorists have made into discourses of culture and agency. Readings from Irigaray, Kristeva, Rubin, deBeauvoir, Hooks, Spillers, Abel, Abarcon, Harraway, Butler, and others. Ingham

485. Introduction to Writing Theory (2)
Survey of major approaches and theoretical issues in the field of composition and rhetoric. Required of all new teaching assistants in the department. Usually rostered in conjunction with 400 or 486.
486. Teaching Composition: A Practicum (1)
Introduction to teaching writing at Lehigh. Bi-weekly discussions of practical issues and problems in the teaching of freshman composition. Required of all new teaching assistants in the department. Usually rostered in conjunction with English 485.

491. Special Topics (1-3)
A topic, genre, or approach in literature or writing not covered in other courses. May be repeated for credit as title varies. Prerequisite: consent of the graduate program coordinator.

493. Graduate Seminar (3)
Intensive study of, the works of one or more authors, or of a type of literature. May be repeated for credit as title varies.

495. Independent Study (3)
Individually supervised course in an area of literature, film or writing not covered in regularly listed courses. Prerequisite: consent of the graduate program coordinator.

English as a Second Language

Program Director, Judith A. Rance-Roney, Ed.D. (Lehigh)

English as a Second Language courses are offered to both undergraduates and graduates who wish to increase English proficiency in the areas of writing, reading, speaking, and presentation skills. All courses are at an advanced level of English study. For undergraduates, these courses are designed to supplement, not replace, English Department required courses, such as courses towards the freshman writing requirement. An undergraduate may count a maximum of four credit hours of ESLP courses towards an undergraduate degree. For graduate students, the courses are designed around your graduate major field. Graduate students should contact their departments regarding acceptance of credit towards residency requirements. ESLP courses may be repeated for credit with a maximum of three repetitions.

Enrollment. ESL courses during the fall and spring semesters are open to regularly enrolled students at Lehigh University. Therefore, visas cannot be issued for English language courses alone, nor can students be admitted to Lehigh University only to study ESL except on a one or two course basis under the General College Division students (GCD) Program and with the permission of the ESL Director.

Summer Intensive Program. In June, July and August, a special non-credit intensive ESL program called STEP/UP is offered to advanced ESL students who wish to study university/academic English in a challenging environment. This program is open to all ESL students. Unlike the fall and spring courses, contact the ESL Program for more information and a brochure.

Testing. English language proficiency testing is conducted for all new incoming undergraduate and graduate students whose first language is not English during new student orientations in August and January. Specific placement in courses will be determined based on the results of this testing.

The Freshman Composition Requirement. The courses English 3 and English 5, composition for ESL students, may be applied towards the composition requirement for undergraduates. See the English Department course listings for additional information.

Courses:

ESLP 1 ESL Advanced Structure, Grammar, and Semantics (1)
Instruction in understanding and using advanced English sentence structures in writing and speaking. Advanced academic vocabulary and grammar development to improve writing sophistication and accuracy. 4 hours per week.

ESLP 2 ESL Academic Writing and Reading (1)
The writing process and composing skills, editing skills, vocabulary development and reading fluency for ESL students. Required for graduate students who score below 73 on the Michigan Test and/or for students needing additional writing proficiency. Undergraduates may enroll after or concurrent with English 3. 6 hours per week.

ESLP 3 ESL Clear Speech and Conversation (1)
Conversational English, colloquial language and idioms, pronunciation and accent reduction and practice in basic listening skills for an academic setting. Basic oral language development for graduate or undergraduate students. 4 hours per week.

ESLP 4 ESL Academic Speaking (1)
Correct use of grammatical structures in oral English and practice in accurate pronunciation. ESL students will explore the functions of American English in an academic setting. For graduate and undergraduate students who wish to perfect advanced speech. 4 hours per week.

ESLP 11 ESL Technical Writing and Composition (1)
Formal composition and technical writing including general technical vocabulary, technical sentence structure, and research skills for the advanced ESL student. Prerequisite: successful completion of ESL 1 (ESL Academic Writing and Reading) or ENGL 5, or with permission of ESL Director. 4 hours per week.

ESLP 12 ESL Advanced Speech and Presentation Skills (1)
Development of advanced speaking skills and presentation techniques through a study of formal spoken rhetoric, accent reduction, and platform skills. For the undergraduate or graduate student seeking formal speech skills and/or for teaching assistants. (Required for TAs with SPEAK scores 200 - 229) Prerequisite: successful completion of ESLP 2 (302) or ESLP 3 (303), or SPEAK score 180+ or permission of ESL Director. 4 hours per week.

Environment and Society

This program, based principally in the College of Arts and Sciences, is designed for students interested in how people both create and respond to environmental problems, issues, and constraints. By emphasizing the interrelation between human social systems and environmental circumstances, the minor complements Lehigh’s programs in environmental science and engineering and should be especially attractive to students in those majors.

Many of the minor’s approved courses focus on the public policies and discourse associated with current environmental issues; others focus on the longer-term adaptations of social systems to changing environmental situations. Only a couple of the courses in the minor have specific prerequisites; so students can easily select a minor program to suit their personal tastes and interests, especially if the minor is declared by the end of the sophomore year.

Each student’s minor program consists of courses totalling 16 credits chosen in consultation with the program director from among the courses listed below. The only stipulation is that at least eight credits must be in “core” courses (i.e., courses in which 75%-100% of the subject matter concerns environment and society).

For further information, please contact the program director, Sharon M. Friedman, Department of Journalism and Communication, University Center, Room 8C, (758-4179).
Core Courses (minimum of 8 credits)

Anth/Ciss 121 Environment and Culture (3)
Anth 305 Anthropology of Fishing (3)
CE 172 Fundamentals of Environmental Pollution (3)
Eco 311 Environmental Economics (3)
Eco 314 Energy Economics (3)
Hist 315 American Environmental History (4)
Jour 125 Environment, the Public, the Mass Media (4)
Jour 323 Scientific and Environmental Controversies (4)
Pols 111 The Politics of the Environment (4)

Related Courses

Anth 12 Human Evolution and Prehistory (3)
Anth/Ciss 345 Evolution of the State (3)
Jour/STS 124 Politics of Science (3)
Jour 313 Special Topics in Science Writing (1-4)
Pols 115 Technology as Politics (4)
Pols 177 Urban Politics (4)
Rel 6 Religion and the Ecological Crisis (4)
SSP 165 Contemporary Social Problems (3)

[16 credits are required for the environment and society minor]

Environmental Writing

See Listings under Journalism and Communication

Finance

Professor: Stephen G. Buell, Ph.D. (Lehigh).
Associate professors: James A. Greenleaf, Ph.D. (N.Y.U.)
Chairperson, Department of Business: Richard J. Kish, Ph.D. (Univ. of Florida); Stephen F. Thode, D.B.A. (Indiana); Gerald M. Vasconcellos, Ph.D. (Univ. of Illinois).
Adjunct professors: David L. Muething, Ph. D. (M.I.T.); Samuel C. Weaver, Ph.D. (Lehigh).

The finance major offered by the Department of Business requires fifteen credit hours beyond the core requirements. Each finance major selects either the Business Finance or Financial Economics track.

Business Finance

required courses:

Fin 323 Investments (3)
Fin 328 Corporate Financial Policy (3)
plus two of the following:
Fin 324 Security Analysis (3)
Fin 330 Financial Flows and Markets (3)
Fin 331 Bank Management (3)
Fin 332 Multinational Business Finance (3)
Fin 334 Speculative Markets (3)
Fin 335 Advanced Financial Modeling (3)
Fin 336 Real Estate Finance (3)
plus one additional 300-level finance or finance/economics course.

Financial Economics

required courses:

Fin 323 Investments (3)
Fin 328 Corporate Financial Policy (3)
plus two of the following:
Fin 332 Monetary-Fiscal Policy (3)
Fin 340 International Finance (3)
Fin 353 Public Economics and Government Finance: Federal (3)
Fin 354 Public Economics and Government Finance: State and Local (3)
plus one additional 300-level finance or finance/economics course.

For Advanced Undergraduates and Graduate Students

Courses numbered 200 and above in the college of business and economics are open to sophomores only on petition.

Fin 225. Business Finance (3) fall, spring
Introductory corporation finance, which stresses a managerial approach to asset management and capital structure. Financial policies regarding the acquisition of funds and their allocation among competing assets within the firm. Prerequisites: Eco 145, Eco 115, Math 41 and 44 or Math 51, Acc 151. Buell

Fin 240. Introduction to Real Estate (3) spring
A survey of the four broad perspectives of real estate: legal, economic, financial, and business. Topics include: legal and physical rights to real estate; the nature and operation of real estate markets; valuation and appraisal of real estate; financing alternatives; and the real estate development process. Prerequisite: Fin 225 or permission of instructor.

Fin 323. Investments (3) fall, spring
The nature of risk and the form of returns to financial assets. Investor objectives, attitudes, and constraints are considered within the risk-return matrix as the basis for investment decisions. Problems of timing, market characteristics, and portfolio management. Prerequisite: Fin 225. Kish

Fin 324. Security Analysis (3) fall
Factors influencing the value of financial securities: earnings forecasts and expectations, uncertainty, required returns, supply and demand for securities and funds, and investor attitudes. Implications of market factors, technical approaches, timing, and screening. Prerequisites: Fin 323. Not ordinarily open to CBE graduate students. Kish

Fin 328. Corporate Financial Policy (3) fall, spring
Advanced corporate finance; capital budgeting, working capital management, leasing, mergers, and financing. Case studies and complex problems. Prerequisite: Fin 225. Not ordinarily open to CBE graduate students. Thode, Kish

Fin 330. Financial Flows and Markets (3) fall
Functions and portfolios of financial intermediaries. Sectoral demand and supply of funds, nature and role of interest rates, term structure and forecasting, impact of inflation and regulation on financial intermediaries and markets, and current developments in the financial system. Prerequisites: Eco 129 or 229 and Fin 225. Not ordinarily open to CBE graduate students. Vasconcellos

Fin 331. Bank Management (3) spring
Management of bank assets and liabilities within U.S. system’s legal and economic constraints. Bank Management Simulator is used to examine relationships between asset, liability, and profitability decisions. Prerequisites: Eco 129 or 229 and Fin 225 senior standing or consent of instructor. Not ordinarily open to CBE graduate students. Vasconcellos

Fin 332. (Eco 332) Monetary-Fiscal Policy (3)
Monetary, credit and fiscal policies of government and central banks, with particular reference to the policies of the United States Treasury and the Federal Reserve System. Prerequisite: Eco 119 or 129 or 229.

Fin 333. Multinational Business Finance (3) fall
Issues that underlie the investment, financing, and dividend decisions of multinational firms. Current transactions in foreign currencies, direct and portfolio investment and associated risk management when dealing in foreign countries. Prerequisite: Fin 328. Not ordinarily open to CBE graduate students. Vasconcellos
Fin 334. Derivative Securities Markets (Options, Futures, etc.)
(3) spring
Theoretical and practical aspects of various instruments and markets that involve financial derivative securities (options, futures, swaps, CMO’s, etc.). Emphasis on applications to corporate finance and portfolio management. Prerequisite: Fin 323. Greenleaf

Fin 335. Advanced Financial Modeling (3) fall
Modeling of complex financial decisions including bond refunding, security valuation, option pricing, currency swaps, and leasing. Utilizes the problem-solving capabilities of modern microcomputer spreadsheets. Prerequisites: Fin 323 and Fin 328 or consent of instructor. Not ordinarily open to CBE graduate students. Buell, Thode

Fin 336. Real Estate Finance (3) fall
An advanced survey of modern residential and commercial real estate financing techniques from the viewpoints of the borrower and the lender. Topics include: the principles of financing decisions; financing methods and techniques; institutional sources of funds for real estate, and real estate financing decision-making. The course includes lectures, demonstrations, spreadsheet software exercises, and guest speakers. Prerequisite: Fin 225. Thode

Fin 340. (Eco 340) International Finance (3)
Analysis of balance of payments and disturbances and adjustment in the international economy; international monetary policies. Prerequisite: Eco 129 or 229. Callahan, Gunter

Fin 353. (Eco 353) Public Economics and Government Finance: Federal (3)
A course dealing with the expenditures and revenues of the Federal government. Major topics include public choice theory, benefits-cost analysis, the theory of public goods, the economics of taxation and the design of tax structures. Prerequisites: Eco 1 or Eco 11 and 12.

Fin 354. (Eco 354) Public Economics and Government Finance: State and Local (3)
A course dealing with the expenditures and revenues of state and local governments. Major topics include the theory of fiscal federalism, intergovernmental fiscal transfers, the design of state and local tax structures, capital budgeting and debt finance, pension funds and school finance. Prerequisites: Eco 1 or Eco 11 and 12.

Fin 371. Directed Readings (3)
Readings in various fields of finance designed for the student with a special interest in some field of finance not covered in scheduled courses. Prerequisite: consent of the department chairperson. May be repeated.

Fin 372. Special Topics (1-3)
Special problems and issues in finance for which no regularly scheduled course work exists. When offered as group study, coverage varies according to interests of instructor and students. Prerequisite: consent of department chairperson. May be repeated.

Fin 373. Finance Internship (1-3)
Based on a student’s work experience, a sponsoring faculty member shall direct reading, projects and other assignments - including a “capstone report.” It should be noted that the work experience, by itself, is not the basis for academic credit. The faculty directed activity may be provided concurrent with the work or as a follow up to the work experience. In the latter case (follow up), arrangements must be made in advance of the work engagement so as to enhance the follow up experience (keeping logs, concurrent reading assignments, etc.). Prerequisites: Fin 323 and Fin 328.

Fin 374. Portfolio Management Practicum (1-3)
Readings, projects and papers designed to complement the leadership and analytical activities associated with the management of the Student Investment Club portfolio and similar activities. Prerequisites: Fin 323 and permission of instructor.

Fin 377. Advanced Topics - Investments (3, may be repeated)
Advanced topics relating to specific areas of investment such as derivatives, global investing, and quantitative analysis. The intent is to provide in-depth coverage of selected areas that can only be given cursory attention in the introductory course (Fin 323). The course content may vary between instructors and over time. Prerequisite: Fin 323. Department permission required.

Graduate Courses

GBUS 406. Financial Management (3)
Introduction to financial management. Topics include: financial statement analysis, capital budgeting, capital structure, valuation, risk analysis, and working capital management. Prerequisite: GBUS 401 Weaver, Kish, Thode.

GBUS 420. Investments and Portfolio Management (3)
A survey course in investments. Primarily from the perspective of an institutional investor, but consideration given to corporate finance and personal investing. Topics include: valuation, risk management, and portfolio theory. Course includes exposure software and databases used by “Wall Street” professionals. Prerequisite: GBUS 406 Greenleaf

GBUS 421. Advanced Investment and Portfolio Analysis (3)
Theoretical and empirical examination of recent developments in portfolio theory. Prerequisite: GBUS 420. Greenleaf, Muething

GBUS 422. Options and Financial Futures (3)
Examination of the theory and applications of a variety of derivative instruments used in corporation finance, banking and investments. Topics include: forward contracts (including swaps and repos), futures contracts, and options (listed over-the-counter, and embedded). Prerequisite: GBUS 420

GBUS 423. (ECO 423) Valuation Seminar (3)
Determinants of financial asset values. The role of uncertainty, imprecise forecasts, risk preferences, inflation, and market conditions. Prerequisite: GBUS 406. Kish

GBUS 424. Cases in Financial Management (3)
Integration of multiple topics in corporation finance through analysis of complex cases, including: capital budgeting, working capital management, leasing, mergers, and financing. Prerequisite: GBUS 406. Thode

GBUS 425. Real Estate Finance and Investing (3)
An upper-level course in modern real estate financing techniques from the perspectives of both the borrower and the lender. Subject matter encompasses the following areas: The Principles of Financing Decisions; Financing Methods and Techniques; Institutional Sources of Funds for Real Estate; and, Real Estate Financing Decisions. Students are assumed to have backgrounds in the basics of finance, micro and macroeconomics, statistics and quantitative analysis. The course consists of: lectures, demonstrations, software applications, and practitioner presentations. Thode

GBUS 426. Financial Management of Financial Institutions (3)
Asset and liability management of commercial banks, savings and loan associations, life insurance companies, and pension funds. Short and long run responses to changes in economic conditions, interest rates, and regulations. Prerequisite: GBUS 406. Vasconcellos

GBUS 427. (ECO 427) Banking and Monetary Policy (3)
Analysis of the U.S. monetary and banking systems. Financial markets. Central bank controls, monetary theory and policy. Prerequisite: a course in money and banking. Innes

GBUS 428. (ECO 428) Capital and Interest Theory (3)
Theories of interest and capital. Annuities; applications of present value theory; investment valuation under uncertainty and risk; term structure of interest rates; the theory of savings, cost of capital and capital formation. Prerequisite: a course in finance.
Fundamental Sciences


The curriculum in fundamental sciences is designed to enable students to achieve a breadth of academic background in the fields of modern science and at the same time, through an option, to master the discipline of one of them, approximately to the level of a minimum bachelor's program. The options and electives provide sufficient flexibility to enable a student to prepare for employment in industry or government for graduate study in a field, or for teaching mathematics or science at the secondary level. Fundamental science students are required to concentrate in a major. Students can organize acceptable programs including the substantive course elements related to any one among several areas such as chemistry, physics and mathematics, biology, earth and space science, science of living systems, materials, computer science, and architecture, or meaningful combinations of any two.

The freshman year is identical with that of all students in the College of Engineering and Applied Science. The Humanities and Social Science requirements of the college must also be satisfied. The discipline of a field will be provided by the inclusion of at least fifteen semester hours or from a combination that constitutes the core of one of the combination fields. Examples of these combination majors include: biochemistry, geophysics, bioengineering, applied mathematics, biophysics, and computer science. Students pursuing double concentrations may, with the approval of their adviser, substitute for one of the science courses of the sophomore year a basic course in the area of concentration.

The details of the student's program are worked out by the student with the advice of the curriculum adviser, and with the approval of the department chairperson concerned with the fields of concentration.

Recommended Sequence of Courses

freshman engineering year (see Section III)

sophomore year, first semester (15 credits)
EES 31 Introduction to Environmental and Organic Biology (4) or
EES 21 Introduction to Earth Materials and Processes and Laboratory (4)
Chm 51,53 Organic Chemistry and Laboratory (4)
Math 23 Analytic Geometry and Calculus III (4)
Eco 1 Economics (4)

sophomore year, second semester (17 credits)
major subject (3)
approved elective (3)
Math 205 Linear Methods (3)
Phys 21,22 Introductory Physics II and Laboratory (5)
HSS elective (3)

junior year, first semester (16 credit hours)
EES 21 Introduction to Earth Materials and Processes and Laboratory (4) or
EES 31,32 Introduction to Environmental/ Organismal Biology and Laboratory (4)
Psych 1 Introduction to Psychology (4)
Math 231 Probability and Statistics (3)
major (3)
HSS elective (3)

junior year, second semester (15 credit hours)
approved electives (6)
major (6)
elective (3)
The department offers a program of independent research under the direction of an individual faculty member (History 391, 392). A maximum of six credits may be used toward this project. Normally students pursue their research in the second semester of the junior year and the first semester of their senior year; the project may also be undertaken during the senior year. Students who do well on their research project will graduate with department honors. Students planning to pursue this option should take History 202 in the spring of their junior year. Honors students may plan special programs, including more in-depth study of two cultural areas rather than three.

Students earning a grade of 5 on the American or European Advanced Placement exam will receive 6 credits; students earning a grade of 6 will receive 3 credits.

The department recommends that students intending to major in history take Math 12, Basic Statistics, to fulfill their college math requirement.

Department Major Requirements

**Classes of 1997, 1998, 1999**

A history major consists of 33 hours; normally 11 courses.

**History 11, 12 Survey of Europe.**

*Maximum of nine additional hours in courses below the 100 level, including any Advanced Placement credit.*

**History 201 or 202** (students planning to pursue independent research are strongly urged to take History 202).

*Minimum of 12 additional hours of courses at the 200 or 300 level. At least one course from each of the groups listed below:*

**GROUP A COURSES**


**GROUP B COURSES**


**GROUP C COURSES**

Hist 5, 31, 49, 50, 75, 171, 177, 341, 342, 368.

Hist 105, 300, 303, 371, 391, 392, or provisional courses will be placed in one of the above groups in accordance with their contents and emphases.

**Major Requirements Class of 2000 and above**

(Students in the classes of 1997-1999 may petition to complete the major with these requirements.) A history major consists of 35 hours, normally nine courses, as follows:

Hist 11, Survey of Europe to 1648 (majors are encouraged to take Hist. 17 concurrently).

Hist 12, Survey of Europe Since 1648 (majors are encouraged to take Hist. 18 concurrently).

Hist 201, Historical Perspectives, or Hist. 202; Introduction to Historical Research.

One course in history of Asia, Africa, or Latin America (see Group C list, above).

Minimum of 12 hours of courses numbered 203 or higher (except Hist. 300).

**Requirements for Honors:**

Students wishing to graduate with honors must have 40 credits and must have completed History 391.

To graduate with a history major, a minimum 24 hours must be graded course work taken at Lehigh.

**History Minor Requirements**

Each student’s minor program is prepared in consultation with the advisor of minors in the history department. *Advanced placement credit may not be used for the minor program.*
22. (Clas 22) Roman History (3)
   Rome from its origins to A.D. 476. Political, social and religious
devotions. Transformation of the late Roman Empire to the early
medieval period. (SS) Phillips

31. (Asia 31) History of Japanese Industrialization since 1890 (3)
The late Tokugawa economic development, rise of an entrepreneurial
class, importation of western technology, and the rise of social, political,
and economic institutions which support industrial growth. Students are
encouraged to take Hist 32 consecutively. (SS) Cooper

32. Japanese Industrialization: Laboratory (1)
   Directed study of an issue in history of Japanese Industrialization. May
   only be taken concurrently with Hist 31. (SS) Cooper

41. United States to 1865 (3) fall
   Native American cultures; European settlement; development of slavery
   and free labor systems; the Revolution; founding of the new nation;
   19th century social, economic, cultural, and political development; Civil
   War. Students are encouraged to take Hist 44 concurrently. Not open to
   students who have taken Hist 9. (SS) Soderlund, Shade

42. United States, 1865-1941 (3) spring
   America's transformation into an industrial and global power from
   Reconstruction after the Civil War to the Great Depression; includes
   social, political, and cultural developments. Not open to students who
   have taken Hist 10. (SS) Cooper, Simon, Smith

43. United States Since 1939 (3) spring
   World War II; Cold War at home and abroad; Civil Rights movement; the
   1960s: Vietnam, the welfare state and social upheavals; new forms of
   cultural expression; feminism; rise of neo-conservatism. Students are
   encouraged to take Hist 46 concurrently. Not open to students who have
   taken Hist 139.0 Pettigrew, Simon, Smith

44. United States to 1865; Laboratory (1)
   Directed study of an issue in United States History to 1865. May only
   be taken concurrently with Hist 41. (SS)

45. United States 1865-1941; Laboratory (1)
   Directed study of an issue in United States History, 1865-1941. May
   only be taken concurrently with Hist 42. (SS)

46. United States Since 1939; Laboratory (1)
   Directed study of an issue in United States History since 1939. May
   only be taken concurrently with Hist (HU)

49. History of Latin America (4)
   Spanish and Portuguese colonization of America and the struggles for
   independence, preceded by a brief view of the ancient American
civilizations and Iberian backgrounds. (SS) Saeger

50. History of Latin America (4)
   Continuation of Hist 49. The development of the Latin American
   nations in the nineteenth and twentieth centuries. (SS) Saeger

75. (MFL 75, Asia 75) Chinese Civilization (4)
   The development of traditional Chinese thought, beliefs, technology,
   and institutions from a historical perspective, from earliest times to
   China's encounter with the West. (HU) Pankenier

104. Themes in History (2 or 4)
   Seminar on a particular theme or topic not covered by a currently listed
   offering. (HU or SS depending on topic of seminar).

107. Technology and World History (4)
   Development of technology and its relationship to political, economic,
military and cultural aspects of world civilization from pyramids to the
   present. (SS) Smith
110. American Military History (4)
The American military tradition from colonial times to the present. America’s wars and the development and operation of military institutions within the political, economic, ideological, and technological milieu of American society. Not open to students who have taken Hist 310. (SS) Saeger

111. Engineering in the Modern World (4)
Roles played by engineers and engineering in the modern world, focusing on major achievements, failures, prominent engineers, and evolution of the profession. (SS) Smith

120. Revolutionary America (4)
Origins and development of the American republic from 1750 through the adoption of the Federal Constitution. (SS) Soderlund

124. (WS 124) Women in America (4)
Roles of women in American society from colonial to present times: attitudes toward women, female sexuality, women’s work, and feminism. (SS) Cooper, Soderlund

129. (AAS 129) Black Political Thought in America (4)
Examination of black political thought, leadership, and movements for social justice in the United States from 1880 to 1968. The lives, ideas, and programs of major black leaders: Booker T. Washington, W.E.B. DuBois, Marcus Garvey, Malcolm X, and Martin Luther King, Jr. (SS) Scott

130. (AAS 130) African American History (4)
Blacks in America from the first importation of Africans to the implementation of Civil Rights laws. West African origins, slave trade, slavery, free blacks and emancipation and study of Reconstruction, segregation, urbanization, and the struggle for racial equality. (SS) Scott

132. An Introduction to Canada (2)
A brief overview of major themes in Canadian history with emphasis on economic and political developments in nineteenth and twentieth centuries. (SS) Simon

136. Division and Reunion, 1820-1890 (4)
American abolitionism and the origins of the Civil War; the Second American Revolution; Reconstruction and its sequel. (SS) Shade

145. (STS 145) Introduction To the History of Science (4)
The history of modern science, primarily physical and biological, with emphasis on the development of major theoretical models since the eighteenth century. (SS) Goldman

149. The Barbarian West (4)
Merger of Greco-Roman, Germanic and Christian institutions and culture in Western Europe to mid-eleventh century. Evolution of the church, feudalism, and manorialism, and the foundations of the Carolingian and Holy Roman empires. (HU)

150. Medieval Civilization (4)
Formation and development of western culture to about 1400. Rise of universities and towns, legal development and origins of representative government, origins of nation-states, scholasticism and decline of the medieval church. (HU)

152. (Clss 152/WS 152) Women in Antiquity (4)
Interdisciplinary study of women in Greece and Rome. Literary, archaeological and historical evidence and approaches. Cross-cultural material. (SS) Phillips

154. (Rel 154) The Holocaust: History and Meaning (4) spring
The Nazi Holocaust in its historical, political and religious setting. Emphasis upon the moral, cultural and theological issues raised by the Holocaust. (HU)

157. (Rel 157) The Renaissance and Reformation (4) spring
Transition from medieval to early modern society: decline of medieval civilization; political, social and cultural changes of the Renaissance; the varieties of Protestantism; the wars of religion. (HU) Baylor

158. Early Modern Europe (4)
Transformation of European civilization from the 30 Years War to the outbreak of the French Revolution. Origins and development of the European state system; absolutism; commercial expansion and competition for empire; science; the Enlightenment and its impact on European culture and politics (HU) Baylor

159. Revolutionary Europe, 1789-1870 (4)
Revolutions and reactions; the rise and spread of liberalism, nationalism, and socialism. (HU) Duffy

160. Europe in the Age of Total War, 1870-1945 (4)
Origins of two world wars; revolutionary governments in Germany, Italy, and Russia. (HU) Duffy

161. (Clss 161) Roman Law (4)
Examination of Roman legal systems from the Twelve Tables to the Digest of Justinian. Emphasis on development of legal concepts and their historical context. Readings in primary sources; lectures; discussion. (SS) Phillips

162. Contemporary Europe (4)
Development of European States since 1945; European Community; Soviet influence and collapse. (HU) Duffy

163. France Since 1789 (4)
France’s tumultuous transformation from an absolutist monarchy to a modern democratic Republic. Explores major cultural, social and economic changes, with particular attention given to industrialization and urbanization, gender and class, Church and State relations, the French Left and France’s unique contribution to modern philosophy, art and culture. (SS) Turner

171. (AAS 271) History of Southern Africa (4)
Africa south of the Zambezi, especially after the arrival of the Europeans in the Cape, with special attention to conflicts between Africans, Boers and British, exploitation of minerals, apartheid, American policy, and socialism in Angola and Mozambique. (SS) Scott

177. (Asia 177, MFL 177) China Enters the Modern Age (4)
The collapse of the imperial order and China’s agonizing transformation into a modern nation over the past 150 years. The impact of imperialism, war, radical social change, and protracted revolution on Chinese beliefs, values, and institutions. (HU) Pankenier

180. (Rel 180) Religion and the American Experience (4)
The historical development of major religious groups in this country from colonial times to the present. Their place in social and political life, and the impact of the national experience upon them. Emphasis on religious freedom and pluralism, and the church-state relationship. (HU)

For Advanced Undergraduates And Graduate Students
Graduate students taking 200 or 300 level courses receive 3 credits.

201. Historical Perspectives (4) spring
Methodologies and interpretations of Western historians from ancient times to the present. (HU)/Baylor

202. Introduction to Historical Research (4)
An introduction to historical interpretation, research design, and methodology. Students will study an historical topic or topics through secondary and primary sources. Honors candidates will apply this knowledge to a design of their thesis project. Required of all students planning to pursue an honors thesis. Permission of Department chairman required. (SS)
203. Public History in America (4)
An examination of the public role of history in American life. The origins of museums, historical societies, archives and historic preservation with emphasis on the various uses of history by different segments of society. (SS)

303. Topics in History (4)
Intensive study in a particular area of history for advanced students. Topics may vary; may be repeated for credit with consent of department chairperson. (ND)

307. History of American Industrial Technology (4)
Origin and evolution of American technology and industry from the nineteenth century to the present. Investigates dynamics of major industries in national and international contexts. (SS) Smith

312. (Clss 312) Decline and Fall of the Roman Empire (4)
Political, social, and economic history of the Roman Empire, A.D. 117-535. Romanization of the provinces, diffusion of Christianity, and special attention to transformation to medieval period. Includes readings in translation of primary sources. (SS) Phillips

313. (Clss. 313) Golden Age of Greek Democracy (4)
Greek history of the seventh through fifth centuries B.C. Emphasis on the contrasting political and social systems of Athens and Sparta with consideration of related economic and military history. Attention to art, gender, literature, religion. Discussion and lectures; papers. (SS) Phillips

314. (Clss 314) Age of Caesar and Christ (4)
Roman History of the first century A.D. Political, cultural, and socioeconomic changes; special attention to the evolution of absolute power. Lectures, discussions, papers. (SS) Phillips

315. American Environmental History (4)
Relationship between Americans and their natural environment from the colonial period to the present: impact of European settlement, attitudes toward wilderness, role of technological development, rise of preservation and conservation movements, establishment of national parks, recent environmental protection legislation. (SS) Cutchiffe

319. Colonial America (4)
Founding and growth of colonies in North America through 1763. Emphasis on motives for settlement, Native American-European relations, the economic, social, and political development of the British West Indies and mainland provinces. (SS) Soderlund

323. American Cultural History Since 1900 (4)
Development of American popular culture and media: popular press, Hollywood, radio, television, sports, and advertising, and the meanings these institutions have created in 20th-century United States. (HU) Pettigrew

325. (SPP 325, WS 325) History of Sexuality and the Family in the U.S. (4)
Changing conceptions of sexuality and the role of women, men, and children in the family and society from the colonial to the post-World War II era. Emphasis on the significance of socio-economic class and cultural background. Topics include family structure, birth control, legal constraints, marriage, divorce, and prostitution. (SS) Shade, Soderlund

326. (SPP 326, WS 326) Social Class in American History (4)
Emphasis on the nineteenth and twentieth century, focusing on: emergence of a white-collar middle class; condition and treatment of the poor and growth of welfare state; conditions of industrial workers, struggle to organize unions and their later decline; indicators of social status and exclusion among the rich; changing distribution of income and wealth over time and extent of social mobility. (SS) Simon

327. American Intellectual History to 1900 (4)
Emphasis on initial conceptions of America, religion in the colonies, political culture of the Revolution, romantic movement in art and literature, and reform and utopian movements of the 19th century. (HU) Pettigrew

328. American Intellectual History Since 1900 (4)
Social, literary, and political thought in 20th-century with emphasis on pragmatism and progressivism, maturation of American literary culture, ideas of American exceptionalism at mid-century, civil rights movement and feminism, neo-conservatism and recent trends. (HU) Pettigrew

331. (AAS 331) United States and Africa (4)
Reciprocal relationships between North America and the African continent from the slave trade in the eighteenth century to the twentieth century Afrocentric movement; impact of Americans on the shaping of modern Africa, Pan-African relations; influence of African Americans on US policies toward Africa. (SS) Scott

332. Slavery and the American South (4)
The emergence and demise of the Apocalyptic institution of African American slavery in British North America and the Old South. African background; colonial beginnings; nineteenth-century slave community; the ruling race and proslavery ideology; the death of slavery and its aftermath; slavery and freedom in a comparative context. (SS) Shade

334. American Urban History (4)
Relationship of economic and technological change to growth of cities and creation of an urban network. Social problems of cities—slums and housing, transportation, public health—and efforts at social and political reform. Urban planning; racial ghettos; urbanization; suburbanization; urban renewal. (SS) Simon

335. Origins of American Politics, 1789-1840 (4)
Colonial beginnings; the Articles of Confederation and the Constitution; the creation of a new nation; the development of American political parties; the antebellum American state. Not open to students who have taken Hist 135. (SS) Shade

338. Psychohistory (4)
Uses of psychology in history and biography; exploration of problems of methodology, verification of evidence, conceptual frameworks and theories of personality; potentialities and limitations of psychological investigation as an historical technique. (SS) Dowling

341. Mexico and Central America (4)
Emphasis on Mexico and Guatemala from the era of the Aztec through the wars of independence to the twentieth century revolutions. (SS) Saeger

342. Argentina, Brazil and Chile (4)
Eighteenth-century Spanish imperial readjustments, independence, the emergence of new societies, twentieth-century extremist movements, and the problems of developing nations. (SS) Saeger

343. English History, 1471-1660 (4)
England under the Tudor monarchy and the problems facing its successors culminating in the civil wars and Interregnum. Political, economic, intellectual and religious developments of the period. (HU) Duffy

344. English History 1660-1789 (4)
Constitutional monarchy from the Stuart Restoration to the French Revolution. English civilization in an age of oligarchy, especially the political, social, economic and intellectual sectors. (HU) Duffy

345. Victorian Britain (4)
Development of democracy, liberalism, religious ferment, industrialization, class conflict, socialism, and empire in Victorian Britain. (HU) Duffy
346. Great Britain in the 20th Century (4)  
Effects of world wars, loss of great power status, economic decline, social conflict, welfare state, modern political parties, Irish problem on 20th century Britain. (HU) Duffy

347. Russia to 1855 (4)  
Emergence of Russian autocracy; impact of the Mongol invasions; Westernization and transformation of society and culture; economic development toward emancipation of the serfs. (HU) Kohls

348. Russia Since 1855 (4)  
Russia in the context of European history: emancipation of the serfs and impact upon political, social, economic development; reasons for the growth of revolutionary pressure; collapse of autocracy; the revolutions of 1917; the Soviet era and the collapse of the Soviet Union. (HU) Kohls

349. (MFL 349) Cultural History of Medieval Russia (3)  
Survey of medieval Russian history from the eleventh to the late seventeenth century. Historical works on the period, early Russian epics, chronicles, apocryphal legends, saints' lives, sermons, epistles, lays, folk poetry, and Russian picturesque tales. Development of ecclesiastical art and architecture. Influence of Russian culture Classical, Byzantine, and European models. (HU)

350. (WS 353) Women in European History, 1500-Present (4)  
Examines the position of women in Europe since the Renaissance. Particular attention is given to changing conceptions of women and their roles in society, the evolution of women's work, the origins, growth and impact of feminism, and gender distinctions as reflected in law, politics, popular culture and leisure. (SS) Turner

351. (Rel 355) European Cultural History I (4)  
Major developments in European culture from the late Middle Ages through the 17th century. Late scholasticism, humanism and the Renaissance, varieties of Protestantism, origins of modern science. (HU) Baylor

352. European Cultural History II (4)  
Transformation of European culture from the 18th century to the present. The Enlightenment, cultural impact of the French and industrial revolutions, romanticism and ideologies of the 19th century, contemporary European thought. (HU) Turner

353. Early Modern Germany, 1500-1850 (4)  
The emphasis will be on one or more of the following topics: the Reformation, the Thirty Years' War and its impact, absolutism, the rise of Prussia, the failure of German liberalism. (HU) Baylor

354. Modern Germany, 1850 to Present (4)  
Focus on one or more of the following topics: nationalism and unification, the Second Empire, World War I, the Weimar republic, the Nazi movement, the Third Reich, and post-war Germany. (HU) Baylor

355. American Legal History (4)  
The interrelationship between law and social development with emphasis on modern period. Founding of constitutional government and balance of power within the federal system, the problem of slavery, legal support and regulation of business, and the use of law in various reform and civil rights movements. (SS) Pettigrew

356. (Arch 361) Evolution of Highrise Building Construction (3)  
The new materials iron and concrete led to new ways of thinking about building. The Industrial Revolution initiated the development of our modern culture of building and our current urban society. (HU) Peters

357. (Arch 363) Evolution of Long-Span Bridge Building (3)  
New materials, forms of education and technology contributed to advance structural understanding. Specialization and the rise of technological thinking led to new bridge types and increasing span size. (HU) Peters

358. (Arch 365) Evolution of the Modern Building Process (3)  
The criteria of trade-time and money-entered the world of building in the 19th century. The unplanned interlude between the design and the inauguration of a building became a new professional field: the building process. (HU) Peters

359. Seminar in Latin American History (4)  
Readings and individual investigation of selected topics. (SS) Saeger

360. Independent Study (2-4)  
Directed readings in a topic or area of history not covered by current course offerings. For students of demonstrated ability and adequate preparation. Prerequisite: consent of department chairperson. May be repeated for credit with permission up to a maximum of 6 credits. (ND)

361. Honors Thesis in History (4)  
Opportunity for undergraduate majors in History or American Studies to pursue an extended project for senior honors. By invitation and department permission only. (ND)

362. Honors Thesis in History (2)  
Continuation of History 391 available under exceptional circumstances where additional credit for honors project is warranted. Department permission only. (ND)

GRADUATE WORK IN HISTORY
Lehigh University has been granting advanced degrees in history for more than half a century. Its graduates have become university and college professors, secondary school teachers and administrators, museum directors, and public servants. The graduate program focuses primarily on the areas in which the department is particularly strong in faculty and resources, notably Colonial America and the history of Technology, Science, and Medicine. The department works closely with the Lawrence Henry Gipson Institute for Eighteenth Century Studies which sponsors yearly symposia and provides research support for both faculty and students. The history of Technology program is closely tied to Lehigh's Science, Technology, and Society program.

Lehigh's libraries are especially rich in materials for graduate research in history, particularly in the fields listed above. It has an extensive collection of scholarly periodicals and monographs. Graduate programs provide intensive and specialized study, and the policy of limited enrollment permits close relations between faculty and students.

Admission to graduate study in history is competitive and dependent upon the applicant's undergraduate preparation and record, recommendations, and Graduate Record Examination scores. Besides general requirements for the Graduate School, the following special requirements apply to graduate study in history.

Master of Arts
There are two masters programs. Under Plan I, a candidate may earn the degree by successfully completing twenty-seven hours of approved course work and submitting a thesis of the length and quality that would make it suitable for publication as a scholarly article. The paper may build on work presented in a graduate research seminar in the program. A student seeking to present a lengthier master's thesis may do so with twenty-four hours of approved course work. Candidates continuing toward a doctorate should select Plan II. Candidates declaring Plan II take thirty hours of approved course work and pass examinations in two fields chosen from American, British, European and Latin American history, and history of science and technology. Candidates in either plan are required to maintain a 3.0 average in all graduate work and to take at least one research seminar.

Doctor of Philosophy
Candidates for the doctor of philosophy in history must maintain a 3.25 history average and a 3.0 over-all average on all graduate work taken at Lehigh or elsewhere. Students entering with a master's degree take a qualifying examination before beginning their second semester at Lehigh. During the second semester, doctoral students select two major and two
minor fields in which to take comprehensive written and oral examinations. The candidate will also choose a dissertation field and a dissertation advisor who will chair the special committee which will oversee the student's graduate program. The other members of the special committee will be those faculty who are examiners in the selected fields and one professor from outside the department relevant to the candidate's major field. The candidate will then, in consultation with the members of the committee, prepare for the examination in those fields. The special committee may compel additional work beyond the minimum requirements given above. No professor may direct more than one field, but the direction of a field may involve two professors. An original dissertation is required and may be written only in a major field and must be successfully defended to the examining committee.

**Major Fields.** Major fields are Technology, Modern Britain, Colonial America, Nineteenth Century United States, Twentieth Century United States. (The Nineteenth and Twentieth century fields may be divided topically rather than chronologically; for example, a student may be examined in labor/social history, 1800-present and in political history, 1800-present.)

**Minor Fields.** Any of the major fields listed above may also be minor fields. Other minor fields may be Ancient History; Medieval and Early Modern Europe; Modern Europe; Latin America; Science; Medicine; Science, Technology and Society studies.

**Language requirements.** The qualifying examination in one language must be passed before beginning course work beyond the master's degree in order that the language may be used in doctoral course work. The candidate's special committee, appointed by the chairman of the department, will designate any additional languages for the student, if needed. Languages normally chosen are French, Spanish, Italian, German or Russian. Graduate-level competence in statistical methods and computer application are acceptable as replacement for a foreign language. All graduate majors take Hist 401 and either 404 or 405. All Ph.D. candidates must take 18 hours of directed readings and one research seminar beyond the M.A. More detailed regulations are given in the *Handbook for Graduate Work in History*, available in the history department office.

**GRADUATE COURSES IN HISTORY**

**401. Methods in Historical Research (3)**
Techniques of research in history: training in the critical handling of documentary materials, in measuring the value of evidence, and in formal presentation of the results of research. Required of all graduate students in history. Shade

**404. Historiography: Europe (3)**
The approach, methods and interpretations of the leading historians of Europe.

**405. Historiography: America (3)**
The approach, methods and interpretations of the leading historians of America

**407. Seminar in the History of American Industrial Technology (3)**
Origin and Evolution of American technology and industry from the nineteenth century to the present. Investigates dynamics of major industries in national and international context. Not open to students who have taken Hist 307. Smith

**415. Introduction to the History of Technology in Western Civilization (3)**
Analysis and historiography of the history of technology. Smith

**440. Readings in Colonial American History (3)**
Study in small groups under the guidance of a faculty member of the literature of the seventeenth and eighteenth centuries. May be repeated for credit with the permission of the department chairman.

**441. Readings in Nineteenth Century American History (3)**
Study in small groups under the guidance of a faculty member of the literature of the nineteenth century. May be repeated for credit with the permission of the department chairman.

**442. Readings in Twentieth Century American History (3)**
Study in small groups under the guidance of a faculty member of the literature of the twentieth century. May be repeated for credit with permission of the department chairman.

**443. Readings in English History (3)**
Study in small groups, under the guidance of a faculty member, of the literature of a particular period, problem, or area of English history. May be repeated for credit with permission of the department chairman.

**444. Readings in Latin American History (3)**
Study in small groups, under the guidance of a faculty member, of the literature of a particular period, problem, or area of Latin American history. May be repeated for credit with permission of the department chairman.

**445. Readings in the History of Science (3)**
Study in small groups under the guidance of a faculty member on the history of science. May be repeated for credit with permission of the department chairman.

**446. Readings in the History of Technology (3)**
Study in small groups under the guidance of a faculty member of the history of technology. May be repeated for credit with permission of the department chairman.

**447. Readings in European History (3)**
Study in small groups, under the guidance of a faculty member, of the literature of a particular period, problem or aspect of European history. May be repeated for credit with permission of the department chairman.

**452. Research in American History (3)**
An intensive research seminar on a phase of American history. May be repeated for credit with permission of the department chairman.

**453. Research in English History (3)**
An intensive research seminar on a phase of English history. May be repeated for credit with permission of the department chairman.

**454. Research in Latin American History (3)**
An intensive research seminar on a phase of Latin American history. May be repeated for credit with permission of the department chairman.

**455. Research in History of Science and Technology (3)**
An intensive research seminar on a phase or aspect of the history of science and technology. May be repeated for credit with permission of the department chairman.

**457. Research in European History (3)**
An intensive research seminar on phase of European history. May be repeated for credit with permission of the department chairman.

**471. Special Topics in History (1-3)**
Individual study under direction of a faculty member of a topic in history. May be repeated for credit.

**472. Special Topics in History (1-3)**
Individual study under direction of a faculty member of a topic in history. May be repeated for credit.
Industrial and Manufacturing Systems Engineering

Professors. Keith M. Gardiner, Ph.D. (Manchester); Mikell P. Groover, Ph.D. (Lehigh); Louis A. Martin-Vega, Ph.D. (Univ. of Florida) chairperson; Nicholas G. Odrey, Ph.D. (Penn State); G. Sathyarayanan, Ph.D. (Michigan Tech); Emory W. Zimmers, Jr., Ph.D. (Lehigh).

Associate professors. Laura I. Burke, Ph.D. (California-Berkeley); Robert H. Storer, Ph.D. (Georgia Tech); Louis J. Pietan, Ph.D. (Lehigh); Gregory L. Tonkay, Ph.D. (Penn State); George R. Wilson, Ph.D. (Penn State); Szu-Yung David Wu, Ph.D. (Penn State).

Assistant professor. Joseph C. Hartman, Ph.D. (Georgia Tech).


Industrial engineering (IE) is concerned with the analysis, design, and implementation of integrated systems of people, materials, information, and equipment to accomplish useful work. The discipline of industrial engineering is applicable in nearly all industries, whether the industry involves manufacturing of a product or delivery of a service. Job functions performed by IEs include: methods analysis, work measurement, cost estimation, equipment selection, engineering economy, facilities planning, production planning and scheduling, inventory control, quality control, information systems, project management, operations management, and engineering management. Manufacturing systems engineering (MSE) is a specialty field associated with industrial engineering that emphasizes functions and technologies such as process planning, plant layout design, manufacturing resource planning, production management, production line design, automation, robotics, flexible manufacturing systems, and computer integrated manufacturing.

Career Opportunities
IE graduates are sought by nearly all industrial corporations as well as government agencies and other service institutions. In addition to the manufacturing industries, which traditionally hire IEs, other employers of our graduates include management consulting firms, banks, hospitals, railroads, the postal service, and private parcel delivery services. A typical career path of an industrial engineer is to start in an entry level engineering position or line supervision, and to progress through various management positions in the firm or institution. Significant numbers of industrial engineers ultimately become chief executive officers in their respective organizations.

The Curriculum
The IE curriculum is designed to provide graduates with the skills and knowledge that employers expect of young industrial engineers beginning their professional careers. It includes the basic mathematical, physical, and social sciences, together with the principles and methods of engineering analysis and design that are specific to industrial engineering. These principles and methods include probability and statistics, engineering economy, cost accounting, operations research, work methods and measurement, manufacturing processes, production and inventory control, and information systems.

Specialized industrial engineering electives in the senior year include: advanced operations research, discrete event simulation, organization planning and control, statistical quality control, database design, and data communications technologies. Electives related to manufacturing systems engineering include: computer integrated manufacturing, industrial robotics, facilities planning and material handling, production engineering, and metal machining analysis.

Physical Facilities
The Industrial and Manufacturing Systems Engineering Department is located in the Harold S. Mohler Laboratory at 200 West Packer Avenue at the northwest corner of the Lehigh University Asa Packer campus. The Mohler Lab building contains the classrooms, laboratories, and faculty offices of the department. Labs in the Mohler Laboratory building include:

Computer Integrated Manufacturing (CIM) Laboratory. The CIM lab contains a variety of computer systems and software that includes computer-aided design and engineering (CAD and CAE), numerical control part programming, discrete event simulation, facilities design, process design, and process control.

Manufacturing Technology Laboratory. The MTL contains equipment for instruction and research in manufacturing processes, numerical control (NC), NC part programming, material handling and storage, industrial control systems, and metrology.

Robotics and Automation Laboratory. This lab contains a variety of industrial robots and other automated systems to provide students with hands-on experience in the planning and use of this kind of equipment.

Electronics Manufacturing Laboratory. The EML is a new laboratory currently being developed as a teaching and research facility.

Technologies include electronics assembly, soldering, screen printing, inspection, and other processes associated with printed circuit card fabrication and assembly.

Work Systems Laboratory. This classroom-laboratory affords the opportunity for undergraduate students to analyze and plan human work activities for individual workstations and worker team situations.

A full-scale manual assembly line is available for study.

Considerable use is made of university computer facilities in IE coursework, and an IE/Computing Center workstation-laboratory containing fifteen RISC 6000 engineering workstations is located in the Mohler Laboratory building.

Specialty Areas in Industrial Engineering
The Industrial and Manufacturing Systems Engineering Department at Lehigh University emphasizes four areas in its undergraduate program: (1) manufacturing systems and processes, (2) operations research, (3) information systems, and (4) production and operations management. The I&MSE curriculum includes 15 credit hours of advanced (300 IE level) courses plus six credit hours of free electives. Students can emphasize one of these areas if they choose, or select courses from several areas to design their own individual program. Listed below are the advanced courses associated with the four specialty areas (includes courses in other departments). Senior I&MSE majors also request to take up to two graduate (400 IE level) courses to meet their program requirements.

Manufacturing Systems and Processes. Students specializing in this area should select 300 level courses from the following list:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>IE 319</td>
<td>Material Handling and Facilities Planning (3)</td>
<td></td>
</tr>
<tr>
<td>IE 324</td>
<td>Industrial Robotics (3)</td>
<td></td>
</tr>
<tr>
<td>IE 332</td>
<td>Quality Control (3)</td>
<td></td>
</tr>
<tr>
<td>IE 340</td>
<td>Production Engineering (3)</td>
<td></td>
</tr>
<tr>
<td>IE 342</td>
<td>Computer Integrated Manufacturing (3)</td>
<td></td>
</tr>
<tr>
<td>IE 344*</td>
<td>Metal Machining Analysis (3)</td>
<td></td>
</tr>
<tr>
<td>IE 345</td>
<td>Manufacturing Information Systems (3)</td>
<td></td>
</tr>
<tr>
<td>Mat 303</td>
<td>Microprocessor of Materials (3)</td>
<td></td>
</tr>
<tr>
<td>Mat 309</td>
<td>Composite Materials</td>
<td></td>
</tr>
<tr>
<td>Mat 314</td>
<td>Advanced Metal Forming (3)</td>
<td></td>
</tr>
<tr>
<td>Mat 335</td>
<td>Principles of Semiconductor Materials Processing (3)</td>
<td></td>
</tr>
<tr>
<td>Mat 342</td>
<td>Inorganic Glasses (3)</td>
<td></td>
</tr>
<tr>
<td>*IE 344</td>
<td>CROSSE with Mat 344</td>
<td></td>
</tr>
</tbody>
</table>

Operations Research. Students specializing in this area should select 300 level courses from the following list:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>IE 316</td>
<td>Advanced Operations Research (3)</td>
<td></td>
</tr>
<tr>
<td>IE 332</td>
<td>Quality Control (3)</td>
<td></td>
</tr>
<tr>
<td>IE 339</td>
<td>Queuing Theory (3)</td>
<td></td>
</tr>
<tr>
<td>CSc 327</td>
<td>Artificial Intelligence Applications (3)</td>
<td></td>
</tr>
<tr>
<td>CSc 340</td>
<td>Design and Analysis of Algorithms (3)</td>
<td></td>
</tr>
<tr>
<td>Math 312</td>
<td>Applied Statistics (3)</td>
<td></td>
</tr>
<tr>
<td>Math 338</td>
<td>Regression Analysis (3)</td>
<td></td>
</tr>
<tr>
<td>Math 341</td>
<td>Mathematical Models and Their Formulation (3)</td>
<td></td>
</tr>
<tr>
<td>MIE 340</td>
<td>Advanced Mechanical Design (3)</td>
<td></td>
</tr>
</tbody>
</table>
Information Systems. Students specializing in this area should select 300 level courses from the following list:
IE 307 Advanced Systems Analysis and Design (3) 
IE 309 Introduction to Information Systems (3) 
IE 310 Database Analysis and Design (3) 
IE 316 Advanced Operations Research (3) 
IE 341 Data Communication Systems Analysis and Design (3) 
IE 342 Computer Integrated Manufacturing (3) 
IE 343 Microprocessor Systems in IE (3) 
IE 345 Manufacturing Information Systems (3) 
CSE 327 Artificial Intelligence Applications (3) 
CSE 340 Design and Analysis of Algorithms (3) 
CSE 368 Artificial Intelligence Programming (3) 
ECE 319 Digital System Design (3) 
ECE 320 Logic Design (3) 
ECE 345 Speech Synthesis and Recognition (3)

Production and Operations Management. Students specializing in this area should select 300 level courses from the following list:
IE 319 Material Handling and Facilities Planning (3) 
IE 324 Industrial Robotics (3) 
IE 332 Quality Control (3) 
IE 334 Organizational Planning and Control (3) 
IE 340 Production Engineering (3) 
IE 342 Computer Integrated Manufacturing (3) 
Mgt 309 Industrial Purchasing and Materials Management (3) 
Mgt 331 Industrial Relations and Public Policy (3) 
Mgt 333 Personnel Management (3)

Special Opportunities
The following special opportunities are available to majors in industrial and manufacturing systems engineering:
Nontechnical minor. Students may choose to pursue a nontechnical minor in an area of the humanities and social sciences. The Minors Program section of this catalog should be consulted for details. Possible minors include classics, economics, history, international relations, materials science, philosophy, and psychology. Most nontechnical minors require 15 credit hours of coursework in the department, which can usually be satisfied within the 21 total credit hours of humanities, social sciences, and free electives available in the IMSE curriculum. Graduate Courses. Students in industrial and manufacturing systems engineering can petition to take up to two graduate IE courses (400-level) to satisfy two of their five 300-level IE course requirements. The petitioning senior must have a good scholastic record (generally above a 3.0 GPA).

5 Year Engineering/Master of Business Administration (MBA) Program.
Students in the College of Engineering and Applied Science may pursue a special five-year BS/MBA program by enrolling in the courses listed below (some of which will be electives) while completing their major in one of the B.S. programs in the College during their first four years. At the end of this period, the student must take the GMAT exam and complete the regular application process through the College of Business and Economics. If admitted to the MBA Program, the student will be granted their MBA upon completion of 10 to 16 courses. The number of courses required depends upon the waivers earned by completing the courses listed below with a grade of B- or better.

Prerequisite Courses (Grade of C or better required.)
Eco 1 Principles of Economics or both Eco 11 and Eco 12
Math 21 Analytic Geometry and Calculus I (Math 31, 41 also accepted)
Math 22 Analytic Geometry and Calculus II (Math 32, 44 also accepted)
Engr 1 Engineering Computations (Mgt 1, Acct 111, IE 24 also accepted)

Background Courses (Grade of B- or better required)
Acct 151 Introduction to Financial Accounting (Waives Acct 403)
Law 201 Business Law (Waives Law 404)
IE 121 Probability and Statistics (Waives Eco 401)
(Eco 145, Math 231 also accepted)
IE 222 Operations Research - Deterministic Models (Waives Mgt 401)

Core Courses (Grade of B- or better required in both courses in order to earn waiver)
Acct 152 Introduction to Managerial Accounting
Acct 324 Cost Accounting (Waives Acct 413)
Eco 119 Intermediate Macroeconomic Analysis
Eco 229 Money and Banking (Waives Eco 409)
Fin 225 Business Finance
Fin 3XX Any upper level finance elective (Waives Fin 411)
Mgt 270 Organization Theory and Behavior
Mgt 321 Organizational Behavior Workshop (Waives Mgt 413)
Mkt 211 Contemporary Marketing
Mkt 3XX Any upper level marketing elective (Waives Mkt 413)

For more information contact Director of MBA Program.

It is possible to get a BSIE degree in four years, without overloading or attending summer sessions, and, at the same time, to earn six waivers toward the MBA degree. To do so take Acct 151, Acct 152, Acct 324, Eco 119, Eco 129 and Law 201. These courses all satisfy requirements for the BSIE degree, either as substitutes for required courses, or as HSS electives or as free electives. At the same time, students taking these courses, plus IE 121 and IE 222 (required for the BSIE degree), can earn six waivers. The College of Business and Economics requires that grades in courses used to earn waivers be B- or better.

Students having a BSIE degree and six waivers can complete the MBA degree by taking twelve additional courses. This can be done in one academic year, either in two semesters, or in two semesters and one or two summer sessions.

Major Requirements
See freshman year requirements, section III.

sophomore year, first semester (16 credit hours)
IE 111 Engineering Probability and Statistics (3)
E 112 Computer Graphics (1)
Math 23 Analytic Geometry & Calculus III (4)
Phys 21, 22 Introductory Physics IIand Laboratory (5)
Mat 33 Engineering Materials and Processes (3)

sophomore year, second semester (17 credit hours)
IE 121 Applied Engineering Statistics (3)
IE 122 Software Tools (1)
IE 131 Work Systems and Facilities Planning (3)
IE 132 Work Systems Laboratory (1)
ME 104 Thermodynamics I (3)
Acct 108 Intro to Accounting (3)
HSS Humanities/Social Sciences elective (3)

junior year, first semester (17 credit hours)
IE 115 Fundamentals of Modern Manufacturing (3)
IE 116 Manufacturing Laboratory (1)
IE 221 OR - Probabilistic Models (3)
Math 205 Linear Methods (3)
Mech 2 Elementary Engineering Mechanics (3)
Eco 1 Principles of Economics (4)

junior year, second semester (17 credit hours)
IE 124 Engineering Economy (3)
IE 222 OR - Deterministic Models (3)
### Undergraduate Courses

#### Industrial Employment (0)

Usually following the junior year, students in the industrial engineering curriculum are required to do a minimum of eight weeks of practical work, preferably in the field they plan to follow after graduation. A report is required. Prerequisite: Sophomore standing.

#### Engineering Probability and Statistics (3)

Random variables, probability models and functions, and expected values. Statistical inference, estimation, hypothesis testing, and goodness of fit. Prerequisite: Math 22.

#### Computer Graphics (1)

Introduction to interactive graphics and construction of multi-view representations in two- and three-dimensional space. Applications in industrial engineering. Prerequisite: Sophomore standing in industrial engineering, Engr. 1.

#### Fundamentals of Modern Manufacturing (3)

Study of modern production methods. Machining and other metal working processes, electrical and electronics manufacturing, and nontraditional processing. Introduction to automation, numerical control, and industrial robots. Prerequisite: Mat 33.

#### Manufacturing Laboratory (1)

Laboratory exercises and experiments in manufacturing processes and systems. Prerequisite: IE 115, concurrently.

#### Applied Engineering Statistics (3)

The application of statistical techniques to solve industrial problems. Topics include regression and correlation, analysis of variance, quality control, and reliability. Prerequisite: IE 111 or Math 231.

#### Software Tools (1)

Introduction to application software tools, including word processing, spreadsheets, and statistical packages. Problems for solution will be drawn from other courses in the sophomore program. Prerequisites: Engr. 1; IE 121, previously or concurrently.

#### Work Systems and Facilities Planning (3)

Techniques of methods analysis, work measurement, and facilities design. Man-machine systems, assembly systems, operations analysis, time study, predetermined time systems, work sampling, incentive systems, plant layout, and materials handling. Prerequisite: IE 121, either previously or concurrently.

#### Work Systems and Facilities Planning Laboratory (1)

Laboratory exercises and projects in methods analysis, operations analysis, plant layout, and related topics. Prerequisite: IE 131, concurrently.

#### Senior Project (3)

The use of industrial engineering techniques to solve a major problem in either a manufacturing or service environment. Problems are sufficiently broad to require the design of a system. Consideration of human factors in the system design. Laboratory. Prerequisite: Senior standing in industrial engineering.

#### Production Analysis (3)

A course for the engineering student not majoring in industrial engineering. Engineering economy; application of quantitative methods to facilities analysis and planning, operations planning and control, work measurement and scheduling, and operating systems analysis. Prerequisites: Math 23.

#### Operations Research - Probabilistic Models (3)

Probabilistic models in operations research. Topics include queueing theory, probabilistic inventory models, Markov analysis, and simulation, including use of a simulation language. Prerequisite: IE 111 or Math 231.

#### Operations Research - Deterministic Models (3)

Deterministic models in operations research. Topics include linear programming, integer programming, networks, dynamic programming, and classical optimization. Prerequisite: Math 205.

#### Information Systems Analysis and Design (3)

An introduction to the technological as well as methodological aspects of computer information systems. Content of the course stresses basic knowledge in database systems. Topics include: database design and evaluation, query languages and software implementation.

#### Production and Inventory Control (3)

Techniques used in the planning and control of production and inventory systems. Topics include forecasting, inventory models, operations planning, and scheduling. Prerequisite: IE 221, either previously or concurrently, and IE 121, IE 222.

#### Simulation (3)

Applications of discrete and continuous simulation techniques in modeling industrial systems. Simulation using a high level simulation language. Design of simulation experiments. Prerequisites: IE 121 and IE 221.

#### Advanced Systems Analysis and Design (3)

Study of advanced techniques and their application in the analysis and design of information systems. Emphasis is placed on tools and techniques used for structured analysis and design, and on prototyping of systems. Prerequisite: IE 224 or equivalent.
309. Introduction to Information Systems (3) fall
Study of information systems analysis and design with emphasis on
management issues. Interfaces between information systems and
databases and data communications are examined. Effects of information
systems on organizational relationships are considered. Example
information system will be designed and implemented. Prerequisite: IE
224 or equivalent.

310. Database Analysis and Design (3) spring
Conceptual analysis of data is considered through data structures and
models. Logical design of databases is studied in the context of the
relational model of data. Prerequisite: IE 224 or equivalent.

316. Advanced Operations Research Techniques (3)
A survey of advanced topics in operations research. Topics include
advanced linear programming, dynamic programming, integer
programming, decision analysis, game theory and nonlinear
programming algorithms. Prerequisites: IE 221 and IE 222.

319. Material Handling and Facilities Planning (3)
Material handling systems, storage systems and automatic
identification. Facilities planning including layout planning and facility
location. Prerequisite: IE 131 or consent of department chair.

321. Experimental Industrial Engineering (1-3)
Experimental projects in selected fields of industrial engineering,
approved by the instructor. A written report is required. May be
repeated for academic credit.

324. Industrial Robotics (3)
Introduction to robotics technology and applications. Topics include
robot anatomy, controls, sensors, programming, work cell design, part
handling, welding, and assembly. Laboratory exercises. Prerequisites:
Mech 2, Math 205.

328. Engineering Statistics (3)
Random variables, probability functions, expected values, statistical
inference, hypothesis testing, regression and correlation, analysis of
variance, introduction to design of experiments, and fundamentals of
quality control. Prerequisite: Math 23 or equivalent. This course
cannot be used by IE undergraduates as an IE 300 level elective.

332. Product Quality (3)
Introduction to engineering methods for the monitoring control and
improvement of product quality. Topics include statistical models of
quality measurements, statistical process control, acceptance sampling,
and quality management principles. Some laboratory exercises.
Prerequisite: IE 121.

334. Organizational Planning and Control (3) fall
Design of organization and procedures for managing functions of
industrial engineering. Analysis and design of resource planning and
control, including introduction of change in man-machine systems;
manpower management and wage administration. Prerequisite: IE 131 or
168.

339. Queuing Theory (3)
Models for analyzing waiting lines and congestion systems. Methods
and techniques for formulating Markov and non-Markov queues,
networks, and approximation techniques. Prerequisite: course in
probability theory.

340. Production Engineering (3) fall
Develop plans of manufacturing for discrete parts. Product design
analysis and engineering materials utilization. Economic analysis of
process design alternatives. Introduction to mechanization, automation,
and flexible manufacturing systems. Term project. Laboratory.
Prerequisite: IE 115.

341. Data Communication Systems Analysis and Design (3)
An introduction to the hardware as well as performance evaluation of
data communication networks. Emphasis on data transmission,
coding, data link control, communication networking techniques, and
queueing/simulation analysis of network performance. Prerequisite: IE
224 and IE 221 or equivalent.

342. Computer Integrated Manufacturing (3) spring
Analysis and design of manufacturing systems using digital computers.
Principal topics: computer-aided techniques, group technology,
applications of minicomputers to manufacturing systems. Introduction
to adaptive control, numerical control, and optimization strategies for
discrete parts manufacturing. Term project. Prerequisite: IE 224, IE 115
or equivalent.

343. Microprocessor Systems in IE (3) fall
Fundamentals of microprocessors and microcomputers for industrial
engineering applications. Topics include basic digital concepts,
microprocessor programming interfacing, data acquisition and system
development for timing, counting, decision making and control.
Laboratory. Prerequisite: IE 224 and IE 115 or equivalent.

344. (Mat 344) Metal Machining Analysis (3) spring
Intensive study of metal cutting emphasizing forces, energy,
temperature, tool materials, tool life, and surface integrity. Abrasive
processes. Laboratory and project work. Prerequisite: IE 115 or ME
240 or Mat 206.

345. Manufacturing Information Systems (3)
This course examines the foundations for information systems required
to support the manufacturing function throughout the product life
cycle. Students will be exposed to the problems of design,
implementation, and management by way of assigned readings, class
discussion of cases, and a research project.

Graduate Programs
Several programs leading to masters and doctor's degrees are offered by
the Department of Industrial and Manufacturing Systems Engineering.
All IMSE graduate students are required to satisfy core requirements in
manufacturing and operations research. To satisfy the core requirement
in manufacturing, the student must complete either IE 340 or IE 342.
To satisfy the core requirement in operations research, the student must
complete either IE 305 or IE 316. Core requirements may also be
satisfied by previous coursework. In this case, the student must
petition the IMSE graduate committee to waive the core requirement in
the relevant area. All core course prerequisites must also be satisfied.
Prerequisites may be satisfied by (1) previous course work; (2)
completing the prerequisite course without graduate credit, or (3)
passing the final examination of the prerequisite course with a grade of
B or better.
A Ph.D. student is required to complete core requirements with grades
of B or better before being formally admitted to Ph.D. candidacy.
Further information about graduate programs is contained in the
Graduate School section of this catalog as well as an IMSE graduate
brochure available from the department. In addition, several documents
are available from the department which describe the requirements for
each of our graduate programs.

M.S. in Industrial Engineering
The minimum program for the master of science degree in IE consists of
24 credit hours of approved coursework and completion of a
satisfactory thesis. Courses in other departments for which the student
has the prerequisites may be integrated into the MSIE program. Subject
to advisor approval, up to nine credit hours of 300 and 400-level
courses from other departments may be included in the IE masters
program. The other department courses usually include other
engineering disciplines, mathematics, computer science, and business
and economics.
M.Eng. in Industrial Engineering
This program of study is for those students whose interests are toward engineering design rather than research. The program provides opportunity to gain breadth of field by required coursework in all areas of study within the department. In addition, an engineering project must be completed under the supervision of the faculty.

M.S. in Management Science
This program requires a minimum of 30 credit hours of approved coursework. The program leads to the Master of Science degree in Management Science.

M.S. in Manufacturing Systems Engineering
This is an interdisciplinary graduate program leading to the Master of Science degree in Manufacturing Systems Engineering. See separate catalog listing under Manufacturing Systems Engineering.

M.S. in Quality Engineering
This is a specialized graduate program offered by the Department of Industrial and Manufacturing Systems Engineering leading to the Master of Science degree in Quality Engineering. See separate catalog listing under Quality Engineering.

Ph.D. in Industrial Engineering
The graduate program leading to the doctor of philosophy (Ph.D.) degree is organized to meet the individual goals and interests of graduate students whose professional plans include teaching, consulting, or research in an educational, governmental, or industrial environment. Each doctoral candidate is required to demonstrate: (1) a high level of proficiency in one or more fields of industrial and manufacturing systems engineering, and (2) a capacity for independent research through the preparation of a dissertation related to his/her field of specialization.

Areas of Graduate Study
The areas of graduate study emphasized in the Department of Industrial and Manufacturing Systems Engineering are as follows:

Manufacturing Systems and Processes. Graduate study in manufacturing involves coursework and research in any of a variety of subjects, including manufacturing processes, automation, robotics, numerical control, computer integrated manufacturing, process control, material handling, and production scheduling. In manufacturing processes, the department specializes in the material removal processes, such as machining (e.g., turning, milling, drilling, grinding) and nontraditional processes (e.g., water jet cutting, electrochemical machining). Additional manufacturing process technologies are covered in other departments in the College of Engineering and Applied Science, in particular, the Materials Science and Engineering Department.

Operations Research. The operations research graduate area is intended to prepare students to analyze, formulate, and solve problems using analytical methods and computational techniques. Topics emphasized in the department include mathematical programming, combinatorial optimization, queuing theory, neural networks, and stochastic processes. There are many settings in which operations research problems are encountered, but those which arise in the context of manufacturing are of particular interest to the Department of Industrial and Manufacturing Systems Engineering. Students can expect to study challenging problems at both the masters and doctoral levels.

Information Systems. Graduate study in information systems covers the methodological and technological development of computer information systems. Of particular interest at Lehigh are the systems needed to drive integrated manufacturing and service industries. Such systems are becoming increasingly important in the trend toward real-time planning and control, with embedded decision making capabilities. Topics include data communication, telecommunication and computer networks, database processing systems, artificial intelligence and expert systems, object oriented technology, and computer-based production planning and inventory control. The information systems area is further supplemented by courses offered by the Department of Electrical Engineering and Computer Science.

405. Special Topics in Industrial Engineering (3)
An intensive study of some field of industrial engineering.

408. (Acct 433) Management of Information Systems (3)
Philosophies and methods for systematic planning, development, and implementation of management information systems. Concepts of information resource management, and strategic and long-range planning of information systems and services. Prerequisite: IE 224 or Acct 311 or equivalent.

409. Data Dependent Systems (3)
Theory and applications of an approach to process modeling, analysis, prediction, and control based on an ordered sequence of observed data. Single or multiple time series are used to obtain scalar or vector difference/differential equations describing a variety of physical and economic systems. Prerequisite: IE 121 or equivalent.

410. Design of Experiments (3)
Experimental procedures for sorting out important causal variables, finding optimum conditions, continuously improving processes, and trouble shooting. Applications to laboratory, pilot plant and factory. Prerequisite: Some statistical background and experimentation in prospect. Prerequisite: IE 121 or equivalent.

411. Networks and Graphs (3)
This course examines the theory and applications of networks and graphs. Content of the course stresses the modeling, analysis and computational issues of network and graph algorithms. Topics include: complexity theory, trees and arborescences, path algorithms, network flows, matching and assignment, primal-dual algorithms, Eulerian and Hamiltonian walks and various applications of network models. Prerequisite: IE 316 or equivalent.

415. Manufacturing Management (3)
Analysis of the factors entering into the development of manufacturing management philosophy, decision-making process in areas of organization, planning, operation, and control of manufacturing. Influence of the social, technical, and economic environment upon manufacturing management decisions.

416. Dynamic Programming (3)
The principle of optimality and recursive solution structure; multidimensional problems; reduction of dimensionality and approximation; stochastic control; nonserial systems; relationship to calculus of variation; applications. Prerequisite: IE 316 or equivalent.

417. (Mgt 445) Advanced Mathematical Programming (3)
Theoretical and algorithmic structure of optimization methods; search strategies for unconstrained optimization; conditions for constrained optima; algorithmic strategies for smooth and non-smooth constrained problems. Applications in stochastic multiobjective, equilibrium, and large scale mathematical programs. Prerequisite: IE 316 or equivalent.

419. Sequencing and Scheduling (3)
Systematic analysis of models for production planning and scheduling. Topics include facility location and production allocation; resource planning techniques; hierarchical planning; static and dynamic scheduling of activities to production (or project) resources. Prerequisites: IE 251 and IE 316 or equivalent.

421. Nontraditional Manufacturing Processes
Analysis of the processes, sensors, machine tools, and control systems in water jet cutting, electrochemical machining, electric discharge machining, laser and ion beam machining, and ultra high precision machining processes. Prerequisite: Consent of instructor.

422. Measurement and Inspection Systems (3)
Study of measurement instruments and sensors for manufactured products. Metrology standards, performance characteristics of
measuring devices, calibration, error analysis, and gaging. Mechanical, optical, and other techniques. On-line monitoring and control for product quality, and sensor integration and fusion.

424. Robotic Systems and Applications (3)
Detailed analysis for robotic systems in manufacturing and service industries. Topics include task planning and decomposition, motion trajectory analysis, conveyor tracking, error detection and recovery, end effector design, and systems integration. Prerequisite: IE 324 or consent of instructor.

426. Artificial Neural Networks (3)
Neural networks and their function in decision problems in engineering. Pattern recognition and optimization with emphasis on evaluation techniques.

429. Artificial Intelligence Techniques in Combinatorial Optimization (3)
Study of Artificial Intelligence techniques applied to practical combinatorial optimization problems such as routing, scheduling, partitioning, network design, and VLSI layout/placement. Content of the course includes: NP-completeness, exact and approximation algorithms, heuristic search methods, and probabilistic search methods such as simulated annealing, genetic algorithms, and Tabu search. Prerequisites: IE 222, or IE 316 or equivalent.

430. (Mgt 430) Management Science Project (3) spring
An analysis of a management problem and its solution incorporating management science techniques. An individual written report is required. Recommended to be taken in the last semester of the program.

431. Operations Research Seminar (3)
Extensive study of selected topics in techniques and models of operations research.

433. Manufacturing Engineering Seminar (3)
Extensive study of selected topics in the research and development of manufacturing engineering techniques.

437. Advanced Database Analysis and Design (3)
Intensive treatment of design and application of modern database technology, including information modeling and logical design of databases. Particular emphasis on applications to the manufacturing environment. Prerequisite: IE 310 or equivalent.

438. Advanced Data Communication Systems Analysis and Design (3)
Study of technological development, operational algorithms and performance analysis in data networks. Emphasis on the recent development in communication technologies, modeling and simulation of large scale networks, routing models and algorithms, and flow control issues. Prerequisite: IE 341 and IE 316, or equivalents.

439. Applications of Stochastic Processes (3)
Introduction to stochastic processes, application in queueing theory and inventory theory. Prerequisites: IE 221 or equivalent.

442. Total Quality Management (3)
Principles and techniques of TQM; principles of Deming, Juran, Taguchi, and others; standards, metrics, costs, benchmarking, quality circles, and continuous improvement; Malcolm Baldrige and other awards, ISO 9000, case studies.

443. Automation and Production Systems (3)
Concepts and principles of automated production lines; analysis of transfer lines; partial automation; mechanized assembly system; flexible manufacturing systems; industrial robots; line balancing; product and process design considerations. Prerequisite: IE 115 or equivalent.

448. Industrial Control Systems for Manufacturing (3)
Techniques used to control manufacturing systems: numerical control, digital control, programmable logic controllers, and sensors. Prerequisite: IE 343 or equivalent or consent of instructor.

449. Advanced Computer-Aided Manufacturing (3)
Numerical control in manufacturing; CAD/CAM systems; computer monitoring and control of manufacturing operations; adaptive control of manufacturing operations. Manufacturing resource planning, computer-aided process planning, and shop floor control. Prerequisite: IE 342 or consent of the department chair.

450. Manufacturing Problems (3)
Discussion and solution of manufacturing problems involving several subfunctions, with emphasis on problem identification and definition; selection of techniques of analysis; procedures for evaluation of proposed solutions.

458. (Eco 458) Game Theory (3)
A mathematical analysis of how people interact in strategic situations. Applications include strategic pricing, negotiations, voting, contracts and economic incentives, and environmental issues. Prerequisites: a calculus course and Eco 105 or 115.

460. Engineering Project (1-3)
An intensive study of an area of industrial engineering with emphasis upon design and application. A written report is required.

461. Readings (1-3)
Intensive study of some area of industrial engineering which is not covered in general courses.

490. Thesis (1-6)

499. Dissertation (1-15)

Information Systems

Associate professors: Marilyn M. Greenstein, Ph.D. (Temple); James A. Hall, Ph.D. (Oklahoma); Susan A. Sherer, Ph.D. (Pennsylvania).

The objective of this new major in the College of Business and Economics is to enable students to establish a career path in information systems.

Required Courses:
1. Managing Information Systems Development (IS3XX): This would be a new course that would cover the basics of systems analysis and design as well as management of systems development and implementation (3).
2. Practicum: Either Mgt. 311, LUMAC (3) or possible future internship.
3. Programming: Either CSC 11 (4) or CSC 17 (4) or possible future COBOL course.
4. Database Systems: Either IE 224 (3) or CSC 241 (3).

Elective Courses:
Choose 2 from any of the following:

- Mgt 302 Quantitative Models - Conceptual (3)
- ECE 116 Software Engineering (3)
- CSC 330 Advanced Software Engineering Tools (3)
- CSC 262 Programming Languages (3)
- IE 341 Data Communications (3)

New possible future course in Electronic Commerce

Consult Professor Susan Sherer for other related courses.
Undergraduate Courses
BIS 311. Managing Information Systems Development (3)
Managing the development and implementation of information systems for business. Project management for business systems implementation. Business systems analysis and design. Implementation of custom designed as well as packaged systems. Cost-benefit analysis and risk management of systems implementation. Prerequisites: CSC 11 or 17, and IE 224 or CSC 241; and Acc 211 or 311; or consent of instructor.

Interdisciplinary Technology Courses
See listings under Science, Technology and Society.

International Careers
Alvin Cohen, Ph.D. (Florida), professor of economics and director, International Careers major.

This major in the College of Arts and Science is designed to meet the needs of the student who has decided upon an international business, or political focus for his education. It uses elements of the traditional liberal arts and business school curricula. Among those traditional liberal arts elements are courses in economics, government, history, international relations, and language. With respect to business school offerings, there are courses in accounting, finance, and economics. The major also represents an excellent foundation for MBA graduate study leading to an, a law degree, and graduate programs in the social sciences.

Each student completes the courses in the common core, takes twelve credit hours from offerings in economics, government, history, international relations, and social relations as related to an area of geographical concentration, and twelve credit hours in a functional option. Although not a requirement, students should study the language related to their area of specialization.

Major Requirements
Common Core (19 credit hours)
- Eco 1 Economics (4)
- Polis 3 Comparative Politics (4) or IR 10 (4)
- Math 51 or its equivalent (4)
- Eco 145 or its equivalent (4)
- Acc 151 or 108 (4)

Geographical Concentrations (12 credit hours from any one of the four areas)

Functional Options
Pick one of the two listed below:

International Business (12 credit hours)
- Eco 129 Money and Banking (3)
- Eco 303 Economic Development (3)
- Eco 339 International Trade (3)
- Eco 340 International Finance (3)

Public Administration (12 credit hours)
- Eco 353 Public Finance (3)
- IR 353 International Institutions (3)
- Polis 322 Politics of Developing Nations (4) or Eco 303 Economic Development (3)
- Polis 260 Public Administration (4)

International Relations
Professor and Chairperson. Rajan Menon, Ph.D. (Illinois), Monroe J. Rathbone Professor
Professors. Bruce E. Moon, Ph.D. (Ohio State); Oles M. Smolansky, Ph.D. (Columbia), University Professor; Raymond F. Wylie, Ph.D. (London-England).
Assistant professor. Chaim D. Kaufmann, Ph.D. (Columbia).
Emeritus Professors. Henderson B. Bradldick, Ph.D. (Washington); Carey B. Joynt, Ph.D. (Clark); Zdenek J. Slouka, Ph.D. (Columbia).

The Field of International Relations: The reality of an interdependent world is brought home to us every day. Fast-flying, highly accurate nuclear weapons have breached the state's ability to protect its citizens as never before. National economies are so sensitive to the trade and monetary policies and instability of other countries that governments are forced to recognize the limitations of purely national economic policies in a highly interdependent world. Resource depletion, pollution, refugee relief, the indebtedness of developing countries, and nuclear proliferation are truly global problems beyond the ability of any one state, no matter how powerful, to address alone. In sum, International Relations is not a remote abstraction that educated men and women can afford to ignore.

The Department of International Relations seeks to provide students with a systematic understanding of world politics. The questions that preoccupy scholars of International Relations are too numerous to list here, but students who major in International Relations can expect to acquire a detailed knowledge of topics such as: contending theories of world politics; the international system; area studies; the foreign policies of the major powers; international security and arms control; regional conflicts; global problems such as terrorism, refugee relief, and pollution; international political economy; and the role of international organizations such as the United Nations, the International Monetary Fund, and the World Bank. As should be apparent from this list, International Relations is a multi-disciplinary field and draws upon concepts and theories from Political Science, History, Economics, Anthropology, Sociology, Philosophy, Religion Studies, and Psychology. Our majors are encouraged to take courses in these disciplines.

The Curriculum: To meet our educational goals, the Department of International Relations has devised a new curriculum based on four 4-credit courses per semester. The major consists of five segments: 1) a gateway course; 2) a functional core comprising three courses and a one-hour laboratory; 3) an area studies focus of two courses; 4) advanced electives (two courses); and 5) a free elective (one course). These curricular innovations will be explained in full when students visit the Department to declare a major. Students considering a major in International Relations are strongly advised to take Eco 1 (Economics); and Math 12 (Basic Statistics) to fulfill their College distribution requirements.

Students may also minor in International Relations by taking the gateway course (IR 10) and three other courses offered by the Department.

Beyond the Curriculum: In close cooperation with the International Education Office, the department assists students interested in study abroad programs. In addition, Lehigh has an array of summer programs, which involve course work and/or internships in such countries as China, the Czech Republic and the United Kingdom.

Every semester a variety of speakers with expertise on various aspects of world affairs visit Lehigh. Together with the International Center for Democracy and Social Change, the Department arranges the annual Cohen International Relations Lecture Series, which has featured speakers such as Robert McNamara, Valery Girard d'Estang, Vaclav Havel, Hans Dietrich Genscher, Kim Campbell, Oscar Arias, Wole Soyinka, and Andrei Kozyrev.
The student-run World Affairs Club sponsors a number of activities each year, including student-faculty socials, guest speaker and related programs. It also cooperates with the Model United Nations program to send a Lehigh delegation each year either to various U.S. conferences (e.g., Harvard) or the North American Model UN in Toronto, Canada. Another delegation is sent annually to the European Union Simulation in Washington, D.C. From time to time, delegations are also sent to other student conferences, including West Point and the U.S. Naval Academy.

The Department also offers an internship program for students interested in working in Lehigh's International Education Office, the Office of Community Affairs and other agencies on or off campus. These and other programs are organized in cooperation with the International Center for Democracy and Social Change, which coordinates a broad range of international studies programs throughout the College of Arts and Sciences.

Upon Graduating: We are often asked about the employment prospects of students majoring in International Relations. We take very seriously their questions regarding career planning. While a degree in International Relations does not lead to a specific career in the way that, for example, accounting or engineering does, a major in International Relations, by emphasizing clarity in speech and writing, analytical skills, and a detailed knowledge of world politics prepares students for careers in government, journalism, law, international business, and teaching and research. Our majors currently work in all of these fields. Some have gone directly into careers upon graduation; others have enrolled in graduate schools prior to employment.

Major in International Relations
The major consists of nine 4-credit courses plus a lab, for a total of 37 credits. The distribution of these courses is as follows:

- **Gateway course**
  - IR 10 Introduction to World Politics (4)

- Functional core (3 courses plus lab)
  - IR 56 European International Relations (4)
  - IR 110 Laboratory in International Relations (1)
  - IR 125 International Political Economy (4)
  - IR 205 Theories of International Relations (4)

- Area studies focus (2 courses).
  Any two IR area studies courses, not including 300-level courses and U.S.-based courses. See Department for list of acceptable courses.

- **Advanced electives**
  Any two IR courses numbered 200-389.

- **Free elective**
  Any IR course other than IR 1, 90.

**Departmental Honors**
To graduate with honors, a major in international relations must
(a) attain an average of at least 3.5 in the courses constituting the major program; and
(b) complete a two-semester honors thesis in the senior year.

**Minor in International Relations**
The minor consists of four 4-credit courses, for a total of 16 credits: IR 10, one advanced IR elective numbered 200-389, and two free IR electives other than IR 1, 90.

**Undergraduate Courses**
IR 1. Current Issues in World Affairs (3)
This is a survey course designed primarily for non-IR majors or minors. The purpose is to acquaint students with some of the concepts and historical facts behind current global issues. The content of this course will, in part, be dictated by international events as they unfold. Barkey. (SS)

IR 10. Introduction to World Politics (4)
Introduction to the major principles, concepts, and theories of international relations, along with a historical background focusing on the 19th and 20th centuries. Topics to be covered include the nature of power, balance of power theories, national interest, decision-making in foreign policy, theories of war and expansion, patterns of cooperation, and international political economy. Menon. (SS)

IR 23. Alternative World Futures (4)
after a survey of the major political, military, economic, and social trends of the 20th century, the course will examine the challenges that are likely to confront the world in the 21st century. Topics to be explored include environmental and population problems, the changing nature of war, ethnic conflict and nationalism, and the emerging balance of global economic and military power. Menon. (SS)

IR 34. Society, Technology and War (4)
The role of war in the modern world: the impact of social, economic, and technological change on the function and conduct of war; World Wars I and II; Vietnam; the nuclear revolution; possible future developments. Kaufmann. (SS)

IR 56. European International Relations (4)
Survey of European international relations since the French Revolution with an emphasis on the rise and decline of the major powers. Among the topics discussed will be nationalism, imperialism, the causes of war, and attempted peace settlements. After 1945, the focus will be on the effects of the Cold War, the emergence of the European Union, and the impact of the collapse of the USSR on the political and social institutions of Europe. Smolansky. (SS)

IR 61. (ASIA 61) East Asian International Relations (4)
Introduction to East Asian international relations with emphasis on the 19th and 20th centuries: historical background; Cold War conflicts; Japan's rise to power; the development of Korea and the NICs; Southeast Asia; U.S. and Russian policies; current and future issues. Wylie. (SS)

IR 72. The United States in the Global Economy (4)

IR 74. United States Foreign Policy (4)
Major themes and trends in U.S. foreign policy, with attention to both the historical evolution of contemporary policy and key current problems. Emphasis is upon critical examination of the interests and values that underlie the goals of policy and the theories that shape perceptions of how they can be met. Sources of U.S. policy, including decision-making structures, policy processes, and the role of the public and media. Kaufmann. Moon. (SS)

IR 75. Canada-United States Relations (2)
Introduction to Canada’s relations with the United States, with emphasis on the post-1945 period. Coverage of political, economic and security issues in the bilateral relationship and the broader international scene. A half-semester course. Wylie. (SS)

IR 81. Middle East in World Affairs to 1945 (4)
Political, economic, and social forces behind the rise of modern states in the Middle East; area's role in international politics from Napoleon's invasion of Egypt to the end of World War II. Smolansky. (SS)

IR 82. Middle East in World Affairs Since 1945 (4)
Rise of Turkish, Iranian, and Arab nationalism; creation of Israel; decline of British and French power; growth of U.S. and Soviet influence; Middle East as the world's major oil producer. Smolansky. (SS)
IR 110. Laboratory in International Relations (1)
Basic elements of research and writing for international relations majors. Topic selection, search techniques, basic library resources, thesis formulation, canons of evidence, rules of citation. Co-requisite: must be taken concurrently with IR 56, 125 or 205. Staff. (SS)

IR 119. Issues in International Relations (1-4)
Readings on selected themes in world politics, with theme to change each semester. Offered on an occasional basis only. Staff. (SS)

IR 125. International Political Economy (4)
Principles governing the interaction between the economic and political components of international phenomena. Political causes and consequences of trade and investment. Foreign economic policy and its relationship to domestic economic policy and other aspects of foreign policy. Determinants of foreign economic policy. Prerequisites: Economics 1, 11 or 12; and IR 10. Moon. (SS)

IR 161. (ASIA 161) China in World Affairs (4)
China in world affairs; emphasizing role in Pacific Rim: historical background; domestic politics; foreign and security policies; relations with regional and global powers; policies toward Third World; current and future issues. Wylie. (SS)

IR 163. (ASIA 163) Japan in World Affairs (4)
Japan in world affairs, emphasizing role in Pacific Rim: historical background; domestic politics; foreign and security policies; relations with major powers; policies toward Third World; current and future issues. Wylie. (SS)

IR 164. (ASIA 164, REL 164) Japan’s Response to the West (4)
A survey of Japanese history and culture from 1500 to the present, following the theme of Japan’s contact with the West. What enabled Japan to modernize and Westernize so successfully? Topics covered include: theexpulsion of Christianity, the first samurai mission to the U.S., the postwar American occupation, and contemporary issues. Readings include Japanese novels and short stories (in translation). Kraft. (SS)

IR 167. Diplomacy of Russia to 1917 (4)
Expansion of the Russian Empire; principles of Russian foreign policy and their specific applications under the Tsarist governments, treated partially as background of Soviet policy; interaction between Russian domestic and foreign affairs. Smolansky. (SS)

Topical and chronological survey of Soviet foreign relations; Soviet efforts to survive in a hostile capitalist environment; consolidation of gains made during World War II; origins of Cold War; frictions within the Communist bloc (Eastern Europe, China); nuclear arms race; striving for detente; activity in the Third World; Gorbachev and collapse. Smolansky. (SS)

IR 169. International Relations of Russia and Eastern Europe (4)
The Soviet collapse and the emergence of Russia. Russia’s relations with the other newly-independent states that emerged following the disintegration of the Soviet union. The international relations of Eastern Europe (including the Balkans). Menon. (SS)

IR 177. International Relations of Latin America (4)
Survey of major international and domestic crises facing Central and South America. Examines factors affecting Latin American system of states such as international debt, involvement of foreign powers, and social and political instabilities. Barkey. (SS)

IR 205. Theories of International Relations (4)
Analysis of the role of theory in historical explanation, prediction, and policy design. Examination of important theoretical approaches to international relations, including role of states’s external environment; balance of power; international institutions; economic and political structures of states; nationalism; role of bureaucracies and individual leaders; impact of beliefs and images, psychological explanations. Prerequisites: IR 10 and 56. Kaufmann (SS)

IR 246. (JOUR 246) International Communication (4)
Role of international news media in world affairs. Global theories of the press; process and influence of U.S. reporting of international affairs; survey of global media systems; global communication controversies. Lule. (SS)

IR 302. Rise and Decline of Empires (4)
An overview of the expansion, over-extension, and collapse of empires. Focus on alternative theories of empires as well as historical cases. Prerequisites: IR 10 and 56. Menon. (SS)

IR 321. Economic Relations of Advanced Industrial Societies (4)
Foreign economic policies of advanced industrial nations. Bilateral and multilateral economic relations; international economic regimes and institutions; interdependence and cooperation; managing conflict. Prerequisite: IR 125. Moon. (SS)

IR 322. Political Economy of North-South Relations (4)
Political economy of relations between developed and less developed countries. Explanations for choices of development policy, especially issues of trade, foreign aid, and foreign direct investment. Consequences of North-South transactions. Controversies over system structure and international institutions. Prerequisite: IR 125. Moon. (SS)

IR 323. Political Economy of Newly Industrializing Countries (4)
Issues of development, debt and adjustment in newly industrializing countries. Analysis of the differences between the development strategies adopted in Latin America and East Asia. Explanations for patterns of success and failure. Origins of underdevelopment; the politics of failed development strategies; the challenge of the increasingly competitive world economy and relations with the U.S. and other developed nations. Prerequisite: IR 125. Barkey. (SS)

IR 332. Role of Force in International Relations (4)
Theories of war and international insecurity; arms races; influence of domestic politics and bureaucracies; mismeasure; tools of war prevention; deterrence; alliances; collective security; arms control. Nationalism; the nuclear and information revolutions; the changing usefulness of force. Prerequisites: IR 10 and 56. Kaufmann. (SS)

IR 344. International Politics of Oil (4)
Historical influence of oil in international politics and the role it plays today. Focus on differing views of producers, such as Middle Eastern and Latin American states, and consuming nations, largely the economically developed Western states. Barkey. (SS)

IR 354. International Relations of the Middle East (4)
Importance of the Middle East in contemporary world politics; strategic location and natural resources as factors affecting interests of the great powers. Interplay of international, regional and internal forces. Prerequisite: IR 81 or 82. Smolansky. (SS)

IR 364. International Relations of East Asia/Pacific Rim (4)
Research-oriented seminar on contemporary international relations of East Asia/Pacific Rim. Special emphasis on China, Japan and regional organizations. Substantial research paper on topic of students’ own choice is required. Prerequisite: IR 61, 161, 163 or 164. Wylie. (SS)

IR 388. Honors Thesis in International Relations (4)
Honors Thesis in international relations for majors with senior standing and with a 3.5 GPA who wish to engage in an intensive, two-semester research project under the direct guidance of a faculty member in the student’s special area of interest. Departmental permission required. May be repeated for credit. Staff (SS)
IR 390. Readings in International Relations (1-4)
Directed course of readings intended for students with special competence or interest in fields of international relations not fully covered by regular course offerings. May be repeated for credit. Departmental permission required. Staff. (SS)

IR 393. Seminar in International Relations (4)
Advanced seminar focusing on discussion and research on specialized subjects in international relations. Variable subject matter. Offered by faculty on rotating basis. May be repeated for credit. Senior standing and departmental permission required. Staff. (SS)

IR 394. Special Topics in International Relations (1-4)
Intensive, research-oriented study for students with a special competence or interest in fields of international relations not fully covered by regular course offerings. May be repeated for credit. Departmental permission required. Staff. (SS)

IR 395. Internship in International Relations (1-4)
Internship in public or private agency. May be repeated for credit. Departmental permission required. Staff. (SS)

In addition to the above listings, the following courses are acceptable for the IR major and minor:

AAS 271. (Hist 271) The United States and Africa (4) Scott. (SS)
Pols 336. U.S. Foreign Policy and Latin America (4) Stewart-Gambino. (SS)

Japanese

See Listings under Modern Foreign Languages.

Jewish Studies

The Jewish Studies minor offers students the opportunity to explore the history, literature, religion, and social institutions of the Jewish people from its inception to the present. The diversity of courses highlights the interaction of Judaism with other world civilizations and the mutual influences between Judaism and societies and cultures of Europe, the Middle East, and the United States. Through the Jewish Studies minor, a student has the opportunity to study Judaism from the perspective of various academic disciplines.

The program is designed to be of interest to students with diverse interests and fields of concentration. The study of Jewish society and culture can enhance one's understanding of European or American society and culture. Students of psychology and sociology will find that Jewish Studies contributes to their understanding of such issues as prejudice and anti-Semitism, assimilation, and religious-cultural pluralism.

The study of Jewish religion and philosophy brings one face to face with such problems as God, religious faith and doubt, moral responsibility, evil and human suffering. In addition, studying Judaism in comparison with another religious tradition heightens one's understanding of both religions. The study of Judaism introduces the student of literature to a broad sample of diverse literary forms and themes from diverse periods and cultural settings. The formal program of courses is augmented through a program of lectures, colloquia, films, and other cultural events. Study abroad, particularly in Israel, is encouraged to augment and broaden students' understanding of Jewish civilization. Under the sponsorship of the Philip and Muriel Berman Center for Jewish Studies, students may study for a semester or a year at the Hebrew University in Jerusalem or Tel Aviv University. During the summer, students may earn up to six credit hours by participating in the Tel Aviv University summer program or the Hebrew University summer study program in Jerusalem. For further information on programs in Israel and scholarships available, students should contact Shirley Ratnau of the Berman Center. Students should coordinate their minor program in Jewish Studies with the director of the center, Laurence J. Silberstein, Maginnes Hall.

A minimum of sixteen credit hours is to be selected from the following courses. (A maximum of eight credit hours of Hebrew may be counted.) In addition to the following courses, which are offered regularly, new courses are offered annually. Students should check with the Jewish Studies office, Maginnes 324, for an updated list.

Hebr 1 Elementary Modern Hebrew I (4)
Hebr 2 Elementary Modern Hebrew II (4)
Hebr 11 Intermediate Modern Hebrew I (4)
Hebr 12 Intermediate Modern Hebrew II (4)
IR 81 Middle East in World Affairs to 1945 (4)
IR 82 Middle East in World Affairs Since 1945 (4)
Phil/Rel 129 Jewish Philosophy (3)
Phil 133 Medieval Philosophy (3)
Rel 73 The Jewish Tradition (4)
Rel 111 Jewish Scriptures/Old Testament (4)
Rel 112 Jewish Origins: The Beginnings of Judaism and Jewish Diversity in the Greco-Roman World (4)
Rel 121 Sources for the Life of Jesus: Jewish and Christian Context (4)
Rel 130 The Mystical Tradition: Judaism (4)
Rel 132 Hasidic Tales (4)
Rel/WS 138 Women in Jewish History (4)
Rel 139 Jewish Folklore (4)
Rel 150 Forms of Jewish Identity in the Modern World (4)
Rel 152 American Judaism (4)
Rel Hist 154 The Holocaust: History and Meaning (4)
Rel 155 Jewish Thought since the Holocaust (4)
Rel 156 Israel, Zionism, and the Renewal of Judaism (4)
Rel/WS 158 Sex and Gender in Judaism: The Feminist Critique (4)
Rel 174 Contemporary Theology (4)
Rel 186 Judaism in Israel and the United States (4)
Rel 371 Directed Readings (1-4)
US 85 American Jews: Politics and Culture (3)

Journalism and Communication

Professor. Sharon M. Friedman, M.A. (Penn State), Iacocca Professor and director of science writing program; Carole M. Gorney, M.S.J. (Northwestern), APR, Fellow (PRSA) director of public relations concentration.
Associate professors. Jack Lule, Ph.D. (Georgia) chairperson; Walter W. Trimble, M.A. (Ohio State).

Adjunct professors. Kenneth Friedman, Ph.D. (Penn State); Glenn Kranzley, B.A. (Penn State); Robert Rosenwein, Ph.D. (Michigan); Nancy S. Ross, M.A.T. (Cincinnati); William White, M.A. (Ohio State); Dina Wills, Ph.D. (Oregon), director of communication minor.

The department of journalism and communication offers major and minor programs in journalism (news and public relations concentrations) and science writing, and an interdisciplinary communication minor.

Journalism is crucial to the public life of a democracy. At its best, journalism serves as a watchdog to government, offers a voice for the powerless at home and abroad, entertains and instructs the public, represents the views of varied constituencies, monitors and protects the environment and public resources, and provides a common memory for a people.
The purpose of the journalism program is to provide students with the knowledge and skills to fulfill such roles. The program emphasizes research, writing, editing, and critical thinking and analysis. Students integrate online technology with legal and ethical thinking and a global perspective that will prepare them for numerous opportunities in and out of journalism.

In the news concentration, students take courses in news and feature writing, editing and design, and law and ethics, advanced research and reporting, a seminar in mass media issues, and a professional internship. In addition, students pursue a concentration in areas such as government, history, international relations, languages, religion studies, various scientific disciplines, social relations, and urban studies.

In the public relations concentration, students take a core set of journalism courses, including editing and design, law and ethics, feature writing and a professional internship. They also take courses in public relations theory, writing, case studies, applied public relations and a practicum. In addition, students take choice courses in specialties such as public affairs, hospital, health care and corporate communication.

A second major program available to students is the science writing major. Students learn to write about pure and applied scientific research, technology, engineering, the environment and medicine and health for a variety of audiences ranging from the general public to scientists and engineers in industry and government. Students can also gain experience in the science writing field research program. A minor in science writing is available that may be valuable for students with majors in science or engineering.

An interdisciplinary minor in communication is offered for students interested in developing oral communication skills and a better understanding of how people share meaning through persuasive use of rhetoric, logic and symbols in public, one-to-one and small group communication.

Career opportunities are numerous for graduates of the department. Students in the news concentration find work with newspapers, wire services, magazines, cable, television and radio stations, public relations and other media outlets. Others have used their background in journalism as a basis for the study and practice of law, graduate study in a variety of disciplines, government service, teaching and business management.

Students in the public relations concentration will be prepared for both entry-level positions and for later management responsibilities in government, corporations, hospitals, health care organizations, universities, sports information, nonprofit agencies and other groups.

Students in science writing can expect to pursue careers in science journalism; public relations for scientific societies, government agencies, universities or hospitals; technical writing for industry and government agencies, and other areas, such as management, administration and teaching. The program also prepares students for graduate study in science writing, journalism and other disciplines.

The interdisciplinary minor in communication will be useful to students interested in organizational and written communication, law, business, philosophy, government, marketing, teaching, telecommunication, or other careers where successful communication is important.

Suggested math course. Math. 12, Basic Statistics, is highly recommended for students contemplating a Journalism or Science Writing Major. While not required, this course should be taken instead of another math course to fulfill the college's distribution requirement, if possible.

**Core Curriculum**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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</thead>
<tbody>
<tr>
<td>Jour 13</td>
<td>Editing and Design (3)</td>
</tr>
<tr>
<td>Jour 122</td>
<td>Media Ethics and Law (3)</td>
</tr>
<tr>
<td>Jour 212</td>
<td>Feature Writing (4)</td>
</tr>
<tr>
<td>Jour 361</td>
<td>Internship (4)</td>
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</table>

**Upper-level Courses**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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</thead>
<tbody>
<tr>
<td>Jour 365*</td>
<td>Advanced Research and Reporting (4)</td>
</tr>
<tr>
<td>Jour 366</td>
<td>Seminar in Mass Media Issues and Cases (2)</td>
</tr>
</tbody>
</table>

**Choice Courses**

Plus three courses, with a common, interdisciplinary, intellectual core, grounded in the liberal arts, chosen in consultation with a journalism advisor. At least two courses must be at or above the 200 level. (9-12)

36-39 total credits for news concentration journalism major

*Writing intensive

**Examples of choice course groups for news concentration:**

Students are free to make their own choices in consultation with a major.

<table>
<thead>
<tr>
<th>Course Code</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Jour 246</td>
<td>International Communication</td>
</tr>
<tr>
<td>IR 101</td>
<td>Theories of International Relations</td>
</tr>
<tr>
<td>Pols 322</td>
<td>Politics of Developing Nations</td>
</tr>
<tr>
<td>Jour 125</td>
<td>Environment, the Public and the Mass Media</td>
</tr>
<tr>
<td>His 315</td>
<td>American Environmental History</td>
</tr>
<tr>
<td>Jour 323</td>
<td>Scientific and Environmental Controversies</td>
</tr>
<tr>
<td>Pols 177</td>
<td>Urban Politics</td>
</tr>
<tr>
<td>His 334</td>
<td>Urban Anthropology</td>
</tr>
<tr>
<td>Eco 312</td>
<td>Urban Economics</td>
</tr>
<tr>
<td>Jour 327</td>
<td>Mass Comm and Society</td>
</tr>
<tr>
<td>Jour 391</td>
<td>Special Topics in Journalism</td>
</tr>
<tr>
<td>Pols 351</td>
<td>Constitutional Law</td>
</tr>
<tr>
<td>Phil 122</td>
<td>Philosophy of Law</td>
</tr>
<tr>
<td>Pols 306</td>
<td>Public Policy Process</td>
</tr>
<tr>
<td>Comm 143</td>
<td>Persuasion</td>
</tr>
<tr>
<td>Pols 329</td>
<td>Propaganda</td>
</tr>
<tr>
<td>Ssp 333</td>
<td>Social Psychology of Politics</td>
</tr>
<tr>
<td>Pols 337</td>
<td>Religion and Politics in Latin America</td>
</tr>
<tr>
<td>Rel 159</td>
<td>Roman Catholicism in the Modern World</td>
</tr>
<tr>
<td>Rel 221</td>
<td>Topics in Asian Religions</td>
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**Public Relations Concentration**

**Preliminary Courses:**

<table>
<thead>
<tr>
<th>Course Code</th>
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</thead>
<tbody>
<tr>
<td>Jour 127</td>
<td>Public Relations Principles (4)</td>
</tr>
<tr>
<td>Jour 128*</td>
<td>Writing for Public Relations (4)</td>
</tr>
</tbody>
</table>

**Core Curriculum:**

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<td>Jour 361</td>
<td>Internship (4)</td>
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**Upper-level Courses:**

<table>
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<tr>
<th>Course Code</th>
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<tbody>
<tr>
<td>Jour 229</td>
<td>Public Relations Case Studies (4)</td>
</tr>
<tr>
<td>Jour 233</td>
<td>Public Relations Practicum (1-4)</td>
</tr>
<tr>
<td>Jour 306</td>
<td>Applied Public Relations (4)</td>
</tr>
</tbody>
</table>

Plus two courses from specialty areas below (6-8)

37-39 total credits for public relations concentration journalism major

*Writing intensive
Choice courses for public relations concentration will be chosen from the following specialty areas:
Public Affairs (Political Science)
Corporate Public Relations
Hospital/Health Care
Science/Environment
Sports Information

**Journalism/Science Writing**
required preliminary courses
Jour 1  Brown & White (1)
Jour 11 News Writing (4) or
Jour 123 Basic Science and Technical Writing (3) or
Jour 314 Communicating Technical Information (3)

**Core Curriculum**
Jour 2-3  Brown and White (2)
Jour 13  Editing (3)
Jour 122  Media Ethics and Law (3)
Jour 124  Politics of Science (3)
Jour 125  Environment, the Public and the Mass Media (4)
Jour 323  Scientific and Environmental Controversies (4)
Jour 361  Internship (4)
Jour 365  Advanced Research and Reporting (4)
Plus 4 hours in Journalism or Communication at or above the 100 level or Pols 177.

35 credits are required for journalism/science writing major.

**Note:** A minimum of three semesters is required on The Brown and White. The course involves work on the student newspaper. One of the three required semesters must be taken during the student's junior year, and one must be taken during the senior year.

**Required science courses.** A minimum of twenty-four credits in the physical, biological, environmental or social sciences or engineering is required. These hours can be concentrated in any one area or distributed among all five areas, although an area concentration is recommended. Dual majors in journalism/science writing and a science are encouraged. Science courses should be chosen in consultation with the major adviser.

**Science writing field research program.** Available to science, environmental and technical writing students at the junior or senior level, this program provides practical experience in scientific research and science writing for students who work on and write about research projects directed by university scientists and engineers. Another segment of the program allows students to attend major scientific meetings as fully accredited science reporters. Students observe professional science writers in action and write their own stories about the scientific sessions and press conferences held at the meetings.

**Journalism Minor**
Students who wish to declare a minor program in journalism must be majors in another discipline and take the following:
Jour 1-2  Brown & White (2)
Jour 11  News Writing (4)
Jour 13  Editing (3)
Jour 212  Feature Writing (4)
One other Journalism course at or above the 100 level
16-17 credits are required.

**Public Relations Minor**
Jour 127  Public Relations Principles (4)
Jour 128  Writing for Public Relations (4)
Jour 229  Public Relations Case Studies (4)
Jour 233  Public Relations Practicum (1-4)**
Jour 361  Internship (4)

**Science Writing Minor**
Jour 1  Brown and White (1)
Jour 2  Brown and White (1) or
Jour 231  Science Writing Practicum (1) or
Jour 361  Internship (2)
Jour 11  News Writing (4) or
Jour 123  Basic Science and Technical Writing (3)
Jour 124  Politics of Science (3)
Jour 125  Environment, the Public and the Mass Media (4)
Jour 323  Scientific and Environmental Controversies (4)
16 credits are required for journalism/science writing minor.

**Communication Minor**

**Purpose:** This minor guides students to a better understanding of how people share meaning through persuasive use of rhetoric, logic and symbols in public, small group, dyadic, organizational and visual communication. It will be relevant to students interested in law, organizational communication, philosophy, government, marketing, teaching, or any occupation where it is essential to communicate information to others successfully.

The perspectives taken by the minor are those of rhetorical theory and communication theory. The student will become acquainted with major theories, concepts and issues concerning the available means of persuasion, and with the techniques used to communicate successfully with others. Experiential learning includes the construction and delivery of oral presentations, writing, graphics and participation in small group and teamwork situations.

This interdisciplinary minor is administered by the Department of Journalism and Communication. It is advised by an interdisciplinary committee of faculty members with both teaching and research interests in these areas. Students are encouraged to become involved with communication research activities under the guidance of interested faculty members.

**Courses.** The minor represents 17-18 credit hours. It consists of one required course in communication theory (Comm 143 or SSP 135) and one required course in public speaking (Comm 130). An additional 10-11 credits may be chosen from two of the four groups below. One of these courses must be at or above the 200-level. With the consent of the participating instructor and the director of the minor, a student may elect to take a Special Topics (Comm 325) project as part of the 10-11 elective credit hours. Another possible elective is a 4-credit internship in Journalism and Communication or in Art and Architecture, provided that the student meets all departmental requirements for such an internship.

The director is Dina Wills, Department of Journalism and Communication, University Center.

**Required courses (6-7 credits)**
Comm 130  Public Speaking (3) and either
Comm 143  Persuasion and Influence (4) or
SSP 135  Human Communication (3)

**Elective courses (10-11 credits)** chosen from at least two of these groups. One course must be at or above the 200-level.

Group I—Public Communication
Comm 60  Fundamentals of Speech Communication (3)
Comm 331  Business and Professional Speaking (3)
Comm 144  Effective Interviewing (3)
Pols 329  Propaganda and American Politics (4)
Jour 127  Public Relations Principles (4)


1. Brown and White (1) every semester
Enrollment constitutes membership on the staff of the semi-weekly undergraduate newspaper. Newspaper staff members are selected based on their interests and skills. Students who pre-register for this course are told at the beginning of the semester whether they have been selected for the staff. Prerequisite: Jour 11 or Jour 123 or consent of the department chairperson. Lule/Timble. (ND)

11. News Writing (4) every semester
Preparation and practice in gathering and writing news; definition and components of news; structure and style of the news story; introduction to interviewing and editing. (ND)

13. Editing (3) every semester
Study of and practice in editing and rewriting stories for newspapers and magazines; headline writing; techniques of newspaper and magazine design, including typography, grids, and use of photographs and other artwork; microcomputer-based desktop publishing. Prerequisite: Jour 11 or Jour 123. Trimble. (ND)

101. Media, Sports and Society (3) summer
Analysis of social, political and economic implications of media sports coverage; emphasis placed on media coverage of events of international scope, such as the World Cup, World Series and the Olympics; special attention paid to the role of the sports press in coverage of issues such as AIDS, racism, sexism, drug use and terrorism. Lule. (SS)

102. How to Watch TV (4) summer
Analysis and discussion of television programming from the standpoint of its potential effects on audience perceptions, public opinion, social issues and values, individual learning, and behavior. Programming viewed both inside and outside the classroom includes news programs, news magazines, talk shows, sitcoms, dramas, cartoons, soap operas, commercials, and infomercials. To help focus discussions, students are assigned appropriate readings from the popular media and social science research. Corney. (ND)

111. Sportswriting (3) summer
Principles and practice of writing about sports for general print and specialized publications; emphasis placed on instruction in reporting, writing and editing; topics covered include the history of sports journalism; recent trends in the field; ethical considerations, and the exploration of social and political issues through sportswriting. Lule. (ND)

122. Media Ethics and Law (3) spring
First Amendment theory and history; ethical and legal issues involving libel, privacy, obscenity, newsgathering, access, and fair trials; national and international concerns over censorship, prior restraint and manipulation and control of information. Lule. (SS)

123. Basic Science and Technical Writing (3) every semester
Writing about science and technology subjects for audiences ranging from lay persons to scientists and engineers. Includes instruction in news and feature writing plus interviewing for lay audiences. With emphasis on organization and clear writing techniques. As course progresses, material becomes more technical in nature, concentrating on how to write effective technical reports, progress reports, letters and memos. Prerequisite: six hours of science or engineering or consent of department chairperson. S. & K. Friedman. (SS)

124. (STS 124) Politics of Science (3) spring
Organization of the U.S. scientific community; interaction with federal government, mass media and society; history of science-government connection; role of science advisory system; technological controversies. S. Friedman. (SS)

125. Environment, the Public and the Mass Media (4) every semester
Exploration of environmental problems and public perceptions about them. Roles played in environmental controversies by government, environmental groups, industry and mass media. Risk communication about environmental hazards. S. & K. Friedman. (SS)
127. Public Relations Principles (4) fall
Emphasis on management function of public relations, including research, planning, counseling, programming, communication and evaluation. Study of communication and persuasion theory, public opinion and ethics. Student teams work outside class for a community client, helping research, plan and implement an actual public relations program during the semester. (SS)

128. Public Relations Writing (4) spring
Basics of news writing (structure and style) applied to the preparation of informational, promotional and persuasive news releases; principles of effective media relations, and methods to generate positive publicity; preparation of media kits (backgrounders, fact sheets, story tip sheets). Student teams work outside class to develop a publicity plan and supporting publicity materials for an on-campus student organization-sponsored event. Prerequisite: Jour 127 (ND)

129. Specialized Writing in Public Relations (3) fall
Preparation and writing of promotional and publicity materials, including public service announcements, for radio and television; preparation of audio-visual materials and presentations; planning and conducting news conferences; media interview techniques in negative situations; writing informational and persuasive speeches for others. Students will produce finished public service announcements and will be videotaped giving actual media interviews. Prerequisite: Jour 11 or 123 or consent of department chairperson. Gorney. (ND)

135. (Spy 135) Human Communication (3)
Processes and functions of human communication in relationships and groups. Rosenwein. (SS)

141. Photojournalism (3) summer
Ethics and history of photojournalism; instruction and practice in basic camera and darkroom techniques; use of microcomputer to manipulate and print photographs; cropping and sizing photographs and production of layouts using microcomputer-based desk-top publishing. Students must provide own 35mm camera. Trimble, Gorney. (ND)

212. Feature Writing (4) every semester
Concepting and developing feature stories for newspapers and magazines; interviewing techniques; writing non-fiction using the techniques of the novelist; marketing free-lance projects. Trimble. (ND)

214. Reporting of Public Affairs (4)
Reporting and writing news of government on the local, county, state and federal levels; civil and criminal courts; labor, environment, housing and community planning news. Prerequisites: Jour 11 or 123 and Pols 177. Trimble. (ND)

215. Publication Design (3)
Advanced study of publication design: newspapers, magazines, pamphlets, annual reports; symbols, typography, grids, use of photographs and infographics; use of Macintosh computer in page production, and in creating and manipulating art for publication. Prerequisite: Jour 13 or permission of the department chairperson. Trimble. (ND)

220. Reporting on Business and Economics (3)
The principles behind the economy, the markets and companies and how to report on them; the role of business reporting in the media; the use of computer technology in business reporting. Prerequisite: Jour 11 or Jour 123 and Eco 1. (SS)

229. Public Relations Case Studies (4) fall
Analysis of public relations programs and practices in business and industry, government, and non-profit organizations. Study focuses on principles that govern employee, community, consumer and media relations, as well as issues management and special events and promotions. Students select, research and write a fully documented major case study using both primary and secondary sources, as well as preparing audio/visual aids to support an oral presentation to the class at the end of the semester. Prerequisite: Jour 127 (ND)

231. Science Writing Practicum (1-4)
On-site experience as accredited science reporter at major scientific meetings, or writing and research in university laboratories as part of Science Writing Field Research Program. May be repeated for a maximum of eight credits. Prerequisites: Jour 11 or Jour 123 or Jour 311, junior standing, and consent of the department chairperson. S. Friedman. (ND)

233. Public Relations Practicum (1-4) every semester
Practical application of public relations principles to various semester-long projects, or to competitive programs sponsored by professional and academic public relations societies. The amount of credit is negotiable with the instructor based on the extent and complexity of the projects undertaken. Prerequisites: Jour 127 and 128 (with permission, Jour 128 may be taken concurrently with practicum) Jour 229 required for the Bateman Case Study competition (ND)

240. Writing for Broadcasting (4) spring
Basic writing style for radio and television news, and scripting newscasts in a variety of formats, including electronic news gathering and voice overs. Scripting and storyboarding for commercials and public service announcements. A three-hour writing lab is included. A portion of the course is devoted to study and discussion of issues related to television news coverage. (ND)

246. (IR 246) International Communication (4)
Role of international news media in world affairs. Global theories of the press; process and influence of U.S. reporting of international affairs; survey of global media systems; global communication controversies. Lule. (SS)

306. Applied Public Relations (4) spring
Study and application of crisis planning, management and communication principles to problems faced by a variety of profit and non-profit organizations. Study includes effective handling of the release of bad news, negative media coverage, and opposition; planning interviews, news briefings and news conferences. The class works together outside of class to prepare written plans on how to respond to a simulated crisis at various stages of escalation. The class also anticipates questions, prepares answers and rehearses outside of class in order to role play organization spokespersons at a news conference held with journalism students from Jour 11. Prerequisite: Jour 127 and 229. (ND)

311. Science and Technical Writing (3) every semester
Study of and practice in writing about science and technology for general print and specialized science publications. Includes news and feature articles, report writing and analysis of factors that influence science communication to the public. Emphasis on writing and organizational skills and translation of scientific materials into lay language. Should be taken by upperclass and graduate students instead of Jour 123. Prerequisite: six hours of science or engineering or consent of department chairperson. S. & K. Friedman. (ND)

312. Advanced Science Writing (3)
Further practice, on individual basis, in science writing techniques. Prerequisite: Jour 123 or 311. S. Friedman. (ND)

313. Special Topics in Science Communication (1-4)
Research or writing involving a topic, medium or issue in science, environmental or technical communication not covered in other courses. Prerequisite: Nine hours in science or environmental writing or consent of the department chairperson. S. Friedman. (SS)

314. Communicating Technical Information (3)
For upperclass students planning on graduate school and graduate students: instructions in writing about technical subjects from an
academic perspective. Laboratory reports, journal articles, thesis and
dissertations, proposals and oral technical presentations will be
highlighted. Prerequisite: Junior standing or permission of department
chairperson. K. Friedman. (ND)

320. Journalism Proseminar (3) spring
Intensive research and writing on contemporary issues and problems
facing the mass media; methods and approaches for studying the mass
media; course culminates with a seminar thesis based on original and
comprehensive research. Prerequisite: nine hours in journalism, public
relations or communication or consent of the department chairperson.
Lule. (SS)

323. (STS 332) Scientific and Environmental Controversies (4)
Exploration of media coverage of controversial scientific and
environmental topics. Includes discussion of the social responsibilities
of the media. Topics will vary with the semester but usually include
several of the following: genetic engineering, environmental risks such as
dioxin or electromagnetic fields, viruses, or various technology
applications. S. Friedman (SS)

327. (SPsy 327) Mass Communication and Society (3)
A review of theories and research on the relationship of mass
communication to social processes. Intensive analysis of selected media
products (e.g., TV news, dramas, and sitcoms; films; print; music
videos, etc.). Rosenwein. (SS)

361. Internship (1-4)
Professionally supervised work on newspapers, magazines, radio and
television stations, or with public relations organizations. Some
internships involve science writing. May be repeated for a maximum of
eight credits. Prerequisite: Junior or senior standing and declared major
or minor in journalism, science writing, public relations or
communication and consent of the department chairperson. Staff (ND)

365. Advanced Research and Reporting (4) fall
Planning, researching and writing comprehensive news projects; special
attention paid to computer-assisted research, online resources, investigative
techniques, interviewing skills, reporting on local, county, state and federal
governments and courts; emphasis also given to organizing and writing in-
depth articles. Prerequisites: eight hours in journalism and senior standing
or permission of department chair. Lule, Trimble (ND)

366. Seminar in Mass Media Issues and Cases (2) spring.
Case studies in contemporary issues confronting the media;
emphasized given to critical thinking and analysis; cases to be
drawn from news, magazines, public relations, advertising, television,
radios, film and new technology. Prerequisite: Jour 365 or permission of
department chair. Lule (ND)

389. College Scholar Project (1-8)
Opportunity for College Scholars to pursue an extended project. May
be repeated for credit. College-wide course designation. Transcript will
identify department in which project was completed. Prerequisite:
consent of department chair. Staff. (ND)

390. Honors Thesis (1-4)
Directed undergraduate research thesis required of students who apply
for and qualify for graduation with departmental honors. Staff. (ND)

391. Special Topics in Journalism (1-4)
Directed research or writing involving a subject or issue in journalism not
covered in other courses. May be repeated for credit. Prerequisite: Twelve
hours in journalism or consent of the department chair. Staff. (ND)

Communication Courses
Comm 60. Fundamentals of Speech Communication (3)
The basic principles of communication: the informative speech, small
group communication process, principles of persuasion, effects of mass
communication. Two speeches, group project. Wills. (ND)

Comm 130. Public Speaking (3) every semester
Applying the principles of public speaking to making informative and
persuasive presentations effectively. Emphasis on speech composition
and effective oral communication skills. (HU)

Comm 143. Persuasion and Influence (4) fall
The social, symbolic, and rhetorical means of persuasion and how this
persuasive influence is expressed in politics, advertising, and the mass
media. Wills. (SS)

Comm 144. Effective Interviewing (3) spring
Theory of effective interviewing; how to plan and structure an interview
outline; types of questions used in interviews; how to open, conduct
and conclude an interview. Special emphasis on the journalistic,
employment and broadcasting interview. Instructor will use role-playing
and videotaping. Students will prepare and conduct simulated
interviews. Wills. (ND)

Comm 325. Special Topics in Communication (1-4)
Research and writing or performance involving a topic, medium or issue
in journalism, public relations, speech or communication theory not
covered in other courses. Prerequisite: nine hours in journalism, public
relations or communication and consent of department chairperson.
(SB)

Comm 331. Business and Professional Speaking (3) fall
The principles of oral communication as applied to business
and professional situations. Professional presentations, small group
interaction and interpersonal communication in the business setting.
Prerequisite: junior or senior standing. (ND)

Languages
Courses are listed alphabetically under Modern Foreign Languages and
Classical Studies.

Latin American Studies

The minor in Latin American Studies represents an opportunity to
explore the language, literature, history, cultures, and socioeconomic
problems of our neighbors to the south. It provides a perspective on the
problems of other underdeveloped regions of the world, in contrast to
most offerings in the humanities and social sciences that usually focus
on the mainstream of western culture, notably the United States and
Western Europe.

It is worth noting the importance of Latin American cultures in the
future of the hemisphere. Latin America is the most rapidly growing
part of the world, and by the year 2000 it is predicted that the area will
have a population of 600 million, or twice that of Anglo-America.
Several countries, especially Brazil and Mexico, are undergoing rapid
industrial expansion. Consequently, besides the personal values to be
derived from this curriculum, there are business, governmental, and
related career possibilities.

The minor program requires 16 credit hours, chosen from economics,
history, government, Spanish, anthropology, and I.R. in discussion with
the coordinator, Antonio Prieto, Modern Foreign Languages, Maginnes
Hall.

Requirements (6-7) credits
A. History/Culture (4 credits). Choose one of the following:
Hist 49 History of Latin America (4)
Hist 50 History of Latin America (4)
Span 152 The Cultural Evolution of Latin America
(taught in Spanish) (4)
B. Language (4 credits). Choose one of the following:

span 2
Elementary Spanish II (4)

span 12
Intermediate Spanish II (4)

Elective courses (7-9 credits) chosen from the following courses:
No more than two courses may be taken in any one department:

Anth 178
Mesoamerican Archeology (3)

MFL 51
Contemporary Hispanic-American Literature (4)

MFL 53
The Hispanic World and Its Culture (4)

Eco 305
The Economic Development of Latin America (4)

Govt 322
Politics of Developing Nations (4)

Govt 335
Latin American Political Systems (4)

Govt 336
U.S. Foreign Policy and Latin America (4)

Govt 337
Religion and Politics in Latin America (4)

Hist 49-50
History of Latin America (4)

Hist 265
Mexico and the Caribbean (4)

Hist 266
Argentina, Brazil and Chile (4)

Hist 368
Seminar in Latin American History (4)

IR 177
International Relations in Latin America (4)

Span 12
Intermediate Spanish II (4)

Span 263
The Spanish American Short Story (4)

Span 265
Spanish and Latin American Cinema (4)

Span 320
Literature of the Spanish Caribbean (4)

Span 321
Children and Adolescents in Contemporary Spanish American Literature (4)

Span 322
The Short Novel in Contemporary Spanish American Literature (4)

Span 323
Literature and Revolution in Contemporary Cuba (4)

Span 325
Hispanic Literature of the United States (4)

Span 342
The New Narrative in Spanish American Literature (4)

Span 396
Andean Literature (4)

Law

Professor. Perry A. Zirkel, J.D., LL.M. (Yale), Ph.D. (Connecticut),
University Professor of Education and Law.

Associate professors. George A. Nation III, J.D. (Villanova).

Assistant professor. Matthew A. Melone, J.D. (Pennsylvania), C.P.A.

Adjunct professors. Patrick F. McCormick, J.D. (Ohio Northern);
Nancy T. Schneideman, J.D. (Harvard); Charles Shoemaker, Jr., J.D.
(Yale); Patti L. Smith, J.D. (Temple) LL.M. (Villanova); Jeffrey M.
Miller, J.D. (John Marshall Law School).

The Department of Business offers the following undergraduate and graduate courses:

Undergraduate Courses

Law 11. Introduction to Law (3)
A study of the nature and function of law and the legal system,
the study of legal reasoning through the use of the case method.

Law 111. Criminal Trials and Procedures (1)
The course focuses on criminal law and procedure from actual
indictment and/or arrest through and including the appellate procedure.
Tactics and strategy within the framework of the various steps of a
typical criminal proceeding are discussed. Guest speakers contribute to
the course which in the past included Philadelphia Police Inspectors
talking about investigations and polygraphs; an FBI agent on arrests
and Miranda warnings; prominent Philadelphia criminal and trial
lawyers; probation officers and others.

Courses numbered 200 and above in the College of Business and
Economics are open to sophomores only on petition.

Law 201. Legal Environment of Business (3) every semester
The study of the legal relationships of business and government,
business and society and the individual and society. The case method
is used to develop analytical skills. Introduction to contract law and the
law of sales underlying the free market system. Prerequisite: Eco 1 or
Eco 11 and Eco 12.

Law 202. Business Law (3) every semester
The law of sales, contracts, agency, business organizations, secured
transactions, property and negotiable instruments. Prerequisite: Law 201.

Law 221. (Phil 221) Sex-Discrimination and the Law (3)
A critical study of the law of sex discrimination in areas of
constitutional and labor law. A case approach that places emphasis on
the rights of employees and the obligations of employers. Topics
include equal protection, equal employment opportunity, and
affirmative action. (HU)

Law 371. Directed Readings (1-3)
Readings in various fields of law, designed for students who have a
special interest in a field of law.

Law 372. Special Topics (3)
Special problems and issues in commercial law.

Graduate Courses

GBUS 402. Legal Environment of Management (3)
The effect of public and private law on business decisions. The legal
relationship of business and society and business and government,
especially the government regulation of business. Introduction to
contract law underlying the free market system.

GBUS 437. Federal Taxation and Business Decisions (3)
Impact of federal taxation on the structure and timing of business
decisions. Problem-solving methods and research techniques from a
managerial perspective. Prerequisite: a basic course in accounting.

GBUS 474. The Legal Aspects of International Business
A study of the international legal environment of business. The problem
method is used to analyze the differences, difficulties, and opportunities
of international business. Topics to be studied include: importing and
exporting goods, non-tariff trade barriers, transfers of technology, foreign
direct investment, and doing business in the EEC.

Management

Professors. Richard W. Barsness, Ph.D. (Minnesota); Alden S. Bean,
Ph.D. (Northwestern), Kenan Professor of Management and
Technology; John W. Bonge, Ph.D. (Northwestern); Michael G.
Kolchin, D.B.A. (Indiana) Director, Graduate and Professional
Education; Benjamin Litt, Ph.D. (N.Y.U.); John E. Stevens, Ph.D.
(Cincinnati).

Associate professors. Peter P. Poole, Ph.D. (Penn State); Peter M.
Saunders, Ph.D. (University of Toronto); Theodore W. Schie, Ph.D.
(Northwestern); Susan A. Sherrer, Ph.D. (Pennsylvania).


Lecturer. Dale F. Falemelti, MBA (Lehigh).

Adjunct professors. Don S. Follett, M.S. (Cornell); Dennis D.
Newhart, MBA (Lehigh); James R. Sefton, M.S.E.E. (Lehigh).

Management Program and Courses

The Department of Business offers an undergraduate management
major. Majors will select either the Specialization (15 hours) or
Interfunctional (18 hours) track shown below:
Specialization (15 hours)

required courses:

Mgt 302 Quantitative Models-Conceptual (3)
Mgt 321 Organizational Behavior Workshop (3)

*Plus at least one of the following:

Mgt 309 Industrial Purchasing and Materials Management (3)
Mgt 311 LUMAC Management Assistance Counseling (3)
Mgt 331 Industrial Relations and Public Policy (3)
Mgt 333 Personnel Management (3)

Up to two of the following:

Acct 324 Cost Accounting (3)
Eco 333 Managerial Economics (3)
Eco 334 Labor-Management Relations (3)
Eco 335 Labor Economics (3)
Eco 352 Advanced Statistical Methods (3)
Eco 357 Econometrics (3)
Fin 328 Corporate Financial Policy (3)
Mkt 319 New Product Planning (3)
Mkt 321 Marketing in the Industrial Environment (3)
IE 309 Introduction to Information Systems (3)
IE 334 Organizational Planning and Control (3)
IE 332 Product Quality (3)

*Courses other than Mgt 302 and Mgt 321 will be selected in consultation with the faculty advisor to comprise one of the following specialization options: entrepreneurship, human resources management, materials management, and operations management.

Interfunctional (18 hours)

required courses:

Mgt 302 Quantitative Models-Conceptual (3)
Mgt 321 Organizational Behavior Workshop (3)
Acct 324 Cost Accounting (3)
Fin 328 Corporate Financial Policy (3)
Mkt 319 New Product Planning (3)
Mkt 321 Marketing in the Industrial Environment (3)
IE 309 Introduction to Information Systems (3)
IE 334 Organizational Planning and Control (3)
IE 332 Product Quality (3)

Plus one of the following:

Mgt 290 Introduction to Information Systems (3)
Mgt 321 Organizational Planning and Control (3)
IE 332 Product Quality (3)

Undergraduate Courses

Mgt 1. Introduction to Business Computing (3) fall, spring
A one-semester survey of computer technology and software applications in business and economics. Topics include introduction to computer architecture and logic, operating systems, spreadsheets, and data base management systems. Students will develop a basic understanding of Microsoft and the campus-wide network. Limited to freshmen only. (Mgt. 1 will be a prerequisite for many courses in the College of Business and Economics.)

*see class of 2001 blurb in Section III

Mgt 101. (ECO 101) Introduction to Quantitative Methods (3)
Mathematical concepts within a business and economics framework: linear algebra, partial derivatives, constrained optimization, and integral calculus. Meets mathematics prerequisites for entering students in the master of business administration program. Not available for credit to undergraduates in the College of Business and Economics.

Mgt 107. Introduction to Business Communication (2)
The communication process and strategic adaptation of language to meet cultural, institutional and personal needs within a changing business environment. Written and spoken communication through letters, memos, reports and oral presentations. Composition and design of informative, negative and persuasive messages. Nonverbal and intercultural communications. Editing, revision, collaborative composition. Teaming and interpersonal communication. Prerequisite: C- or better in English 1 and 2.

Courses numbered 200 and above in the College of Business and Economics are open to sophomores only on petition.

Mgt 269. Management of Operations in Organization (3) fall, spring
Design, operation and control of activities necessary to generate goods or services of profit and nonprofit organizations. Basic concepts and quantitative modes used in operations. Prerequisite: Eco 145, Math 44 or Math 51. Trent

Mgt 270. Organization Theory and Behavior (3) fall, spring
Formal organizations as ongoing systems. Emphasis is placed on the introduction of theory applicable to the management of human behavior in work environments. Issues at the individual, group, and organizational levels of analysis are addressed. Topics covered include motivation, stress, career processes, leadership, conflict management, decision making, work politics, organizational design, and organizational development. Poole

Mgt 301. Business Management Policies (3) fall, spring
Case study of business problems and the formulation of policies, strategies and tactics to resolve those problems from the standpoint of general management. Long-range goal attainment, policy formulation, and implementation of policy for specific functional areas and the overall firm. Prerequisite: senior standing in the College of Business and Economics, and completion of the college core. Barsness

Mgt 302. Quantitative Models-Conceptual (3)
Quantitative methodologies and their use in business, economics and related areas. Classical optimization techniques, mathematical programming, linear programming, decision theory, game theory, simulation and network models. Prerequisites: Eco 115, Acct 211 and Mgt 269.

Mgt 306. Entrepreneurship and Business Policy (3) spring
Case study of problems in creating new ventures or managing family-owned businesses. Integrates knowledge acquired in other courses and stresses development of strategic and administrative policies for particular functions and the company as a whole. Prerequisites: senior standing, completion of College of Business and Economics core, and Mgt 311, as well as approval of the department chairperson. Students may not receive credit for both Mgt 306 and Mgt 301. Bonge

Mgt 307. Business Communication Skills (3)
Written and spoken communication through letters, memos, reports, and oral presentations. Formal and informal communication networks, and communication processes. Prerequisite: consent of instructor.

Mgt 309. Industrial Purchasing and Materials Management (3)
Negotiating, purchasing, receiving, storing, inventory control, value analysis, purchase information systems, and specialized problems in institutional and government procurement. Lectures and cases. Prerequisite: Mgt 269 or equivalent. Kolchin

Mgt 311. LUMAC Management Assistance Counseling (3) fall, spring
A field studies course providing management assistance to small businesses in the Lehigh Valley. Students work in small groups under faculty supervision on a direct basis with owners. Problem solving and experience in applying marketing, accounting, finance, and/or management concepts to business. Prerequisites: junior standing in the College of Business and Economics. Bonge, Stevens

Mgt 321. Organizational Behavior Workshop (3)
A workshop course examining individual behavior, interpersonal transactions and behavioral processes in small work groups through motivational analysis, role-playing, nonverbal interactions, problem solving and group simulations. Prerequisites: Mgt 270 and permission of the department chairperson. Poole, Kolchin, Litt
Mgt 331. Industrial Relations and Public Policy (3)
An examination of the evolution and current status of U.S. public policy toward the organization and recognition of labor unions, collective bargaining, labor contract administration, and arbitration of disputes as expressed in federal statutes, court decisions, and National Labor Relations Board rulings. Stevens

Mgt 333. Personnel Management (3)
Analysis and resolution of personnel problems in organizations. Human resource planning, recruitment, selection, orientation, training, appraisal, compensation, and development. Lectures and cases. Prerequisite: Mgt 270. Kolchin

Mgt 371. Directed Readings (1-3)
Readings in various fields of management designed for the student who has a special interest in some field of management not covered by the regularly scheduled courses. Prerequisite: consent of the department chairperson. May be repeated.

Mgt 372. Special Topics (1-3)
Special problems and issues in management for which no regularly scheduled course work exists. When offered as group study, coverage varies according to interests of instructor and students. Prerequisite: consent of the department chairperson. May be repeated.

Graduate Courses

GBUS 403. Quantitative Methods in Business and Economics (3)
Management science methods and applications are emphasized for problems of determining the best allocation of scarce resources for product mix, facility location, inventory control, portfolio analysis, customer service, vehicle routing, and scheduling of production and distribution. Lectures and case studies to illustrate various management science methods such as mathematical programming, simulation, decision theory, game theory, network models and statistics. Prerequisite: GECO 401 or equivalent.

GBUS 405. Organizational Behavior and Management (3)
Interpersonal and group behavior in organizations. Issues of organization work and perception, motivation, communications, conflict, leadership, and organization structure. Litt, Poole

GBUS 409. Strategic Information Systems (3)
Study of the strategic impact of information technology on business competition, organizational structure and the nature of work. Explores development and management of information systems strategy, including economics and risks associated with investments in information systems technology. Case studies and applications include operations management, financial services, and marketing and distribution. Sherer

GBUS 410. Operations Management (3)
Understanding the forces or trends affecting operations management along with the tools and systems that directly support operations managers. Topical coverage includes understanding manufacturing and service excellence, sources of competitive advantage, total quality management, just-in-time manufacturing, cross functional integration, manufacturing planning activities, inventory control, forecasting, project management, new product development, process design, and competitive requirements for future success. Special emphasis placed on the linkages between operations and other functional areas. Trent

GBUS 411. Managerial Policy and Decision-Making (3)
Study of the processes used to develop strategic intent and organizational mission; environmental and competitive analysis; strategy formulation and implementation. Contemporary readings, group exercises, and case studies. Prerequisites: MBA core. Stevens

GBUS 440. Human Resource Management (3)
A survey of personnel management activities in organizations. Topics include human resource planning, recruitment, selection, equal employment opportunity, performance appraisal, compensation, career planning, safety and health, and quality of work life issues. Course consists of lectures, discussion, and case analysis. Kolchin

GBUS 441. Organizational Design and Change (3)
Variables relevant to determining the design of structures and processes of organizations; techniques pertinent to organizational adaptation to changed environments, technologies and social factors. Prerequisite: GBUS 405. Bonge

GBUS 442. Seminar in Management Consulting (3)
A study of consulting practices in general and their applications to small business. Processes include a field study/counseling service to a local business. Emphasis is on the identification and analysis of multidisciplinary problems and opportunities and the implementation of recommendations. Prerequisites: Completion of the MBA background courses and permission of the instructor.

GBUS 443. Managing Organizational Cultures and Diversity (3)
Examines the major issues & dilemmas facing American Corporate Enterprise as human diversity in the workplace rises sharply over the next decade due to new cultural populations and lifestyles emerging in the domestic workforce. Closely examined are the organizational challenges of developing managerial leadership styles that focus on both quality management outcomes as well as quality of work life and the overall organizational culture. The course combines speakers from diverse “interest groups” with reflective seminar readings, group writings and class discussions. Position papers and a final paper synthesizing the interactive experience with the seminar learning is required of each participant. Prerequisite: GBUS 405. Litt

GBUS 444. Managerial Communication Skills (3)
Organization, style, and strategy of language to inform, direct, and persuade. Application of writing, reading, speaking, and listening skills to managerial problems. Case studies.

GBUS 445. Labor Management Administration (3)
A study of the U.S. system of industrial relations including the evolution and present status of labor law; union organizing efforts; the strategy of negotiations; the substantive provisions of collective bargaining and the administration of collective agreements. Also considered is the role of unions in the implementation of programs for employee self-management and other workplace innovations.

GBUS 446. Commercial Potential Assessment (3)
A study of the process of bringing an invention to market with emphasis on commercial potential. Industry analysis, competitor intelligence and strategic issues will be emphasized along with the development of market strategy and an overall business plan. Extensive research including data base searches will be included. Instructor permission required.

GBUS 450. Strategic Supply Management (3)
A survey course designed to introduce the MBA/MSE student to the vital role played by supply management in achieving overall effectiveness for the firm in today’s global economy. The course starts by examining the traditional purchasing process and then moves on to an examination of the evolution of purchasing into supply management and, finally, to the role purchasing plays in improving effectiveness of the entire value chain. Course consists of lectures, discussion and case analysis. Kolchin

GBUS 451. Analytical Methods in Management (3)
Application of management science methods to industrial and commercial problems. Scientific method, decision theory, linear programming, inventory control, regression analysis, forecasting,
simulation, and related areas are examined in the context of accounting, finance, marketing, and manufacturing.

**GBUS 452. (IE 417) Advanced Mathematical Programming (3)**
Theory and applications of the extensions of linear programming. Tucker-Kuhn conditions, gradient methods of optimization, simplex-based methods of nonlinear programming, integer programming, branch and bound, zero-one discrete programming and stochastic programming. Prerequisite: a course in linear programming.

**GBUS 453. (IE 430) Management Science Project (3)**
As an individual or as a member of a small group, analysis of a management problem and the design of its solution is made incorporating management science techniques. An individual written report is required. Recommended that it be taken in the last semester of the M.S. in management science program.

**GBUS 492-493. Special Topics (1-3)**
Special problems and issues in management for which no regularly scheduled graduate course work exists. When offered as group study, coverage will vary according to the interests of instructor and students. Prerequisite: consent of the department chairperson. May be repeated.

**GBUS 495. Directed Readings (1-3)**
Graduate readings in management not covered in regularly scheduled course work. Prerequisite: consent of the department chairperson. May be repeated.

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**Management Science**

The industrial and manufacturing systems engineering department, offers a master of science degree in management science.

The management science program is directed toward integrating the scientific method with the functional aspects of organizations by investigating the application of quantitative methodology and systems analysis in the context of such functional areas as accounting, finance, marketing, and production. This integration provides the student with a broader perspective toward managerial decision making in private enterprise and public administration.

Undergraduates with a background in engineering, business, economics, mathematics, or the physical sciences who want a professional career as a staff specialist in management science are appropriate candidates. In addition, those candidates who intend to seek management positions find the management science background advantageous in dealing with the complex problems of industrial, commercial, and public service organizations.

The candidate is assumed to have acquired basic competence in the areas of accounting, marketing, corporate finance, production, data processing, microeconomics, linear algebra, calculus, statistics, and introductory operations research. The minimum program consists of thirty hours.

Inquiries should be directed to the IMSE Graduate Coordinator. This program requires a minimum of 30 credit hours of approved coursework. The program leads to the Master of Science in Management Science.

**Required coursework**
- IE 305 Simulation
- Mgt 321, IE 334 Organizational Behavior Workshop or Organization Planning and Control or Organization Behavior and Management
- Eco 421 Managerial Economics
- IE (Mgt) 430 Management Science Project
- nine hours of quantitative methods
- six hours selected from a functional area
- three hours free elective

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**Sample program**
- IE 305 Simulation
- Mgt 413 Organization Behavior and Management
- Eco 421 Managerial Economics
- IE 316 Advanced Operations Research Techniques
- IE 417 Advanced Mathematical Programming
- Eco 455 Econometrics
- IE 419 Sequencing and Scheduling
- Fin 411 Financial Management
- Fin 431 Advanced Investment Analysis and Portfolio Management

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**Management of Technology**

**Program director.** Alden S. Bean, Ph.D. (Northwestern); Wm. R. Kenan, Jr. professor of management and technology.

**Program faculty.** Keith Gardiner, Ph.D. (University of California), professor of industrial engineering; Benjamin Litt, Ph.D. (NYU), professor of management; Peter P. Poole, Ph.D. (Penn State), associate professor of management; Manashi R. Ray, Ph.D. (Penn State), associate professor of accounting; Theodore W. Schiefe, Ph.D. (Northwestern), associate professor of management; Susan A. Sherer, Ph.D. (Pennsylvania), associate professor of management; Bruce M. Smucker, Ph.D. (Rensselaer), professor of marketing; John K. Smith, Ph.D. (Delaware), associate professor of history; Robert H. Storer, Ph.D. (Georgia Tech), associate professor of industrial engineering; Todd Watkins, Ph.D. (Harvard), assistant professor of economics; Samuel C. Weaver, Ph.D. (Lehigh), adjunct professor of Finance.

The program requires 37 credit hours of graduate work, including a thesis. It is designed for students with undergraduate degrees in science or engineering and several years of work experience in industries characterized by rapid technological change or whose firms compete on the basis of highly specialized knowledge. Students with undergraduate degrees in other fields will be considered based on employer recommendations and other qualifications.

The program may be taken on a part-time basis, typically requiring two courses per semester over two calendar years; or as a full-time program that can be completed in one calendar year.

**Required Course work**
- **GECO 402. Managerial Economics (3) (Taken in conjunction with GECO 404)**

- **GECO 404. Technology, Trade and Economic Growth (1) (Taken in conjunction with GECO 402)**
  Overview of the role of technology in economic systems: productivity and growth effects, relationships to industry structure, impacts on international trade and competitiveness.

**Financial Accounting Seminar**
A two day seminar developed as a refresher in basic accounting principals and standards and to introduce specific accounting issues influencing technology development. Offered by the MoT Program.

**GBUS 406. Financial Management (3)**
Introduction to financial management. Topics include: financial statement analysis, capital budgeting, capital structure, valuation, risk analysis and working capital management. Prerequisite: Financial Accounting Seminar.
in high technology industries; inventors and the importance of patents and licensing; generation and screening of ideas; commercialization term project.

**GBUS 480. Technology Management Seminar (3)**
Review of current literature on technology management with emphasis on relation among business strategy, competitive conditions, management practice and the technological innovation process. Case studies and outside speakers. Critical analysis of research and application to technology management problems. Bean, Schlie.

**GBUS 485. Diffusion and Implementation of Technology (3)**
The adoption and diffusion of innovation, and managing the implementation/utilization/application of new technology in the organization. Emphasizes organization culture and organizational change in technology intensive firms.

**GBUS 490. Thesis (3)**

**IE 442. Total Quality Management (3)**
Principles and techniques of TQM; principles of Deming, Juran, Taguchi, and others; standards, metrics, costs, benchmarking, quality circles, and continuous improvement; Malcolm Baldridge and other awards, ISO 9000, case studies.

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## Manufacturing Systems Engineering

**Program director.** Keith M. Gardiner, Ph.D. (Manchester, England), professor of industrial and manufacturing systems engineering.

**Program faculty.** Mikell P. Groover, Ph.D. (Lehigh), MSE associate director, professor of industrial and manufacturing systems engineering; Alden S. Bean, Ph.D. (Lehigh), professor of management and technology; Marvin Charles, Ph.D. (Brooklyn Polytechnic), professor of chemical engineering; Parveen P. Gupta, Ph.D. (Penn State), associate professor of accounting; Benjamin Litt, Ph.D. (N.Y.U.), professor of management; Alastair D. McCauley, Ph.D. (Carnegie-Mellon), professor of electrical engineering and computer science; Roger N. Nagel, Ph.D. (Maryland), Harvey Wagner Professor of manufacturing systems engineering; John B. Ochs, Ph.D. (Penn State), associate professor of mechanical engineering and mechanics; Nicholas G. Odrey, Ph.D. (Penn State), associate professor of industrial and manufacturing systems engineering; Raymond Pearson, Ph.D. (U. Michigan), associate professor of materials science and engineering; Manash R. Ray, MBA (Indian Institute of Management - Calcutta), associate professor of accounting; Richard Roberts, Ph.D. (Lehigh), professor of mechanical engineering and mechanics; Guruswami Sathyanarayanan, Ph.D. (Michigan Tech), professor of industrial engineering; Kenneth P. Sinclair, Ph.D. (Massachusetts), professor of accounting; Bruce M. Smoakley, Ph.D. (Rensselaer), professor of marketing; Theodore Schlie, Ph.D. (Northwestern), associate professor of management; Robert H. Storer, Ph.D. (Georgia Tech), associate professor of industrial and manufacturing systems engineering; Gregory L. Tonkay, Ph.D. (Penn State), associate professor of industrial and manufacturing systems engineering; George R. Wilson, Ph.D. (Penn State), associate professor of industrial and manufacturing systems engineering; David S. Wu, Ph.D. (Penn State), associate professor of industrial and manufacturing systems engineering.

The manufacturing systems engineering program develops engineers who can design, install, operate, and modify systems involving materials, processes, equipment, facilities, logistics and people with leading edge technologies. It integrates systems perspectives with interdisciplinary course offerings from Lehigh's Colleges of Engineering and Applied Science, and Business and Economics. The 30-credit hour curriculum, leading to a Master of Science degree. may be structured as a
one-year full-time program, beginning in January (some industrial experience is a requirement), or a two-year part-time program for working engineers within a 50-75 mile radius of campus. Courses in the part-time program are scheduled on Thursday evenings and all-day Friday in the Spring and Fall semesters. Seminars, plant tours, specially designed tutorials, and a one-week study tour of industry make up the non-credit program requirements.

Graduate Courses

421. Managing the Manufacturing Life Cycle (3)
Manufacturing as an integrated technical-social-economic system. Linkages between corporate and manufacturing strategies. Combines a systems perspective with project leadership and membership skills for introducing and managing change into manufacturing systems at various life cycle stages.

423. Product Design/Analysis (3)
Integrated approach to design and analysis of products and systems. Principles for robust design and use of computer-aided engineering to model, evaluate, and enhance design. Case studies and design assignments.

425. Production Planning and Resource Allocation (3)
Capacity planning, scheduling, inventory control, and other topics in the management of manufacturing resources. Discrete and continuous simulation models for analysis and design of production systems. Factory information systems and data bases for computer integrated manufacturing.

427. Production Systems (3)
Modern production and assembly methods used in the mechanical and electrical/electronics industries. Techniques for deciding the most appropriate production method for a new product. Computer-aided process planning, group technology, robotics, numerical control, and other automated manufacturing methods.

431. Marketing & the Invention to Innovation Process (3)
Organizational issues and decision-making for capital investments in new technologies. The commercialization process is traced from research and development and marketing activities through the implementation phase involving the manufacturing function. Term project is a commercialization plan for a new manufacturing technology.

433. Technology and the Factory of the Future (3)
Engineering and technological issues affecting future developments in manufacturing. Topics include flexible automation systems, integration of design and production through the factory data network, intelligent machines, the man-machine interface, and the manufacturing management information system.

451. Manufacturing Systems Engineering Project (1-3)

490. Manufacturing Systems Engineering Thesis (1-6)

496. Microelectronics Manufacturing Systems & Technologies (3)
Manufacturing engineering in electronics manufacture: crystal growth, doping, thin film deposition technologies and tooling, pattern generation techniques, contamination control, clean room practices, microelectronics assembly and packaging. Examination of systems design and operation issues.

Career Opportunities in Marketing

The field of marketing offers career opportunities for students in business, economics, liberal arts, engineering, and the physical sciences.

Marketing is pervasive in our society and is a critical function in the promotion of world trade. Creativity and the ability to conduct insightful analyses of competitive business situations are the hallmarks of a well-prepared student who can contribute to a perspective employers organization. Undergraduates and graduates have been able to secure entry-level positions in a variety of marketing activities with firms in advertising and public relations, retail management, industrial sales and purchasing, bank marketing, marketing research, and new product design. Combining the marketing curriculum with related subjects in international relations, psychology and sociology, engineering, and history can often strengthen a students capability to grow beyond his or her formal education period. Students are encouraged to explore the potential enhancement of their educational experience through study abroad programs, internships with business, and research projects with faculty members.

Participation in the Marketing Club student organization is an extracurricular activity that offers a professional orientation program and the enjoyment of socializing with other students from across the campus.

For undergraduates, the marketing major offered by the Department of Business consists of 15 credit hours from the following courses:

**Required courses**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mkt 312</td>
<td>Marketing Research (3)</td>
</tr>
<tr>
<td>Mkt 313</td>
<td>Marketing Communications (3)</td>
</tr>
</tbody>
</table>

**Elective courses**

Three courses (9 credit hours) from the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mkt 315</td>
<td>Consumer Behavior (3)</td>
</tr>
<tr>
<td>Mkt 316</td>
<td>Advertising (3)</td>
</tr>
<tr>
<td>Mkt 319</td>
<td>New Product Planning (3)</td>
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<tr>
<td>Mkt 320</td>
<td>International Marketing (3)</td>
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<tr>
<td>Mkt 321</td>
<td>Business to Business Marketing (3)</td>
</tr>
<tr>
<td>Mkt 330</td>
<td>Retail Management (3)</td>
</tr>
<tr>
<td>Mkt 360</td>
<td>Marketing Practicum (3)</td>
</tr>
<tr>
<td>Mkt 371</td>
<td>Directed Readings (1-3)</td>
</tr>
</tbody>
</table>

For Advanced Undergraduates and Graduate Students

Courses numbered 200 and above in the College of Business and Economics are open to sophomores only on petition.

Mkt 211. Contemporary Marketing (3) fall, spring
The course examines contemporary marketing from a managerial perspective. Design of marketing programs within the context of consumer behavior, the social, economic, and cultural environment, market segmentation, demand, and industry structure. Prerequisite: Eco 1 or Eco 11 and 12. Falcinelli

Mkt 312. Marketing Research (3) fall, spring
Quantitative and qualitative information in routine and nonrecurring decision-making. Statistical design of marketing studies, model building, analysis of research studies, and the development of marketing information systems. Case problems and presentation of student research projects examine problems in communicating research results. Prerequisites: Eco 145 and Mkt 211. Simmons, Hansz

Mkt 313. Marketing Communications (3) fall, spring
Communication-promotion decision processes of organizations. Impact of source, message and media variables on audience response to communication campaigns and the interactions among these variables. Role of personal selling, sales promotion, publicity, and advertising in marketing. Prerequisite: Mkt 211. Simmons

Mkt 315. Consumer Behavior (3)
Principal theories of psychology, sociological psychology, anthropology and economics which contribute to understanding the behavior and
motivations of consumers. Consumer needs and wants; learning theory; the perceptual process; decision-making processes; communication; search behavior; market segmentation and product differentiation; and the adoption and diffusion of innovations. Prerequisite: Mkt 211 and Mkt 312. Simmons, Litt

Mkt 316. Advertising (3) spring
Analysis of advertising campaigns and the societal implications of advertising are considered from a managerial perspective. Prerequisite: Mkt 313. J. Maskulka

Mkt 319. New Product Planning (3) spring
Organization and management of marketing activities related to the development of new and improved products and services. The role of marketing research and product testing in the commercialization process. Application of risk analysis to the screening of ideas for new product candidates. Prerequisites: Mkt 211 and Fin 225. Smucker

Mkt 320. International Marketing (3) fall
The foreign market entry strategies firms may use are examined: export, contractual arrangements, and investment. Student companies implement each strategy in a multinational business game or through case analysis. Prerequisites: Fin 225 and Mkt 211. Hansz, J. Maskulka

Mkt 321. Business to Business Marketing (3)
The marketing of products and professional services from the firm to organizations; marketing principles applied to other than the ultimate customer in society; the role of salespersons as consultants to industrial customers and in professional fields such as banking, advertising, and management advisory services. Smucker

Mkt 330. Retail Management (3) fall
Full coverage of all major retailing topics including consumer behavior, marketing research, store location, service retailing, the retail audit, retail institutions, and international retailing. Students work in groups to conceptualize and develop a retail store of their choice. Prerequisites: Mkt 211 and Mkt 312. T. Maskulka

Mkt 360. Marketing Practicum (3)
The Marketing Practicum combines formal classwork on marketing problem formulation and business communications with an intensive internship or consulting engagement with a business. Students work with client firms to develop individual or team projects, which focus on marketing activities such as market research, strategy development, sales management, and promotion management. Upon completion of the project, students submit a written report and make a formal presentation to clients. Prerequisites: Mkt 211, and either Mkt 312 or Mkt 313. Cannot be taken concurrently with Mkt 311.

Mkt 371. Directed Readings (1-3)
Readings in various fields of marketing designed for the student who has a special interest in some field of marketing not covered in regularly scheduled courses. Prerequisite: consent of the department chairperson. May be repeated.

Mkt 372. Special Topics (1-3)
Special problems and issues in marketing for which no regularly scheduled course work exists. When offered as group study or internship, coverage will vary according to the interests of the instructor and students. Prerequisite: consent of the department chairperson. May be repeated.

Graduate Courses

Graduate students are encouraged to meet with the department chair to discuss their career interests and program planning before beginning formal graduate course work.

GBUS 408. Marketing Management (3)
Planning and managing marketing activities: market analysis, buyer behavior, market segmentation, marketing research, product policy and strategy, distribution channels policy, advertising, and sales force management. Falceini, J. Maskulka

GBUS 460. Strategic Marketing (3)
Strategic issues facing corporations in a highly competitive and rapidly changing environment. Case studies and preparation of a strategic plan. Prerequisite: GBUS 408.

GBUS 461. Advertising and Promotion Management (3)
A broad overview of managerial decisions involved in developing, planning, presenting and implementing advertising and promotion activities for business and not-for-profit organizations. Analysis of current campaigns and a term project are semester assignments. Prerequisite: GBUS 408. J. Maskulka

GBUS 462. Buyer Behavior and Marketing Management (3)
Concepts, methodologies, and current research involving consumer and organizational buying behavior. Prerequisite: GBUS 408. Simmons, Litt

GBUS 463. Management of Sales Operations (3)
Planning and organizing strategic sales programs; developing the sales force through recruitment, training, and motivation; control of sales programs through performance evaluation of sales personnel; and integrating sales with other marketing activities. Prerequisite: GBUS 408.

GBUS 464. Industrial Marketing and Sales Management (3)
Marketing and sales problems associated with manufacturers of industrial products: organization and productivity of the sales force, product line policies, pricing strategies, buyer requirements, customer service, and formal bidding proposals. Prerequisites: GBUS 406 and GBUS 408. Smucker

GBUS 465. New Product Planning in Marketing and Research and Development (3)
The design, development and marketing of new products and processes in high technology industries; inventors and the importance of patents and licensing; generation and screening of ideas; commercialization term project. Prerequisites: GBUS 406 and GBUS 408. Smucker

GBUS 466. Marketing Information and Decision-Making (3)
Obtaining relevant marketing information for decision-making is examined from two perspectives: special projects and information systems. Student projects. Prerequisite: GBUS 408. Hansz, Simmons

GBUS 467. Causal Modeling (3)
This course brings together in a single analytical framework two longstanding traditions: simultaneous equation modeling (regression analysis) and factor analysis (measurement models). Topics covered include measurement error, reliability, validity, confirmatory factor analysis, and latent variable modeling. Prerequisites: Intermediate statistical theory or consent of department chairperson.

GBUS 468. Research Methodology (3)
Criteria which distinguish scientific research from other significant human activities; development of concepts, laws and theories; general principles of research design; measurement theory; and scientific values and ethics. Students are expected to prepare a defensible dissertation proposal during the course. Open only to doctoral students. Simmons

GBUS 469. Advanced Data Analysis (3)
Applications oriented analysis of variance, regression analysis, and multi-variate analysis. SPSS, BMD, and other computer packages are used to analyze empirical data. Prerequisite: Intermediate statistics or permission of department chairperson.
GBUS 475. Marketing and the Global Firm (3)
Emphasis is placed on understanding the process of globalization and its resultant impact on the firms marketing function. Case analysis and/or computer simulations are employed to enhance the students understanding of the challenges and opportunities facing the firm pursuing globalization. Prerequisite: GBUS 408. Hanse, J. Maskulka

GBUS 492, GBUS 493. Special Topics (1-3)
Problems and issues in marketing for which no regularly scheduled graduate course work exists. When offered as group study or internship, coverage varies according to the interests of the instructor and students. Prerequisite: consent of the department chairperson. May be repeated.

GBUS 495. Directed Readings (1-3)
Graduate reading in marketing not covered in regularly scheduled courses. When offered as group study, coverage varies according to the interests of the instructor and students. Prerequisite: consent of the chairperson. May be repeated.

Materials Science and Engineering

Professors. David B. Williams, Ph.D. (Cambridge); Harold Chambers Senior Professor, chairperson; S. Kenneth Tarby, Ph.D. (Carnegie-Mellon); R. D. Stout Professor, associate chairperson; Helen M. Chan, Ph.D. (Imperial College of Science and Technology, England) Class of '77 Professor; Martin P. Harmer, Ph.D. (Leeds, England), Avice Professor, director of Materials Research Center; Richard W. Hertzberg, Ph.D. (Lehigh); New Jersey Zinc Professor; Himanshu Jain, Engr. Sci. D. (Columbia); Charles E. Lyman, Ph.D. (M.I.T.); Arnold R. Marden, Ph.D. (Lehigh); Michael R. Notis, Ph.D. (Lehigh).
Associate Professors. Kary Barmak, Ph.D. (M.I.T.); Wojciech Mistoilek, Sc.D. (U. of Mining and Metallurgy, Krakow, Poland); Loewy Chair; Raymond A. Pearson, Ph.D. (Michigan).
Adjunct professor. Brian R. Lawn, Ph.D. (Western Australia).
Emeritus professors. Betzalel Avizur, Ph.D. (Michigan); Sidney R. Butler, Ph.D. (Penn State); Ye. T. Chou, Ph.D. (Carnegie-Mellon); George P. Conrad II, Sc.D. (M.I.T.); Ralph J. Jacobine, Ph.D. (Notre Dame); Alan W. Pense, Ph.D. (Lehigh); Donald M. Smyth, Ph.D. (M.I.T.); Robert D. Stout, Ph.D. (Lehigh); David A. Thomas, Sc.D. (M.I.T.); John D. Wood, Ph.D. (Lehigh).
Research engineers and scientists. David W. Ackland; Arian O. Benschoter; John DuPrau, B.S. (Ohio State).

As science and technology advance in the 1990s and beyond, progress in many fields will depend on the discovery and development of new materials, processed in more complex ways, and with new kinds of properties. This has recently been demonstrated nicely by the development of superconducting ceramic materials. It is widely recognized that the progress of history has been divided into periods characterized by the materials that mankind has used, i.e., the stone age, the bronze age, and the iron age. Today, materials science and engineering is critical to all other fields of engineering, and advances in these other fields are often limited by advances in materials.

Interest in new materials for solid-state devices, space technology, and superconductivity, as well as a better understanding of the behavior of materials in the design of structures, automobiles and aircraft, plant processing equipment, electrical machinery, etc., have increased the need for people trained in science and technology of materials.

Education for this field of engineering requires basic studies in mathematics, chemistry, physics and mechanics, plus a general background in engineering principles, followed by intensive training in the application of scientific and engineering principles to the development and use of materials in a technological society. In addition, the curriculum offers an introduction to humanistic and social studies; these broaden the student's outlook and enhance professional development after graduation.

The undergraduate program is designed to train graduates for research, development, operations, management and sales careers in industry or for graduate study in various specialties of the field, including the manufacture and applications of metals, ceramics, polymers, composites, and electronic materials. While some graduates go directly into materials-producing companies, a large proportion serve as engineers in the chemical, electrical, transportation, communications, space and other materials consumer industries. A number of students pursue graduate study leading to careers in research and teaching.

Major Requirements
The recommended sequence of courses is shown below. The standard freshman engineering year is shown in section III.

**sophomore year, first semester (17 credits)**
Math 23 Analytic Geometry & Calculus III (4)
Phy 21, 22 Introductory Physics II and Laboratory (5)
Eco 1 Economics (4)
Mat 33 Engineering Materials and Processes (3) or
HSS Humanities/Social Sciences Elect (3)
Mat 10 Materials Laboratory (1)

**sophomore year, second semester (17 credits)**
Math 205 Linear Methods (3)
Mech 2 Elementary Engineering Mechanics (3)
Mat 203 Structure and Characterization of Materials (3)
Mat 205 Thermodynamics and Phase Diagrams (3)
Mat 20 Computational Methods in Materials Science (2)
Mat 33 Engineering Materials and Processes (3) or
HSS Humanities/Social Sciences Elect (3)

**junior year, first semester (18 credits)**
Elec. Elective (3)
HSS Humanities/Social Sciences Elect (3)
Chem 209 Chemistry of Materials (3)
Mat 216 Diffusion and Phase Transformations (3)
Mat 218 Mechanical Behavior of Materials (3)
HSS Humanities/Social Sciences Elective (3)

**junior year, second semester (18 credits)**
Mat 101 Professional Development (2)
Mat 204 Processing and Properties of Polymeric Materials (3)
Mat 206 Processing and Properties of Metals (3)
Mat 214 Processing and Properties of Ceramic Materials (3)
ECE 81 Principles of Electrical Engineering (4)
Elec. Elective (3)

**senior year, first semester (16 credits)**
Mat 201 Physical Properties of Materials (3)
Mat 202 Design, Selection, and Failure Analysis of Engineering Materials (4)
HSS Humanities/Social Sciences Elect (3)
IE 111 Engineering Probability and Statistics (3) or
Math 231 Probability and Statistics (3)

**senior year, second semester (18 credits)**
Mat 302 Electronic Properties of Materials (3)
Mat 338 Materials Reports (3)
ChE 60 Unit Operations Survey (3)
Elec. Elective (3)
Approved Elect. Approved Elective (3)**
For the approved electives and/or engineering science electives, two courses should be taken from one of the following five specialization categories:

1. **Metals**
   - Mat 310: Fundamentals of Corrosion
   - Mat 314: Advanced Metal Forming
   - Mat 317: Imperfections in Crystals
   - Mat 344: Metal Machining Analysis

2. **Ceramics**
   - Mat 315: Physical Properties of Structural and Electronic Ceramics
   - Mat 335: Principles of Semiconductor Materials Processing
   - Mat 342: Inorganic Glasses
   - Mat 348: Materials Science for Electronic Applications
   - Mat 396: Chemistry of Nonmetallic Solids

3. **Polymers**
   - Mat 393: Physical Polymer Science
   - Mat 388: Polymer Synthesis and Characterization Lab
   - Mat 309: Composite Materials

4. **Industrial Option**
   - Mat 327: Industrial Project (4)
   - Mat 329: Industrial Project (4)

5. **Research Option**
   - Mat 240: Research Techniques (3)
   - Mat 291: Undergraduate Research (3)

*The industrial option is designed to prepare students as plant materials engineers. The emphasis in Mat 327 and 329 is a team approach to the solution of actual plant problems. The courses are conducted in cooperation with local industries. Three days per week are spent at the plant of the cooperating industry on investigations of selected problems. The option is limited to a small group of seniors, selected by the department from those who apply. Summer employment is provided when possible for those who elect to initiate the program during the summer preceding the senior year.

**For those students who may be interested in research or development, and intend to pursue graduate work, a research option is offered. In this option, students take Mat 240 and 291. Financial support may be available for those students who elect to initiate a research program during the summer preceding the senior year. The option is limited to a small group of selected students.

**Undergraduate Courses**

10. **Materials Laboratory (1)**
    - Fall
    - Introduction to experimental methods used to fabricate and measure the structure and properties of materials. Thermal and mechanical processing and properties are emphasized. Specimen preparation and examination by optical microscopy. Prerequisite: Mat 33 previously or concurrently.

20. **Computational Methods in Materials Science (2)**
    - Spring
    - The use of computers and computational methods to solve problems in materials science and engineering. Students will employ both commercial packages and their own code in order to complete assignments. Students will utilize word processing and display packages to present results of projects. Prerequisite: Engr. 1 or equivalent. (ES I), (ED 1)

33. **Engineering Materials and Processes (3)**
    - Fall-Spring
    - Application of physical and chemical principles to understanding, selection, and fabrication of engineering materials. Materials considered include metals, polymers, ceramics, composites and electronic materials. Case studies of materials used range from transportation systems to microelectronic devices. Staff. (ES 2), (ED 1)

101. **Professional Development (2)**
    - Fall
    - Seminar on the role and purpose of engineering in society; the meaning of being a professional; the role of creativity, communications and decision making in the engineering process; expectations and problems of young engineers; personal goals; choosing a career. Required reading. Written reports based on library research. Prerequisite: junior standing. (ED 1)

107. **Special Topics in Materials (1-3)**
    - Fall
    - A study of selected topics in materials science and engineering not covered in other formal courses.

192. **Structural Materials (3)**
    - Fall
    - The major classes of materials—metals, ceramics and concrete, polymers, and composites with emphasis on their suitability for structural applications. The dependence of material properties on atomic bonding, microstructure, processing, and service conditions. Some laboratories on determination of mechanical properties. Required for civil engineering students. Prerequisite: Mech 12. Hertzberg. (ES 3)

For Advanced Undergraduates and Graduate Students

201. **Physical Properties of Materials (3)**
    - Fall
    - Basic concepts of modern physics and quantum mechanics needed for an understanding of electrons in solids. The experimental development leading to wave mechanics is emphasized. Uses of the Schrodinger equation as the basis for the free electron theory of metals and band theory. Optical properties are developed leading to a discussion of lasers. Prerequisite: Phys 21, Mat 33, Math 205. Jain. (ES 2.5), (ED 0.5)

203. **Structure and Characterization of Materials (3)**
    - Spring
    - Atomic structure and types of bonding. Crystalline and amorphous states. Crystal structures, and fundamental aspects of crystallography (space lattice, Miller indices, symmetry elements). Crystal defects (point, line, and plane). Basic principles of structure determination by x-ray diffraction. Microscopical techniques (light and electron optical), and their application to material characterization. Prerequisite: Chem 21, Mat 10 and Mat 33 previously or concurrently. Chan, Lyman, Notis, Williams. (ES 3)

204. **Processing and Properties of Polymeric Materials (3)**
    - Spring
    - The structure-property relationships in polymers will be developed, emphasizing the glass transition, rubber elasticity, crystallinity, and mechanical behavior. Elements of polymer processing. Extrusion of plastics and films, and fiber spinning operations. Lectures and laboratories. Prerequisite: Chem 209 or one semester of organic chemistry. Pearson. (ES 1.5), (ED 1.5)

205. **Thermodynamics and Phase Diagrams (3)**
    - Spring
    - The three laws of thermodynamics. Gibbs free energy and thermodynamic basis for equilibrium. Solution thermodynamics. Binary and ternary equilibrium phase diagrams. Application of thermodynamics to materials problems. Lectures and laboratories. Prerequisite: Math 23 and Mat 33 or equivalent. Tarby. (ES 3)

206. **Processing and Properties of Metals (3)**
    - Spring
    - The production and purification of metals, their fabrication, and control of their properties. Includes topics such as precipitation hardening, hot and cold working, and casting. Lectures and laboratories. Prerequisite: Mat 205. Marder. (ES 1), (ED 2)

214. **Processing and Properties of Ceramic Materials (3)**
    - Spring
216. Diffusion and Phase Transformations
Fundamental diffusion equations; liquid-solid transformations; solid-solid transformations; transformation kinetics; metastable transformations; diffusionless transformations; examples of various transformations in different materials and their effect on properties. Prerequisite: Mat 203, Mat 205. Williams, Notis, Barmak. (ES 2, ED 1)

218. Mechanical Behavior of Materials
Deformation and fracture behavior of materials. Elastic and plastic behavior, with emphasis on crystallographic considerations. Strengthening mechanisms in solids. Static and time-dependent fracture from microstructural and mechanical viewpoints. Fatigue failure. Prerequisites: Mech 2, Mat 203, and Mat 33. Hertzberg, Pearson, Chan. (ES 1.5, ED 1.5)

221. STS 221 Materials in the Development of Man
Development of materials technology and engineering from the stone age to atomic age as an example of the interaction between technology and society. In-class demonstration laboratories on composition and structure of materials. Term projects using archaeological materials and alloys. Course intended for, but not limited to, students in the humanities and secondary science education. Engineering students may not use this course for engineering science or technical elective credit. Notis

240. Research Techniques
Study and application of research techniques in materials science and engineering. Research opportunities, design of experimental programs, analysis of data, presentation of results. Selection of research topic and preparation and defense of research proposal. Restricted to a small number of students selected by the department from those who apply. (ES 3)

291. Undergraduate Research
Application of research techniques to a project in materials science and engineering selected in consultation with the faculty. Normally preceded by Mat 240.

302. Electronic Properties of Materials
The electronic structure of materials, i.e., band and zone theory, is presented from a physical point of view. Electrical conductivity in metals, semiconductors, insulators and superconductors is discussed. Simple semiconductor devices reviewed. Magnetic properties are examined in the context of domain theory and applications are discussed. Optical and dielectric properties of semiconductors and ferroelectrics are considered. Prerequisite: Mat 33, Mat 201, Mat 203. Jain, Notis. (ES 2, ED 1)

309. Composite Materials
The principles and technology of composite materials. Processing, properties, and structural applications of composites, with emphasis on fiber-reinforced polymers. Lectures and some field trips or laboratories. Prerequisite: Mat 33 or equivalent. Mech 2. (ES 2, ED 1)

310. Independent Study in Materials
Provides an opportunity for advanced, independent study of selected topics in materials science and engineering not covered in other formal courses.

312. (ChE 312, Chem 312) Fundamentals of Corrosion

314. Advanced Metal Forming
Extension of Mat 303. Topics to be included: friction, lubrication and wear, failure and damage in metal forming, and deformation in composite metals and in powder metallurgy. Forming alternatives for specific products such as cans, tubes, wires and others will be compared. Recent developments of new forming processes. Prerequisite: Mat 325. (ES 1, ED 2)

315. Physical Properties of Structural and Electronic Ceramics
Structure-property relationships in ceramics. Mechanical behavior including plasticity, hardness, elasticity, strength and toughness mechanisms. Thermal behavior including specific heat, thermal expansion, thermal conduction and thermal shock. Electrical behavior including application of tensors and crystal physics to electrodynamics. Prerequisites: Mat 214 or consent of instructor. Harmer. (ES 3)

317. Imperfections in Crystals
The major types of crystal defects and their role in controlling the properties of materials. Point, line and planar defects, their atomic configurations and experimental techniques to study their characteristics. Emphasis on the role of dislocations and grain boundaries in the control of mechanical properties. Prerequisite: Mat 203 or consent of instructor. Rickman. (ES 3)

319. Current Topics in Materials Science
Selected topics of current interest in the field of materials engineering but not covered in the regular courses. May be repeated for credit with consent of the department chairperson. Prerequisite: Consent of department chairperson. (ES 3)

320. Analytical Methods in Materials Science
Selected topics in modern analysis and their application to materials problems in such areas as thermodynamics, crystallography, deformation and fracture, diffusion. Prerequisite: Math 231 or 205. Rickman. (ES 3)

325. Design, Selection, and Failure Analysis of Engineering Materials
Review of different classes of engineering materials and mechanical stress states experienced by structural components. Failure analysis and prevention of engineering component failure. Introduction to product liability litigation. Problem solution-oriented selection and design of materials with appropriate fabrication, thermal, and surface finish processes. Lectures plus laboratories which require individual design and execution of experiments to solve both materials selection and failure analysis problems. Prerequisite: Mat 204, Mat 206, Mat 214, and Mat 218. Marder (ES 1), (ED 3)

327. Industrial Project
Restricted to a small group of seniors and graduate students selected by the department from those who apply. Three full days per week are spent on development projects at the plant of an area industry, under the direction of a plant engineer and with faculty supervision. Tarby, Chan, Lyman, (ED 4)

329. Industrial Project
To be taken concurrently with Mat 327. Course material is the same as Mat 327. (ED 4)

333. (EES 337, Chem 337) Crystallography and Diffraction
Introduction to crystal symmetry, point groups, and space groups. Emphasis on materials characterization by x-ray diffraction and electron diffraction. Specific topics include crystallographic notation, stereographic projections, orientation of single crystal, textures, phase identification, quantitative analysis, stress measurement, electron diffraction, ring and spot patterns, convergent beam electron diffraction (CBED), and space group determination. Applications in mineralogy, metallurgy, ceramics, microelectronics, polymers, and catalysts. Lectures and laboratory work. Prerequisites: Mat 203 or EES 133 or senior standing in chemistry. Lyman, Chan. (ES 3)
334. (EES 338) Electron Microscopy and Microanalysis (4)
Fall Fundamentals and experimental methods in electron optical techniques including scanning electron microscopy (SEM) conventional transmission (TEM) and scanning transmission (STEM) electron microscopy. Specific topics covered will include electron optics, electron beam interactions with solids, electron diffraction and chemical microanalysis. Applications to the study of the structure of materials are given. Prerequisite: consent of the department chairperson. Williams, Lyman. (ES 4)

335. (ChE 335) Principles of Semiconductor Materials Processing (3)
Description and analysis of the processing steps involved in microelectronic material fabrication. Emphasis will be placed on the chemistry of the fabrication steps, mathematical modeling of the transport and chemical reaction phenomena, and interpretation of experimental methods and data. Prerequisite: a course in thermodynamics and senior standing. (ES 3)

338. Materials Reports (3) Spring
Written and oral communication through various types of reports and talks. Evaluation on both technical content and quality of presentation. Use of information sources, graphics, and visual aids. Videotaping and peer critique of oral presentations. Prerequisite: senior standing.

342. Inorganic Glasses (3)
Definition, formation and structure of glass; common glass systems; manufacturing processes; optical, mechanical, electrical and dielectric properties; chemical durability; glass fibers and glass ceramics. Lectures and laboratories. Prerequisite: Mat 33. Jain, Chan. (ES 3)

344. (IE 344) Metal Machining Analysis (3)
Intensive study of metal cutting emphasizing forces, energy, temperature, tool materials, tool life, and surface integrity. Abrasive processes. Laboratory and project work. Prerequisite: IE 115 or ME 240 or Mat 206. (ES 2), (ED 1)

348. Materials Science for Electronic Applications (3)
Materials technology for integrated circuit packaging systems. Dielectric, thermal and mechanical considerations; tinning methods; resistor and ceramic capacitor materials and incorporation of active devices into packaging systems; multilayer package design and processing. Individualized semester project involving forensic examination of failures using scanning electron microscopy and microprobe analysis. Prerequisite: Mat 201, and Mat 33. Notis. (ES 2), (ED 1)

367. (ChE 367) Metal Films and Coatings: Processing, Structure, and Properties (3)
Focus will be on the processing, structure, and properties of metal films and coatings. Processing methods will include evaporation, sputtering, chemical vapor deposition (CVD), plasma-assisted CVD, ion implantation, electrodeposition, metal bath solidification, weld overlay, thermal spraying, and diffusion. Characterization of thin films and coatings will be done with the use of sophisticated analytical instrumentation, including spectroscopic methods, microscopy and diffraction techniques. Characterization methods are explored in conjunction with processing techniques and film/coating properties via class assignments that are designed to introduce students to the archival scientific literature. Prerequisite: Senior standing in Chemical Engineering or Materials Science and Engineering, or permission of the instructor(s). (ES 1.5), (ED 1.5)

388. (ChE 388, Chm 388) Polymer Synthesis and Characterization Laboratory (3) Spring
Techniques include: free radical and condensation polymerization; molecular weight distribution by gel chromatography; crystallinity and order by differential scanning calorimetry; pyrolysis and gas chromatography; dynamic mechanical and dielectric behavior; morphology and microscopy; surface properties. Prerequisite: Senior level standing in Chemical Engineering, Chemistry, or Materials Science and Engineering, or permission of the instructor. (ES 2), (ED 1)

393. (ChE 393, Chm 393) Physical Polymer Science (3)
Structural and physical aspects of polymers (organic, inorganic, natural). Molecular and atomic basis for polymer properties and behavior. Characteristics of glassy, crystalline states (including viscoelastic and relaxation behavior) for single and multicomponent systems. Thermodynamics and kinetics of transition phenomena. Structure, morphology and behavior. Prerequisite: Senior level standing in Chemical Engineering, Chemistry, or Materials Science and Engineering, or permission of the instructor. (ES 1.5), (ED 1.5)

396. (Chem 396) Chemistry of Nonmetallic Solids (3)
Chemistry of ionic and electronic defects in nonmetallic solids and their influence on chemical and physical properties. Intrinsic and impurity-controlled defects, nonstoichiometric compounds, defect interaction. Properties to be discussed include: diffusion, sintering, ionic and electronic conductivity, solid-state reactions, and photoconductivity. Prerequisite: Chem 187 or Mat 205 or equivalent. (ES 3)

For Graduate Students
The department offers three degrees; a master of science, a master of engineering, and a doctor of philosophy in science and materials engineering.

While a diversity of programs and curricula are available to a person interested in graduate study in the area of materials, generally the degree is earned in the department of materials science and engineering. However, thesis and dissertation research may be a part of programs under way in the department or at the Materials research Center or other departments or centers.

The department has a large enough staff and graduate enrollment to enable it to suit the needs of students whose interests range from the science of materials through materials engineering. At the same time, those advanced students who want experience in teaching are able to teach under the guidance of the senior staff.

The foundation for successful graduate work in the department includes sound preparation in chemistry, physics and mathematics, and adequate breadth of general education. Candidates entering the department who have obtained their previous degrees in fields other than materials may be required to take certain undergraduate courses without credit toward the graduate degree.

The programs of the department are flexible. Upon acceptance, each student is assigned a faculty advisor. Under the advisor’s direction, the student plans a course of study to satisfy individual needs and interests. Most advanced-degree recipients find careers in industry or industrial or governmental research and development laboratories. A smaller number have gone into teaching, consulting or academic research.

Graduate facilities for research are located in the Whitaker Laboratory, in the interdisciplinary Materials Research Center, the Sherman Fairchild Laboratory, and other associated laboratories. The laboratories are well equipped with both generalized equipment as well as sophisticated research equipment.

Specialized equipment such as conventional and scanning transmission electron microscopes, scanning electron microscopes, electron microprobe, X-ray diffraction units, closed-loop mechanical testing equipment, and crystal-growing and zone-processing equipment are maintained and operated by skilled technicians. After receiving the required instructions, graduate students operate this equipment.

Departmental facilities are supplemented by central computer facilities, microcomputers, and a fine science and engineering library.

Special Programs and Opportunities
The department has established specific recommended programs for the M.S., the M.Eng., and the Ph.D., emphasizing the following areas: electron microscopy and microanalysis of all materials, physical metallurgy, ceramics, polymers and composites, mechanical behavior, electronic materials, and manufacturing processes.
These programs are flexible. Students in an area such as fracture may work in the department or in cooperation with the Materials Research Center or the department of mechanical engineering. The ceramics program emphasizes the study of the electrical and mechanical behavior of various ceramic systems. The study of solid-state materials for electronic applications is done largely in the Sherman Fairchild Laboratory. The department also cooperates with the chemical engineering and chemistry departments in the graduate Polymer Science and Engineering Program.

**Major Requirements**

The Graduate School requirements are explained in Section IV. In the department of materials science and engineering, a candidate for the M.S. completes a thesis. This normally represents six of the thirty semester hours required for this degree. Candidates for the M.Eng. complete three crack propagating studies of metals and polymers.

A candidate for the Ph.D. prepares a preliminary program of courses and research, providing for specialization in some phase of the field (largely through research) in consultation with the advisor. Prior to formal establishment of the doctoral program by the special committee and its approval by the Graduate School, the student passes a qualifying examination that must be taken early in the first year of doctoral work. The department does not require a foreign language. It does require preparation and defense of a research proposal as a portion of the general examination.

Of the courses listed above only those in the 300 series are available for graduate credit. There are many additional offerings in materials under the listings of other departments.

Most graduate students receive some form of financial aid. Several kinds of fellowships and assistantships are available. This type of aid generally provides for tuition, an allowance for experimental supplies, and a stipend. For details of graduate scholarships, fellowships and assistantships, please refer to Section IV.

**Research Activities**

Graduate students conduct their research in facilities located in the department or the Materials Research Center, or other centers and institutes. The following list of activities notes the many areas of interest. Asterisks (*) indicate research of an interdisciplinary nature.

Materials science. Crystal growth*; defect chemistry and electrical properties of insulating and semiconducting oxides*; growth and deformation of bicrystals; dislocation studies; meteorites and lunar materials; processing of metal insulator semiconductor structures and their evaluation and application to integrated circuits*; quantitative metallography; structure and behavior of solid-state materials*.

Mechanical behavior. Correlation of microstructure with mechanical behavior of low-alloy, high-strength steels; deep drawing, impact extrusion and ironing; electron fractography*; environmental crack kinetics*; fatigue fracture; flow through converging conical dies; friction measurement; theoretical analysis of metal-forming methods and correlation with metallurgical parameters; toughness of weld metal; weldability of steels.

Ceramics. Electrical properties of electronic ceramics*; hot pressing studies*; grain growth in oxides*; electrical and magnetic properties of oxides*; creep modeling of ceramics*; electron microscopy of dislocation structures*; defect chemistry and electrical properties of ceramic oxides and glasses*; deformation and fracture of structural ceramics and ceramic composites*.

Physical metallurgy. Brittle fracture characteristics and fatigue properties of low-alloy, high-strength steels*; diffusion-controlled growth; kinetics of solid-state reactions*; physical metallurgy of aluminum alloys; strengthening mechanisms; structure and morphology of martensite; ternary diffusion; transformation during joining; transmission electron microscopy of crystal defects.

Polymers. Environmental effects on polymers*; fatigue crack propagation in engineering plastics*; fracture surfaces of crystalline polymers*; ion transport in polymer membranes; mechanical behavior of interpenetrating networks*; mechanical behavior of polyvinyl chloride*; micromechanics of polymer fracture*; polymers from renewable resources; properties of polymer composites*; reclamation of scrap polymeric materials*; viscoelastic damping.

Chemical metallurgy. Mathematical modeling of metallurgical processes; thermodynamics of metallic solutions; thermodynamics and phase equilibria.

Electronic materials. Origin and properties of defects in semiconductors and insulators; processing of materials used in VLSI device structures, processes studied include ion implantation, rapid thermal processing, chemically enhanced oxidation, LPCVD, sputtering, and plasma etching and deposition.

**Graduate-Level Courses**

**401. Thermodynamics and Kinetics I (3)** fall


**402. Thermodynamics and Kinetics II (3)** spring

Continuation of Mat 401. Derivation of fundamental diffusion equations, and their application to single and multicomponent systems. Theoretical models of nucleation and growth (including spinodal decomposition), and comparison with experimental observations. Kinetics of solid state transformations, including phase transformations and particle coarsening.

**403. Structure and Properties I (3)** fall

The underlying principles of the structure of materials and relationship to properties. Mathematical foundations such as applications of partial differential equations, and group theory and tensor properties. Crystal structure including symmetry, point and space groups, and crystal symmetry and properties. Study of recent reviews and classic sources.

**404. Structure and Properties II (3)** spring

Continuation of Mat 403. Defects in crystals in relationship to properties, including point, line, and planar defects. Non-crystalline structure including covalent-ionic, metallic, and polymeric glasses; related concepts such as short-range order and fractal geometry. Concludes with student presentations on important topics from Mat 403 and 404.

**406. Solidification (3)**

Structure, theory and properties of liquids. Homogeneous and heterogeneous nucleation theory and experimental results. Solidification phenomena in pure, single and multiphase materials including the nature of the freezing interface, segregation, constitutional supercooling, dendritic growth, crystallographic effects, the origin of defects, crystal growing, zone processes. Prerequisite: consent of the chairperson.

**408. Transformations (3)** fall

The thermodynamic, kinetic and phenomenological aspects of a wide spectrum of solid-state phase transformations. Theories of nucleation, growth and coarsening of second-phase precipitates. Application of the theories to continuous and discontinuous reactions, massive, martensitic and bainitic transformations in metals. Transformations in nonmetals. Prerequisite: Mat 205 or equivalent. Marder, Smith, Williams

**409. Current Topics in Materials (3)**

Recent practical and theoretical developments in materials. This course may be repeated for credit if new material is covered. Prerequisite: consent of the department chairperson.

**410. Physical Chemistry of Metals (3)**

Discussions of reactions involving gases and reactions involving pure condensed phases and a gaseous phase. Ellingham diagrams and equilibria in metal-oxygen-carbon systems. Consideration of the behavior of solutions and methods for determining thermodynamic properties of solutions by experimentation and computation. Prerequisite: Mat 205 or equivalent. Tarby
411. Modern Joining Methods (3)
The foundations upon which the joining processes rest; the present limitations of the various processes; the trends in new developments; the engineering and structural aspects of joining. Prerequisite: Mat 216 and 218 or equivalent. Pense

412. Magnetic Properties of Materials (3)
Fundamental concepts of magnetism and magnetic properties of ferromagnetic media. Magnetic and nonmagnetic materials. Current application areas considered as examples. Prerequisite: Phys 31 or 363 or equivalent. Notis, Barnak

413. Analysis of Metal Forming Processes (3)
Three-dimensional stress and strain analysis. Yield criteria, plastic flow and the upper and lower bound theorems. Analysis of metal forming processes, including drawing and extrusion, press work, rolling and spinning. The emphasis is on presenting several approaches to each problem.

415. Mechanical Behavior of Ceramics (3)
Strength, elasticity, creep, thermal stress fracture, hardness, abrasion and high-temperature deformation characteristics of single- and multicomponent brittle ceramic solids. Statistical theories of strength, static and cyclic fatigue, crack propagation, fracture toughness. Correlation of mechanical behavior, microstructure, and processing parameters. Prerequisite: Mat 218 or consent of the department chairperson. Notis, Harmer

416. Atom Movements (3)
Phenomenological and atomistic development of the laws of diffusion and their solution. Influence of gradients of concentration, potential, temperature and pressure. Effects of structural defects on diffusion in metals and nonmetals. Prerequisite: Math 23 and Math 205 or the equivalent.

417. Deformation and Strength of Solids (3)
Topics related to deformation of solids including creep, strengthening mechanisms, annealing of deformed solids, preferred orientation. Primary emphasis is on crystalline materials. May be repeated for credit if different material is covered. Prerequisite: Mat 218 or equivalent. Hertzberg, Notis

418. Fatigue and Fracture of Engineering Materials (3) fall

419. Advanced Physical Metallurgy (3)
Application of physical metallurgy principles to materials systems. Transformation structures and the influence of morphology on properties. Alloy design and heat treatment for improved strength, toughness, creep, corrosion resistance, electrical and magnetic properties. Prerequisite: Mat 325 or equivalent. Marder

421. Fracture Analysis (3)
Application of fracture mechanics concepts, microstructural analysis, and fracture surface characterization to the analysis and prevention of engineering component failures. Extensive use of case histories. Introduction to legal aspects of product liability. Prerequisite: Mat 218 or Mech 313 or equivalent. Hertzberg

423. Advanced Transmission Electron Microscopy (4)
The theory and practice of operation of the transmission and scanning transmission electron microscopes. Techniques covered include bright field, high resolution and weak-beam dark field, lattice imaging, diffraction pattern indexing and Kikuchi line analysis. The theory of diffraction contrast is applied to the interpretation of electron micrographs. Specimen preparation techniques. Prerequisite: Mat 334 or equivalent. Williams

425. Topics in Materials Processing (3)
Topics such as ceramics, metal, and polymer synthesis and compaction phenomena. Theories of sintering and grain growth. Physical behavior of sintered compacts. Techniques of fiber and crystal growth. Vapor deposition and ultra-high-purity materials preparation. Desirable preparation: Mat 204 or 206 or 214, and Mat 218. Prerequisite: consent of the department chairperson.

427. Advanced Scanning Electron Microscopy (4)
The theory and practice of operation of the scanning electron microscope and electron microprobe. Techniques covered will include high-resolution scanning, quantitative electron probe microanalysis. Electron beam sample interactions, X-ray spectrometry, and electron optics will be discussed in detail. Prerequisite: Mat 334 or equivalent.

429. Dielectric and Electrical Properties of Ceramics (3)
Basic concepts of dielectric and electrical phenomena in ceramics including dielectric loss, dielectric breakdown, ferroelectricity, piezoelectricity, mixed conduction, and interfacial effects. Physical and materials aspects of technologically important ceramics such as thermistors, varistors, boundary layer capacitors, solid electrolytes, gas sensors, glasses etc. Prerequisite: Mat 201 or equivalent. Jain

430. Glass Science (3)
Definition and formation of glass. Structure of common inorganic (including metallic) and polymeric glass systems. Methods of glass melting. Phase separation of devitrification. Physical properties including diffusion, electrical conductivity, chemical durability, and optical and mechanical properties. Special products including glass ceramics, optical fibers, photosensitive glasses, etc. Visit to a glass manufacturing plant may also be included. Prerequisite: Mat 315 or equivalent. Jain

431. Sintering Theory and Practice (3)
Science and technology of the sintering of solid state materials. Driving force and variables. Critical review of the sintering models. Coverage of single phase, multiphase and composite systems. Special sintering techniques such as fast firing, rate controlled sintering, hot pressing and transient second phase sintering. Sintering of specific ceramic and metal systems. Prerequisite: Mat 214 or equivalent. Harmer

432. Theories of Silicon Oxidation (3)
A critical review is given of advanced theories of silicon oxidation. Present accepted theory (Deal-Grove) is inadequate for explaining thin (state-of-the-art >200) oxides. Course will consider most recent approaches to theory of thin gate insulators. It will also include new experimental approaches that use “impurity gaseous doping” and halogen additions.

437. (Mech 437) Dislocations and Strength in Crystals (3)
Theory and application of dislocations. Geometrical interpretation; elastic properties; force on a dislocation; dislocation interactions and reactions; multiplication. Dislocations in crystal structures. Selected topics in strengthening, plastic flow, creep, fatigue and fracture are discussed. Prerequisite: Math 205 or 231, or Mat 320; Mat 317, or consent of the department chairperson. Wei

443. (Chem 443) Solid-state Chemistry (3)
Crystal structure, diffraction in crystals and on surfaces, bonding and energy spectra in solids, dielectrics, surface states and surface fields in crystals. Prerequisite: one course in linear algebra and one course in quantum mechanics. Klier
458. Materials Design (3)
Analysis of design requirements for materials components. Selection of materials and processes. Study of failures in process and service and application of recent metallurgical and materials engineering knowledge for improved design. Solution and discussion of industrial problems, and outline of experimental approach. Prerequisite: consent of the chairperson.

460. Engineering Project (1-3)
In-depth study of a problem in the area of materials engineering or design. The study is to lead to specific conclusions and be embodied in a written report. Intended for candidates for the M.Eng. May be repeated for a total of three credit hours.

461. Advanced Materials Research Techniques (3)
Study of the theory and application of selected advanced techniques for investigating the structure and properties of materials. May be repeated for credit with the approval of the department chairperson.

482. (Chm 482, ChE 482) Engineering Behavior of Polymers (3) spring
A treatment of the mechanical behavior of polymers. Characterization of experimentally observed viscoelastic response of polymeric solids with the aid of mechanical model analogs. Topics include time-temperature superposition, experimental characterization of large deformation and fracture processes, polymer adhesion, and the effects of fillers, plasticizers, moisture and aging on mechanical behavior.

485. (Chm 485, ChE 485) Polymer Blends and Composites (3) fall
An intensive study of the synthesis, morphology, and mechanical behavior of polymer blends and composites. Mechanical blends, block and graft copolymers, interpenetrating polymer networks, polymer impregnated concrete, and fiber and particulate reinforced polymers are emphasized. Prerequisite: any introductory polymer course or equivalent.

Mathematics

Professors. Donald M. Davis, Ph.D. (Stanford), chairperson; Bennett Eisenberg, Ph.D. (M.I.T.); B. K. Ghosh, Ph.D. (London); Samuel L. Gulden, M.A. (Princeton); Wei-Min Huang, Ph.D. (Rochester); Jacob Y. Karakia, Ph.D. (Lehigh); Samir A. Khabbaz, Ph.D. (Kansas); Jerry P. King, Ph.D. (Kentucky); Gregory T. McAllister, Ph.D. (Berkeley); head of the Division of Applied Mathematics and Statistics; George E. McCluskey, Ph.D. (Pennsylvania); head of the Division of Astronomy; Eric P. Salathe, Ph.D. (Brown), director of the Institute for Biomedical Engineering and Mathematical Biology; Murray Schechter, Ph.D. (N.Y.U.); Andrew K. Snyder, Ph.D. (Lehigh); Lee J. Stanley, Ph.D. (Berkeley); Gilbert A. Stengle, Ph.D. (Wisconsin); Joseph E. Yukich, Ph.D. (M.I.T.).

Associate professors. Bruce A. Dodson, Ph.D. (S.U.N.Y. at Stony Brook); Vladimir Dobric, Ph.D. (Zagreb, Croatia); David L. Johnson, Ph.D. (M.I.T.); Clifford S. Queen, Ph.D. (Ohio State); Penny D. Smith, Ph.D. (Polytechnic Institute of Brooklyn); Susan Szczepanski, Ph.D. (Rutgers); Ramamirtham Venkataraman, Ph.D. (Brown).

Assistant professors. Garth Isaak, Ph.D. (Rutgers); Terrence Napier, Ph.D. (University of Chicago).

Adjunct professor. Howard Fegan, Ph.D. (Oxford).

Mathematics is the universal language of science, and is essential for a clear and complete understanding of virtually all phenomena. Mathematical training prepares a student to express and analyze problems and relationships in a logical manner in a wide variety of disciplines including the physical, engineering, social, biological, and medical sciences, business, and pure mathematics itself. This is a principal reason behind the perpetual need and demand for mathematicians in education, research centers, government, and industry.

The department offers three major programs leading to the degrees of bachelor of arts in mathematics, bachelor of science in mathematics, and bachelor of science in statistics. It also offers five minor programs for undergraduates.

The Division of Astronomy and the Division of Applied Mathematics and Statistics are parts of the Department of Mathematics. Details on these divisions may be found in separate listings in the catalog.

Calculus Sequences
There are three calculus sequences: Math 21, 22, 23; Math 31, 32, 33; Math 51, 52. The 21-23 sequence and the 31-33 sequence cover roughly the same material, but the 31-33 sequence does it in more depth and with more rigor. The 31-33 sequence should be considered by students who have demonstrated exceptional ability in mathematics. Students who may wish to take the 31-33 sequence include those in science and engineering who are contemplating a possible major in mathematics. Most students of science and engineering will take the 21-23 sequence. The 31-33 sequence will be accepted in place of either of the other sequences, and 21-23 will be accepted in place of 51-52. Math 51 and 52 are designed primarily for students in business and the biological sciences. Credit will be awarded for only one course in each of the following groups: 21, 31, and 51; 22, 32, and 52; 23 and 33. If two courses in the same group are taken, credit will be given for the more advanced course; 3x is the most advanced, while 5x is the least advanced.

B.A. in Mathematics
The B.A. program in mathematics emphasizes fundamental principles as well as the mastery of techniques required for the effective use of mathematics. The program has the flexibility and versatility needed to prepare students for careers in government, industry and education. The program provides a solid foundation for those who want to pursue advanced study in any mathematically oriented field.

The program involves a total of 121 credit hours, 42 of which are in required major courses listed below. The remaining 79 credit hours are for college and university requirements, general electives, and additional mathematics courses that a student may wish to take.

Required Major Courses (42 credit hours)
Math 21, 22, 23 Calculus I, II and III (12) or
Math 31, 32, 33 Honors Calculus I, II, III (12)
Math 205 Linear Methods (3) or
Math 320 Ordinary Differential Equations (4)
Math 219 Principles of Analysis I (4)
Math 243 Algebra (4)
Math 244 Linear Algebra (4)
Math 220 Principles of Analysis II (4) or
Math 316 Complex Analysis (4) or
Math 208 Complex Variables (3)
Math 210 Electives (1-2)

Note: The twelve hours of electives must be approved by the students major advisor. A student must achieve an average of 2.0 or higher in major courses.

B.S. in Mathematics
There are two programs that lead to the degree of Bachelor of Science in Mathematics: a General Mathematics Option and an Applied Mathematics Option. The former is recommended for students who wish to pursue mathematics in combination with a related field (such as physics, computer science or economics). The latter provides a broad background in the major areas of applicable mathematics. A student participating in the program is enlisted in the mathematics department. The programs involve a total of 121 credit hours, and each is divided into four parts. A student must achieve an average of 2.0 or higher in major courses.

Each student is assigned a faculty advisor to guide an individual program and supervise the choice of electives.
General Mathematics Option

College and University Requirements (37 credit hours)

Required Major Courses (39 credit hours)
Math 21, 22, 23 Calculus (12) or
Math 31, 32, 33 Honors Calculus (12)
Math 12 Statistical Methods or
Math 231 Probability and Statistics (3)
Math 205 Linear Methods (3)
Math 219 Principles of Analysis I (4)
Math 208 Complex Variables (3) or
Math 316 Complex Analysis (4) or
Math 220 Principles of Analysis II (4)
Math 243 Algebra (4)
Math 244 Linear Algebra (4)
two CSc courses or one CSc course and Eng 1.

Major Electives (12 credit hours) Three courses with specific mathematical content chosen with the approval of the faculty advisor

Electives (33 credit hours) These are to be selected with the approval of the faculty advisor to include at least 15 credit hours from at least two fields of application.

Applied Mathematics Option

College and University Requirements (37 credit hours). See Section III.

Required Major Courses (45 credit hours)
Math 21, 22, 23 Calculus (12) or
Math 31, 32, 33 Honors Calculus (12)
Math 12 Statistical Methods or
Math 231 Probability and Statistics (3)
Math 205 Linear Methods (3)
Math 208 Complex Variables (3) or
Math 316 Complex Analysis (4) or
Math 219 Principles of Analysis I (4)
Math 230 Numerical Methods (3)
Math 243 Algebra (4) or
Math 261 Discrete Structures (3) or
Math 244 Linear Algebra (4)
Math 320 Ordinary Differential Equations (4)
Math 322 Methods of Applied Analysis I (3)
two CSc courses or one CSc course and Eng 1.

Major Electives (12 credit hours)
Three courses with specific mathematical content chosen with the approval of the faculty advisor.

Electives (27 credit hours)
These are to be selected to include a field of application with the approval of the faculty advisor.

B.S. in Statistics

Statistics is concerned with the development and application of techniques for collecting, analyzing and interpreting data in such a way that the reliability of the conclusions can be quantified. Statistical analysis thus forms a fundamental tool in all experimental sciences and is important in understanding chance phenomena. Mathematical principles, especially probability theory, underlie all statistical analyses.

The program involves a total of 121 credit hours, which are divided into four parts.

College and University Requirements (37 credit hours) section III.

Required Major Courses (42 credit hours)
Math 21, 22, 23 Calculus I, II and III (12) or
Math 31, 32, 33 Honors Calculus I, II, III (12)
Math 12 Basic Statistics (4)
Math 205 Linear Methods (3)
Math 309 Theory of Probability (3)
Math 310 Probability and Its Applications (3)
Math 312 Applied Statistics (3)
Math 334 Mathematical Statistics (4)
Math 338 Regression Analysis (4)
Math 374 Statistical Project (3)
CSc 11 Introduction to Computing (4)
CSc 17 Data Structures (4)

Note: Math 12 may be replaced by Math 231. A student must achieve an average of 2.0 or higher in major courses.

Major Electives (12 credit hours)
Four courses chosen from: Math 208, 219, 230, 244, 320, 322, IE 221, 222, 316, 332, 339.

Professional Electives (30 credit hours)
These are to be selected from at least two fields of application of statistics and probability, such as biology, psychology, social relations, computer science, engineering, economics, and management.

The major and professional electives must be approved by the faculty advisor.

Departmental Honors

Students may earn departmental honors by writing a thesis during their senior year. Students are accepted into the program during their junior year by the department chairperson. This acceptance is based upon the student's grades and a thesis proposal, which the student must prepare in conjunction with a thesis advisor selected by the student. An oral presentation as well as a written thesis are required for completion of the program.

Minor Programs

The department offers five minor programs in different branches of the mathematical sciences. The minors are designed to provide recognition to those students who take a program of study in mathematics or a related area in addition to their major requirements in the engineering, arts and science or business curricula. Each program requires four courses shown below, and Math 23 or 33. For substitutions, the student should consult the chairperson.

Minor in Pure Mathematics
Math 219, 243, 244
Math 220 or 303 or 307 or 316 or 342

Minor in Applied Mathematics
Two of Math 205, 208, 230, 231, 244, 320
Math 322
Math 323 or 341

Minor in Probability and Statistics
Math 12 or 231
Math 309
Two of Math 310, 312, 334, 338

Minor in Actuarial Science
Math 202, 205, 230, 231
Math 309 or 334
For information on examinations of actuarial societies, students may consult their minor advisor.

Minor in Astronomy
Phys 21, Astr 2
Astr 211 or 221
Astr 332 or 342

Undergraduate Courses

0. Preparation for Calculus (2) summer-fall

Intensive review of fundamental concepts in mathematics utilized in calculus, including functions and graphs, exponentials and logarithms,
and trigonometry. This course is for students who need to take Math 51 or 21, but who require remediation in precalculus. In particular, students who fail the Math 51 Readiness Exam must pass Math 0 before being admitted to Math 51. The credits for this course do not count toward graduation, but do count on the GPA and current credit count. Prerequisite: department permission.

5. Introduction to Mathematical Thought (3-4) spring
Meaning, content, and methods of mathematical thought illustrated by topics that may be chosen from number theory, abstract algebra, combinatorics, finite or non-Euclidean geometries, game theory, mathematical logic, set theory, topology. (MA)

9. Introduction to Finite Mathematics (4) fall
Systems of linear equations, matrices, introduction to linear programming. Sets, counting methods, probability, random variables, introduction to Markov chains. (MA)

12. Basic Statistics (4) fall-spring
A first course in the basic concepts and methods of statistics with illustrations from the social, behavioral, and biological sciences. Descriptive statistics: frequency distributions, mean and standard deviation, two-way tables, correlation and regression; random sampling, rules of probability, probability distributions and parameters, parameter estimation, confidence intervals, hypothesis testing, statistical significance. (MA). Students may not have credit for Math 12 & Eco 145.

21. Calculus I (4) fall-spring
Functions and graphs; limits and continuity; derivative, differential, and applications; Taylor's Theorem and other approximations; indefinite and definite integrals; trigonometric, logarithmic, exponential, and hyperbolic functions. (MA)

22. Calculus III (4) fall-spring
Applications of integration; techniques of integration; separable differential equations; infinite sequences and series; curves and vectors in the plane. Prerequisite: Math 21 or Math 31. (MA)

23. Calculus III (4) fall-spring
Vectors in space; partial derivatives; Lagrange multipliers; multiple integrals; vector analysis; exact differential equations and second-order differential equations with constant coefficients. Prerequisite: Math 22 or Math 32. (MA)

31. Honors Calculus I (4) fall
Same topics as in Math 21, but taught from a more thorough and rigorous point of view. (MA)

32. Honors Calculus II (4) fall-spring
Same topics as in Math 22, but taught from a more thorough and rigorous point of view. Prerequisite: Math 31. (MA)

33. Honors Calculus III (4) fall-spring
Same topics as in Math 23, but taught from a more thorough and rigorous point of view. Prerequisite: Math 32. (MA)

43. Survey of Linear Algebra (3) fall
Matrices, vectors, vector spaces and mathematical systems, special kinds of matrices, elementary matrix transformations, systems of linear equations, convex sets, introduction to linear programming. (MA). Students may not receive credit for both Math 51 & 43.

51. Survey of Calculus I (4) fall-spring
Limits. The derivative and applications to extrema, approximation, and related rates. Exponential and logarithmic functions, growth and decay. Integration. Partial derivatives and extrema. Prerequisite: Passing score on Readiness Exam, or Math 0.

52. Survey of Calculus II (3) fall-spring
Trigonometric functions and related derivatives and integrals. Techniques of integration. Differential equations. Probability and calculus. Prerequisite: Math 21 or 31 or 51.

61. Linear Algebra for Business and Economics (2) fall-spring
Matrices, solutions of linear systems, linear programming, examples from business and economics, computer solutions. (MA). Students may not receive credit for both Math 61 & 43.

75. Calculus I, Part A (2) fall
Covers the same material as the first half of Math 21. Meets three hours per week, allowing more class time for each topic than does Math 21. (MA)

76. Calculus I, Part B (2) spring
Continuation of Math 75, covering the second half of Math 21. Meets three hours per week. Final exam for this course is identical to the Math 21 final. Prerequisite: Math 75. (MA)

171. Readings (1-3) fall-spring
Study of a topic in mathematics under individual supervision. Intended for students with specific interests in areas not covered in the listed courses. Prerequisite: consent of the department chairperson. (MA)

For Advanced Undergraduates and Graduate Students
Courses listed as (3-4) are 3 credits for graduate students and 4 credits for undergraduates. The extra credit will frequently involve some extra workshops or projects.

202. Problem Solving (1)
Practice in solving problems using calculus, linear algebra, probability, and statistics. Problems taken from actuarial examinations and mathematics contests. Prerequisites: Math 205 and Math 231 or consent of the department.

205. Linear Methods (3) fall-spring
Linear differential equations and applications; matrices and systems of linear equations; vector spaces; eigenvalues and application to linear systems of differential equations. Prerequisite: Math 23 or Math 33 or Math 52. (MA)

207. (ChE 207) Introduction to Biomedical Engineering and Mathematical Physiology (3) fall
Topics in human physiology and mathematical analysis of physiological phenomena, including the cardiovascular and respiratory systems, biomechanics, and renal physiology; broad survey of bioengineering. Independent study projects. Prerequisite: Math 205. (MA)

208. Complex Variables (3) fall-spring
Functions of a complex variable; calculus of residues; contour integration; applications to conformal mapping and Laplace transforms. Prerequisite: Math 23 or Math 33. (MA)

219. Principles of Analysis (4) fall-spring
Existence of limits, continuity and uniform continuity; Heine-Borel Theorem; existence of extreme values; mean value theorem and applications; conditions for existence of the Riemann integral; absolute and uniform convergence; emphasis on theoretical material from the calculus of one variable. Prerequisite: Math 23 or Math 33. (MA)

220. Principles of Analysis II (4) spring
Continuation of Math 219. Functions of several variables; line and surface integrals; implicit functions. Prerequisite: Math 219. (MA)

230. Numerical Methods (3) fall
Representation of numbers and rounding error; numerical solution of equations; quadrature; polynomial and spline interpolation; numerical solution of initial and boundary value problems. Prerequisites: Math 205 (previously or concurrently) and knowledge of either FORTRAN or PASCAL. (MA)
231. Probability and Statistics (3) fall-spring
Probability and distribution of random variables; populations and random sampling; chi-square, t, and F distributions; estimation and tests of hypotheses; correlation and regression theory of two variables.
Prerequisite: Math 23 or Math 33 or Math 52. (MA)

234. Fractal geometry (3-4) metric
Metric spaces and iterated function systems; various types of fractal dimension; Julia and Mandelbrot sets. Other topics such as chaos may be included. Small amount of computer use. Prerequisite: Math 23 or Math 33. (MA)

243. Algebra (3-4) spring
Introduction to basic concepts of modern algebra: groups, rings, and fields.
(MA)

244. Linear Algebra (3-4) fall
Thorough treatment of the solution of n simultaneous linear equations in n unknowns, including a discussion of the computational complexity of the calculation. Vector spaces, linear dependence, bases, orthogonality, eigenvalues. Application as time permits. Prerequisite: Math 52 or Math 205 or Math 243. (MA)

251. Combinatorics (3-4)
Topics selected from enumeration, graphs and networks, Ramsey theory, ordered sets, min-max duality, and designs. Theory will be motivated by applications from operations research and computer science.
Prerequisite: Math 22 or consent of instructor. (MA)

261. (CSc 261) Discrete Structures (3)
Topics in discrete mathematical structures chosen for their applicability to computer science and engineering. Sets, propositions, induction, recursion; combinatorics; binary relations and functions; ordering, lattices and Boolean algebra; graphs and trees; groups and homomorphisms.
Prerequisites: Math 21, and either CSc 11 or Engr 1.
(MA)

303. (Phil 303) Mathematical Logic (3-4) fall
A course, on a mathematically mature level, designed not only to acquaint the student with logical techniques used in mathematics but also to present symbolic logic as an important adjunct to the study of the foundations of mathematics. Prerequisite: non Math majors need Phil 114. (MA)

304. Axiomatic Set Theory (3-4) spring
A development of set theory from axioms; relations and functions; ordinal and cardinal arithmetic; recursion theorem; axiom of choice; independence questions.
Prerequisite: Math 219 or consent of the department chairman. (MA)

307. General Topology I (3-4) fall
An introductory study of topological spaces, including metric spaces, separation and countability axioms, connectedness, compactness, product spaces, quotient spaces, function spaces.
Prerequisite: Math 219. (MA)

309. Theory of Probability (3) fall
Probabilities of events on discrete and continuous sample spaces; random variables and probability distributions; expectations; transformations; simplest kind of law of large numbers and central limit theorem. The theory is applied to problems in physical and biological sciences.
Prerequisite: Math 23 or Math 33 or Math 52. (MA)

310. Probability and Its Applications (3) spring
Continuation of Math 309. Random variables, characteristic functions, limit theorems; stochastic processes, Kolmogorov equations; Markov chains, random walks.
Prerequisite: Math 309 or consent of the department chairman. (MA)

312. Applied Statistics (3)
Exploratory data analysis; Monte Carlo methods; randomization and resampling. Computational aspects based on software tools and statistical packages.
Prerequisite: Math 12 or Math 231. (MA)

316. Complex Analysis (3-4) spring
Concept of analytic function from the points of view of the Cauchy-Riemann equations, power series, complex integration, and conformal mapping.
Prerequisite: Math 219. (MA)

320. Ordinary Differential Equations (3-4) spring
The analytical and geometric theory of ordinary differential equations, including such topics as linear systems, systems in the complex plane, oscillation theory, stability theory, geometric theory of nonlinear systems, finite difference methods, general dynamical systems.
Prerequisite: Math 205, or both Math 23 and Math 244. (MA)

322. Methods of Applied Analysis I (3) fall
Fourier series, eigenfunction expansions, Sturm-Liouville problems, Fourier integrals and their application to partial differential equations; special functions. Emphasis is on a wide variety of formal applications rather than logical development.
Prerequisite: Math 205 or consent of the department chairperson. (MA)

323. Methods of Applied Analysis II (3) spring
Green's functions; integral equations; variational methods; asymptotic expansions, method of saddle points; calculus of vector fields, exterior differential calculus.
Prerequisite: Math 322. (MA)

327. Groups and Rings (3-4) fall
An intensive study of the concepts of group theory including the Sylow theorems, and of ring theory including unique factorization domains and polynomial rings.
Prerequisite: Math 243 or consent of the department chairperson. (MA)

329. Recursive Functions and the Theory of Computation (3-4)
Core development of classical recursion theory, enumeration, index and recursion theorems, using a simple programming language as a model of computation. Other models of computation and Church's Thesis. Recursive operators and their fixed points. (MA)

334. Mathematical Statistics (3-4) spring
Populations and random sampling; sampling distributions; theory of statistical estimation; criteria and methods of point and interval estimation; theory of testing statistical hypotheses.
Prerequisite: Math 231 or Math 309. (MA)

338. Regression Analysis (3-4) spring
Least square principles in multiple regression and their interpretations; estimation, hypothesis testing, confidence and prediction intervals; residual analysis, multicollinearity, selection of regression models; comparison of data sets, analysis of variance and covariance, simultaneous inference procedures. Use of computer packages for statistical analysis.
Prerequisite: Math 12 or 231. (MA)

340. (CSc 340) Design and Analysis of Algorithms (3) spring
Algorithms for searching, sorting, counting, graph and tree manipulation, matrix multiplication, scheduling, pattern matching and fast Fourier transforms. Abstract complexity measures and the intrinsic complexity of algorithms and problems in terms of asymptotic behavior; correctness of algorithms.
Prerequisites: Math 23 and CSc 15, or consent of the department chairperson.
(MA)

341. Mathematical Models and Their Formulation (3) spring
Mathematical modeling of engineering and physical systems with examples drawn from diverse disciplines such as traffic flow, laser drilling, mold solidification, rocket design and business planning.
Prerequisite: Math 205. (MA)
342. Number Theory (3-4)
A survey of elementary and nonelementary algebraic and analytic methods in the theory of numbers. Includes the Euclidean algorithm, Diophantine equations, congruences, quadratic residues, primitive roots, number-theoretic functions as well as one or more of the following topics: distribution of primes, Pell’s equation, Fermat’s theorem, partitions. Prerequisite: Math 219 or consent of the department chairperson. (MA)

347. Problem Solving (1) fall-spring
Emphasis on problems in analysis, linear algebra, and applications. May be repeated for credit with consent of the department chairperson. Prerequisites: Math 219 and Math 244. (MA)

350. Special Topics (3) fall-spring
A course covering special topics not sufficiently covered in listed courses. Prerequisite: consent of the department chairman. May be repeated for credit. (MA)

371. Readings (1-3) fall-spring
The study of a topic in mathematics under appropriate supervision, designed for the individual student who has studied extensively and whose interests lie in areas not covered in the listed courses. Prerequisite: consent of the department chairman. May be repeated for credit. (MA)

374. Statistical Project (3)
Supervised field project or independent reading in statistics or probability. Prerequisite: consent of the department chairperson. (MA)

391. Senior Honors Thesis (3) fall-spring
Independent research under faculty supervision, culminating in a thesis presented for departmental honors. May be repeated once for credit. Prerequisite: consent of chairperson. (MA)

Graduate Programs in Mathematics
The department offers graduate programs leading to the degrees of master of science in mathematics and the doctor of philosophy in mathematics. To begin graduate work in mathematics a student must present evidence of adequate undergraduate preparation. The undergraduate program should have included a year of advanced calculus, a semester of linear algebra, and a semester of abstract algebra.

M.S. in Mathematics
The master’s program demands thirty credit hours of graduate courses with at least eighteen hours at the 400 level. With the permission of the chairperson, up to six hours of these courses can be replaced by a thesis. All students in the master’s program must also pass a comprehensive examination.

With a judicious choice of courses a student in the master’s program can specialize in pure mathematics, applied mathematics, or statistics. The M.S. degree can serve both as a final degree in mathematics or as an appropriate background for the Ph.D. degree.

Ph.D. in Mathematics
The plan of work toward the doctor of philosophy degree will include a comprehensive examination and a qualifying examination. The latter tests the student’s command of some of the following areas: analysis, functional analysis, algebra, combinatorial theory, geometry, topology, probability, statistics, logic, numerical analysis, and differential equations. A general examination, a foreign language examination, and the doctoral dissertation and its defense complete the work for the Ph.D. degree.

The department accepts candidates for the Ph.D. who desire to specialize in any of the areas listed above. Each candidate’s plan of work must be approved by a special committee of the department. Although there are no specific course requirements, the Ph.D. candidates normally take several courses related to their area of specialization.

Graduate Programs in Applied Mathematics
See program description in Section IV.

Graduate Courses
401. Real Analysis I (3) fall
Set theory, real numbers; introduction to measures, Lebesgue measure; integration, general convergence theorems; differentiation, functions of bounded variation, absolute continuity; Lp spaces. Prerequisites: Math 220 or consent of department chairperson.

402. Real Analysis II (3) spring
Metric spaces; Introduction to Banach and Hilbert space theory; Fourier series and Fejer operators; general measure and integration theory, Radon-Nikodym and Riesz representation and theorems; Lebesgue-Stieltjes integral. Prerequisites: Math 307 and Math 401.

404. Mathematical Logic (3)
Topics in quantification theory relevant to formalized theories, recursive functions, Godel’s incompleteness theorem; algorithms and computability.

405. Partial Differential Equations I (3) fall
Classification of partial differential equations; methods of characteristics for first order equations; methods for representing solutions of the potential, heat, and wave equations, and properties of the solutions of these equations; maximum principles. Prerequisite: Math 220 or its equivalent.

406. Partial Differential Equations II (3) spring
Continuation of Math 405. Emphasis on second order equations with variable coefficients and systems of first order partial differential equations. Prerequisite: Math 405.

407. Theory and Technique of Optimization (3)
Linear programming: simplex and revised simplex methods, duality theory; unconstrained optimization by one dimensional search methods; convexity and Kuhn-Tucker conditions, applications to methods for constrained optimization.

408. Algebraic Topology I (3)
Polyhedra; fundamental groups; simplicial and singular homology.

409. Mathematics Seminar (1-6) fall
An intensive study of some field of mathematics not offered in another course. Prerequisite: consent of the department chairperson.

410. Mathematics Seminar (1-6) spring
Continuation of the field of study in Math 409 or the intensive study of a different field. Prerequisite: consent of the department chairperson.

414. Topics in Ordinary Differential Equations (3)
Topics from the analytical and qualitative theory of differential equations and dynamical systems such as: structural stability, ordered chaos and strange attractors, bifurcation theory, normal forms, asymptotic methods, spectral theory of differential operators, boundary value problems. Prerequisite: consent of the department chairperson.

416. Complex Function Theory (3) fall
Continuation of Math 316. Prerequisite: Math 316 or consent of the department chairperson.

419. Linear Operators on Hilbert Space (3)
Algebra and calculus of bounded and unbounded operators on Hilbert space; spectral analysis of self-adjoint, normal, and unitary operators. Interplay between operator theory and classical function theory is emphasized. Prerequisites: Math 220, and Math 208 or Math 316.
421. Introduction to Wavelets (3)
Continuous and discrete signals; review of Fourier analysis; discrete wavelets; time-frequency spaces; Haar and Walsh systems; multiresolution analysis; Hilbert spaces; quadratic mirror filters; fast wavelet transforms; computer code; applications to filtering, compression, and imaging. Prerequisite: ECE 108, Math 205, or consent of instructor.

423. Differential Geometry 1 (3)
Differential manifolds, tangent vectors and differentials, submanifolds and the implicit function theorem. Lie groups and Lie algebras, homogeneous spaces. Tensor and exterior algebras, tensor fields and differential forms, de Rham cohomology, Stokes theorem, the Hodge theorem. Prerequisite: Math 219, 220, or Math 243 or Math 244 or Math 205 with consent of instructor.

424. Differential Geometry II (3)
Curves and surfaces in Euclidean space; mean and Gaussian curvatures, covariant differentiation, parallelism, geodesics, Gauss-Bonnet formula. Riemannian metrics, connections, sectional curvature, generalized Gauss-Bonnet theorem. Further topics. Prerequisite: Math 423.

428. Fields and Modules (3) spring
Field theory, including an introduction to Galois theory; the theory of modules, including tensor products and classical algebras. Prerequisite: Math 327.

430. Numerical Analysis (3) spring
Multistep methods for ordinary differential equations; finite difference methods for partial differential equations; numerical approximation of functions. Use of computer required. Prerequisite: Math 230 or consent of the department chairperson.

431. Calculus of Variations (3)
Existence of a relative minimum for single and multiple integral problems; variational inequalities of elliptic and parabolic types and methods of approximating a solution. Prerequisite: Math 220 or its equivalent.

435. Functional Analysis I (3) fall
Banach spaces and linear operators; separation and extension theorems; open mapping and uniform boundedness principles; weak topologies; local convexity and duality; Banach algebras; spectral theory of operators; and compact operators. Prerequisites: Math 307 and Math 401.

436. Functional Analysis II (3) spring
Continuation of Math 435. Topics such as distribution theory, nonlinear operators, fixed point theory and applications to classical analysis. Prerequisite: Math 435.

443. General Topology II (3)
Continuation of Math 307, with such topics as filters and nets, topological products, local compactness, paracompactness, metrizability, uniformity, function spaces, dimension theory. Prerequisite: Math 307.

444. Algebraic Topology II (3)
Continuation of Math 408. Cohomology theory, products, duality. Prerequisite: Math 408.

445. Topics in Algebra (3)
Selected topics reflecting the interests of the professor and the students. Prerequisite: Math 444.

449. Topics in Algebra (3)
Intensive study of topics in algebra with emphasis on recent developments. Prerequisite: consent of the department chairman. May be repeated for credit with the consent of the department chairperson.

450. Special Topics (3) fall-spring
Intensive study of some field of the mathematical sciences not covered in listed courses. Prerequisite: consent of the department chairman. May be repeated for credit with the consent of the department chairperson.

453. Function Theory (3)
The development of one or more topics in function theory, such as analytic continuation, maximum modulus principle, conformal representation, Taylor series analysis, integral functions, Dirichlet series, functions of several complex variables. Prerequisite: Math 416.

455. Topics in Number Theory (3)
456. Topics in Number Theory (3)
Selected topics in algebraic and analytic number theory. Prerequisites: Math 316 and Math 327. May be repeated for credit with the consent of the department chairperson.

461. Topics in Mathematical Statistics (3)
An intensive study of one or more topics such as theory of statistical tests, statistical estimation, regression, analysis of variance, nonparametric methods, stochastic approximation, and decision theory. Prerequisites: Math 334 and Math 401. May be repeated for credit with the consent of the department chairperson.

462. Nonparametric Statistics (3) fall
Order and rank statistics; tests based on runs, signs, ranks, and order statistics; chi-square and Kolmogorov-Smirnov tests for goodness of fit; the two-sample problem; confidence and tolerance intervals. Prerequisite: Math 231 or 309.

463. Advanced Probability (3)
Measure theoretic foundations; random variables, integration in a measure space, expectations; convergence of random variables and probability measures; conditional expectations; characteristic functions; sums of random variables, limit theorems. Prerequisites: Math 309 and Math 401.

464. Advanced Stochastic Processes (3)
Theory of stochastic processes; stopping times; martingales; Markov processes; Brownian motion; Skorohod imbedding; Brownian bridge, laws of suprema; Gaussian processes. Prerequisites: Math 309 and Math 401.

471. Homological Algebra (3)
Modules, tensor products, categories and functions, homology functors, projective and injective modules. Prerequisite: Math 428.

472. Group Representations (3)
Linear representations and character theory with emphasis on the finite and compact cases. Prerequisite: Math 428 or consent of the department chairperson.

490. Thesis
499. Dissertation

**Mechanical Engineering and Mechanics**

Professors. Charles R. Smith, Ph.D. (Stanford), chairman; Philip A. Blythe, Ph.D. (Manchester, England); Forbes T. Brown, Sc.D. (M.I.T.); Terry J. Delph, Ph.D. (Stanford); Fazel Erdogan, Ph.D. (Lehigh); G. Whitney Snyder Professor; D. Gary Harlow, Ph.D. (Cornell); Ronald J. Hartman, Ph.D. (Lehigh); Stanley H. Johnson, Ph.D. (Berkeley); Arturs Kalins, Ph.D. (Michigan); Jacob Y. Kazakia, Ph.D. (Lehigh); Edward K. Levy, Sc.D. (M.I.T.), director, Energy Research Center; Alistair K. Macpherson, Ph.D. (Sydney, Australia); Sudhakar Neti,
Ph.D. (Kentucky); Herman F. Nied, Ph.D. (Lehigh); John Ochs, Ph.D. (Penn State); Tulga M. Ozsoy, Ph.D. (Istanbul, Turkey); Richard Roberts, Ph.D. (Lehigh); Donald O. Rockwell, Ph.D. (Lehigh), Paul B. Reinhold Professor; Kenneth N. Sawyer, Ph.D. (Brown); Eric Varley, Ph.D. (Brown); Arkady Voloshin, Ph.D. (Tel-Aviv, Israel); J. David A. Walker, Ph.D. (Western Ontario, Canada); Robert P. Wei, Ph.D. (Princeton). Paul B. Reinhold Professor.

Associate professors: Meng-Sang Chew, Ph.D. (Columbia); John P. Coulter, Ph.D. (Delaware); Antonios Liakopoulos, Ph.D. (Florida); Robert A. Lucas, Ph.D. (Lehigh), associate chairman; N. Duke Pereira, Ph.D. (California, Los Angeles).

Assistant professor: Alparslan Oztekin, Ph.D. (Illinois)

Engineering is a creative profession aimed at satisfying needs of society through the combination of material, human and economic resources.

The programs in Mechanical Engineering and in Engineering Mechanics are designed so that students will be ready upon graduation to pursue satisfying and productive careers in a wide variety of fields. Separate degree programs are offered leading to the degrees of Bachelor of Science in Mechanical Engineering or Bachelor of Science in Engineering Mechanics.

Graduates with either degree are equipped for work in engineering, research and development, government service or industry. Those with ability and interest have the necessary background to pursue further studies at the graduate level.

Because of the flexibility of the curriculum, candidates for either degree may combine the study of mechanical engineering or engineering mechanics with that of other fields, such as business, industrial engineering, chemical engineering, electrical engineering, materials engineering and biology. The resulting interdisciplinary programs can prepare programs that are well designed for work in areas such as manufacturing, engineering management, systems design, nuclear engineering, energy conversion and conservation, environmental engineering, materials engineering or biomechanics.

Undergraduates become thoroughly familiar with Lehigh's computer-aided design (CAD) laboratory. This laboratory is a teaching facility where the students learn a set engineering tools that can be applied to solve a wide variety of problems.

B.S. in Mechanical Engineering

Mechanical Engineering is one of the broadest of the engineering professions, dealing generally with systems for energy conversion, material transport and the control of motion and forces.

Mechanical engineers may choose from among many different activities in their careers, according to their interests and the changing needs of society. Some concentrate on the conversion of thermal, nuclear, solar, chemical and electrical energy, or on the problems of air, water, and noise pollution. Some concentrate on the design of mechanical systems used in transportation, manufacturing or health care industries or by individual consumers. Some will be working, a decade from now, in fields that do not yet exist. Most will be engaged with concepts involving all four dimensions of space and time.

The curriculum leading toward the bachelor of science in mechanical engineering combines a broad base in mathematics, physical sciences, and the engineering sciences (mechanics of solids, materials, dynamics and fluid, thermal and electrical sciences), including laboratory. Special emphasis is placed on the practice of modern Product Development, combining state-of-the-art computer-aided design and manufacturing methods in a business-oriented framework. Several specific application fields are chosen toward the end of the program in the form of four or more courses elected from a wide variety of 300-level offerings. Courses in mechanical engineering and engineering mechanics are equally available.

The course requirements for a B.S. degree in Mechanical Engineering are listed below. In addition to required mathematics, physics, chemistry and basic engineering courses, the program includes eight courses in humanities and social sciences (see Humanities/Social Sciences), two free electives and four approved electives. The total graduation requirement is 133 credits.

**Undergraduate Curriculum in Mechanical Engineering**

**Freshman year (see Engineering, freshman year, Section 111)**

**Sophomore year, first semester (16 credit hours)**

- ME 10 Graphics for Engineering Design (4)
- Mech 2 Elementary Engineering Mechanics (3)
- Math 23 Analytic Geometry & Calculus III (4)
- Phy 21, 22 Introductory Physics II and Laboratory (5)

**Sophomore year, second semester (17 credit hours)**

- ME 21 Mechanical Engineering Lab I (1)
- ME 104 Thermodynamics I (3)
- Mech 12 Strength of Materials (3)
- Mat 33 Engineering Materials and Processes (3)
- Math 205 Linear Methods (3)
- Eco 1 Economics (4)

**Junior year, first semester (18 credit hours)**

- ME 111 Professional Development (1)
- ME 121 Mechanical Engineering Lab II (1)
- ME 205 Thermodynamics II (3)
- ME 231 Fluid Mechanics (3)
- Mech 102 Dynamics (3)
- ECE 81 Principles of Electrical Engineering I (4)
- HSS Humanities/Social Sciences (3)

**Junior year, second semester (18 credits)**

- ME 101 Mechanical Engineering Design I (2)
- ME 240 Manufacturing (3)
- ME 242 Mechanical Engineering Systems (3)
- ME 252 Mechanical Elements (3)
- ECE 162 Electrical Laboratory (1)
- Math 208 Complex Variables (3)
- Math 231 Probability and Statistics (3)
- HSS Humanities/Social Sciences (3)

**Senior year, first semester (16 credit hours)**

- ME 201 Mechanical Engineering Design II (2)
- ME 207 Mechanical Engineering Lab III (2)
- ME 321 Introduction to Heat Transfer (3)
- Approved Elective (3)
- HSS Humanities/Social Sciences (3)
- free elective (3)*

**Senior year, second semester (17 credit hours)**

- ME 208 Mechanical Engineering Lab IV (2) or
- ME 210 Laboratory Projects (2)
- Approved Electives (9)
- HSS Humanities/Social Sciences (3)
- free elective (3)

*See free electives

Twelve credits of APPROVED ELECTIVES must be taken according to the following distribution.

**At least one course (3 credits)** from the following list of engineering science electives:

- ME 322 Gas Dynamics (3)
- ME 331 Advanced Fluid Mechanics (3)
- ME 343 Control Systems (3)
- Mech 302 Advanced Dynamics (3)
- Mech 305 Advanced Mechanics of Materials (3)

**At least two courses (6 credits)** from the following list of elective courses having design or manufacturing content:

- ME 310 Directed Study (1-3)
- ME 312 Synthesis of Mechanisms (3)
- ME 323 Reciprocating and Centrifugal Engines (3)
- ME 340 Advanced Mechanical Design (3)
ME 341  Mechanical Systems (3)
ME 342  Dynamics of Engineering Systems (3)
ME 345  Fluid Power (3)
ME 348  Computer-Aided Design (3)
ME 360  Nuclear Reactor Engineering (3)
Mech 312  Finite Element Analysis (3)

Any design or manufacturing course taken outside of Mechanical Engineering must be approved by the student's advisor.

Other approved elective courses in the Department of Mechanical Engineering and Mechanics are:

ME 387  Digital Control (3)
Mech 307  Mechanics of Continua (3)
Mech 313  Fracture Mechanics (3)
Mech 326  Aerodynamics (3)

B.S. in Engineering Mechanics

The curriculum in Engineering Mechanics is designed to prepare students for careers in engineering research and development, and is especially appropriate for students wishing to specialize in the analysis of engineering systems. In many industries and governmental laboratories there is a demand for men and women with broad training in the fundamentals of engineering in which engineering mechanics and applied mathematics play an important part.

The first two years of the curriculum is the same as that in Mechanical Engineering. One of the advantages of the curriculum is the flexibility it offers through 18 credits of technical and 6 credits of personal electives in the junior and senior years. Beyond the sophomore year there are required courses in dynamics, solid mechanics, fluid mechanics, heat transfer, principles of electrical engineering, mathematics, vibrations, and senior laboratories or projects. It is recommended that the electives be chosen either to concentrate in areas such as applied mathematics and computational mechanics, solid mechanics, engineering materials, and fluid mechanics, or to obtain further depth in all areas. Each student must select a minimum of 12 credits from the courses listed under options and six additional credits of approved technical electives from this list or from other courses offered in the departments of mathematics, physics or chemistry, or in the college of engineering and applied science. The academic advisor for the Engineering Mechanics program will provide guidance in formulating the student's goals and choosing electives.

In addition to the required and elective courses in mathematics, sciences and engineering, the B.S. degree program in Engineering Mechanics includes eight courses in Humanities and Social Sciences (see Humanities/Social Sciences). The total graduation requirement is 131 credits.

Undergraduate Curriculum in Engineering Mechanics

**Freshman and sophomore years: same as ME curriculum**

**Junior year, first semester (17 credit hours)**

ME 121  Mechanical Engineering Lab II (1)
ME 231  Fluid Mechanics (3)
ME 240  Manufacturing (3)
Mech 102  Dynamics (3)
ECE 81  Principles of Electrical Engineering (4)
HSS  Humanities/Social Sciences (3)

**Junior year, second semester (16 credit hours)**

ME 242  Mechanical Engineering Systems (3)
ECE 162  Electrical Laboratory (1)
Math 208  Complex Variables (3)
Math 230  Numerical Methods (3)
HSS  Humanities/Social Sciences (3)
ME 207  Mechanical Engineering Lab III (2) or
ME 210  Lab Projects (2)
ME 321  Introduction to Heat Transfer (3) (or equivalent)
HSS  Humanities/Social Sciences (3)

Senior year, first semester (17 credit hours)

ME 207  Mechanical Engineering Lab III (2) or
ME 210  Lab Projects (2)
ME 321  Engineering Mechanics electives (3) (or equivalent)
ME 322  Methods of Applied Analysis I (3)
HSS  Humanities/Social Sciences (3)

Typical recommended options:

**Applied Mathematics and Computational Mechanics**

Mech 305  Advanced Mechanics of Materials (3)
Mech 312  Finite Element Analysis (3)
Math 309  Theory of Probability (3)
Math 322  Methods of Applied Analysis I (3)
Math 323  Methods of Applied Analysis II (3)

**Solid Mechanics**

Mech 305  Advanced Mechanics of Materials (3)
Mech 307  Mechanics of Continua (3)
Mech 312  Finite Element Analysis (3)
Mech 313  Fracture Mechanics (3)
Math 322  Methods of Applied Analysis I (3)

**Engineering Materials**

Mech 305  Advanced Mechanics of Materials (3)
Mech 313  Fracture Mechanics (3)
Mat 218  Mechanical Behavior of Materials (3)
Phy 31  Introduction to Quantum Mechanics (3)
Phy 363  Physics of Solids (3)

**Fluid Mechanics**

ME 331  Advanced Fluid Mechanics (3)
Mech 326  Aerodynamics (3)
Math 322  Methods of Applied Analysis I (3)

**Undergraduate Courses in Mechanical Engineering**

**ME 10. Graphics for Engineering Design (4) full**
Graphical description of mechanical engineering design for visualization and communication by freehand sketching, projection drawings, and 3-D solid geometric representation. Creation, storage, and manipulation of such graphical descriptions using state-of-the-art, commercially available, computer-aided engineering software. Introduction to design process through design projects. Geometrical design consideration of various manufacturing processes. Lectures and laboratory. (ES 2), (ED 2)

**ME 21. Mechanical Engineering Laboratory I(1) fall, spring**
Laboratory methods employed in mechanical engineering and mechanics. Planning and execution of experiments, analysis of data, and writing of reports. Introduction to elementary instrumentation. Prerequisite: Mech 12, previously or concurrently. (ES 0), (ED 0)

**ME 101. Mechanical Engineering Design 1 (2) spring**
Industry-based design projects. Design methodology, feasibility study of design alternatives. Oral and written communications. Prerequisites: ME 10, Mech 12, ME 104. (ES 0), (ED 2)

**ME 104. Thermodynamics I (3) fall, spring**
Basic concepts and principles of thermodynamics with emphasis on simple compressible substances. First and second law development, energy equations, reversibility, entropy and efficiency. Properties of pure substances and thermodynamic cycles. Corequisites: Math 23 and Phys 11. (ES 3), (ED 0)
ME 111. Professional Development (1) fall
Examination of ethical and professional choices facing mechanical engineers. Written and oral communications. Industrial field trips. (ES 0.5), (ED 0.5)

ME 121. Mechanical Engineering Laboratory II (1) fall, spring
A continuation of ME 21 including use of transducers, advanced instrumentation, and data acquisition. Emphasis on experimental exercises that illustrate, and/or introduce material from thermodynamics, and fluid mechanics. Includes proposal writing and interpretation of results. Prerequisites: ME 21, ME 104, and ME 231. (ME 231 may be taken concurrently.) (ES 1), (ED 0)

ME 201. Mechanical Engineering Design II (2) fall
Industry-based design projects continued from ME 101. Design, analysis, and simulation by student teams. Fabrication, assembly, and testing of prototypes when practical. Oral and written reports required. Prerequisite: ME 101 and ME 202. (ME 252 may be taken concurrently). (ES 0), (ED 2)

ME 205. Thermodynamics II (3) fall, spring

ME 207. Mechanical Engineering Laboratory III (2) fall
Formulation of laboratory experiments through open-ended planning, including decision criteria for laboratory techniques and approaches. Execution of experiments based on individual plans, followed by assessment of experimental results. Prerequisite: ME 121. (ES 1), (ED 1)

ME 208. Mechanical Engineering Laboratory IV (2) spring
Formulation of laboratory experiments through open-ended planning, including decision criteria for laboratory techniques and approaches. Execution of experiments based on individual plans, followed by assessment of experimental results. Prerequisite ME 121. (ES 1), (ED 1)

ME 210. Laboratory Projects (1-2) fall, spring
Experimental work including planning, design and development of apparatus, data collection and analysis as it pertains to an engineering problem. Progress is reported in the form of several planning and project reports. Prerequisite: Consent of department chairperson. (ES 1), (ED 1)

ME 231. Fluid Mechanics (3) fall, spring
Kinematics of fluid flow and similarity concepts. Equations of incompressible fluid flow with inviscid and viscous applications. Turbulence. One-dimensional compressible flow, shock waves. Boundary layers, separation, wakes and drag. Prerequisite: Math 205. (ES 3), (ED 0)

ME 240. Manufacturing (3) spring
Analytical and technological base for several manufacturing processes and common engineering materials. Processes include metal cutting, metal deformation, injection molding, thermforming, and composites. Process planning, computer-aided manufacturing, manufacturing system engineering, and quality measurements. Design project. Weekly laboratory. Prerequisites: ME 10, Mat 33, Mech 12. (ES 1.5), (ED 1.5)

ME 242. Mechanical Engineering Systems (3) fall, spring
The modeling and analysis of mechanical, fluid, electrical, and hybrid systems, with emphasis on lumped models and dynamic behavior, including vibrations. Source-load synthesis. Analysis in temporal and frequency domains. Computer simulation of nonlinear models, and computer implementation of the superposition property of linear models. Prerequisites: Mech 102, Math 205 and, previously or concurrently ME 231. (ES 2), (ED 1)

ME 252. Mechanical Elements (3) fall, spring
Methods for the analysis and design of machine elements such as springs, gears, clutches, brakes, and bearings. Motion analysis of cam and selected mechanisms. Projects requiring the design of simple mechanisms of mechanical sub-assemblies. Prerequisites: Mech 12, ME 10 and Mech 102. (ES 1.5), (ED 1.5)

For Advanced Undergraduates and Graduate Students

ME 310. Directed Study (1-3) fall, spring
Project work on any aspect of engineering, performed either individually or as a member of a team made up of students, possibly from other disciplines. Project progress is reported in the form of several planning and project reports. Direction of the projects may be provided by faculty from several departments and could include interaction with outside consultants and local communities and industries. Prerequisite: consent of the department chairperson. (ES 1), (ED 2)

ME 312. Synthesis of Mechanisms (3) fall
Geometry and constrained plane motion with application to linkage design. Type of number synthesis. Comparison of motion analysis by graphical, analytical, and computer techniques. Euler-Savary and related curvature techniques as applied to cam, gear and linkage systems. Introduction to the analysis of space mechanisms. Prerequisites: Math 205, Mech 102. Lucas. (ES 1), (ED 2)

ME 321. Introduction to Heat Transfer (3) fall, spring
Analytical and numerical solutions to steady and transient one- and two-dimensional conduction problems. Forced and natural convection in internal and external flows. Thermal radiation. Thermal design of engineering processes and systems. Prerequisites: ME 104, ME 231. Nuti, Blythe, Levy. (ES 2), (ED 1)

ME 322. Gas Dynamics (3) spring

ME 323. Reciprocating and Centrifugal Engines (3) fall
Thermal analysis and design of internal combustion engines (conventional and unconventional), gas turbine engines, air breathing jet engines, and rockets. Components such as jet nozzles, compressors, turbines, and combustion chambers are chosen to exemplify the theory and development of different types of components. Both ideal fluid and real fluid approaches are considered. Prerequisite: ME 205. (ES 2.5), (ED 0.5)

ME 331. Advanced Fluid Mechanics (3) fall

ME 340. Advanced Mechanical Design (3) fall
Probabilistic design of mechanical components and systems. Reliability functions, hazard models and product life prediction. Theoretical stress-strength-time models. Static and dynamic reliability models. Optimum design of mechanical systems for reliability objectives or constraints. Prerequisite: Math 231 or consent of instructor. Harlow. (ES 2), (ED 1)

ME 341. Mechanical Systems (3) spring
Advanced topics in mechanical systems design. Kinematics and dynamics of planar machinery. Shock and vibration control in machine elements. Balancing of rotating and reciprocating machines. Design
Mech 12. Strength of Materials (3) fall, spring
Mohr's circle for stress; plastic deformation, failure criteria; transverse
shearing stresses in beams; deflection analysis of beams; strain energy
methods; column buckling; analysis of thick-walled cylinders.
Prerequisites: Mech 2 and Math 23. (Math 23 may be taken concurrently). (ES 2), (ED 1)

Mech 102. Dynamics (3) fall, spring
Particle dynamics, work-energy, impulse-momentum, impact, systems
of particles; Kinematics of rigid bodies, Kinetics of rigid bodies in plane
motion, energy, momentum, eccentric impact. Prerequisites: Mech 2 and
Math 23. (ES 3), (ED 0)

Mech 103. Principles of Mechanics (4)
Composition and resolution of forces; equivalent force systems;
equilibrium of particles and rigid bodies; friction. Kinematics and
kinetics of particles and rigid bodies; relative motion; work and energy;
impulse and momentum. Prerequisites: Math 23 and Phys 11. (ES 4),
(ED 0)

For Advanced Undergraduates and Graduate Students
Mech 302. Advanced Dynamics (3) spring
Fundamental dynamic theorems and their application to the study of
the motion of particles and rigid bodies, with particular emphasis on
three-dimensional motion. Use of generalized coordinates; Lagrange's
equations and their applications. Prerequisites: Mech 102 or 103; Math
205. Johnson. (ES 3), (ED 0)

Mech 305. Advanced Mechanics of Materials (3) fall
Strength, stiffness, and stability of objects used in mechanical
engineering. Stresses and deformations for problems such as thick-
walled cylinders, spinning disks, thermal stresses, contact stresses,
curved beams, beam-columns, torsion, pressure vessels, energy
methods, and limit analysis. Projects relate analysis to engineering
design. Prerequisites: Mech 12, Math 205. Nied. (ES 2.5), (ED 0.5)

Mech 307. Mechanics of Continua (3)
Fundamental principles of the mechanics of deformable bodies. Study of
stress, velocity and acceleration fields. Compatibility equations,
conservation laws. Applications to two-dimensional problems in finite
elasticity, plasticity, and viscous fluids. Prerequisite: Mech 305. Varley.
(ES 3), (ED 0)

Mech 312. Finite Element Analysis (3) spring
Basic concepts of analyzing general media (solids, fluids, heat transfer,
etc.) with complicated boundaries. Emphasis on mechanical elements
and structures. Element stiffness matrices by minimum potential energy.
Isoparametric elements. Commercial software packages (ABAQUS,
NISA) are used. In addition, students develop and use their own finite
(ES 1.5), (ED 1.5)

Mech 313. Fracture Mechanics (3) spring
Fracture mechanics as a foundation for design against or facilitation of
fracture. Fracture behavior of solids; fracture criteria; stress analysis of
cracks; subcritical crack growth, including chemical and thermal effects;
fracture design and control, and life prediction methodologies.
Prerequisites: Mech 12, Math 205, or approval of department. Nied,
Wei. (ES 2), (ED 1)

Mech 326. Aerodynamics (3) spring
Application of fluid dynamics to flows past lifting surfaces. Normal
force calculations in inviscid flows. Use of conformal mappings in two-
dimensional airfoil theory. Kutta condition at a trailing edge; physical
basis. Viscous boundary layers. Thin airfoil theory. Section design;
pressure profiles and separation. Lifting line theory. Compressible
subsonic flows; Prandtl-Glauert Rule. Airfoil performance at supersonic
speeds. Prerequisites: ME 231 and Math 208. Blythe. (ES 2.5),
(ED 0.5)
Mech 350. Special Topics (3)
A study of some field of engineering mechanics not covered elsewhere.
Prerequisite: consent of the department chairperson.

Graduate Programs
The department offers programs leading to the degrees of master of science, master of engineering, and doctor of philosophy in Mechanical Engineering, Applied Mechanics, and Applied Mathematics.

Subject to approval, courses from other engineering curricula, such as materials science and engineering, and chemical, electrical, and industrial engineering, together with courses in mathematics and engineering mathematics, may be included in the degree program.

The Applied Mathematics Program in the College of Engineering and Applied Science is supervised by the Division of Engineering Mathematics. For a listing of faculty associated with the program, see Engineering Mathematics.

Master of Science
The M.S. degree program provides students with opportunities for more in-depth studies in mechanical engineering and mechanics and a broader background in related subject areas. In addition to a required two-course mathematics sequence (ME 442, ME 443), breadth is ensured through a series of required (three of four) core courses (ME 423, ME 430, Mech 408 and Mech 425). Depth is ensured through selected electives in the student’s area of interest. A special program in Integrated Product Development (IPD) has different requirements, including ME 413, ME 442, and two new courses, ME 450A (Integrated Product Development) and ME 450B (Manufacturing). A thesis option and a non-thesis option are offered. The thesis option is for students who wish to enhance their capabilities in mechanical engineering and mechanics and to gain research project experience in a team effort with a faculty member; it requires six credit hours of thesis in a specialized area. The non-thesis option is for students having advanced postgraduate students in a specialized area.

A candidate for the M.S. degree program is expected to possess a thorough knowledge of undergraduate mathematics and mechanics. Math 205, 208 and 322, and Mech 302 and 305, or their equivalents, are considered prerequisites.

Students who wish to pursue the M.S. in Applied Mathematics follow the requirements listed under Interdisciplinary Graduate Programs.

Doctor of Philosophy
A student who plans to work for the doctorate should submit a general plan to the department chairperson during the first year and arrange for the qualifying examinations. Candidacy for the Ph.D. degree requires satisfactory completion of a qualifying examination, which emphasizes a broad grasp of fundamentals, and the formation of a special Ph.D. Committee. In most cases, largely through the dissertation, the candidate emphasizes one or more specialized fields and engages in extensive research in collaboration with one or more faculty members. Research opportunities involve strong programs in both analysis and experimentation.

A special requirement for the Ph.D. in Applied Mathematics are listed under Interdisciplinary Graduate Programs.

Research Facilities
The department has a wide range of computational, computer graphics and experimental systems. The department's CAD Lab has over 50 computers that include high-end engineering workstations from IBM, HP and Silicon Graphics. The University supports networks of hundreds of PCs as well as links to the Internet with thousands of online services.

Experimental facilities include eleven pulsed and continuous laser units for laser diagnostics in the areas of fluid and solid mechanics, four image processing systems, a number of unique facilities for observing and controlling flow past surfaces and through machines. There are well-equipped laboratories for multi-disciplinary studies of crack growth in deteriorating environments and at elevated temperatures of up to 700°C, in conjunction with a number of surface analysis and electron microscopy facilities on campus.

Extensively equipped, interdepartmental robotics, controls, and manufacturing laboratories are also available.

Other facilities include the latest mechanical, electrodynamic and servo-controlled hydraulic testing machines, photelastic equipment, and Moiré strain measuring instruments.

Recent Research Activities

Continuum and solid mechanics. Formulation of field equations and constitutive equations in non-linear elasticity theories; mechanics of viscoelastic solids and fluids, plasticity theory; generalized continuum mechanics; thermomechanical and electromechanical interactions; analyses and modeling of manufacturing processes; free vibration and dynamic response of elastic shells, plastic-deformation of shells; thin-walled structures; influence of cracks on the strength of structural members and of interfaces; hydraulic fracture; applications to reliability and durability of composites, structural and microelectronic components, and to processes for resource recovery.

Thermofluids. Structure of turbulent boundary layers, wakes and jets; vortex-solid boundary interactions; boundary layers in compressible flow, including hypersonic regimes; vortex breakdown in internal machinery and in flow past wings; drag reduction in turbulent flows; induced noise and vibration; flutter of blades in axial-flow turbomachinery and of blades on aircraft; unsteady aerodynamic flows past three-dimensional wings and bodies; flow structure and heat transfer at end-wall junctions in rotating machinery and on surfaces of aircraft; flows through micro-hydro-electromechanical systems; convective heat transfer in systems of electronic components; flows through complex components of power generation systems; transport of coal particles; coal and heat transfer in fluidized beds; cycle analysis applied to coal gasifiers; control optimization of heat pumps; laser-Doppler and particle velocimetry; liquid crystal sensors for heat transfer, Raman spectral techniques applied to two-phase flow; laser diagnostics and image processing of complex flow and heat transfer systems.

Theoretical fluid mechanics. Vortex boundary layer interaction, modeling of turbulent boundary layers; geophysical flows such as frontal systems and mountain flows; statistical mechanics of plasmas, liquids and shock waves; finite amplitude waves in stratified gases and liquids; shock wave propagation; non-Newtonian flows in flexible tubes with application to hemorheology; magneto-fluid mechanics; wing theory; thermally driven flows.

Design. Geometric modeling; tolerance analysis and synthesis; assembly modeling; geometric dimensioning and tolerancing; 3-D digitizing; data and information structures; design for manufacturing; design methodology, tools and practices; expert systems in design; industry projects with Integrated Product Development (IPD) focus.

Manufacturing. Free form surface machining; coordinate measuring machine applications to geometric dimensions and tolerances; Taguchi’s method; injection molding; sheet metal fabrication; FEA/FEM applications to plastic deformation of metals; rapid prototyping; intelligent manufacturing incorporating process modeling, sensor subsystems for in-situ product quality monitoring, and knowledge based control for real-time process adaptation; blow molding.
ME 423. Heat and Mass Transfer (3) spring
This course is a first graduate course in the basic concepts of heat and mass transfer, providing a broad coverage of key areas in diffusion, conduction, convection, heat and mass transfer, and radiation. Topics covered include: the conservation equations, steady and transient diffusion and conduction, periodic diffusion, melting and solidification problems, numerical methods, turbulent convection, transpiration and film cooling, free convection, heat transfer with phase change, heat exchanges, radiation, mixed mode heat and mass transfer. Walker, Neti

ME 424. Turbulent Flow (3)
Stability of laminar flow; transition to turbulence. Navier-Stokes equations with turbulence. Bounded turbulent shear flows; free shear flows; statistical description of turbulence. Prerequisite: ME 331. Rockwell

ME 426. Radiative and Conductive Heat Transfer (3)
Principles of radiative transfer; thermal-radiative properties of diffuse and specular surfaces; radiative exchange between bodies; radiative transport through absorbing, emitting and scattering media. Advanced topics in steady-state and transient conduction; analytical and numerical solutions; problems of combined radiative and conductive heat transfer. Prerequisite: ME 321 or ChE 421. Varley

ME 427. (ChE 427) Multiphase Heat Transfer (3)
Heat transfer and fluid dynamics of multiphase systems. Subcooled, nucleate, and film boiling; bubble nucleation; dynamics of bubble growth and collapse; vapor-liquid concurrent flow regimes; two-phase pressure drop and momentum exchange, low instabilities; convective-flow boiling; simultaneous heat and mass transfer. Prerequisite: ME 321 or ChE 421. Chen

ME 428. Boundary Layers and Convective Heat Transfer (3)
Navier-Stokes and energy equations, laminar boundary layer theory, analysis of friction drag, transfer and separation. Transition from laminar to turbulent flow. Turbulent boundary layer theory, Prandtl mixing length, turbulent friction drag, and heat transfer. Integral methods. Flow in ducts, wakes and jets. Natural convection heat transfer. Prerequisite: ME 331 or ME 321. Levy, Liakopoulos

ME 430. Advanced Fluid Mechanics (3) fall
This course is a first graduate course in incompressible fluid mechanics, providing a broad coverage of key areas of viscous and inviscid fluid mechanics. Topics covered include: Flow kinematics, differential equations of motion, viscous and inviscid solutions, vorticity dynamics and circulation, vorticity equation, circulation theorems, potential flow behavior, irrotational and rotational flows, simple boundary layer flows and solutions, and real fluid flows and consequences. Smith

ME 431. Advanced Gas Dynamics (3)

ME 432. Topics in Gas Dynamics (3)

ME 433. (ChE 433, ECE 433) State Space Control (3)
State-space methods of feedback control system design and design optimization for invariant and time-varying deterministic, continuous systems; pole positioning, observability, controllability, modal control, observer design, the theory of optimal processes and Pontryagin's
Maximum principle, the linear quadratic optimal regulator problem, Lyapunov functions and stability theorems, linear optimal open loop control; introduction to the calculus of variations; introduction to the control of distributed parameter systems. Intended for engineers with a variety of backgrounds. Examples will be drawn from mechanical, electrical and chemical engineering applications. Prerequisite: ME 343 or ECE 212 or ChE 386 or consent of instructor. Johnson, Georgakis

ME 434. (Che 434, ECE 434) Multivariable Process Control (3)
A state-of-the-art review of multivariable methods of interest to process control applications. Design techniques examine include loop interaction analysis, frequency domain methods (Inverse Nyquist Array, Characteristic Loci and Singular Value Decomposition) feed forward control, internal model control and dynamic matrix control. Special attention is placed on the interaction of process design and process control. Most of the above methods are used to compare the relative performance of intensive and extensive variable control structures. Prerequisite: ChE 433 or ME 433 or ECE 433 or consent of instructor. Georgakis

ME 436. (Che 436, ECE 436) Systems Identification (3)
The determination of model parameters from time-history and frequency response data by graphical, deterministic and stochastic methods. Examples and exercises taken from process industries, communications and aerospace testing. Regression, quasi-linearization and invariant-imbedding techniques for nonlinear system parameter identification included. Prerequisite: ChE 433 or ME 433 or ECE 433 or consent of instructor. Johnson

ME 437. (Che 437, ECE 437) Stochastic Control (3)
Linear and nonlinear models for stochastic systems. Controllability and observability. Minimum variance state estimation. Linear quadratic Gaussian control problem. Computational considerations. Nonlinear control problem in stochastic systems. Prerequisite: ChE 433 or ME 433 or ECE 433 or consent of instructor. Staff

ME 439. Fluid Mechanics of Turbo-machinery (3)

ME 442. Analytical Methods in Engineering I (3)
Analytical methods of solution for discrete and continuous engineering systems. Theoretical, numerical and approximate methods of solution applied to equilibrium, characteristic value and propagation types of engineering problems. Staff

ME 443. Analytical Methods in Engineering II (3) spring
Continuation of ME 442.

ME 444. Experimental Stress Analysis in Design (3)
Fundamental concepts of strain measurements and application of strain gages and strain gage circuits. Two- and three-dimensional photoelasticity, stress separation techniques, birefringent coatings, moiré methods, caustics. Use of image analysis in data acquisition and interpretation. Selected laboratory experiments. Voloshin

ME 446. Mechanical Reliability (3)
Design of mechanical engineering systems to reliability specifications. Probabilistic failure models for mechanical components. Methods for the analysis and improvement of system reliability. Effect of component tolerance and parameter variation on system failure. Reliability testing. Prerequisite: Math 231 or Math 309. Harlow

ME 450. Special Topics (3)
An intensive study of some field of mechanical engineering not covered in more general courses.

ME 451. Seminar (1-3)
Critical discussion of recent advances in mechanical engineering.

ME 458. Modeling of Dynamic Systems (3)
Modeling of complex linear and nonlinear energetic dynamic engineering systems. Emphasis on subdivision into multipoint elements and representation by the bondgraph language using direct, energetic, and experimental methods. Field lumping. Analytical and graphical reductions. Simulation and other numerical methods. Examples including mechanisms, electromechanical transducers, electric and fluid circuits, and thermal systems. Brown, Johnson

ME 460. Engineering Project (1-6)
Project work on some aspect of mechanical engineering in an area of student and faculty interest. Selection and direction of the project could involve interaction with local communities or industries. Prerequisite: consent of the department chairperson.

ME 464. Computer-Aided Geometric Modeling (3)
Representation schemes for geometric modeling, computational geometry for curve and surface design, finite-element meshing and NC tool path generation, interfacing different CAD/CAM databases, interactive computer graphics programming. Prerequisite: ME 348 or consent of instructor. Ozsoy

ME 466. Fundamentals of Acoustics (3)

ME 490. Thesis

ME 499. Dissertation

Graduate Courses in Engineering Mechanics

Except for core courses, graduate courses are generally offered every third semester.

Mech 402. Advanced Analytical Mechanics (3)
Fundamental dynamical theorems and their applications to advanced problems; generalized coordinate; Lagrange’s equations; fudged and moving constraints; nonholonomic systems; Hamilton’s principle; Hamilton’s canonical equations; contact transformations; Hamilton-Jacobi partial differential equation. Prerequisite: Mech 302 or consent of the department chairperson. Johnson

Mech 405. Response of Systems to Random Loads (3)
Stochastic processes; correlation functions and power spectra; response of mechanical systems to one-dimensional and multidimensional random load fields; probability of the random vibrations of mechanical systems; applications to failure prediction. Prerequisite: consent of the department chairperson. Harlow

Mech 406. Advanced Dynamics and Vibrations (3)
Kinematical and mathematical preliminaries, basic notions of variational calculus; Hamilton’s principle. Lagrange equations, discrete systems; dynamics of continuous systems. Sturm-Liouville theory, eigenvalue problems; transient and frequency response. There will be frequent examples of the application of these techniques to the analysis of shafts, beams, membranes, and plates. Prerequisites: ME 242 and Mech 302. Erdogan, Johnson

Mech 407. Wave Propagation in Solids (3)
Wave propagation in deformable elastic solids; problems in half-space and layered media; application of integral transformations. Erdogan, Delph, Varley
Mech 408. Introduction to Elasticity (3) fall
This course is a first graduate course in solid mechanics. It addresses: kinematics and statics of deformable elastic solids; compatibility, equilibrium and constitutive equations; problems in plane elasticity and torsion; energy principles, approximate methods and applications. Staff

Mech 409. Theory of Elasticity I (3)
Kinematics of deformation, analysis of stress, stress-strain relations, strain energy function. Reciprocal theorem. Methods for two-dimensional boundary value problems applied to anti-plane, torsion, bending and plane problems. Approximate and numerical methods of solution. Prerequisites: Math 205; Mech 305 or equivalent course in advanced mechanics of materials. Erdogan, Hartranft

Mech 410. Theory of Elasticity II (3)
Advanced topics in the theory of elasticity. The subject matter may vary from year to year and may include, e.g., theory of potential functions, linear thermoelasticity, dynamics of deformable media, integral transforms and complex-variable methods in classical elasticity. Problems of boundary layer type in elasticity; current developments on the micro-structure theory of elasticity. Prerequisites: Mech 409, Math 208, or consent of the department chairperson. Erdogan

Mech 411. (Phys 471) Continuum Mechanics (3)
An introduction to the continuum theories of the mechanics of solids and fluids. This includes a discussion of the mechanical and thermodynamical bases of the subject, as well as the use of invariance principles in formulating constitutive equations. Applications of the theories to specific problems are given. Staff

Mech 412. Theory of Plasticity (3)

Mech 413. Fracture Mechanics (3)
Elementary and advanced fracture mechanics concepts; analytical modeling; fracture toughness concept; fracture toughness testing; calculation of stress intensity factors; elastic-plastic analysis; prediction of crack trajectory; fatigue crack growth and environmental effects; computational methods in fracture mechanics; nonlinear fracture mechanics; fracture of composite structures; application of fracture mechanics to design. Prerequisites: Math 205, Mech 305 or equivalent course in advanced mechanics of materials. Erdogan, Nied, Wei

Mech 414. Viscoelasticity and Creep (3)
Mechanical models for linear viscoelastic materials, representations by differential operators and hereditary integrals, creep and relaxation functions, correspondence principle, quasi-static analysis, wave propagation, nonlinear material behavior, uniaxial creep laws, multiaxial generalizations, creep damage and failure. Prerequisite: Mech 408. Delph

Mech 415. (CE 468) Stability of Elastic Structures (3)
Basic concepts of instability of a structure; bifurcation, energy increment, snap-through, dynamic instability. Analytical and numerical methods of finding buckling loads of columns. Postbuckling deformations of cantilever columns. Dynamic buckling with nonconservative forces. Effects of initial imperfections. Inelastic buckling. Instability problems of thin plates and shells. Prerequisite: Math 205. Kalnins

Mech 416. (CE 464) Analysis of Plates and Shells (3)
Bending of rectangular and circular plates, plates under lateral loads, plates with thermal and inelastic strains, effect of inplane forces, large deflections. Geometry and governing equations of a shell, shells of revolution, membrane states, edge solutions, solution by numerical integration, applications to pressure vessels. Prerequisites: Math 205; Mech 305 or equivalent course in advanced mechanics of materials. Kalnins

Mech 417. Mixed Boundary Value Problems in Mechanics (3)

Mech 418. Finite Element Methods (3)
Finite element approximations to the solutions of differential equations of engineering interest are developed from variational principles or by Galerkin's method. Linear and nonlinear example from heat transfer, solid mechanics, and fluid mechanics are used to illustrate applications of the method. The course emphasizes the development of computer programs to carry out the required calculations. Prerequisite: knowledge of FORTRAN. Delph

Mech 419. (CHE 419) Asymptotic Methods in the Engineering Sciences (3)

Mech 421. Fluid Mechanics (3)

Mech 422. Fluid Mechanics (3)
Similarity and dimensional analysis. Exact solution for viscous incompressible flow. Singular perturbation theory, with application to flows at low and high Reynolds number. Hydrodynamic stability. Depending on interest, additional topics from Magnetohydrodynamics, kinetic theory, wing theory, turbulence, water waves, flows in flexible tubes. Prerequisite: Mech 421. Staff

Mech 424. Unsteady Fluid Flows (3)
Gas dynamics, finite amplitude disturbances in perfect and real gases; channel flows; three-dimensional acoustics; theories of the sonic boom. Motions in fluids with a free surface; basic hydrodynamics, small amplitude waves on deep water; ship waves; dispersive waves; shallow water gravity waves and atmospheric waves. Hemodynamics; pulsatile blood flow at high and low Reynolds number. Models of the interaction of flow with artery walls. Varley

Mech 425. Analytical Methods in Dynamics and Vibrations (3)
spring
This course is a first graduate course in dynamics and vibrations. It treats three-dimensional rigid body motion by vector methods and multidegree of freedom systems by variational principles. Discrete modal analysis and continuous modal analysis of one-dimensional systems plus finite-element formulation of numerical problems constitutes about one-third of the course. There is a brief treatment of advanced impact. Use of symbolic computer codes is encouraged. Johnson
Mech 437. (Mat 437) Dislocations and Strengths in Crystals (3)
Theory and application of dislocations. Geometrical interpretation;
estastic properties; force on a dislocation; dislocation interactions and
reactions; multiplication. Dislocations in crystal structures. Selected
topics in strengthening plastic flow, creep, fatigue and fracture are
discussed. Prerequisites: Math 205 or 231, or Mat 320; Mat 317, or
cert of the department chairperson. Wei

Mech 445. Non-deterministic Models in Engineering (3)
Application of probability and stochastic processes to engineering
problems for a variety of applications. Modeling and analysis of
common non-deterministic processes. Topics are selected from the
following: linear and nonlinear models for random systems; random
functions; simulation; random loads and vibrations; Kalman filtering,
identification, estimation, and prediction; stochastic fracture and fatigue;
probabilistic design of engineering systems; and spatial point processes.
Prerequisites: advanced calculus and some exposure to probability and
statistics. Harlow

Mech 450. Special Problems (3)
An intensive study of some field of applied mechanics not covered in
more general courses.

Mech 454. Mechanics and Design of Composites (3)
Mechanics of anisotropic materials. Manufacturing and measurements
of uniaxial properties. Stress analysis for design of composite
structures. Hypoelastic effects, residual stresses. Laminate design,
micromechanics of lamina. Bolted and bonded joints. Impact and damage
in composites. Lectures and laboratory. Prerequisite: Mech 305 or
equivalent course in advanced mechanics of materials. Voloshin

Mech 490. Thesis

Mech 499. Dissertation

Graduate Courses in Engineering Mathematics
Students in the Applied Mathematics Program also have access to the
graduate courses listed under Mechanical Engineering, Engineering
Mechanics, and Mathematics, as well as other engineering departments.

EMA 425. Variational Methods in Science and Engineering (3)
Variational problems with one independent variable; Euler-Lagrange
equations; methods of solution; space and time dependent fields; null
Lagrangians and inhomogeneous Dirichlet data; problems with
constraints; symmetries and conservation laws; variational
approximation methods, Rayleigh-Ritz, Galerkin, finite element,
and collocation. Problems and examples will be drawn from the mechanics of
solids, fluids, and related fields. Prerequisite: consent of chairman. Staff

EMA 450. Special Topics (3)
An intensive study of some field of engineering mathematics not
covered in other courses.

EMA 490. Thesis

EMA 499. Dissertation

Military Science

Professor. LTC Robert W. Wolfenden, M.A. (Providence College),
chairperson.

Assistant professors. CPT Joseph J. Forster, B.S. (Sul Ross State);
CPT Irene Klaeser, M.A. (Webster University); CPT Steven Nott, B.A.
(University of Wisconsin); CPT John O'Brien, B.S. (U.S. Military
Academy).

Instructors. MSG James R. Landers; SFC Thomas Gleason; SSG Leida
Anderson.

The Department of Military Science, established in 1919,
conducts the Army Reserve Officers Training Corps (ROTC) program
at Lehigh University. This is one of the oldest ROTC programs in the
nation. The Army ROTC program provides a means for students to
qualify for a commission as an officer in the Active Army, Army
Reserve, or Army National Guard.

The objectives of the military science program are to develop
leadership and management ability in each student; to provide a basic
understanding of the Army's history, philosophy, organization,
responsibilities, and role in American society; and to develop
fundamental professional knowledge and skills associated with
commission. These objectives are achieved through classroom
instruction, leadership laboratories, field trips, role playing, leadership
simulations, and individual assessment and counseling. Army ROTC
offers a four-year program and a two-year program. The four-year
program consists of a two-year basic course and a two-year advanced
course. The two-year program consists of the two-year advanced course
offered to students with previous military experience, and those who
have successfully completed a six-week ROTC basic summer camp.
Basic course students incur no obligations for service in the Army as a
result of taking these courses.

Basic Course. The basic course, normally taken in the freshman and
sophomore years, provides training and instruction in leadership, public
speaking, and basic military subjects, such as the Army's role and
organizational structure, history and philosophy of the Army, basic
tactics, land navigation, first aid, group dynamics, and leadership traits
and characteristics. Basic course students incur no military obligation.

Advanced Course. The advanced course is normally taken in the
junior and senior years. The instruction includes management, military
skills, advanced leadership and tactics, logistics, administration, military
law, ethics, and professionalism, and includes attendance at ROTC
Advanced Camp. Students receive $150 per month subsistence pay
during the junior and senior years.

To enroll in the advanced course, an applicant, completes either the
basic course or the six-week basic summer camp; has received basic
course credit for previous military experience; or is a nursing student
and is accepted for enrollment by the university and the department of
military science.

Uniforms and Equipment. All uniforms and equipment needed by
the student for military science courses are supplied by the department.
Students are charged only for items not returned when they leave
the program.

Transfers. Qualified students transferring from another institution
may enter the ROTC program at the appropriate level and year,
provided they have received the necessary credits, the recommendation
of their former professor of military science (if applicable), and the
approval of the university.

Obligation after graduation. Upon graduation a student will receive a
commission as a Second Lieutenant in either the Active Army or the
Reserve Forces. If offered active duty, scholarship students serve four
years while non-scholarship students serve three. If offered reserve
duty, students normally serve six to eight years in a Reserve or National
Guard unit.

Graduate studies. ROTC graduates may request to delay their
active service to pursue a full-time course of instruction leading to an
advanced degree. Delay does not lessen the active service obligation
unless the degree is obtained at government expense. The three major
areas of concentration are medical school, law school, and all other
categories.

Course credit. Students in the College of Arts and Science and the
College of Business and Economics may substitute military science
advanced credits for six hours of electives. In the College of Engineering
and Applied Science, six credits of advanced ROTC work are
permissible within the normal program of each student, irrespective of
curriculum. For curricula that include more than six hours of personal
electives in the junior and senior years, inclusion of the more than six
hours of ROTC credit with normal programs can be effected only with
the approval of academic advisers. All military science credits, including
those in the basic course, apply toward the student's overall cumulative
grade point average.
Individuals are commissioned as officers in the United States Army after completion of the ROTC program and the advanced camp and completion of their bachelor's degree requirements. They then qualify in branches (specialties) such as the Corps of Engineers, Infantry, Armor, Aviation, Field Artillery, Air Defense Artillery, Signal Corps, Military Intelligence, Chemical Corps, Ordnance Corps, Finance, Transportation, Military Police, Adjutant General, Quartermaster, Medical Service Corps, or Nursing. Officers work as leaders/managers, specialists, or combinations of the two depending on the assignment.

There are many opportunities for advanced military and civilian schooling beginning with nearly three months of training in the branch specialty. A person may later receive an additional specialty in such areas as systems analysis, research and development, foreign area specialization, comptroller, or public affairs. Students selected for reserve forces duty are provided with the opportunity to maintain the options of a military or civilian career upon completion of the program. Those individuals who receive reserve forces duty become officers in the Army Reserve or Army National Guard in their hometown area and essentially have a part-time military career. Active duty officers are assigned at various locations throughout the world. An officer can earn retirement through both programs after twenty years of service.

**Programs and Opportunities**

**ROTC Scholarship Program.** This program is designed to offer financial assistance to outstanding young men and women entering the ROTC program who are interested in an Army career. Scholarships provide up to $20,000 annual tuition, a textbook and supplies allowance, and laboratory fees, in addition to pay of $150 per month for the period the scholarship is in effect. Three-year and two-year scholarships are available to outstanding cadets who are currently enrolled in the four-year ROTC program and are completing their freshman or sophomore year of college. This program is also open to all qualified students who are not currently enrolled in Army ROTC.

Four-year scholarships are open to all students entering ROTC as freshmen. Applications for scholarship must be made to Headquarters, U.S. Army Cadet Command, Fort Monroe, VA by July 15th prior to the senior year for early selection, but no later than November 15th for normal application. Applications may be obtained by calling 1-800-USA-ROTC. Application booklets are also available from most high school guidance offices, or may be obtained from the Military Science Department.

**Two-Year Program.** Students who want to enroll in ROTC after their sophomore year may apply. Applicants must successfully complete a six-week basic ROTC summer camp and have two years of undergraduate or graduate studies remaining. The student is paid for the six-week encampment and receives transportation costs to and from the camp. Additional scholarships are available at this camp.

**Physical Facilities.** Army ROTC uses areas on and adjacent to the university campus to conduct field training. These locations are excellent for outdoor activities such as orienteering, patrolling, and survival training. Fort Irwin in New Mexico, located east of Harrisburg, Pa., and Fort Dix, N.J., located east of Philadelphia, Pa., are used for field training exercises and weapons familiarization during the two annual weekend field exercises. Gettysburg National Park and the Pentagon are also visited each year.

**Off-campus U.S. Army Training Schools.** Cadets may be selected to attend the following U.S. Army Schools: Airborne School (Fort Benning, Georgia), Air Assault school (Fort Campbell, Kentucky), Mountain Warfare School (Ethan Allen Training Center, Vermont), and Northern Warfare School (Fort Greely, Alaska). This off-campus program is fully funded by the U.S. Army. Many other installations throughout the world may be visited through the Cadet Troop Leader Training program. Nursing students may choose to attend the Nurse Summer Training Program at Army hospitals located throughout the United States.

**Minor in Military Science.** A minor in Military Science is available in the College of Arts and Science. A minor in Military Science consists of 37 credit hours beyond the basic Military Science course and is designed to provide the student with an academic foundation necessary to support continued intellectual growth and stimulate future inquiry in the realm of civil military affairs and Military Science. Credit hours are required to be distributed as follows:

- **Military Science (12)**
  - MS 101 Advanced Military Skills (3)
  - MS 161 Advanced Leadership (3)
  - MS 113 Military Command and Staff (3)
  - MS 114 Officer Responsibilities, Ethics and Military Professionalism (3)
  - MS 118 Special Military Topics (1)

- **History (3)**
  - Hist 310 American Military History (3)

- **International Relations (3)**
  - (Select one course from one of the following categories)
    - International Relations
    - Government

- **Written Communications (3)**
  - (Select one course from one of the following categories)
    - Creative Writing
    - Scientific Writing
    - Writing for Mass Communications

- **Human Behavior (3)**
  - (Select one course from one of the following categories)
    - General Psychology
    - Sociology
    - Anthropology
    - Ethics

- **Foreign Language (6)**

- **Math (3)**

- **Computer Literacy (3)**

**Commissioning Requirements** Individuals must complete either the two-or four-year programs, attend the advanced camp, receive a college degree, have a cumulative GPA of 2.0, and complete all professional military education requirements to become commissioned officers in the United States Army.

**Course Descriptions**

Leadership Laboratory is conducted for all students on three Sundays per semester. The Leadership Laboratory provides students the opportunity to demonstrate an understanding of the leadership process and develop fundamental military skills.

Instruction at several levels on a variety of subjects with military application provides the context within which students are furnished opportunities to both teach and lead in a group setting. Responsibility is expanded as the student progresses through the program. In the senior year, the students assume the responsibility for the planning, preparation and conduct of the laboratory. Leadership Laboratory is mandatory for all students enrolled in Military Science courses.

15. **Introduction to Military Science (1)** Fall

The American Army as an institution, its roots, history, customs and traditions and philosophy of leadership. Emphasis on development and role of a professional officer corps. Includes leadership laboratory.

16. **Leadership Assessment and Group Dynamics (1)** spring

Role of individual and leader within the group, leadership skills and characteristics. Emphasis on problem solving and application. Includes laboratory and FTX.
23. Topographic Analysis and Land Navigation (2) fall
Maps as tools in basic terrain analysis and as navigational aids and introduction to small unit tactics. Emphasis on application and field exercises at individual and small group levels. Includes laboratory and FTX.

24. Leadership Theory and Management (2) spring
Contemporary theories, traits and principles and small unit tactics development. Leadership philosophies, communications, leader-follower relationships, and leadership problem-solving. Leadership simulations. Includes laboratory and FTX.

101. Advanced Military Skills (3) fall
Essential junior officer skills: advanced land navigation, principles of war, small unit tactical planning, tactics and techniques of the soldier, team leading techniques, oral communications and trainer skills. Emphasizes application and field experience. Includes laboratory and FTX. Prerequisite: permission of department chairman.

102. Advanced Leadership (3) spring
Critical examination of leadership qualities, traits and principles with emphasis on military environment. Self, peer, and instructor leadership evaluation. Advanced military skills reinforced. Includes laboratory, FTX and a 5 day leadership exercise. Prerequisite: permission of department chairman.

113. Military Command and Staff (3) fall
Role, authority and responsibility of military commanders and staff in personnel, logistics and training management. Staff procedures, problem solving, training methods and oral and written communications skills used in military organizations. Includes leadership laboratory and FTX. Prerequisite: permission of department chairman.

114. Officer Responsibilities, Ethics and Military Professionalism (3) spring
Development of the Professions of Arms, its fundamental values and institutions. Ethical responsibilities of military professionals in contemporary American society. Just war theory, international law of war, and American military law. Also covered are current topics to assist cadets in making the transition to the officer corps and service on active duty or in the reserve forces. Includes leadership laboratory and FTX. Prerequisite: permission of department chairman.

118. Special Topics for the Army Officer (1) fall, spring
Seminar covering special problems and issues dealing with responsibilities of the commissioned officer as leader, manager, and mentor, not covered in other courses. Prerequisite: permission of the department chairman.

Advanced ROTC Summer Camp
This is a six-week training program normally conducted at Fort Lewis, WA. Prerequisites are completion of the basic military science courses or their equivalent and MS 101 and 102. The summer camp experience, in coordination with respective engineering curricula, may be used to fulfill the industrial employment requirements of the engineering courses, CE 100, IE 100, and Mat 100.

Modern Foreign Languages

Professors. Lenora D. Wolfgang, Ph.D. (Pennsylvania), French
Associate professors. Marie-Sophie Armstrong, Ph.D. (Oregon), French; Marie-Helene Chabat, Ph.D. (U.C. San Diego), French; Constance Cook, Ph.D. (Berkeley), Chinese; Linda S. Lefkowitz, Ph.D. (Princeton), Spanish; Mary Nicholas, Ph.D. (Pennsylvania), Russian; David W. Pankenier, Ph.D. (Stanford), Chairperson, Chinese; Antonio Prieto, Ph.D. (Princeton), Spanish; Vera Stieghman, Ph.D. (Indiana), German; D. Alexander Waldenrath, Ph.D. (Berkeley), German.


Knowledge of other languages opens the door to other cultures, traditions, and perspectives on the world, and promotes deeper insight into one's own language and culture. Proficiency in foreign languages is indispensable in a broad range of professions such as journalism, government, international affairs, law, the armed forces, and business. A bachelor of arts degree with a major in languages provides excellent preparation for professional careers in law, business, and the media. Foreign language study is required for graduate study in many disciplines, as well as for research in science and technology. International experience is personally enriching and enhances career prospects.

Languages offered

Lehigh offers Mandarin Chinese, French, German, Hebrew, Japanese, Russian, and Spanish.

Courses include writing and speaking, reading and listening, literature, civilization, and professional areas such as business and health careers. A number of cultural courses are given in English, but most offerings stress classroom use of the language. Facilities include an International Multimedia Resource Center (IMRC). Within the IMRC in Maginnis Hall are a state-of-the-art multimedia computer lab (Maginnis 470) dedicated primarily to foreign language multimedia and World Wide Web applications and the World View Room (Maginnis 490) in which is shown a regular daily schedule of foreign language news and feature programming received via international satellite TV networks.

Language Requirements

The honors major in international relations requires foreign language study. The College Scholar program in the College of Arts and Science; the major in Russian and Soviet Studies, the major in Asian Studies, the minors in Latin American studies, Russian Area Studies, Asian Studies and in military science require language study. Students taking the B.A. in international relations or in foreign careers are expected to study a language. Students choosing a foreign language at elementary level towards their general studies requirement in the College of Engineering must take a minimum of one year (two courses). Some doctoral programs also require foreign language competence, usually assessed by the department of modern foreign languages.

Advising. Because of the sequential nature of language study and the variety of specializations available, the department pays special attention to student advising. Students who take courses in French, German, Russian, Spanish, and placement scores (Advanced Placement or College Board Achievement Test) do not give them a clear indication of their level of placement, but they should consult with their instructor or the department chairperson. Faculty members responsible for more advanced advising are currently as follows: Chinese minor and Asian Studies major and minor, Pankenier; French major, Chabat; French minor, Armstrong; German major and minor, Steigmann; Russian minor and area studies, Nicholas; Spanish major, Prieto; Spanish minor, Lefkowitz.

Major programs. The department offers major programs in French, German, and Spanish. The candidate for the major is expected to demonstrate adequate written and oral command of the language, as well as knowledge of its literature and culture. A period of study abroad is strongly recommended.

Double majors and Arts-Engineering majors including a language component are well received by employers. Studies in the two areas are carefully coordinated by major advisors.

Minor programs. The department offers minor programs in Chinese, French, German, Russian, and Spanish, and coordinates these studies with a student's major requirements in any college.

Related programs. These are available in Asian Studies, Foreign Careers, Jewish Studies, Latin American Studies, and Russian Studies.
Language of instruction. All courses are taught in the target language except MFL courses listed under “Foreign Culture and Literature Taught in English.” Students are thereby accustomed to considering the language as an active means of communication and not solely as an object of study.

Courses in English. The department offers elective courses in English on literary, cultural, and social subjects. These courses have no prerequisite and may, in most cases, be taken to fulfill preliminary distribution requirements. One of these courses may be included in the major, listed under “Foreign Culture and Literature Taught in English.”

Study Abroad and Foreign Study Awards. The department encourages students of foreign languages to spend a summer, a semester, or for a full year on an approved program of study abroad. Exchange agreements with partner institutions are continually being developed. The department offers a limited number of travel scholarships for foreign study to qualified students. Applications should be submitted by November 1 for the spring semester and by March 15 for summer or fall. For credit transfer, students must consult in advance with their major adviser, foreign language adviser, other appropriate departments, the Office of International Education and when appropriate, the Office of Financial Aid.

A selective program of foreign summer internships is being developed. Lehigh offers summer programs through the Lehigh Valley Association of Independent Colleges (LVAc). Programs are offered in Poitiers (France), Bonn (Germany), and Seville (Spain) for six credits each. A faculty member, acting as program director, accompanies the students. Courses are taught at intermediate and advanced levels by qualified instructors from host institutions. Summer programs sponsored by the Lehigh-LVAc Center for Jewish Studies include Hebrew in Israel.

Credits and grades are fully transferable under normal LVAc cross-registration procedures. Interested students should consult with the department of Modern Foreign Languages, Maginnes Hall.

Foreign Culture and Literature Taught in English

These courses on foreign cultures and comparative topics carry no prerequisites; knowledge of the foreign language is not required.

Language majors may take one course taught in English by the department for credit toward a major requirement. Interested students should consult their language major advisers.

MFL 23. Lehigh in Russia (1-8)
A summer program in Russia, taught in English. (HU)

MFL 24. The Empire of the Tsar: A Journey Through 19th-Century Russia (4)
Classics of 19th-century Russia; contemporary essays and autobiographical writing; fiction. (HU)

MFL 25. Heretics and Madmen of 20th-Century Russia (4)
Major figures of 20th-century Russian literature. Heresy, dissent, and censorship, and the position of the artist in a totalitarian society; major intellectual and artistic trends of the century; Russia’s intense interaction, borrowing, and influence on the West. (HU)

MFL 26. The Decadent Imagination in Russian Literature: 1890-1915 (4)
Poetry, fiction, and drama of Russian symbolism and other related avant-gardisms of the fin-de-siècle in the context of contemporary European influences. (HU)

MFL 27. Russian Classics (4)
Russian classics in translation. (HU)

MFL 28. The East European Film Experience (4)
Survey of recent and historical films from eastern Europe. Lecture/discussion and a weekly screening. (HU)

MFL 43. German Literature in Translation (4)
One period or theme in German literature. (HU)

MFL 51. Contemporary Hispanic-American Literature (4)
Reading and discussion of distinguished Latin American writers: Borges, Garcia Marquez, Cortazar and Vargas Llosa. (HU)

MFL 53. The Hispanic World and Its Culture (4)
Characteristics and values of the people of Spain and Latin America in literary works and other material. Hispanic cultural contributions to Western civilization. (HU)

MFL 72. (ASIA 72) Immortal Images: Traditional Chinese Literature in Translation (4)
Explore age-old themes in literature as diverse as pre-modern novels, ghost stories, poetry, divination manuals, and medical texts. (HU)

MFL 73. (ASIA 73) Fiction into Film: Modern Chinese Literature in Translation (4)
Focus on cultural issues such as the role of politics and gender in modern Chinese novels and films. (HU)

MFL 74. (ASIA 74) Chinese Cultural Program (1-8)
A summer program in China, taught in English. (HU)

MFL 75. (ASIA 75) (Hist 75) Chinese Civilization (4)
The development of traditional Chinese thought, beliefs, technology, and institutions from a historical perspective, from earliest times to China’s encounter with the West. (HU)

MFL 140. (Cogs 140, Anth 140, Psyc 140) Introduction to Descriptive Linguistics (3)
Relationship between language and mind; formal properties of language; language and society; how languages change over time. (SS)

MFL 173. The Literature of the Americas (4)
Significant literary dialogue between writers of the United States and Spanish America, including Borges, Dos Passos, Morrison, Faulkner, Garcia Marquez, Neruda, Poe, Whitman, and Vargas Llosa, among others. (HU)

MFL 177. (Hist 177, Asia 177) China Enters the Modern Age (4)
The collapse of the imperial order and China’s agonizing transformation into a modern nation-state over the past 150 years. The impact of imperialism, war, radical social change, and protracted development on Chinese traditions, values, and institutions. (HU)

MFL 349. (Hist 349) Intellectual and Cultural History of Medieval Russia (4)
Survey of medieval Russian history from the eleventh to the late seventeenth century. Historical works on the period, early Russian epics, chronicles, legends, saints’ lives, sermons, folk poetry, and Russian picaresque tales. Development of art and architecture. Manouelian. (SS)

Chinese

Preliminary courses. These may be replaced by advanced standing for students who qualify.

Chinese 1 Elementary Chinese I (4)
Chinese 2 Elementary Chinese II (4)
Chinese 11 Intermediate Chinese I (4)
Chinese 12 Intermediate Chinese II (4)

Requirements for the minor. A minimum of sixteen credit hours selected from Chinese 1 through 291.
Undergraduate Courses in Chinese

Chin 1. Elementary Chinese I (4) fall
Spoken and written Mandarin Chinese; the Pinyin transcription system used in the People’s Republic of China; introduction to Chinese calligraphy, pronunciation, basic speech patterns, and vocabulary. Weekly laboratory and conversation practice. (HU)

Chin 2. Elementary Chinese II (4) spring
Continuation of Chin 1; more vocabulary and sentence patterns, reading and writing Chinese characters. Weekly laboratory and conversation practice. Prerequisite: Chin 1 or equivalent. (HU)

Chin 11. Intermediate Chinese I (4) fall
Advanced character texts and vocabulary; folktales, brief readings in Chinese. Weekly laboratory and conversation practice. Prerequisite: Chin 2 or equivalent. (HU)

Chin 12. Intermediate Chinese II (4) spring
Continuation of Chin 11; oral and written exercises. Weekly laboratory and conversation practice. Prerequisite: Chin 11 or equivalent. (HU)

Chin 41. Modern Written Chinese I (1-4) fall
Reading and writing modern colloquial Chinese; emphasis on character acquisition and written expression. Suitable especially for students who need additional work with Chinese characters to supplement existing oral skills. Prerequisite: Chin 2 or equivalent and consent of the instructor. (HU)

Chin 42. Modern Written Chinese II (1-4) spring
Continuation of Chin 41. Prerequisite: Chin 11, Chin 41, or equivalent and consent of the instructor. (HU)

Chin 141. Advanced Chinese I (4) fall
Advanced reading and oral comprehension; film, prose, poetry, journalistic Chinese. Conversation and writing practice. Prerequisite: Chin 12 or equivalent. (HU)

Chin 142. Advanced Chinese II (4) spring
Continuation of Chin 141; more advanced readings, conversation and composition. Prerequisite: Chin 141 or equivalent. (HU)

Chin 251. Special Topics (1-4)
Literary and linguistic topics not covered in regular courses. May be repeated for credit. Prerequisite: consent of the instructor. (HU)

Chin 371. Special Topics (1-4)
Directed study of an author, genre, or period not covered in regular courses. May be repeated for credit. Prerequisite: consent of the instructor. (HU)

French
Preliminary courses. These may be replaced by advanced standing for students who qualify.

Fren 1 Elementary French I (4)
Fren 2 Elementary French II (4)
Fren 11 Intermediate French I (4)
Fren 12 Intermediate French II (4)

Requirements for the major. A minimum of thirty-two credit hours is required beyond Fren 12 as follows:
Fren 143 and 144, Advanced Oral and Written French (8)
Fren 151 and 152, Survey of Literature (8)
One or two courses from the following: Fren 146, 150, 181, 191, or any course at the 200 level (4-8).
Two or three courses at the 300 level (8-12).

Requirements for the departmental honors major. Forty credit hours are needed. Requirements are the same as for the major, plus eight additional hours of advanced study on a literary or cultural subject normally taken as an honors thesis (Fren 371) and a 3.20 average in the major.

Recommended related courses. Students majoring in French are urged to take elective courses on related subjects, either within or outside the department, as approved by their adviser.

Requirements for the minor. Sixteen credit hours are required above Fren 12 as follows:
Fren 143 (4)
Two or three of 144, 146, 151, 152, 159, 181, 191, or any two courses at the 200 level (4-8).
Two or three courses at the 300 level (4-8).

Requirements for advanced courses. Except where otherwise noted, 200- or 300-level courses are open to students having completed six credit hours of French beyond Fren 12. Exceptions require the consent of the instructor.

Study Abroad. A period of study in a French-speaking country is strongly encouraged for qualifying students. Agreements are in effect with Paul Valéry University, Montpellier, and Ecole Supérieure de Commerce, Poitiers. For these and LVAIC summer programs, both grades and credits are transferred. For other approved programs, consult the Office of International Education.

Undergraduate Courses in French

Fren 1. Elementary French I (4) fall
Basic conversational French, illustrating essential grammatical principles, reading simple texts and writing. Language laboratory video. (HU)

Fren 2. Elementary French II (4) spring
Continuation of Fren 1. Prerequisite: Fren 1 or appropriate Achievement Test score before entrance, or consent of instructor. (HU)

Fren 11. Intermediate French I (4) fall
Completion of grammar and grammar review. Video, readings, and discussion. Prerequisite: Fren 2 or appropriate Achievement Test score before entrance, or consent of instructor. (HU)

Fren 12. Intermediate French II (4) spring
Readings and discussion. Prerequisite: Fren 11 or appropriate Achievement Test score before entrance, or consent of instructor. (HU)

For Advanced Undergraduates And Graduate Students

Fren 143. Advanced Written French (4)
Intensive practice in written French and introduction to literary criticism. Prerequisite: Fren 12, or Achievement Test score of 590 or consent of instructor. (HU)

Fren 144. Advanced Oral French (4)
Emphasis on oral work. Prerequisite: Fren 12, or Achievement Test score of 590 or consent of instructor. (HU)

Fren 146. French for Business and Foreign Careers (4)
For students who want “professional” French but are uncertain of their readiness for highly specialized material. Intensive review of grammar, reading of simple contemporary texts, conversation, composition, and letter writing. Prerequisite: Fren 12 or consent of instructor. (HU)

Fren 151. Survey of French Literature I (4)
From the Middle Ages through the 18th century. Prerequisite: Fren 143 or 144 or consent of instructor. Wolfgang. (HU)

Fren 152. Survey of French Literature II (4)
Representative works of the 19th and 20th centuries. Prerequisite: Fren 143 or 144, or consent of instructor. Armstrong. (HU)

Fren 159. The French-Speaking World and Its Culture (4)
Cultural, social, and artistic development of France and the French-speaking world. Prerequisite: Fren 143 or 144, or consent of instructor. Armstrong, Chabot. (HU)
Fren 181. French Cultural Program (1-8)
A summer program abroad. Formal instruction in the French language and direct contact with the people and their culture during one or two months in a French-speaking country. (For LVAIC courses, see Fren 191, 291 below.) (HU)

Fren 223. Love and the French Novel (4)
Representative works from each period of French literature from Tristan et Isolde and La Princesse de Cleves to Gide's L'Immoraliste. Style, themes, myths and story patterns are analyzed. Wolfgang. (HU)

Fren 271. Readings (4)
Study of the works of some author or group of authors or a period, or of a literary theme. May be repeated once for credit. (HU)

Fren 281. French Cultural Program (1-6)
A program in a French-speaking country offering formal language courses and cultural opportunities. (For LVAIC courses, see Fren 291 below.) (HU)

Fren 302. Medieval French Literature (4)
Introduction to Old French from La Chanson de Roland to Francois Villon. Wolfgang. (HU)

Fren 303. Arthuan Romances (4)

Fren 306. Renaissance Writers (4)
Study of the major writers of the period, including Ronsard, Rabelais, and Montaigne. Wolfgang. (HU)

Fren 311. French Classicism (4)
French classical theatre, novel, and criticism, with emphasis on Corneille, Racine, Moliere, Pascal, Lafayette, Malherbe, and Boileau. Chabut. (HU)

Fren 313. The Age of Enlightenment (4)
The Philosophes and Encyclopedistes of the 18th century, with emphasis on Voltaire, Rousseau, Montesquieu, and Diderot. Chabut. (HU)

Fren 318. Drama in the Twentieth Century (4)
Contemporary French drama with an analysis of its origins and movements. Armstrong. (HU)

Fren 319. Twentieth Century Novel and Poetry (4)
Detailed study of representative major works. Armstrong (HU)

Fren 320. Contemporary French Fiction (4)
Reading and discussion of contemporary works of fiction (post-1980). Study of how these works fit into the context of French literature and relate more specifically to major literary currents of the 20th century. Armstrong. (HU)

Fren 321. Twentieth-Century French Short Fiction (4)
Examination, within the framework of short fiction (tales, short stories, short novels), of the major literary currents which have made up twentieth-century literature, exploring works by Camus, Cocteau, Gracq, Peyre de Mandarigues, Robbe-Grillet, Sarraute, Sartre, and others. Instruction in French. Armstrong. (HU)

Fren 345. Advanced French for Business and Foreign Careers (4)
Understanding and writing French for business and international affairs. Readings and oral presentations of current interest, with technical vocabulary (marketing, finance, industry, agriculture, communications, transport, real estate, economic relations, environment, etc). (HU)

Fren 369. Readings (4)
Advanced study of an author, period, or theme. Topics vary. May be repeated once for credit. (HU)

Fren 370. Internship (1-6)
Designed to give advanced qualified students the chance to acquire field experience and training with selected firms and governmental agencies in French-speaking countries. Assigned readings, written reports, and employer performance evaluations are required. (HU)

Fren 371. Independent Study (1-6)
Special topics under faculty guidance, including honors thesis. May be repeated once for credit. Prerequisite: consent of instructor. (HU)

German Preliminary courses. These may be replaced by other courses when a student qualifies for advanced standing.

Germ 1 Elementary German I (4)
Germ 2 Elementary German II (4)
Germ 11 Intermediate German I (4)
Germ 12 Intermediate German II (4)

Requirements for the major. A minimum of thirty-two credits beyond Germ 12. At least one at 300 level with concentration on 100, 200, and 300 level.

Requirements for the departmental honors major. Requirements are the same as for the major, plus: two additional advanced courses at the 300 level; dissertation or comprehensive examination (written or oral); a 3.0 G.P.A. in courses in the major.

Recommended related courses. Students majoring in German are urged to take courses on related subjects, either within or outside the department, as approved by their adviser.

Requirements for the minor. Sixteen credits above Germ 12 are required including at least one at 300-level.

Requirements for advanced courses. The prerequisite for all 200-level courses is at least one three-credit course taught in German beyond Germ 12 or equivalent. The prerequisite for all 300-level courses is at least two three-credit courses beyond Germ 12 (course in English excluded) or equivalent. Prerequisite may be waived by consent of the chairperson.

Undergraduate Courses in German

Germ 1. Elementary German I (4)
Fundamentals of German; reading of simple texts; simple conversation and composition; vocabulary building. Three class hours plus one laboratory or drill hour each week. No previous German required. (HU)

Germ 2. Elementary German II (4)
Continuation of Germ 1, including reading of more advanced texts. Three class hours plus one laboratory or drill hour each week.
Prerequisite: Germ 1 or equivalent. (HU)

Germ 11. Intermediate German I (4)
Review of grammar, composition, reading of intermediate texts, vocabulary building. Prerequisite: Germ 2 or four units of entrance German or consent of instructor; one hour of lab. (HU)

Germ 12. Intermediate German II (4)
Continuation of Germ 11. Prerequisite: Germ 11 or consent of instructor; one hour of lab. (HU)

Germ 81. German Cultural Program (1-8)
Summer program abroad. Formal instruction in the language and the culture of a German-speaking country. (HU)

Germ 163. Introduction to German Culture (4)
Lectures, readings, and discussion of selected aspects of German culture. Prerequisite: Germ 12 or equivalent, or consent of instructor; one hour of lab, video, or library, plus report. (HU)
Germ 165. Introduction to the German Literary Tradition (4)
Representative works from one or more of the major periods of German literature. Prerequisite: Germ 12 or equivalent, or consent of instructor; one hour of library plus written report. (HU)

Germ 167. Conversation and Composition (4)
Intensive practice in oral and written German. Prerequisite: Germ 12 or equivalent, or consent of instructor; one hour of video or library with written report. (HU)

Germ 169. Business German (4)
Introduction to German for business and foreign careers. Understanding, reading, writing, and speaking of German with an emphasis on technical vocabulary. Partial preparation for International Certificate of Business German. Prerequisite: Germ 12 or equivalent, or consent of instructor; one hour of lab. (HU)

Germ 181. German Cultural Program (1-8)
Summer program abroad. Formal instruction in the language and the culture of a German speaking country.

For Advanced Undergraduates And Graduate Students

Germ 201. Survey of German Literature I (4)
German literature to the second half of the 18th century. Readings, literature, and discussion of representative works. (HU)

Germ 202. Survey of German Literature II (4)
From the Age of Goethe to the present. Readings, lectures, and discussion of representative works; one hour of library plus written report. (HU)

Germ 211 (Thtr 211). Introduction to German Drama (4)
Drama as a literary genre; plays from various periods of German Literature; one hour of library or tapes, and written report. (HU)

Germ 218 (Thtr 218). Goethe’s “Faust” (4)
Study of Goethe’s play with an introduction to the Faust tradition; weekly paper on assigned topic. (HU)

Germ 231. New German Cinema (4)
Oral discussion and written analysis of selected films. (HU)

Germ 241. Advanced Composition and Conversation (4)
Practice in writing and speaking in German; one hour of TV program, or library research with paper. (HU)

Germ 250. Special Topics (1-4)
Literary and linguistic topics not covered in regular courses. May be repeated for credit. (HU)

Germ 281. German Cultural Program (1-8)
Study abroad. Formal instruction in German and direct contact with the people and their culture during at least one month in a German-speaking country. Prerequisites: Consent of German study abroad adviser. (HU)

Germ 301. Medieval German Literature (4)
Lectures and readings in medieval literature in translation. Introduction to Middle High German; one hour of library and weekly research paper. (HU)

Germ 302. Renaissance, Reformation, and Baroque (4)
Writers and literary movements from the end of the Middle Ages through the Baroque; weekly research paper on topic. (HU)

Germ 303. German Romanticism (4)
Early and late romanticists; one hour of research paper, or lab films with paper. (HU)

Germ 305. 20th-Century German Literature (4)
Topics in German literature of the 20th century; weekly research paper. (HU)

Germ 315. Translation and Stylistics (4)
Translations from such areas as politics, business, and athletics. Stylistically correct German in professional letters, resumes, and academics. Understanding German in various regions of Central Europe; paper on translation from newspaper or periodical. (HU)

Germ 320. Berlin in the Twenties (4)
Literature and culture of the Weimar Republic; paper from weekly library research. (HU)

Germ 325. 19th-Century German Literature (4)
Representative writers of post-Romanticism; weekly library research paper. (HU)

Germ 341. Advanced Phonetics, Linguistics, Composition, Conversation and Translation (4)
Essay writing and translation from and into German; TV programs and paper on one segment. (HU)

Germ 344. The Age of Enlightenment and Classicism (4)
Selected works of the period; weekly paper from library research. (HU)

Germ 350. Special Topics (1-4)
Literary or linguistic topics not covered in regular courses. May be repeated for credit. Prerequisite: permission of the instructor. (HU)

Germ 370. Internship (1-8)
Designed to give advanced qualified students the chance to acquire field experience and training with selected firms and governmental agencies in German-speaking countries. Assigned readings, written reports, and employer performance evaluations are required. Prerequisite: Germ 167 and/or approval of the staff in German. (HU)

Hebrew
The department offers courses both separately and in the context of the Jewish Studies minor (Section 111)

Hebr 1. Elementary Modern Hebrew I (4)
Classroom and laboratory instruction to develop hearing, speaking, reading and writing the language. Cultural, ethnic and religious dimensions of Israeli society. Tapes, textual materials, short stories. No previous study of Hebrew required. (HU)

Hebr 2. Elementary Modern Hebrew II (4)
Continuation of Hebrew I utilizing the audio-lingual approach. Fundamentals of the language, structure and sounds; the Hebrew verb; reading and vocalized stories; written exercises; tapes; short stories. Prerequisite: Hebr 1 or its equivalent. (HU)

Hebr 11. Intermediate Modern Hebrew I (4)
Classroom and laboratory instruction to develop fundamental patterns of conversation and grammar; composition, reading of texts, laboratory work and sight reading; comprehension, speaking, reading and writing of unvocalized materials. Prerequisite: Hebr 2 or qualifying examination. (HU)

Hebr 12. Intermediate Modern Hebrew II (4)
Continuation of Hebrew 11. Reading of texts, including selected short stories, outside reading and supplementary material; increased emphasis on oral presentation. Prerequisite: Hebr 11 or approval of the department chairperson.
Japanese
See Asian Studies major and minor.

JPS 1. Elementary Japanese I (4) fall
Introduction to the oral and written language with emphasis on spoken Japanese and syllabaries. Language laboratory. (HU)

JPS 2. Elementary Japanese II (4) spring
Continuation of Japanese I. Prerequisite: Japanese I or equivalent. (HU)

JPS 11. Intermediate Japanese I (4) fall
Continuation of Japanese II. Structural patterns in both spoken and written languages. 150 kanji (Chinese characters). Prerequisite: JPS 2 or equivalent. (H.U.)

JPS 12. Intermediate Japanese II (4) spring
Continuation of Japanese 11. Prerequisite: Japanese I or equivalent. (H.U.)

JPS 141. Advanced Japanese I (4) fall
Advanced reading and oral comprehension. Conversation and writing practice. Prerequisite: JPS 12 or equivalent. (H.U.)

JPS 142. Advanced Japanese II (4) spring
Continuation of JPS 141. Prerequisite: JPS 141 or equivalent. (H.U.)

JPS 296. Special Topics (1-4)
Literary or linguistics topics not covered in regular courses. May be repeated for credit. Prerequisite: consent of instructor. (H.U.)

Russian
Requirements for minor. Sixteen credit hours of Russian are required not including MFL 21, 22, 321 or 322.

RUSS 1. Elementary Russian I (4) fall
Classroom and laboratory, audio and video introduction to the fundamentals of conversational and grammatical patterns; practice in pronunciation, simple conversation, reading and writing. (H.U.)

RUSS 2. Elementary Russian II (4) spring
Continuation of RUSS 1. Prerequisite: RUSS 1, or two years of entrance Russian. (H.U.)

RUSS 11. Intermediate Russian I (4) fall
Classroom and laboratory practice in conversation. Development of reading and writing skills. Prerequisite: RUSS 2 or three units of entrance Russian or equivalent. (H.U.)

RUSS 12. Intermediate Russian II (4) spring
Continuation of RUSS 11. Prerequisite: RUSS 2 or 11, or equivalent. (H.U.)

RUSS 141. Conversation and Composition I (4) fall
Intensive practice in oral and written Russian; laboratory practice in aural comprehension. Readings and discussions on Russian literature and culture. Prerequisite: RUSS 12 or three units of entrance Russian. (H.U.)

RUSS 142. Conversation and Composition II (4) spring
Continuation of RUSS 141. Prerequisite: RUSS 141. (H.U.)

RUSS 215. Russian Classics: Russian Literature with Variable Topic and Credit (4) (H.U.)

RUSS 221. The Emergence of Russian Fiction: The 19th Century (4)
Development of genre, the role of the reader; symbolic significance of the fictional space each author creates, from the claustrophobic slums of Petersburg to the endless reaches of the steppe. Readings include Pushkin's Eugene Onegin, Lermontov's A Hero of Our Time, Gogol's Dead Souls, and Dostoevsky's White Nights. (H.U.)

RUSS 231. Russian in the Real World I (4)
Readings and conversations about selected nonliterary topics including the social and natural sciences, business, economics, the environment, current political events in Russia and throughout the former Soviet Republics. (H.U.)

RUSS 232. Russian in the Real World II (4)
A continuation of RUSS 231. (H.U.)

RUSS 241. The End of the Empire: Russian Literature Since 1985 (4)
Recent developments in Russian fiction. Trends in the pictorial arts, film, prose and poetry. (H.U.)

RUSS 251. Special Topics (4) fall
Intensive study of literary or linguistic topics. Prerequisite: RUSS 142. May be repeated for credit. Nichols. (H.U.)

RUSS 252. Special Topics (4) spring
Intensive study of literary or linguistic topics. Prerequisite: RUSS 142 or 251. May be repeated once for credit. Nichols. (H.U.)

RUSS 370. Internship (1-8)
Designed to give advanced qualified students the chance to acquire field experience and training with selected firms and governmental agencies in Russian-speaking countries. Assigned readings, written reports, and employer performance evaluations are required. Prerequisites: RUSS 141 or 142 and approval of faculty committee on internship. (H.U.)

RUSS 391. Special Topics (1-4)
Independent study or research under faculty guidance on a literary, linguistic, or methodological topic. May be repeated once for credit. May be used to satisfy the doctoral language requirement. Prerequisite: consent of instructor. Nichols. (H.U.)

Spanish
Preliminary courses. These may be replaced by other courses if students achieve advanced standing.

SPAN 1. Elementary Spanish I (4)
SPAN 2. Elementary Spanish II (4)
SPAN 11. Intermediate Spanish I (4)
SPAN 12. Intermediate Spanish II (4)

Requirements for the major. A total of thirty-two credit hours are required above SPAN 12 as follows: SPAN 141, 142, 151, 152. SPAN 191 or 291 may be considered. Three 300-level courses and the remaining course at the 100-level or above.

Requirements for departmental honors major. Forty credit hours are required above SPAN 12 as follows: thirty-two credits, as for the major; eight additional credit hours at the 300-level; and a 3.20 G.P.A. in the major.

Requirements for the minor. Sixteen credits are required above SPAN 12, as described for three minor tracks.

Spanish American Track: SPAN 141, 152, a 300-level course in Spanish American literature, one course at the 200-level or above. For Latin American Studies Track, see Latin America Studies. Peninsular Track: SPAN 141, 151, a 300-level course in Peninsular literature, one course at the 200-level or above. Professional Track: SPAN 141, 151 or 152, 211, one course at the 200-level or above.

Recommended related courses. Students majoring in Spanish are urged to take courses on related subjects inside or outside the department, as approved by their adviser.

Requirements for advanced courses. The normal prerequisite for 200- and 300-level literature courses in Spanish is SPAN 151 and/or 152. Exceptions require consent of chairperson.
Undergraduate Courses in Spanish

Span 1. Elementary Spanish I (4) fall
Basic conversational Spanish illustrating essential grammatical principles. Reading of simple texts and writing. Lab required. (HU)

Span 2. Elementary Spanish II (4) spring
Continuation of Span 1. Prerequisite: Span 1 or equivalent. (HU)

Span 11. Intermediate Spanish I (4) fall
Limited review of elementary grammar concepts and introduction to more advanced grammar. Emphasis on discussion, reading, and writing about significant topics in the Spanish-speaking world. Students will be required to complete one hour of independent lab work, plus lab contact hour. Prerequisite: Span 2 or equivalent. (HU)

Span 12. Intermediate Spanish II (4) spring
Practice and application of previously learned grammar to give maximum exposure to Spanish in contemporary contexts. Materials include articles from current periodicals, video, and literature from Spain and Spanish America, plus lab contact hour. (HU)

Span 131. Communicating in Spanish for Medical Personnel (4)
For prospective medical personnel communicating with Spanish-speaking patients. Dialogues, health-care vocabulary. Review of grammar. Language laboratory practice, plus hospital intensive hour. Prerequisite: Span 12 or equivalent. Lefkowitz (HU)

Span 133. Phonetics and Pronunciation (4)
Comparison of Spanish and English sounds; descriptions of Spanish vowels and consonants in their various positions. Oral practice in Language Laboratory. Special emphasis on accent and intonation patterns. Prerequisite: Span 2. Staff (HU)

Span 141. Advanced Grammar (4) fall
Intensive review of Spanish grammar with stress on finer points. Analysis of syntax and style. Students may choose an optional fourth independent hour for improving grammar through writing, plus writing lab/cooperative learning hour. Prerequisite: Span 12 or equivalent. Staff (HU)

Span 142. Advanced Conversational Spanish (4) spring
Conversational practice stressing the building of vocabulary, based on literary texts and topics of general interest. Designed to stimulate fluent and spontaneous use of spoken Spanish. Enrollment limited to 15. Prerequisite: Span 141 or equivalent. Staff (HU)

Span 151. Cultural Evolution of Spain (4) fall
The historical and cultural evolution of Spain. Discussion of major literary works in their cultural and historical contexts. Prerequisite: Span 141 or 142 or consent of instructor; two 2-hour sessions. Lefkowitz. (HU)

Span 152. Cultural Evolution of Latin America (4)
The historical and cultural evolution of Latin America. Discussion of representative literary works in their cultural and historical contexts; two 2-hour sessions. Prerequisite: Span (HU)

Span 199. Special Topics (4)
For students who take a course, not offered by Lehigh, at another institution. May be repeated once for credit. Prerequisite: approval of faculty. (HU)

For Advanced Undergraduates And Graduate Students

Span 211. Practical Business Spanish (4)
For students with a basic knowledge of Spanish: the language in business, law, international and social relations. Letter-writing, comprehension of technical texts, specialized professional vocabulary and review of grammar. Prerequisite: Span 141 or equivalent. Staff (HU)

Span 212. Writing Skills (4)
Improving writing proficiency through practice in composition and translation. Prerequisite: Span 141 or equivalent, plus independent writing hour. Staff. (HU)

Span 231. Spanish American Literature (4)
Literature of the pre-Colombian, conquest, and colonial periods. Oral and written reports; two 2-hour sessions. Prerequisite: Span 151 or 152. (HU)

Span 263. The Spanish American Short Story (4)
Comparative study of the literary problems posed by the work of significant short-story writers such as Quiroga, Borges, Cortázar, Ribeiro, and others. Prerequisite: Span 152. Prieto or O’Bryan. (HU)

Span 265. Spanish and Latin American Cinema (4) fall
Oral discussion and written analysis of selected films; three contact hours and two lab hours. Prerequisite: Span 142 or equivalent. (HU)

Span 281. Spanish Cultural Program (1-8)
A program abroad. Formal instruction in Spanish grammar, conversation and culture during one or more months in Spain or Latin America on an approved program. (For LVAIC courses, see Span 191 and 291 below.) Prerequisite: Span 12. (HU)

Span 291. Special Topics (2-4)
Study of an author or theme, or completion of a special project. Topics vary. May be repeated once for credit. Prerequisites: Span 151 or 152 or permission of the instructor. Staff (HU)

Span 303. Don Quijote (4)
Reading and critical analysis; two 2-hour sessions. Prerequisite: Span 151. Lefkowitz. (HU)

Span 305. Spanish Literature of the Middle Ages (4)
Reading and discussion of outstanding works such as El Cid, El Libro de Buen Amor and La Celestina. Topics vary. Prerequisite: Span 151. Lefkowitz. (HU)

Span 308. The Spanish Novel Since 1939 (4)
The evolution of the novel from post civil war to the present. Reading of Cela, Lafoiet, Delibes, Redonda, and Marse, among others. Prerequisite: Span 151 or permission of the instructor. (HU)

Span 320. Literature of the Spanish Caribbean (4)
Study of representative works with emphasis on Cuba and Puerto Rico. Writers include Barnet, Carpentier, Sanchez, and Rodriguez. Prerequisite: Span 152. Prieto. (HU)

Span 321. Children and Adolescents in Contemporary Spanish American Literature (4)
Discussion of narrative techniques and the category of the self as they relate to the images of adolescence and childhood in works by such authors as Vargas Llosa, Reinaldo Arenas, Jose Blanco, and Silvina Ocampo. Prerequisite: Span 152. Prieto. (HU)

Span 322. The Short Novel in Contemporary Spanish American Literature (4)
Reading and discussion of representative works by Garcia Marquez, Onetti, Rulló, Biyo Casares, and others. Prerequisite: Span 152. Prieto or O’Bryan. (HU)

Span 323. Literature and Revolution in Contemporary Cuba (4)
Study of works written after 1959 by dissident, non-dissident, and exiled authors (Desnoes, Norberto Fuentes, Benitez Rojo, Cabrera Infante). Discussion of problems raised by the social function of intellectuals and of literature, as they relate to themes, modes of writing, genres. Prerequisite: Span 152. Prieto. (HU)
Span 325. Hispanic Literature of the United States (4)
Discussion of fiction, poetry, drama, and film from the main groups in the
U.S. Hispanic population. Discussion of Hispanic ethnic identity,
linguism, and minority issues. Prerequisite: Span 152. Prieto. (HU)

Span 342. The New Narrative in Spanish American Literature (4)
Critical evaluation of distinguished works of Spanish American prose
fiction of the 1960's and 1970's. Readings by Donoso, Fuentes, García
Marquez and Vargas Llosa, among others. Prerequisite: Span 152 or
permission of the instructor. O'Bryan. (HU)

Span 379. Internship (2-4)
Designed to give advanced qualified students the chance to acquire field
experience and training with selected firms and governmental agencies in
Spanish-speaking countries or agencies serving the Hispanic community.
Assigned readings, written reports, and employer performance
evaluations are required. Prerequisites: Span 141 or 142 and approval of
faculty. (HU)

Span 391. Special Topics (2-4)
Study of an author, theme, period, or completion of a special project.
May be repeated once for credit. Prerequisites: Span 151 or 152 or
permission of the instructor. Staff. (HU)

Study Abroad Programs
These courses are offered by Lehigh or under the cooperation agreement
with the Lehigh Valley Association of Independent Colleges. Summer or
semester study abroad at approved programs may be incorporated into
foreign language majors and minors with the permission of the
appropriate advisor to a maximum of 16 credits toward the major and 8
credits toward the minor.

Chinese
Chin 91. Chinese Language and Culture Abroad (1-8)
Intensive study of conversational Chinese in China; reading,
development of writing skills and selected aspects of Chinese culture.
(HU)

Chin 191. Intermediate Chinese Language and Culture Abroad
(1-8)
Alternative to Chin 91 at the intermediate level. (HU)

Chin 291. Advanced Chinese Language and Culture Abroad (1-8)
Summer or semester study in China at advanced level. (HU)

French
Fren 191. French Language and Culture II Abroad (1-8)
Intensive practice in France of conversational French, rapid review of
basic grammar, reading and analysis of moderately difficult texts,
development of writing skills, supplemented by study of selected
aspects of contemporary French civilization. Prerequisites: consent of
chairperson and proficiency examination in France. (HU)

Fren 291. French Language and Culture III Abroad (1-8)
Intensive practice in France of spoken and written French, aimed at
providing the student with extensive proficiency of expression and the
ability to discriminate linguistic usage. Idiomatic expressions and an
introduction to stylistics. Reading and analysis of more difficult texts,
supplemented by in-depth study of selected aspects of contemporary
French civilization. Prerequisites: consent of chairperson and proficiency examination in France. (HU)

Germ 191. German Language and Culture II Abroad (1-8)
Intensive practice in Germany of conversational German, rapid review of
basic grammar, reading and analysis of moderately difficult texts,
development of writing skills, supplemented by the study of selected
aspects of contemporary German civilization. Prerequisites: consent of
chairperson and proficiency examination in Germany. (HU)

Germ 291. German Language and Culture III Abroad (1-8)
Intensive practice in Germany of spoken and written German, aimed at
providing the student with extensive proficiency of expression and the
ability to discriminate language usage. Idiomatic expressions and an
introduction to stylistics. Reading and analysis of more difficult texts,
supplemented by in-depth study of selected aspects of contemporary
German civilization. Prerequisites: consent of chairperson and proficiency examination in Germany. (HU)

Hebrew
For courses in Israel including study of Hebrew, see Jewish Studies.

Japanese
Jpns 91. Japanese Language and Culture Abroad (1-8)
Intensive study of conversational Japanese in Japan; development of
reading and writing skills; selected aspects of Japanese culture. (HU)

Jpns 191. Intermediate Japanese Language and Culture Abroad
(1-8)
Alternative to Jpns 91 at the intermediate level. (HU)

Jpns 291. Advanced Japanese Language and Culture Abroad (1-8)
Summer or semester study in Japan at advanced level on selected topics.
(HU)

Russian
Russ 91. Russian Language and Culture Abroad (1-8)
Intensive practice in Russia of conversational Russian, reading,
development of writing skills and selected aspects of Russian culture. (HU)

Russ 191. Intermediate Russian Language and Culture Abroad
(1-8)
Alternative to Russ 91 at a more advanced level. (HU)

Russ 291. Advanced Russian Language and Culture Abroad (1-8)
Summer or semester study in Russia at advanced level on selected
topics. (HU)

Spanish
Span 191. Spanish Language and Culture II Abroad (1-8)
Intensive practice in Spain of conversational Spanish, rapid review of
basic grammar, the reading and analysis of moderately difficult texts,
development of rudimentary writing skills, supplemented study of
selected aspects of contemporary Spanish civilization. Prerequisites:
consent of chairperson and proficiency examination in Spain. (HU)

Span 291. Spanish Language and Culture III Abroad (1-8)
Intensive practice in Spain of spoken and written Spanish aimed at
providing the student with extensive proficiency of expression and the
ability to discriminate linguistic usage. Idiomatic expressions and an
introduction to stylistics. Reading and analysis of more difficult texts,
supplemented by in-depth study of selected aspects of contemporary
Spanish civilization. Prerequisites: consent of chairperson and proficiency examination in Spain. (HU)

Music

Professors. Paul Salerni, Ph.D. (Harvard); Steven Sarnetz, D.M.A.
(Wisconsin); Nadine Sine, Ph.D. (N.Y.U.), Chairperson
Assistant Professor. Paul Chou, M.M. (SUNY - Stony Brook)
Lecturer. William Warfield, M.M. (Manhattan)
Adjunct Professors. Nancy S. Biddleck, M.M. (Temple); Debra Field,
B.M.E. (U.Houston); HeeYoun Kim, M.M. (Northwestern); James
Koch, B.M. (NEC); Richard Metzger, M.M. (Marywood); Al
Neumeyer, M.M. (Trenton); Lawrence Wright, M.M. (Juilliard); Laura
Johnson, M.F.A., (Boston University).
Private Instructors. Bass: Peter Paulsen; Bassoon: Susan Shaw;
The music department offers courses in music history, literature, theory, and composition, in addition to performance experience in instrumental and vocal ensembles, and private instruction. Facilities include a listening library, practice rooms, an electronic studio, a computer assisted car-training facility, a class keyboard studio, a first-rate recording studio, and concert and rehearsal rooms.

A student graduating with the music major will have a strong foundation in music theory and substantial exposure to western music from the Middle Ages to the present. This curriculum will prepare a student for graduate studies in musicology, music theory, or composition. A music major or minor taken in conjunction with a business major may lead to a variety of careers in arts management or in the recording and music publishing industries. For some, a double major or a minor in music will not lead to a career but to a life-long involvement with an art form that gives lasting satisfaction.

Major program. Students majoring in music must take a minimum of 32 credit hours (excluding Mus 80), to include fourteen hours in musicianship and theory (Mus 11, 82, 243, 245), nine in music history (any three from Music 233, 234, 235, 236), and three in performance courses (Mus 22-79). The remaining six credits for the major may be elected from department offerings and may include up to three additional performance courses.

Minor program. The minor requires a minimum of 17 credits and may include Mus 80 and 90. The program is designed to be flexible but must include Mus 11, and Mus 82, one music history or literature course (Mus 80, 90, 130-132, 233-236), and two performance courses (Mus 22-79). The student may choose the remaining six credits from musicianship courses, including up to three additional performance or musicianship courses.

Concert Requirement. Each semester majors and minors must attend three concerts approved by the music department.

Departmental Honors. A student must have a 3.5 average in courses in the major to pursue honors. Candidates for departmental honors should submit to the department chair a written proposal, prepared in consultation with a faculty project advisor, by the end of the junior year. The project could result in a research paper, a composition, or a performance. Upon acceptance of the project by the department faculty, the student should register with Honors 350 for 1 to 6 credits, which may be taken all at once or over the senior year. The awarding of departmental honors will be contingent on the quality of the completed project.

Private lessons. Lessons in a wide variety of instruments and voice lessons may be taken for one credit. They must be arranged through the department at a set fee that is not included in tuition. Please note that pre-registering for lessons cannot guarantee availability due to difficulties in scheduling.

Performing groups. Admission to band, choir, ensembles, and orchestra is by audition, and students receive one credit per semester by registering for the appropriate course number. Although there is no limit to the number of courses in this series that may be taken, should students with their advisor to determine the number that may be applied toward graduation (e.g. only eight credits are applicable in the College of Arts and Science).

Most department performances take place in Baker Hall, a 1,000-seat theatre in the new Zoelmer Arts Center. In cooperation with the Center, the department co-sponsors a variety of guest artists, many of whom offer master classes to music students.

Course Offerings
Please note that many upper level courses have no prerequisites beyond Mus 11 or SO and are open to anyone with basic knowledge of musical terminology.

11. Basic Musicianship (2) fall
Rudiments of musical notation, beginning skills in sight-singing, eartraining, rhythm and keyboard. (HU)

21-79. Applied music and performance courses may be repeated for graduation credit up to eight times in the CAS, six times in CEAS and CBE. Prerequisite: Admission to Music 22-61 by audition. Music 71-79 and 96 have fees.

21. Marching Band (1) fall. (ND)
22. Wind Ensemble (1) spring (HU)
23. Concert Band (1) spring (HU)
24. Jazz Ensemble (1) fall-spring (HU)
25. Jazz Band (1) fall-spring (HU)
31. University Choir (1) fall-spring (HU)
32. Choral Union (1) fall-spring (HU)
33. Overtones (1) fall-spring. Co-requisite: Mus 31 (HU)
37. Scenes from Opera and Musical Theatre (1) fall-spring (HU)
39. Brass Ensemble (1) fall-spring (HU)
48. Chamber Music Collegium (1) fall-spring (HU)
51. LUVME (1) fall-spring (HU)
52. Percussion Ensemble (1) fall-spring (HU)
61. String Orchestra (1) fall-spring (HU)
70. Recital (1-2) fall-spring (HU)
71. Private Piano Study (1) fall-spring (HU)
72. Private Vocal Study (1) fall-spring (HU)
73. Private String Study (1) fall-spring (HU)
74. Private Woodwind Study (1) fall-spring. (HU)
75. Private Brass Study (1) fall-spring (HU)
76. Private Percussion Study (1) fall-spring (HU)
77. Private Organ Study (1) fall-spring (HU)
78. Private Acoustic Guitar Study (1) fall-spring (HU)
79. Private Electric Guitar Study (1) fall-spring (HU)
80. Masterpieces of Music (3) fall or spring
Listening skills and awareness of musical styles in Western music developed through study of recognized masterpieces. (HU)

82. Theory I: Harmony (4) spring
Exercises in writing in four-part chorale style. Prerequisite: Mus 11 or equivalent. (HU)

96. Class Piano for Beginners (1) fall-spring
Instruction for beginning piano students, including rudiments of musical notation in relation to the keyboard, beginning pieces for solo piano and the group. (HU)

130. Jazz (3) fall
The history of jazz from the beginning of the century until the present. Examination of the musical contributions of the leading figures in jazz—Joplin, Oliver, Armstrong, Morton, Henderson, Ellington, Basie, Parker, Gillespie, Davis, Coleman, Coltrane, etc. Emphasis on developing listening skills. Prerequisite: Mus 11 or 80 or equivalent. Warfield (HU)

131. Major Genre (3) fall or spring
History and analysis of music of a particular type: Opera, oratorio, symphony, etc. May be repeated for credit as title varies. Prerequisite: Mus 11 or 80 or equivalent. Warfield (HU)

132. Composer and Era (3) fall or spring
Life and development of a composer’s style viewed in historical context. Title varies: Bach, Beethoven, Mozart, etc. May be repeated for credit as title varies. Prerequisite: Mus 11, or SO, or equivalent. Sine. (HU)
196. Recording Techniques (3) Recording music in various popular and classical styles using state of the art studio equipment. Topics include: microphone choice, microphone placement, mixing, equalization, effects processing, digital editing, and post production. Prerequisite: Music 82. Department permission required. (HU)

233. Medieval and Renaissance Music (3) fall, odd
Development of musical style from early Christian chant to the sacred and secular forms of the late sixteenth century, viewed in cultural contexts. Prerequisite: Mus 11 or 80 or equivalent. Sine. (HU)

234. Baroque and Classical Music (3) spring, even
The major genres and composers of the 17th and 18th centuries studied in their cultural context. Prerequisite: Mus 11 or 80 or equivalent. Sine. (HU)

235. Romantic Music (3) fall, even
Study of the major composers and their works from late Beethoven to Mahler and Strauss. Prerequisite: Mus 11 or 80 or equivalent. Sine. (HU)

236. Twentieth-Century Music (3) spring, odd
Beginning with the major trends at the turn of the century, a study of the important composers and works of our century to the present. Prerequisite: Mus 11 or 80 or equivalent. Sine. (HU)

243. Theory II: Counterpoint (4) fall, even
Writing and analyzing pieces in Renaissance and Baroque contrapuntal styles. Prerequisite: Mus 82. Salerni. (HU)

245. Theory III: Form and Analysis (4) fall, odd Analyzing and writing pieces in classical and romantic forms. Exercises in chromatic harmony. Prerequisite: Mus 82. Sametz. (HU)

251. Special Topics (1-3)
Study of musical topics in history or composition not covered in regular courses. May be repeated for credit as title varies. Prerequisite: consent of the department chairperson. (HU)

253. Composition I: Electronic and Acoustic Techniques (3) fall
Writing for acoustic and electronic instruments based on twentieth-century models. Acoustic orchestration, simple recording techniques, analog and digital synthesis, effects processing. Use of the computer for score preparation and as a compositional tool. Prerequisite: Mus 82. Salerni. (HU)

254. Composition II (3) spring
Continuation of Mus 253. Prerequisite: 253. Salerni

291. Independent Study (1-3)
Individually supervised work in history or composition, or continuation of projects begun in regular courses. May be repeated for credit. Prerequisite: consent of department chairperson. (HU)

300. Apprentice Teaching (1-3) (ND)

350. Senior Project (1-6)

Natural Science

Paul B. Myers

This major program provides students with a broad background in the fundamentals of mathematics and science and the opportunity to concentrate to a reasonable extent in one area of science.

The program leads to a Bachelor of Arts degree and is designed especially for the following: 1. those students who want preparation for graduate work or careers in certain of the derivative or interdisciplinary sciences or related professional fields (oceanography, astronomy, psycho-physiology, medicine or dentistry, etc.); 2. those students who plan to teach in secondary schools or community colleges; and 3. those students without fixed career objectives who want undergraduate training in science.

Students who register for the program are required to select an area of concentration (or option) that must be approved by the dean of the College of Arts and science and the director of the program. The option may be chosen in chemistry, biology, geology, psychology, or in an approved interdisciplinary area (biophysics, marine science, biochemistry, computer science, etc.). Courses included in the option are worked out individually for the student by the major adviser.

Qualified students may be given permission at the end of the junior year to enter a program whereby they are able to begin work toward a graduate degree (master of arts, master of science, or master of education) during the senior year. Students enrolled in this program often complete all course requirements for the master's degree with one year of study beyond the bachelor's degree.

required preliminary courses
- Math 21, 22, 23 Analytic Geometry and Calculus I, II and III (12)
- Phy 11, 12 Introductory Physics I and Laboratory I (5)
- Phy 21, 22 Introductory Physics II and Laboratory II (5) or
- Phy 13, 14 General Physics and Laboratory (4)
- Chm 21, 22 Introductory Chemical Principles and Laboratory (5)
- EES 21 Introduction to Earth Materials and Processes (4) or
- Astr 1 The Solar System (3)
- EES 31 Introduction to Environmental and Organismal Biology
- Psy 1 Introduction to Psychology (3)

required major courses
- Chm 51, 52 Organic Chemistry I, II (3,3) and
- Chm 53, 58 Organic Chemistry Laboratory I, II (1,1) or
- Chm 31 Chemical Equilibria in Aqueous Systems (3) and
- Chm 187 Physical Chemistry I (3)
- Math elective (3)

Option (24)

Note: The mathematics elective and courses included in the option are taken with approval of the major advisor.

Students registered for this major normally are expected to choose their option no later than the second semester of the sophomore year.

Philosophy

Professors. Mark H. Bickhard, Ph.D. (Chicago), Henry R. Luce Professor in Cognitive Robotics and the Philosophy of Knowledge; Steven Louis Goldman, Ph.D. (Boston), Andrew W. Mellon Distinguished Professor in the Humanities.

Associate Professors. Gordon Beam, Ph.D. (Yale) chairperson; Robin Dillon, Ph.D. (Pittsburgh); Roslyn Weiss, Ph.D. (Columbia).

Assistant Professors. Alexander Levine, Ph.D. (San Diego); Michael Mendelson, Ph.D. (San Diego).

Philosophy is born of discomfort. Whether it is the need to account for the tragedies of circumstance, the incongruities between our assumptions about the world and what experience and science reveal, or the shock of being exposed to hitherto unimagined conceptual alternatives, philosophy arises in those contexts in which serious questions emerge about the adequacy of our most cherished beliefs.
Philosophy is driven by the unsettling awareness that we are not beings who act exclusively on instinct but are instead able to choose from among a variety of ways of thinking about ourselves, the world in which we find ourselves, and our relations with others. Moreover, the beliefs we hold are not merely incidental facts about us like height or eye color. What we believe is often central to our moral identity, the nature of our personal relationships, the manner in which we regard ourselves and treat others, and the happiness and unhappiness that form the emotional contours of our practical lives. Philosophy is born out of our awareness that despite the centrality of our beliefs to our identity as moral beings, the truth of our beliefs can be uncertain, for on virtually any topic there is a variety of possible viewpoints, not all of which can be equally adequate.

In its attempt to ground our beliefs and justify them, philosophy becomes a reflective and critical conceptual activity concerned with foundational questions regarding our deepest assumptions and intuitions about the nature and extent of human knowledge (epistemology), about the nature of reality and the distinction between appearance and reality (metaphysics), about the nature, scope, and grounds of moral value (ethics), and about the nature and theoretical foundations of formal reasoning and valid inference (logic).

The major program in philosophy is designed to provide a broad exposure to all of these areas as well as a strong grounding in the history of the western philosophical tradition. The program emphasizes the close reading and critical evaluation of classic texts from ancient times to the present, and students can expect to develop sophisticated analytic and expository skills that will enable them to engage in original, critical reflection on their own. To this end, the major program involves a combination of required and elective coursework as well as the opportunity to develop and pursue individual interests under faculty supervision. In addition to its regular course offerings, the department also sponsors a variety of activities (e.g. the annual Selfridge Lecture, the Philosophy Forum, the Faculty Seminar, the Philosophy Club, and the annual, Reading Party, all of which are designed to complement the course offerings and to promote a university-wide philosophical community.

The major program provides excellent preparation for graduate study in philosophy as well as a solid foundation for any career that places a premium upon clear, careful thinking and rigorous conceptual and expository skills.

For additional information about the faculty, frequency of course offerings, and departmental events, please contact the department for a copy of its brochure.

The Minor Program
The minor in philosophy consists of six courses. The courses must include Ancient Philosophy (Phil 131) and at least one course at the 200 level or above. Minor programs are planned in conjunction with the departmental advisor who will help the student plan a program compatible with his or her interests. Minor programs may be, but do not have to be, focused in a particular area such as ethics or the history of philosophy or philosophy of mind.

The Major Program
The major in philosophy consists of eleven courses planned in conjunction with the student’s major advisor. There are 6 required courses including a two semester (6 credit) Senior Thesis, and 5 electives, of which 4 must be at the 200 level or above.

**REQUIRED COURSES**
- Phil 114 Fundamentals of Logic
- Phil 105 Ethics
- Phil 131 Ancient Philosophy
- Phil 135 Modern Philosophy
- Phil 390 Senior Thesis
- Phil 391 Senior Thesis

**ELECTIVES**
5 elective courses, of which 4 must be at the 200 level or above.

**Senior Thesis**
The Senior Thesis (Phil 390-1) is a year-long, independent project during which philosophy majors, with the consent and under the guidance of a faculty sponsor, investigate a topic of special interest to them. The topic may be historical or non-historical, pure or applied, interdisciplinary or disciplinary; the only constraint is that the student secure the cooperation of a faculty sponsor. During the Fall (Phil 390), the student’s energies will be devoted to refining the topic under investigation, working through the bulk of the essential literature, and producing a paper roughly 20 pages in length. During the Spring semester (Phil 391), the student will investigate the same topic more intensively, expanding, revising, and refining the Fall paper into a substantial senior thesis roughly 50 pages in length.

**Honors**
Departmental honors are awarded to philosophy majors if they satisfy two criteria: (a) at the time of graduation, their cumulative average in philosophy is 3.25 or better, and (b) they have successfully defended their senior thesis at an oral examination conducted by the philosophy faculty. Although every senior major will write a senior thesis, only those seniors whose progress is completing their thesis suggests they will pass such an examination will be invited to submit their thesis for honors in philosophy.

**Undergraduate Courses**

1. **The Examined Life: An Introduction to Philosophy (3)**
   What makes a life meaningful, what makes it worth living? In pursuit of an answer to this question this course examines many of the basic questions of philosophy: ethical questions about justice and virtue, epistemological questions about the limits of human knowledge, metaphysical questions about what there is. (HU)

2. **Religion and Ethics in Religious Traditions (4)**
   Introduction to philosopical and religious modes of moral thinking, with consideration given to ethics in the world religious traditions (family life and role of women, social justice, environment, work, models of ethical ideals). Particular issues examined include abortion, corporal punishment (such as the death penalty). Problems in medical ethics, and heavy drinking as a behavioral problem. (HU)

3. **Introduction to Scientific Reasoning (3)**
   Introduction to informal deductive logic, inductive logic, and basic statistical inference. Emphasis is on the employment of these tools in everyday contexts: in weighing legal evidence, interpreting public opinion polls, and deciphering medical research. Assignments include daily newspaper readings. (HU)

4. **Pols 102 Modern Political Heritage (4)**
   Begins where Pol Sci 101 ends; from early modern theorists (e.g., Hobbes) up to contemporary thinkers (e.g., Marx). (SS)

5. **Ethics (3)**
   Examination of right and wrong, good and bad, from classic sources such as Plato, Aristotle, Hume, Kant, Mill and Nietzsche. (HU)

6. **Fundamentals of Logic (3)**
   Introduction to formal deductive logic, involving the construction of logical proofs in a system of natural deduction with some attention to the philosophy of logic. (MA)

7. **Bioethics (3)**
   Moral issues that arise in the context of health care and related biomedical fields in the United States today, examined in the light of the nature and foundation of moral rights and obligations. Topics include: confidentiality, informed consent, euthanasia, medical research and experimentation, genetics, the distribution of health care, etc. (HU)
121. Philosophy in Literature (3) Exploration of philosophical themes through the study of literature and film. Authors may include: Homer, Euripides, Dante, Rimbaud, Sterne, George Eliot, Valery, Joyce, Melville, T.S. Eliot, Rilke, Proust, Musil, Stevens, Cummings, Camus, Sartre, Beckett, Morrison, Barthelme. (HU)

123. Aesthetics (3) Theories, classical and modern, of the nature of beauty and the aesthetic experience. Practical criticism of some works of art, and examination of analogies between arts, and between art and nature. (HU)

124. (Rel 124) Reason and Religious Experience (4) Critical examination, from a philosophical perspective, of some fundamental problems of religion, the nature of religious experience and belief, reason and revelation, the existence and nature of God, the problem of evil, and religious truth. (HU)

127. Existentialism (3) Investigation of the historical development of existentialism from its origins in the nineteenth century (Kierkegaard, Nietzsche) through its marriage to phenomenology in the early twentieth (Heidegger, Sartre, Merleau-Ponty), and out the other side as a vigorous dimension of much literary, psychological, and artistic work produced in the last 50 years. (HU)

128. Philosophy of Science (3) Introduction to the structure and methods of scientific investigation. The nature of explanation, confirmation, and falsification. Scientific progress: What is it? Would it be suffocated by obedience to completely rational methods? (HU)

129. (Rel 129) Jewish Philosophy (3) Consideration of major Jewish thinkers from the first to twentieth centuries confronted questions at the intersection of religion and philosophy: the existence and nature of God, free will, evil, divine providence, miracles, creation, revelation, and religious obligation. (HU)

131. (Clas 131) Ancient Philosophy (3) Historical survey of selected texts and issues in the classical world, from the pre-Socratics through Aristotle, with emphasis on the origins of the western philosophical traditions in ethics, metaphysics, and epistemology. (HU)

132. (Clas 132) Hellenistic Philosophy (3) Historical survey of selected texts and issues in Post-Aristotelian Greek and Roman philosophy from the fourth century B.C. to the third century A.D. Areas of focus may include epicureanism, stoicism, academic and pyrrhonian scepticism, and neoplatonism. (HU)

133. Medieval Philosophy (3) Historical survey of selected texts and issues in western philosophy from the fourth to fourteenth centuries. Attention will be given to the relation between developments in medieval philosophy and major currents in ancient and modern thought. Figures may include Augustine, Aquinas, Ockham, and Nicholas of Autrecourt. (HU)

135. Modern Philosophy (3) Historical survey of selected texts and issues in seventeenth and eighteenth century European philosophy with particular emphasis on developments in epistemology and metaphysics. Attention will be given to the relation of the "modern period" to developments in late medieval philosophy and the rise of the experimental sciences. Figures may include Descartes, Leibniz, Locke, Hume, and Kant. (HU)

139. Contemporary Philosophy (3) Philosophical thought from the late-19th century to the present: pragmatism, linguistic analysis, existentialism, and Marxism. Truth and knowledge, values and moral judgement, meaning, the place of the individual in the physical world and society, and the impact of the scientific method upon all of these. (HU)

140. (Asian Studies 140) Eastern Philosophy (3) Survey of selected texts and issues in the eastern philosophical traditions. Attention will be given to the development and interrelations of these traditions as well as a comparison of western and eastern treatments of selected issues. Areas of focus may include Confucianism, Taoism, and Zen Buddhism. (HU)

205. Contemporary Ethics (3) Examination of significant questions addressed by contemporary moral philosophers. Topics vary, but might include: What is a good person? How can a woman be good in the same way as a man? Is morality relativistic or absolute? Is morality all that important? Prerequisite: Phil 105 or consent of the instructor. (HU)

220. Knowledge and Justification (3) Recent work in epistemology. Questions addressed include: If you don’t know whether you are dreaming, how can you know you have two hands? Does knowledge require answers to all possible doubts or only all reasonable doubts? How should we determine the horizon of the reasonable--psychologically or philosophically? (HU)

224. (Rel 224) Topics in the Philosophy of Religion (4) Selected problems and issues in the Philosophy of Religion. Content varies. May be repeated more than once for credit. (HU)

226. (WS 226) Feminism and Philosophy (3) Analysis of the nature, sources, and consequences of the oppression and exploitation of women and justification of strategies for liberation. Topics include women's nature and human nature, sexism, femininity, sexuality, reproduction, mothering. Prerequisite: At least one previous course in Philosophy or Women's Studies. (HU)

228. Topics in the Philosophy of Science (3) Themes in the natural, life and social sciences. May be repeated for credit as topic varies. Prerequisite: Phil 128 or consent of the department chairperson. (HU)

231. (Clas 231) Figures/Themes in Ancient Philosophy (3) This seminar course will involve in-depth focus upon a major ancient thinker (e.g., Plato, Aristotle, Socrates, Empiricus, Plotinus, etc.) or the classical treatment of a particular theme (e.g., "human nature," "the good life," ethical or political theory, etc.). Content varies. May be repeated more than once for credit. (HU)

233. Figures/Themes in Medieval Philosophy (3) This seminar course will involve in-depth focus upon a major medieval thinker (e.g., Augustine, Boethius, Maimonides, Bonaventure, Dante, etc.) or the medieval treatment of a particular theme (e.g., the relation of "will" and "intellect," the "problem of universals," ethical or political theory, etc.). Content varies. May be repeated more than once for credit. (HU)

235. Figures/Themes in Modern Philosophy (3) This seminar course will involve in-depth focus upon a major seventeenth or eighteenth century thinker (e.g., Descartes, Leibniz, Berkeley, Kant, etc.) or the modern treatment of a particular theme (e.g., the nature of "ideas," the roles of experience, reason, and revelation, ethical or political theory, etc.). Content varies. May be repeated more than once for credit. (HU)

237. Figures/Themes in Nineteenth Century Philosophy (3) This seminar course will involve in-depth focus upon a major nineteenth century thinker (e.g., Hegel, Marx, Kierkegaard, Mill, Peirce, Frege, Nietzsche, James, etc.) or the nineteenth century treatment of a particular theme (e.g., the history of revolution, nihilism, historical origins, history, infinity, etc.). Content varies. May be repeated more than once for credit. (HU)
239. Figures/Themes in Contemporary Philosophy (3)
This seminar course will involve in-depth focus upon a major contemporary thinker (e.g. Russell, Whitehead, Husserl, Heidegger, Wittgenstein, Quine, Habermas, Rorty, Derrida, Davidson, Foucault, Derrida, etc.) or the contemporary treatment of a particular theme (e.g. logical positivism, naturalism, non-foundationalism, existential phenomenology, return to virtue, neo-pragmatism, hermeneutics, post-structuralism, post-modernism, neo-kantian political theory, the politics of identity, etc.). Content varies. May be repeated more than once for credit. (HU)

250. The Minds of Robots and Other People (3)
Is the nature of thinking illuminated by what computers can do? Is the brain just a complex computer? Could a robot feel pain? Be angry? Recent work in artificial intelligence, psychology, and philosophy. (HU)

260. Philosophy of Language (3)
Analysis of the nature of the correspondence between the words we use and the world in which we live. Our unifying theme is the quest for an understanding of truth, conceived as a peculiar relation between language and reality. We examine such central notions as meaning and reference, as understood in historically influential philosophical theories of language. (HU)

264. (Pols 264) Issues in Contemporary Political Philosophy (4)
Selected topics in contemporary political philosophy, such as the Frankfurt school, existentialism, legitimation, authenticity, participatory democracy, and the alleged decline of political philosophy. May be repeated for credit with consent of the political science chairperson. (SS)

265. Philosophy of Mathematics (3)
Survey of metaphysical and epistemological issues from the philosophy of mathematics, with emphasis on the arguments on behalf of mathematical platonism, conventionalism, and psychologism. It is highly recommended that students take Phil 114 and a year of calculus, or otherwise acquire comparable formal background, prior to this course. (HU)

267. (Pols 267) American Political Thought (4)
Critical Examination of American political thought from the founding of the Republic to the present. Writings from Madison, Hamilton, and Jefferson to Emma Goldman, Mary Daly, Malcolm X, Henry Kariel, and others will be discussed. (SS)

303. (Math 303) Mathematical Logic
A course, on a mathematically mature level, designed not only to acquaint the student with logical techniques used in mathematics but also to present symbolic logic as an important adjunct to the study of the foundations of mathematics. Prerequisite for non math majors: Phil 114 (MA)

290. Independent Study (1-4)
Individual philosophical investigation of an author, book, or topic designed in collaboration with a faculty sponsor. Tutorial meetings; substantial written work. May be repeated more than once for credit. Consent of faculty sponsor required. (ND)

390. Senior Thesis
The first part of two semesters intensive research and writing guided by a faculty sponsor in anticipation of completing a senior thesis in philosophy. Individual tutorials; substantial written work. Senior standing as philosophy major and consent of faculty sponsor required. (ND)

391. Senior Thesis
Continuation and completion of Phil 390 under the guidance of a faculty sponsor. Prerequisite: Phil 390; consent of faculty sponsor required. (ND)

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Physics

Professors. Arnold H. Kritz, Ph.D. (Yale), chairperson; Garold J. Borse, Ph.D. (Virginia), associate chairperson; Gary G. DeLeo, Ph.D. (Connecticut); Robert T. Folk, Ph.D. (Lehigh); W. Beall Fowler, Ph.D. (Rochester); James D. Gunton, Ph.D. (Stanford); A. Peet Hickman, Ph.D. (Rice); John P. Hueneckens, Ph.D. (Colorado); Alvin S. Kanofsky, Ph.D. (Pennsylvania); Yong W. Kim, Ph.D. (Michigan); Shelden H. Radin, Ph.D. (Yale); Michael Stavola, Ph.D. (Rochester); Jean Toulouse, Ph.D. (Columbia).

Associate Professors. Brent W. Benson, Ph.D. (Penn State); Daniel C. Hong, Ph.D. (Boston Univ.); Jerome C. Licini, Ph.D. (M.I.T.); Michelle S. Malcuit, Ph.D. (Rochester); H. Daniel Ou-Yang, Ph.D. (U.C.L.A.); Russell A. Shaffer, Ph.D. (Johns Hopkins); Alan D. Streater, Ph.D. (Colorado).

Physics students study the basic laws of mechanics, heat and thermodynamics, electricity and magnetism, optics, relativity, quantum mechanics, and elementary particles. The student also studies applications of the basic theories to the description of bulk matter, including the mechanical, electric, magnetic, and thermal properties of solids, liquids, gases, and plasmas, and to the description of the structure of atoms and nuclei. In addition, the student develops the laboratory skills and techniques of the experimental physicist, skills that can be applied in the experimental search for new knowledge or in applications of the known theories.

A majority of physics graduates go to graduate school in physics, often earning the Ph.D. degree. These people take university or college faculty positions, or work on research in a variety of university, government, or industrial laboratories. Some students choose employment immediately after the bachelor’s degree. They use their many approved and free electives to supplement their science background with applied courses, such as engineering, to develop the skills needed for a position in a particular area.

Because of the fundamental role of physics in all the natural sciences, students also use the physics major as an excellent preparation for graduate study in many other scientific areas, such as applied mathematics, computer science, biophysics, molecular biology, astrophysics, geology and geophysics, materials science and engineering, meteorology, or physical oceanography. Attractive engineering areas with a high science content include aeronautical engineering; nuclear engineering, including both fission and fusion devices; electrical engineering, including instrumentation, electronics, and solid-state devices, electrical discharges and other plasma-related areas; and mechanical engineering and mechanics, including fluids and continuum mechanics. The broad scientific background developed in the physics curriculum is also an excellent background for professional schools, such as law (particularly patent law), medicine, and optometry.

Lehigh offers three undergraduate degrees in physics: the Bachelor of Arts with a major in physics and the Bachelor of Science in Physics in the College of Arts and Sciences, and the Bachelor of Engineering Physics in the College of Engineering and Applied Science. In addition, there are several five-year, dual-degree programs involving physics: The Arts-Engineering program (see the Arts-Engineering section of this catalog), the combination of the Bachelor of Science program in the College of Arts and Sciences with Electrical Engineering (described below), and the combination of Electrical Engineering and Engineering Physics (see the Electrical Engineering and Engineering Physics section of this catalog).

The bachelor of science curriculum in the College of Arts and Sciences requires somewhat more physics and mathematics than the bachelor of arts major, while the latter provides more free electives and three fewer hours for graduation. By making good use of the electives in these programs, either can prepare a student for graduate work in physics or the physical aspects of other sciences or engineering disciplines, or for technical careers requiring a basic knowledge of physics. The bachelor of arts curriculum is particularly useful for those planning careers in areas where some knowledge of physics is needed or useful, but is not the main subject, such as science writing, secondary school teaching, patent law, or medicine.
The bachelor of engineering physics curriculum in the College of Engineering and Applied Science requires an engineering concentration in either solid state electronics or optical sciences, in addition to regular physics and mathematics courses. This four-year program prepares students to do engineering work in an overlap area between physics and engineering, which may be engineering in a forefront area in which it is desirable to have more physics knowledge than the typical engineer has, or may be experimental physics which either relies heavily on forefront engineering or in which the nature of the problem dictates that scientists and engineers will accomplish more working together than separately.

A comparison of the curricula in terms of credit hours in various broad categories is given below.

<table>
<thead>
<tr>
<th>College of Arts and Sciences</th>
<th>College of Engineering in Concentration in Solid State Electronics and Optical Sciences</th>
</tr>
</thead>
<tbody>
<tr>
<td>B.A.</td>
<td>B.S.</td>
</tr>
<tr>
<td>Freshman English (3)</td>
<td>(3)</td>
</tr>
<tr>
<td>Distribution Courses (20)</td>
<td>20</td>
</tr>
<tr>
<td>and major courses (61)</td>
<td>61</td>
</tr>
<tr>
<td>Electives (23)</td>
<td>23</td>
</tr>
<tr>
<td>Total (121)</td>
<td>121</td>
</tr>
</tbody>
</table>

*Not including mathematics or science

The recommended sequences of courses are:

<table>
<thead>
<tr>
<th>College of Arts &amp; Science</th>
<th>Bachelor of Arts</th>
<th>Bachelor of Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall Semester</td>
<td>Spring Semester</td>
<td>Fall Semester</td>
</tr>
<tr>
<td>Freshman Year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engl 1 (3)</td>
<td>Engl 1 (3)</td>
<td>Engl 2, 4, 6, 8, 10</td>
</tr>
<tr>
<td>Phy 12 (1)</td>
<td>Phy 12 (1)</td>
<td>Chm 22 (4)</td>
</tr>
<tr>
<td>Arts 1 (1)</td>
<td>Arts 1 (1)</td>
<td></td>
</tr>
<tr>
<td>Sophomore Year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phy 21 (4)</td>
<td>Phy 21 (4)</td>
<td>Phy 21 (4)</td>
</tr>
<tr>
<td>Phy 22 (1)</td>
<td>Phy 22 (1)</td>
<td>Phy 190 (3)</td>
</tr>
<tr>
<td>Math 23 (4)</td>
<td>Math 205 (3)</td>
<td>Math 23 (4)</td>
</tr>
<tr>
<td>Elective (3)</td>
<td>Elective (3)</td>
<td></td>
</tr>
<tr>
<td>Junior Year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phy 212 (3)</td>
<td>Phy 213 (3)</td>
<td>Phy 212 (3)</td>
</tr>
<tr>
<td>Phy 215 (4)</td>
<td>Phy 264 (3)</td>
<td>Phy 215 (4)</td>
</tr>
<tr>
<td>Phy 260** or Elective (2-3)</td>
<td>Phy 261 (1-2)</td>
<td>Phy 260 (2)</td>
</tr>
<tr>
<td>Math 322 (3)</td>
<td>Math 362 (3)</td>
<td>Math 322 (3)</td>
</tr>
<tr>
<td>Elective (4)</td>
<td>Elective (4)</td>
<td></td>
</tr>
<tr>
<td>Senior Year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phy 340 (3)</td>
<td>Phy 171 (1)</td>
<td>Phy 340 (3)</td>
</tr>
</tbody>
</table>

*or an equivalent course in scientific computing
**only one of the two lab courses (PH 260/1) is required for the B.A.

The electives include at least fourteen credit hours for Bachelor of Science degrees and eleven credit hours for the Bachelor of Arts degree of approved technical electives. Included in this group must be two of the following courses: Phys 363, 369, (352 or 359), and (348 or 365). Students planning graduate work in physics are advised to include Phys 273 and 369 among their electives. Up to 6 credit hours of the following courses may be included as part of the credit hours required for graduation: Aerospace Studies, Jour 1-10, Military Science, and Mus 21-78.

<table>
<thead>
<tr>
<th>College of Engineering &amp; Applied Sciences</th>
<th>Bachelor of Engineering Physics with a concentration in</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall Semester</td>
<td>Spring Semester</td>
</tr>
<tr>
<td>Freshman Year</td>
<td>Fall Semester</td>
</tr>
<tr>
<td>Engl 1 (3)</td>
<td>Engl 1 (3)</td>
</tr>
<tr>
<td>Engl 2, 4, 6, 8, or 10</td>
<td>Engl 1 (3)</td>
</tr>
<tr>
<td>Phy 11 (4)</td>
<td>Phy 11 (4)</td>
</tr>
<tr>
<td>Phy 12 (1)</td>
<td>Phy 12 (1)</td>
</tr>
<tr>
<td>Math 21 (4)</td>
<td>Math 21 (4)</td>
</tr>
<tr>
<td>HSS (3)</td>
<td>HSS (3)</td>
</tr>
<tr>
<td>Elective (3)</td>
<td>Elective (3)</td>
</tr>
</tbody>
</table>

| Sophomore Year                            | Spring Semester                     |
| Phy 21 (4)                                | Phy 21 (4)                          |
| Phy 22 (1)                                | Phy 22 (1)                          |
| Math 23 (4)                               | Math 23 (4)                         |
| ECE 81 (4)                                | ECE 81 (4)                          |
| ECE 108 (3)                               | ECE 108 (3)                         |

| Junior Year                                | Fall Semester                       |
| Phy 212 (3)                               | Phy 212 (3)                         |
| Phy 260 (2)                               | Phy 260 (2)                         |
| ECE 33 (2)                                | ECE 33 (2)                          |
| ECE 123 (2)                               | ECE 123 (2)                         |
| Math 322 (3)                              | Math 322 (3)                        |
| HSS (3)                                   | HSS (3)                             |

| Senior Year                                | Spring Semester                     |
| Phy 340 or HSS or Elective or HSS          | Phy 340 or HSS or Elective or HSS   |
| ME 104 (3)                                | ME 104 (3)                          |
| Phy 363 (3)                                | Phy 363 (3)                         |
| Phy 215 (4)                                | Phy 215 (4)                         |
| SSE Elec* (3)                              | SSE Elec* (3)                       |
| SSE Elec* (3)                              | SSE Elec* (3)                       |
| SSE Elec* (3)                              | SSE Elec* (3)                       |
| HSS* (3)                                  | HSS* (3)                            |
| Elective (3)                              | Elective (3)                        |

*The 11 credit hours of SSE Electives must include ECE 251 or 252 or Phy 273 (must be a design project with an engineer co-advisor).
**The 16 credit hours of OE Electives must include ECE 251 or 252 or Phy 273 (must be a design project with an engineer co-advisor). Must include at least two of ECE 347, ECE 348, ECE 371, ECE 372.

Each program must include at least 30 credits taught by engineers and sufficient engineering design and engineering science to satisfy ABET guidelines.

Combined B.S.(Physics)/B.S.(Electrical Engineering)
The combined Arts/Engineering programs resulting in Bachelors degrees in both Physics and Electrical Engineering may be arranged so that either of the two degrees is completed within the first four years. The suggested curricula are:

<table>
<thead>
<tr>
<th>Physics-Electrical Engineering (Physics First)</th>
<th>Electrical Engineering (Electrical Engineering First)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall Semester</td>
<td>Spring Semester</td>
</tr>
<tr>
<td>Freshman Year</td>
<td>Fall Semester</td>
</tr>
<tr>
<td>Engl 1 (3)</td>
<td>Engl 1 (3)</td>
</tr>
<tr>
<td>Engl 2, 4, 6, 8, or 10</td>
<td>Engl 2, 4, 6, 8, or 10</td>
</tr>
<tr>
<td>Phy 11 (4)</td>
<td>Phy 11 (4)</td>
</tr>
<tr>
<td>Phy 12 (1)</td>
<td>Phy 12 (1)</td>
</tr>
<tr>
<td>Math 21 (4)</td>
<td>Math 21 (4)</td>
</tr>
<tr>
<td>HSS+ (3)</td>
<td>HSS+ (3)</td>
</tr>
<tr>
<td>Elective (1)</td>
<td>Elective (1)</td>
</tr>
</tbody>
</table>

| Sophomore Year                               | Spring Semester                                      |
| Phy 21 (4)                                   | Phy 21 (4)                                           |
| Phy 22 (1)                                   | Phy 22 (1)                                           |
| Math 23 (4)                                  | Math 23 (4)                                          |
| ECE 33 (4)                                   | ECE 33 (4)                                           |
| ECE 123 (3)                                  | ECE 123 (3)                                          |
| Math 322 (3)                                  | Math 322 (3)                                         |
| HSS (3)                                      | HSS (3)                                              |
| Elective (3)                                 | Elective (3)                                         |

| Junior Year                                  | Fall Semester                                        |
| Phy 212 (3)                                  | Phy 212 (3)                                          |
| Phy 260 (2)                                  | Phy 260 (2)                                          |
| ECE 33 (4)                                   | ECE 33 (4)                                           |
| ECE 123 (3)                                  | ECE 123 (3)                                          |
| Math 322 (3)                                  | Math 322 (3)                                         |
| HSS (3)                                      | HSS (3)                                              |
| Elective (3)                                 | Elective (3)                                         |

| Senior Year                                  | Spring Semester                                      |
| Phy 340 or HSS or Elective or HSS            | Phy 340 or HSS or Elective or HSS                    |
| ME 104 (3)                                   | ME 104 (3)                                           |
| Phy 363 (3)                                  | Phy 363 (3)                                          |
| Phy 215 (4)                                  | Phy 215 (4)                                          |
| SSE Elec* (3)                                | SSE Elec* (3)                                        |
| SSE Elec* (3)                                | SSE Elec* (3)                                        |
| HSS* (3)                                     | HSS* (3)                                             |
| Elective (3)                                 | Elective (3)                                         |
Five-year combined bachelor/masters programs. Five-year programs that lead to successive bachelor and masters degrees are available. These programs satisfy all of the requirements of one of the three bachelor’s degrees in Physics (B.A., B.S., B.S.E P.) plus the requirements of the M.S. in Physics in the final year. Depending upon the undergraduate degree received, one summer in residence may be required. Interested students should consult the associate chair of physics no later than the spring semester of their junior year for further detail.

The minor program. The minor in Physics consists of 15 credits of physics courses, excluding Physics 5. No more than one physics course required in a student’s major program may be included in the minor program. The minor program must be designed in consultation with the physics department chair.

Undergraduate Courses in Physics

5. Concepts in Physics (4)
Fundamental discoveries and concepts of physics and their relevance to current issues and modern technology. For students not intending to major in science or engineering. Lectures, demonstrations, group activities, and laboratories using modern instrumentation and computers. This is a non-calculus course; no previous background in physics is assumed. Three class meetings and one laboratory period per week. No prerequisites. DeLeo. (NS)

9. Introductory Heat and Thermodynamics (1)
Temperature, heat, and the laws of thermodynamics; kinetic theory of gases. The student will be scheduled for the appropriate part of Phys 11. Prerequisites: three credit hours of advanced placement, anticipatory exam, or transfer credit for the mechanics part of Phys 11, and consent of the chairperson of the department.

11. Introductory Physics 1 (4)
Kinematics, frames of reference, laws of motion in Newtonian theory and in special relativity, conservation laws, as applied to the mechanics of mass points; temperature, heat and the laws of thermodynamics; kinetic theory of gases. Two lectures and two recitations per week. Prerequisite: Math 21, 31 or 51, previously or concurrently. Folk or Licini. (NS)

12. Introductory Physics Laboratory 1 (1)

13. General Physics (3)
A continuation of Phys 11, primarily for students in the College of Arts and Science and premedical students. Electromagnetism, light, atomic physics, nuclear physics and radioactivity. Prerequisites: Math 11 and Math 21, 31 or 51. Fowler or Radin (NS)

14. General Physics Laboratory (1)
A laboratory course to be taken concurrently with Phys 13. Prerequisite: Phys 12; Phys 13, preferably concurrently. Folk

19. Introductory Optics and Modern Physics (1)
Physical and geometrical optics; introduction to modern physics. The student will be scheduled for the appropriate part of Phys 21. Prerequisites: three credit hours of advanced placement, anticipatory exam, or transfer credit for the electricity and magnetism part of Phys 21, and consent of the chairperson of the department. (NS)

21. Introductory Physics II (4)
A continuation of Phys 11. Electrostatics and magnetostatics; DC circuits; Maxwell’s equations; waves; physical and geometrical optics; introduction to modern physics. Two lectures and two recitations per week. Prerequisite: Phys 11; Math 23, 32, or 52, previously or concurrently Benson or Shaffer. (NS)
22. Introductory Physics Laboratory II (1)  
A laboratory course to be taken concurrently with Phy 21. One three-hour laboratory period per week. Prerequisite: Phy 12; Phy 21, preferably concurrently. Folk.

31. Introduction to Quantum Mechanics (3)  
Experimental basis and historical development of quantum mechanics; the Schroedinger equation; one-dimensional problems; angular momentum and the hydrogen atom; many-electron systems; spectra; selected applications. Three lectures per week. Prerequisite: Phy 13 or 21; Math 205, previously or concurrently. Hickman. (NS)

91. Measurement and Transducers (1)  
Computer-assisted laboratory course, dealing with physical phenomena in mechanics, electricity and magnetism, optics, spectroscopy and thermodynamics. Measurement strategies are developed and transducers devised. Computer simulation, analysis software, and digital data acquisition. Prerequisites: Phys. 21 and 22 or their equivalent or consent of chairperson. Kim. (NS)

171. Physics Seminar (1)  
Discussion of current problems in physics. Intended for seniors majoring in the field. Streater. (NS)

190. Electronics (3)  
DC and AC circuits, diodes, transistors, operational amplifiers, oscillators, and digital circuitry. Two laboratories and one recitation per week. Prerequisites: Phy 21 and 22, or Phy 13 and 14. Stavola. (NS)

For Advanced Undergraduates And Graduate Students

212. Electricity and Magnetism I (3)  
Electrostatics, magnetostatics, and electromagnetic induction. Prerequisites: Phys 21 or 13; Math 205, previously or concurrently. Kritz. (NS)

213. Electricity and Magnetism II (3)  
Maxwell’s equations, Poynting’s theorem, potentials, the wave equation, waves in vacuum and in materials, transmission and reflection at boundaries, guided waves, dispersion, electromagnetic field of moving charges, radiation, Lorentz invariance and other symmetries of Maxwell’s equations. Prerequisite: Phys 212. Gunton. (NS)

215. Classical Mechanics I (4)  
Kinematics and dynamics of point masses with various force laws; conservation laws; systems of particles; rotating coordinate systems; rigid body motions; topics from Lagrange’s and Hamilton’s formulations of mechanics; continuum mechanics. Prerequisites: Phys 21 or Phys 13 and Math 205, previously or concurrently. Ou-Yang. (NS)

260. Laboratory Techniques (2)  
Laboratory practice, including machine shop, vacuum systems, electronic instrumentation, computers and integrated circuits, high-voltage measurements, counting and statistics. Prerequisites: Phys 21 and 22, or Phys 13 and 14. Kanofsky. (NS)

261. Optics, Spectroscopy, and Quantum Physics Laboratory (2)  
Experiments in geometrical optics, interference and diffraction, spectroscopy, lasers, and quantum phenomena. Prerequisites: Phys 21 and 22, or Phys 13 and 14. Malcuit. (NS)

264. Nuclear and Elementary Particle Physics (3)  
Models, properties, and classification of nuclei and elementary particles; nuclear and elementary particle reactions and decays; radiation and particle detectors; accelerators; applications. Prerequisites: Phys 31 and Math 205. Kanofsky. (NS)

273. Research (2-3)  
Participation in current research projects being carried out within the department. Intended for seniors majoring in the field. May be repeated once for credit. (NS)

281. Basic Physics I (3)  
A course designed especially for secondary-school teachers in the master teacher program. Presupposing a background of two semesters of college mathematics through differential and integral calculus and of two semesters of college physics, the principles of physics are presented with emphasis on their fundamental nature rather than on their applications. Open only to secondary-school teachers and those planning to undertake teaching of secondary-school physics. (NS)

282. Basic Physics II (3)  
Continuation of Phys 281. (NS)

312. Advanced Laboratory (1)  
Experiments in modern physics designed to introduce students to measuring techniques and phenomena of current interest. Prerequisite: senior or graduate standing in the field, or consent of the department chairperson. May be repeated for credit. (NS)

332. (Astr 332) High-Energy Astrophysics (3)  
Observation and theory of X-ray and gamma-ray sources, quasars, pulsars, radio galaxies, neutron stars, black holes. Results from ultraviolet, X-ray and gamma ray satellites. Prerequisites: Math 23 or Math 32 or Math 52, previously or concurrently, and Phys 21. McCluskey. (NS)

340. Thermal Physics (3)  
Basic principles of thermodynamics, kinetic theory, and statistical mechanics, with emphasis on applications to classical and quantum mechanical physical systems. Prerequisites: Phys 13 or 21, and Math 23, 32 or 52. Gunton. (NS)

342. (Astr 342) Relativity and Cosmology (3)  
Special and general relativity. Schwarzschild and Kerr black holes. Super massive stars. Relativistic theories of the origin and evolution of the universe. Prerequisites: Math 23 or Math 32 or Math 52, previously or concurrently, and Phys 21. McCluskey. (NS)

348. Plasma Physics (3)  
Single particle behavior in electric and magnetic fields, plasmas as fluids, waves in plasmas, transport properties, kinetic theory of plasmas, controlled thermonuclear fusion devices. Prerequisites: Phys 21, Math 205, and senior standing or consent of the chairman of the department. Kritz. (NS)

352. Modern Optics (3)  
Paraxial optics, wave and vectorial theory of light, coherence and interference, diffraction, crystal optics, and lasers. Prerequisites: Math 205, and Phys 212 or ECE 202. Radin. (NS)

355. Lasers and Non-linear Optics (3)  
Basic principles and selected applications of lasers and non-linear optics. Topics include electromagnetic theory of optical beams, optical resonators, laser oscillation, non-linear interaction of radiation with atomic systems, electro- and acousto-optics, optical noise, optical waveguides, and laser devices. Prerequisites: Phys 31; Phys 213 or ECE 203, previously or concurrently. Malcuit. (NS)

362. Atomic and Molecular Structure (3)  
Review of quantum mechanical treatment of one-electron atoms, electron spin and fine structure, multi-electron atoms, Paule principle, Zeeman and Stark effects, hyperfine structure, structure and spectra of simple molecules. Prerequisite: Phys 31 or Chem 341. OuYang. (NS)

363. Physics of Solids (3)  
Introduction to the theory of solids with particular reference to the physics of metals and semiconductors. Prerequisite: Phys 31 or Math 316 or Chem 341, and Phys 340 or equivalent, previously or concurrently. Stavola. (NS)
365. Physics of Fluids (3)
Concepts of fluid dynamics; continuum and molecular approaches; waves, shocks and nozzle flows; nature of turbulence; experimental methods of study. Prerequisites: Phys 212 or ECE 202, and Phys 340 or ME 104 or equivalent, previously or concurrently. Kim. (NS)

369. Quantum Mechanics I (3)
Principles of quantum mechanics: Schroedinger, Heisenberg, and Dirac formulations. Applications to simple problems. Prerequisites: Phys 31, Math 205; Phys 216, previously or concurrently. Streeter. (NS)

372. Special Topics in Physics (1-3)
Special topics in physics not sufficiently covered in the general courses. Lecture and recitations or conferences. (NS)

382. Applied Solid State Physics (3)
Introduction to solid-state phenomena and their applications, including the electronic, optical, dielectric, and magnetic properties of solid-state materials. Prerequisite: Phys 363, or consent of the chairman of the department. Stavola. (NS)

For Graduate Students
The department of physics has concentrated its research activities within several fields of physics, with the result that a number of projects are available in each area. Current departmental research activities include the following:


Solid-state physics (theoretical). Electronic properties of defects in semiconductors and insulators, electronic structures, electron-lattice interactions, energy band calculations.


Plasma Physics (Theoretical). Studies of heating, current drive, transport, and plasma diagnostics by transient synchrotron radiation in magnetically confined toroidal plasmas. The research is closely related to ongoing and proposed experiments at major fusion laboratories.

Nuclear theory. The few nucleon problem, nuclear structure theory.


Statistical physics (theoretical). Kinetic theory, statistical basis of hydrodynamics, non-linear processes, sound states and internal degrees of freedom in kinetic theory. Study of pattern formation in dendritic growth.

Elementary particles (experimental). Fermi-Salab and Brookhaven are used in channeling, device development, and particle jet studies.


Non-linear optics. Theoretical and experimental work in lasers and non-linear optics.

Candidates for advanced degrees normally will have completed, before beginning their graduate studies, the requirements for a bachelor's degree with a major in physics, including advanced mathematics beyond differential and integral calculus. Students lacking the equivalent of this preparation will make up deficiencies in addition to taking the specified work for the degree sought.

At least eight semester hours of general college physics using calculus are required for admission to all 200- and 300-level courses. Additional prerequisites for individual courses are noted in the course descriptions. Admission to 400-level courses generally is predicated on satisfactory completion of corresponding courses in the 200- and 300-level groups or their equivalent.

Facilities for Research. A renovation and addition to the Physics Building has made available many new research laboratories and improved the quality of the older research space. It also expanded the shop area and provided a direct connection to the Sherman Fairchild Laboratory, where solid-state physics faculty and research space are located.

Among the research equipment available in the various experimental physics laboratories are: three electron spin resonance laboratories; a laboratory for optical detection of magnetic resonance; facilities for optical absorption and luminescence studies; ultraviolet, visible, and infrared spectrophotometer; liquid nitrogen, hydrogen, and helium cryogenic equipment; several shock tubes; film scanning apparatus; cosmic ray detectors; 9 high-power lasers (4 argon-ion lasers, 2 tunable pulsed dye lasers, a ruby laser, and 2 mode-locked, Q-switched Nd-glass lasers); crystal-growth facilities; a mass-spectrometer, large interferometers, an electron microscope, a high-density plasma source; electronic instrumentation for data acquisition and analysis, including several minicomputers, many microcomputers, and signal averagers.

A 3 MeV Van de Graaff accelerator housed in the Sherman Fairchild Laboratory is used to study radiation defects in solids, to analyze impurity distributions in thin films, to develop instrumentation, and to study channeling and nuclear physics. Also available in materials and electrical engineering laboratories in the Fairchild Laboratory are excellent facilities for the preparation of solid-state materials and the fabrication of solid-state devices; these facilities are heavily used by physics students doing experimental solid-state research.

Graduate Courses in Physics

411. Survey of Nuclear and Elementary Particle Physics (3)
Intended for non-specialists. Fundamentals and modern advanced topics in Nuclear and Elementary Particle Physics. Topics include: nuclear force, structure of nuclei, nuclear models and reactions, scattering, elementary particle classification, SU(3), quarks, gluons, quark flavor and color, leptons, gauge theories, GUT, the big bang. Prerequisite: Phy 369. Shaffer

420. Mechanics (3)
Includes the variational methods of classical mechanics, methods of Hamilton and Lagrange, canonical transformations, Hamilton-Jacobi Theory. Hong

421. Electricity & Magnetism I (3)
Electrostatics, magnetostatics, Maxwell's equations, dynamics of charged particles, multipole fields. Haenmekens

422. Electricity & Magnetism II (3)
Electrodynamics, electromagnetic radiation, physical optics, electrodynamics in anisotropic media. Special theory of relativity. Prerequisite: Phys 421. Hickman

424. Quantum Mechanics II (3)
General principles of quantum theory; approximation methods; spectra; symmetry laws; theory of scattering. Prerequisite: Phys 369 or equivalent. Borse

425. Quantum Mechanics III (3)

428. Methods of Mathematical Physics I (3)
Analytical and numerical methods of solving the ordinary and partial differential equations that occur in physics and engineering. Includes treatments of complex variables, special functions, product solutions and integral transforms. Borse.
429. Methods of Mathematical Physics II (3)
Continuation of Physics 428 to include the use of integral equations.
Green's functions, group theory, and more on numerical methods.
Prerequisite: Phys 428. Borse.

431. Theory of Solids (3)
Advanced topics in the theory of the electronic structure of solids.
Prerequisite: Phys 363 and Phys 424. Fowler

442. Statistical Mechanics (3)
General principles of statistical mechanics with application to thermodynamics and the equilibrium properties of matter. Prerequisite:
Phys 340 and 369. Hong.

443. Nonequilibrium Statistical Mechanics (3)
A continuation of Phys 442. Applications of kinetic theory and statistical mechanics to nonequilibrium processes; non-equilibrium
thermodynamics. Prerequisite: Phys 442. Hong

446. Atomic and Molecular Physics (3)
Advanced topics in the experimental and theoretical study of atomic and molecular structure. Topics include fine and hyperfine structure,
Zeeman effect, interaction of light with matter, multi-electron atoms,
molecular spectroscopy, spectral line broadening atom-atom and
electron-atom collisions and modern experimental techniques.
Prerequisite: Phys 424 or consent of the department. Huemmekers

455. Physics of Nonlinear Phenomena (3)
Basic concepts, theoretical methods of analysis and experimental
development in nonlinear phenomena and chaos. Topics include nonlinear dynamics, including period-multiplying routes to chaos and
strange attractors, fractal geometry and devil’s staircase. Examples of both dissipative and conservative systems will be drawn from fluid
flows, plasmas, nonlinear optics, mechanics and waves in disordered media. Prerequisites: graduate standing in science or engineering, or
consent of the chairman of the department. Kim

462. Theories of Elementary Particle Interactions (3)
Relativistic quantum theory with applications to the strong, electromagnetic and weak interactions of elementary particles. 
Prerequisite: Phys 425. Shaffer

465. Nuclear and Elementary Particle Physics (3)
Nuclear structure and phenomena; interactions among elementary particles and methods of studying them. Kanowski

467. Nuclear Theory (3)
Theory of low-energy nuclear phenomena within the framework of nonrelativistic quantum mechanics. Borse

471. (Mech 411) Continuum Mechanics (3)
An introduction to the continuum theories of the mechanics of solids and fluids. This includes a discussion of the mechanical and
thermodynamical bases of the subject, as well as the use of invariance principles in formulating constitutive equations. Applications of
theories to specific problems are given.

472. Special Topics in Physics (1-3)
Selected topics not sufficiently covered in the more general courses. May be repeated for credit.

474. Seminar in Modern Physics (3)
Discussion of important advances in experimental physics. May be
repeated for credit when a different topic is offered.

475. Seminar in Modern Physics (3)
Discussion of important advances in theoretical physics. May be
repeated for credit when a different topic is offered.

491. Research (3)
Research problems in experimental or theoretical physics.

492. Research (3)
Continuation of Phys 491. May be repeated for credit.

Political Science

Professors. Donald D. Barry, Ph.D. (Syracuse), University Professor;
Frank T. Colon, Ph.D. (Pittsburgh); Richard K. Matthews, Ph.D. (Toronto), Distinguished Professor; Edward P. Morgan, Ph.D. (Brandeis); Laura Katz Olson, Ph.D. (Colorado); Howard R. Whitcomb, Ph.D. (S.U.N.Y. at Albany).
Associate professors. Frank L. Davis, Ph.D. (North Carolina),
chairperson; Hannah Stewart-Gambino, Ph.D. (Duke); Albert H. Wurth
Jr., Ph.D. (North Carolina).


The major in political science is designed to promote understanding of political ideas, institutions and processes and to develop skills in analyzing and evaluating political problems.

A balanced program within the discipline, one that exposes the student to various areas of inquiry in political institutions and political
processes as well as in the comparative and philosophical perspectives
of political analysis, has been the way in which the goals of the major
program generally have been achieved. While the major program outlined
below will prove adequate for most student needs, it may be that
because of some special factors such as late transfer or unusual interests
and/or abilities the outlined program does not accommodate some
students. In that case the students may, in consultation with their
adviser, develop a major program that in their judgment will more
depth under prof.

The faculty adviser to the student majoring in political science is
designated by the department. The adviser consults with the student
and approves the major program. The adviser attempts to help the
student relate courses offered by the department to the student’s
educational goals. The adviser also may act as a resource for the student,
and may suggest courses in other disciplines, language courses, and
courses in research techniques that may be of benefit.

A variety of experiential opportunities are available to undergraduates
majoring in political science. The department, for example, offers a
Community Politics Internship every semester that includes
opportunities for internship placements in either local government,
private agencies or law offices. Students are also encouraged to apply
for off-campus, internship opportunities, e.g., American University’s
Washington Semester Program.

Completion of the political science major is considered suitable
training for the undergraduate who wishes to go on to law school, to
become a social science teacher, or to work as a governmental official,
party or civic leader, public affairs commentator, or staff member of a
government research bureau. In addition, the business sector continues
to provide opportunities in areas such as banking, insurance, and
marketing for bachelor of arts graduates with training in the social
sciences. Graduate study is advisable for students contemplating certain
careers: college teaching, research, or public management, for example.

The three core courses are required. Individual exceptions may be
made, for good reasons, by the major adviser with the approval of the
department chairman. Math 12, Basic Statistics, is highly
recommended for students contemplating a major in this department.

Major Requirements
Pols 1 American Political System (4)
Pols 3 Comparative Politics (4)
Pols 100 Introduction to Political Thought (4) or
Pols 101 Ancient Political Heritage (4) or
Pols 102 Modern Political Heritage (4)
electives
Six elective courses with at least one course from each of the two fields listed below including one seminar. One of the electives may, with the consent of the department, be in a cognate field.

**American politics, public law and interdisciplinary**
- PolS 111 The Politics of the Environment (4)
- PolS 115 Technology As Politics (4)
- PolS 174 Political Parties and Elections (4)
- PolS 177 Urban Politics (4)
- PolS 179 The Politics of Women (4)
- PolS 202 Comparative State Politics (4)
- PolS 206 Public Policy Process (4)
- PolS 217 The American Presidency (4)
- PolS 227 Socialization and the Political System (4)
- PolS 229 Propaganda, Media, and American Politics (4)
- PolS 230 Movements and Legacies of the 1960s (4)
- PolS 231 Community Politics Internship (4)
- PolS 233 The Social Psychology of Politics (3)
- PolS 251 Constitutional Law (4)
- PolS 252 Civil Rights (4)
- PolS 254 Politics of the Administrative Process (4)
- PolS 259 U.S. Congress (4)
- PolS 260 Public Administration (4)
- PolS 353 Seminar: Media, Propaganda and Democracy (4)
- PolS 355 Seminar: Interest Group Functions and Coalitions in American Politics (4)
- PolS 373 Seminar: Public Administration (4)
- PolS 375 Seminar: Politics and Ecologically Sustainable Design (4)
- PolS 376 Seminar: National Social Policy (4)

**Political theory and comparative politics**
- PolS 100 Introduction to Political Thought (4)
- PolS 101 Ancient Political Heritage (4)
- PolS 102 Modern Political Heritage (4)
- PolS 125 International Political Economy (4)
- PolS 132 An Introduction to Canada (4)
- PolS 201 Current Political Controversies (4)
- PolS 218 Seminar in Post Soviet Politics (4)
- PolS 221 Research in Political Science (4)
- PolS 222 Politics of Developing Nations (4)
- PolS 235 Latin American Political Systems (4)
- PolS 236 U.S. Foreign Policy and Latin America (4)
- PolS 237 Religion and Politics in Latin America (4)
- PolS 261 Soviet and Post Soviet Politics (4)
- PolS 264 Issues in Contemporary Political Philosophy (4)
- PolS 267 American Political Thought (4)
- PolS 268 Political Economy (4)
- PolS 356 Seminar: Political Philosophy (4)
- PolS 362 Seminar: American Political Thought (4)
- PolS 369 Seminar: Transitions to Democracy (4)
- PolS 370 Seminar: The Citizen versus the Administrative State (4)
- PolS 374 Seminar: Third World Issues (4)

**Political Science Minor**
The minor consists of two of the three core courses listed above (Pols 1, Pols 3, and Pols 100 or 101 or 102) plus any two other political science courses for a total of 16 credits.

**Public Administration Minor**
The minor consists of Pols 260 plus three other courses chosen in consultation with the adviser for a minimum of 15 credits.

**Political Science Honors**
Students must have at least a 3.2 cumulative grade point average, and a 3.3 major grade point average, in order to proceed with departmental honors. Students with honors must complete 10 courses in the major, including an independent study focusing on the honors thesis.

**Undergraduate Courses**

1. **American Political System (4) fall-spring**
Constitutional principles; organization and operation of the national government; and dynamics of power within the U.S. political system. (SS)

3. **Comparative Politics (4) fall-spring**
The political systems of foreign countries; approaches to the study of comparative politics. (SS)

100. **Introduction to Political Thought (4)**
Some of the most significant ancient and modern political theorists: Plato, Aristotle, Machiavelli, Hobbes, Marx, and others. Matthews (ND)

101. **Ancient Political Heritage (4)**
Important political thinkers from the pre-Socrates to early, modern political theorists like Machiavelli. Matthews (SS)

102. **Modern Political Heritage (4)**
Begins where Pols 101 ends: from early, modern theorists (e.g., Hobbes) up to contemporary thinkers (e.g., Marcuse). Matthews (SS)

111. **The Politics of the Environment (4)**
A survey of the major environmental, resource, energy and population problems of modern society, focusing on the United States. The politics of man's relationship with nature, the political problems of ecological scarcity and public goods, and the response of the American political system to environmental issues. Wurth (ND)

115. **Technology as Politics (4)**
Relationship of technology and technological change with politics and public policy. Review of theories of political significance of technology, including technological determinism, technology assessment, technological progress and appropriate technology. Specific issues in technology with emphasis on U.S. Wurth (ND)

125. (IR 125) **International Political Economy (4)**
Principles governing the interaction between the economic and political components of international phenomena. Political causes and consequences of trade and investment. Foreign economic policy in its relationship to domestic economic policy and other aspects of foreign policy. Determinants of foreign economic policy. Prerequisites: Economics 1 or 11 or 12; IR 10. Moon, Barkey (SS)

132. (Eco., Hist., L.R.) **An Introduction to Canada (4)**
An interdisciplinary, team-taught course focusing on history, politics, economies and international relations. Topics covered will include Canada's historical development, recent political and foreign policy, and economic and trade issues. Special attention will be given to contemporary affairs and to Canada's relations with the United States. (SS)

174. **Political Parties and Elections (4)**
Organization, functions, and behavior of parties in the United States; voting behavior, campaigns, and elections. Colon (SS)

177. **Urban Politics (4)**
The structure and processes of city government in the United States; city-state and federal-city relationships; the problems of metropolitan areas; political machines and community power structures; the urban politics of municipal reform; city planning and urban renewal. Colon (SS)

179. (WS 179) **The Politics of Women (4)**
Selected social and political issues relating to the role of women in American society. Focuses on such questions as economic equality, poverty, and work roles, the older woman, gender gap, political leadership, reproduction technology, and sexual violence. Olson (SS)
For Advanced Undergraduates and Graduate Students

201. Current Political Controversies (4)
Selected topical policy issues and alternative approaches to understanding them. Including issues such as problems facing the current President, controversies in Eastern Europe, reproductive technologies, and crises in the American political economy. (SS)

202. Comparative State Politics (4)
Analysis of major questions relating to the role of the states in the American federal system and their relationship with the national government. Colon (SS)

206. Public Policy Process (4)
Power relations and their impacts on selected public policy issues, specifically taxation, housing, environment, poverty, energy, the military, and health. Olson (SS)

213. Teaching Government (4)
Contemporary issues in the teaching of social studies in public and private schools, including those government decisions that affect the educational environment. The course focuses on a specific issue such as urban problems, comparative political systems, ideologies and American political institutions and processes. Designed primarily for secondary school teachers. (SS)

214. Workshop in Teaching Government (4)
Individual research projects, contemporary issues and discussion of proposals for curriculum revisions in the public and private schools. Outside speakers will be invited to attend workshop sessions. Must be taken concurrently with Pol 213 when courses are offered together. (ND)

217. The American Presidency (4)
Role of the executive in the American political process. Includes an analysis of the historical development, selection process, and scope of executive power. Emphasizes domestic and foreign policy initiatives of selected presidents from FDR to today. Prerequisite: Pol 1. Olson (SS)

218. Seminar in Post Soviet Politics (4)
Analysis of selected issues in the politics of the former USSR. Prerequisites: Pol 261 or consent of the instructor. Barry (SS)

221. Research in Political Science (4)
Models in the explanation of political phenomena, appropriateness of measurement techniques; construction of research designs; rationale and application of statistical analyses; individual projects involving the construction and testing of models employing a major social science data set. Prerequisite: Consent of the instructor. Davis (ND)

222. Politics of Developing Nations (4)
Theories of non-Western economic and political development. Human costs for both men and women of development models and their failures. Student groups evaluate models using case-studies primarily from Latin America and Africa. Team approach to analyzing and solving complex development problems in contemporary contexts. Prerequisite: Pol 3. Stewart-Gambino (SS)

227. Socialization and the Political System (4)
The social, ideological, and economic foundations of American politics. Emphasis on supporting institutions—family, schools, and workplace—and processes that foster political attitudes and behavioral patterns. Morgan (SS)

229. Propaganda, Media, and American Politics (4)
Seminar on the role of propaganda with emphasis on mass culture, television, and the relationship between government and mass media. U.S. foreign and domestic policy analyzed using critical propaganda theories. Prerequisite: junior standing. Morgan (ND)

230. Movements and Legacies of the 1960's (4)
The lessons and legacies of 1960's social and political movements, including civil rights, black power, the New Left, campus protests, the Vietnam war and antiwar movement, the counterculture, women's and ecology movements. Prerequisite: junior standing. Morgan (SS)

231. Community Politics Internship (4)
Integrated fieldwork and academic study. Seminar, research paper, and journal; internship with government and social service agencies, political groups, elected officials, and law offices. May be repeated for credit. Prerequisite: consent of instructor. (ND)

233. (Psy 333, SSP 333) The Social Psychology of Politics (3)
Political behavior viewed from a psychological and social psychological perspective. Rosenwein (SS)

235. Latin American Political Systems (4)
Democratic, authoritarian and revolutionary paths to contemporary political issues. Political, economic and social implications of contemporary democratic and neo-liberal political economic policies. Discussion groups and student presentations on prospects for democratic peace and prosperity in the future. Prerequisite: Pol 3. Stewart-Gambino (ND)

236. U.S. Foreign and Latin America (4)
U.S. historical relationship with Central America, Caribbean and South America with emphasis on economic and military dominance. Contemporary issues such as U.S. invasions of Panama and Grenada, U.S. Cuban relations, the militarization of the “drug war,” counterinsurgency. Written analysis of competing U.S. interests across time and regions. Prerequisite: Pol 3. Stewart-Gambino (ND)

237. Religion and Politics in Latin America (4)
Indigenous and “imported” religious structures, the prominent role of the Catholic Church in Latin America, and the recent explosion of Protestant/Pentecostal churches. Emphasis on the intersection of religious belief and power (i.e., gender, local politics, national development, etc.). Short papers integrate material with students’ knowledge of religious/political phenomena. Discussion groups analyze philosophical foundations of belief. Prerequisite: Pol 3 and 236 or 237. Stewart-Gambino (ND)

251. Constitutional Law (4)
The law of the Constitution as expounded by the Supreme Court of the United States. Nature and origins of judicial review, distribution and scope of governmental powers, and economic regulation in a federal system. Detailed consideration of judicial policy decision-making processes. Whitcomb (ND)

252. Civil Rights (4)
A study of constitutional development in political and civil rights. Freedom of speech and of the press, religious freedom, due process of law and equal protection of the laws. Detailed consideration of constitutional issues concerning criminal procedure and racial discrimination. Whitcomb (ND)

254. Politics of the Administrative Process (4)
The authority, procedures, and methods used by executive agencies in the administration of public policy. Analysis of the general problem of adjusting the administrative process to traditional constitutional principles. Barry. (ND)

259. U.S. Congress (4)
Elections for the House and Senate and their significance for the way in which Congress functions. The formal structure of party leadership and committees, House and Senate organizational and functional differences, and informal and formal power of legislation and oversight. Congressional relations with the President, bureaucracy, and Supreme Court. Prerequisite: Pol 1. Davis (SS)
260. **Public Administration (4)**  
The nature of administration; problems of organization and management; public personnel policies; budgeting and budgetary system; forms of administrative responsibility. Colon (ND)

261. **Soviet and Post-Soviet Politics (4)**  
The political systems of the former USSR. The evolution of the Soviet system; the Gorbachev era; the search for new political arrangements. While all of the former Soviet republics will be open for examination in this course, emphasis in the post-Gorbachev period will be placed on the Russian Federation. Barry (ND)

264. **Issues in Contemporary Political Philosophy (4)**  
Selected topics in contemporary political philosophy, such as the Frankfurt school, existentialism, legitimation, authenticity, participatory democracy, and the alleged decline of political philosophy. May be repeated for credit with the consent of instructor. Matthews (SS)

267. **American Political Thought (4)**  
A critical examination of American political thought from the founding of the Republic to the present. Writings from Madison, Hamilton, and Jefferson to Emma Goldman, Mary Daly, Malcolm X, Henry Kariel, and others will be discussed. Matthews (ND)

268. **Political Economy (4)**  
Relationship of democratic politics to government and market, and significance of economic power in the American polity. Economic rationale for the place of the market and economic institutions in politics. Comparison of economic approaches to public policy and organization, like public goods, market failure and collective action with traditional political science approaches. Group mobilization and conflict, non-decisions, and symbolic action. Wurth (ND)

353. **Seminar: Media, Propaganda and Democracy (4)**  
Research seminar on theoretical and applied issues related to democracy vs. political hegemony, as affected by propaganda, the mass media, popular culture, and the capitalist economy. Students will pursue individual research topics linked to common class readings. Weekly paper presentations and critical responses. Prerequisite: Either Pols 229 or both Jour 246 and SSP 337. Morgan (SS)

356. **Seminar: Political Philosophy (4)**  
Critical examination of several of the “great books” and/or “great ideas” in political thought. Students will be required to write a major paper and present their work to the class. Matthews (SS)

358. **Seminar: Interest Group Factions and Coalitions in American Politics (4)**  
The rise of interest group power. Social, economic, and political reasons for groups’ increasing influence. Value of different group resources and influence in particular national policy arenas. Types of more, and less, powerful interests, and the implications of this distribution of power for American politics. Davis (SS)

362. **Seminar: American Political Thought (4)**  
Focus on a narrow topic or theorist in the field—e.g., the work of Jefferson, Madison, Hamilton, or Tocqueville. Students will be required to write a major paper and present it to the class. Matthews (SS)

369. **Seminar: Transitions to Democracy (4)**  
The theoretical and comparative literature on transitions from authoritarianism toward democracy, with particular attention to the former Soviet Union. Barry (SS)

370. **Seminar: The Citizen versus the Administrative State (4)**  
Administrative power and policy. Constitutional and judicial control of administration. Remedies against improper administrative acts. Major emphasis will be on the United States, with some attention given to analogous issues in other countries. Barry (SS)

371. **Readings (1-4)**  
Readings in political science assigned to properly qualified students in consideration of their special interest in particular political institutions and practices. Prerequisite: consent of instructor. (ND)

372. **Readings (1-4)**  
Continuation of Pols 371. Prerequisite: consent of instructor. (ND)

373. **Seminar: Public Administration (4)**  
Public and nonprofit administrative agencies. Focus on the national government administration, but state, municipal, and nonprofit agencies included. Problems of organization and management; personnel policies; budgeting and financial systems; and forms of administrative responsibility. Colon (SS)

374. **Seminar: Third World Issues (4)**  
Focus on Nancy Sheper-Hughes’ Death Without Weeping: The Violence of Everyday Life in Brazil with discussion of “objectivity” in field research, separation between advocacy and observation, and gendered subjects. Student presentations of research topics in latter part of course, emphasizing professional form and collegial cooperation. Prerequisites: Pols 222, 235, 236, 237, or consent of instructor. Stewart-Gambino (SS)

375. **Seminar: Politics and Ecologically Sustainable Design (4)**  
Development of guidelines and applications for public policy and political action directed toward environmental sustainability and political feasibility. Focus on problem-solving and policy design, connecting sustainable environmental goals with workable and responsive institutional designs. Prerequisites: Pols 111, 368, or consent of instructor. Wurth (SS)

376. **Seminar: National Social Policy (4)**  
A readings/research seminar on current social policy questions. Course analyzes, from alternatives political perspectives, such issues as Social Security, Medicare, health care, welfare reform, income inequality, and taxation. Students research a specific social issue of their choice. Class discussion on individual research and common readings. Olson (SS)

381,382. **Special Topics (1-4)**  
A seminar on a topic of special interest in a particular political institution, process, or policy. Prerequisite: consent of the department chairperson. (ND)

For Graduate Students the department of political science offers a graduate program leading to the master of arts degree. The applicant for admission is required to demonstrate adequate undergraduate preparation. Those seeking full time graduate studies must submit Graduate Record Examination results.

**Master of Arts**

The master of arts in political science is a thirty-credit-hour program that can be accomplished in twelve months by full-time students. A comprehensive examination is required. The student may take twenty-four hours of course work and six hours of thesis or may take all thirty credit hours in course work. A graduate-level course in research methods is required of all candidates for the master of arts degree.

The master of arts program is intended for the student with liberal arts or natural science preparation who has a professional interest in government. The master of arts may be a preparatory step toward doctoral work at another institution or a final degree preparatory for teaching in junior and community colleges or research positions in governmental, institutional or industrial settings.

**Graduate Courses**

405. **The Budgetary Process (3)**  
The public budgetary process: competition among interest groups, policy outcomes, intergovernmental relations, and consequences for policy implementation. Davis
407. American Constitutional Development (3)
The law of the Constitution as expounded by the Supreme Court of the United States. Nature and origins of judicial review, institutional aspects of separation of powers and federalism, economic regulation in a federal system, and political and civil rights. Detailed consideration of judicial policy-making processes and judicial biography. Whitcomb

411. The Legal Foundations of Public Administration (3)
The authority, procedures, and methods used by executive agencies in the administration of public policy and the general problem of adjusting the administrative process to traditional constitutional and legal principles. Barry

413. Modern Political Philosophy (3)
A study of selected modern political philosophers and their continuing effect on politics and political philosophy. Matthews

415. State and Local Government (3)
Comparative state government, urban politics, intergovernmental relations, regional and local government. Colon

416. American Environmental Policy (3)
Formation, implementation and impact of environmental policies in the U.S. An examination of the scope of environmental problems, the development of environment as an issue, the role of interest groups and public opinion, the policy-making process, and the various approaches to implementing environmental policy. Special attention to current issues and administrative approaches and to the distinctive character of environmental protection as a political issue. Wurth

419. Theoretical Issues in American Politics (3)
American contributions to main currents in political philosophy from colonial times to present. Matthews

421. Research Methods (3)
Models in the explanation of political phenomena, appropriateness of measurement techniques; construction of research designs; rationale and application of statistical analyses; individual projects involving the construction and testing of models employing a major social science data set. Davis

431. Public Management (3)
The study of bureaucracy and problems of public and nonprofit organization and management, executive leadership; personnel management systems and regulatory administration. Colon

432. Public Policy Process (3)
Impacts of power relationships on selected public policy areas such as the military, agriculture, housing, environmental, energy, poverty, health, and taxation. May be repeated for credit. Olson

434. Internship (3)
Internship in private or public agency. May be repeated for credit.

451. Comparative Politics (3)
Theory and concepts in comparative politics. Analysis of applications in studies of Western and non-Western political systems.

453. Seminar: Media, Propaganda and Democracy (3)
Research seminar on theoretical and applied issues related to democracy vs. political hegemony, as affected by propaganda, the mass media, popular culture, and the capitalist economy. Students will pursue individual research topics linked to common class readings. Weekly paper presentations and critical responses.

456. Seminar: Political Philosophy (3)
Critical examination of several of the “great books” and/or “great ideas” in political thought. Students will be required to write a major paper and present their work to the class. Matthews

458. Seminar: Interest Group Factions and Coalitions in American Politics (3)
The rise of interest group power. Social, economic, and political reasons for groups’ increasing influence. Value of different group resources and influence in particular national policy arenas. Types of, more, and less, powerful interests, and the implications of this distribution of power for American politics. Davis

462. Seminar: American Political Thought (3)
Focus on a narrow topic or theorist in the field—e.g., the work of Jefferson, Madison, Hamilton, or Tocqueville. Students will be required to write a major paper and present it to the class. Matthews

463. Methods of Urban Policy Analysis (3)
Analysis of selected topics in urban or state/local policy. Applied research projects include computer-based statistical analysis. Prerequisite: Govt 421 or consent of the department chairperson. Morgan

469. Seminar: Transitions to Democracy (3)
The theoretical and comparative literature on transitions from authoritarianism toward democracy, with particular attention to the former Soviet Union. Barry

470. Seminar: The Citizen versus the Administrative State (3)
Administrative power and policy. Constitutional and judicial control of administration. Remedies against improper administrative acts. Major emphasis will be on the United States, with some attention given to analogous issues in other countries. Barry

471. Seminar in Teaching Government (3)
Theories and techniques of instruction, learning, evaluation, instructional design and innovation in the teaching of government. Prerequisite: permission of the department chairperson.

473. Seminar: Public Administration (3)
Public and nonprofit administrative agencies. Focus on the national government administration, but state, municipal, and nonprofit agencies included. Problems of organization and management; personnel policies; budgeting and financial systems; and forms of administrative responsibility. Colon

474. Seminar: Third World Issues (3)
Focus on Nancy Shaper-Hughes’ Death Without Weeping: The Violence of Everyday Life in Brazil with discussion of “objectivity” in field research, separation between advocacy and observation, and gendered subjects. Student presentations of research topics in latter part of course, emphasizing professional form and collegial cooperation. Prerequisites: consent of instructor. Stewart-Gambino

475. Seminar: Politics and Ecologically Sustainable Design (3)
Development of guidelines and applications for public policy and political action directed toward environmental sustainability and political feasibility. Focus on problem-solving and policy design, connecting environmental goals with workable and responsive institutional designs. Prerequisites: Both Pol2 111 and 368 or consent of instructor. Wurth

476. Seminar: National Social Policy (3)
A readings seminar on current social policy questions. Course analyzes, from alternative political perspectives, such issues as Social Security, Medicare, health care, welfare reform, income inequality, and taxation. Students research a specific social issue of their choice. Class discussion on individual research and common readings. Olson

481. Special Topics (1-3)
Individual inquiry into some problem of government. Reading, field work, and other appropriate techniques of investigation. Conferences and reports. May be repeated for credit.
Psychology

Professors. Mark H. Bickhard, Ph.D. (Chicago); Henry R. Luce Professor in Cognitive Robotics and the Philosophy of Knowledge; Martin L. Richter, Ph.D. (Indiana); George K. Shortess, (Brown), Professor Emeritus.

Associate professors. Susan Barrett, Ph.D. (Brown); Diane T. Hyland, Ph.D. (Syracuse), chairperson; Barbara C. Malt, Ph.D. (Stanford); William Newman, Ph.D. (Stanford); Padraig O’Searaghda, Ph.D. (Toronto); S. Lloyd Williams, Ph.D. (Stanford).

Assistant professors. James D. Jackson, Ph.D. (Kansas); Gerald W. McRoberts, Ph.D. (Connecticut); Angeliki Nicolopoulou, Ph.D. (Berkeley).

Adjunct professors. Ian Birky, Ph.D. (Oklahoma State); Roy C. Herrnsohn, Ph.D. (N.Y.U.); Edwin J. Kay, Ph.D. (Lehigh); Judith N. Lasker, Ph.D. (Harvard); John G. Nyby, Ph.D. (Texas, Austin); Robert E. Rosenwein, Ph.D. (Michigan); Edward S. Shapiro, Ph.D. (Pittsburgh); Neal G. Simon, Ph.D. (Rutgers); Arnold R. Spokane, Ph.D. (Ohio State).

Major Program in Psychology

The bachelor of arts program in psychology is a social science major requiring a minimum of 33 credit hours in psychology as defined below. Students must complete at least 12 credits beyond the introductory level courses and must complete the major in consultation with the Chairperson of the Psychology Department.

Required Major Courses

Psy 1 Introduction to Psychology (3)
Psy 110 Experimental Design and Statistical Analysis (4)
Psy 210 Experimental Psychology (4)

Plus the following

Three 100-level courses, one from each of the following four Areas. Psych 176 can be used to fulfill only one area.

A) Psych 107 Child Development (3)
Psych 109 Adolescence and Aging (3)

B) Psych 153 Personality (4)

C) Psych 117 Cognitive Psychology (4)
Psych 176 Mind and Brain (4)

D) Psych 176 Mind and Brain (4)
Psych 177 Introduction to Behavioral Neuroscience (3)

and at least four courses, selected from

Psy 305 Abnormal Psychology (4)
Psy 307 Seminar in Cognition (4)
Psy 308 (SSP 308) Seminar in Social Psychology (3)
Psy 314 (SSP 314) Attitudes, Attributions, and Actions (3)
Psy 315 History of Modern Psychology (4)
Psy 318 (WS 318) Seminar in Gender and Psychology (4)
Psy 320 (Educ 320) Psychology of Language (4)
Psy 331 Humanistic Psychology (4)
Psy 333 (SSP 333, Psys 333) Social Psychology of Politics (3)
Psy 335 (Bios 335) Animal Behavior (3)
Psy 351 Cognitive Development in Childhood (4)
Psy 354 Personality Assessment (4)
Psy 356 (SSP 356) Seminar in Personality Psychology (4)
Psy 358 Seminar in Infant Development (4)
Psy 361 (SSP 361) Personality and Social Development in Adulthood (4)
Psy 363 Personality and Social Development in Childhood (4)

Preparation for programs in health-related areas such as nursing, medicine, and dentistry will include additional coursework in biology, chemistry, and physics.

Students should consult the appropriate pre-professional advisers to determine specific requirements.

Honors Program in Psychology

The honors program permits majors of unusual academic ability and interest to explore topics in greater depth than the curricula normally allow. Under faculty supervision, a student normally spends the first semester of the senior year doing library research, learning the appropriate methodology, and preparing a written proposal and oral presentation. In the second semester the proposal is implemented, culminating in a written honors thesis and oral presentation. Successful completion of this program results in "Departmental Honors" being affixed to the student’s transcript.
Eligibility requirements. Eligible students must be psychology majors; have completed the first semester of the junior year with an over all GPA of 3.0; and have completed a minimum of four psychology courses with a GPA of 3.3. Interested students should contact the chairperson.

The Psychology Minor
The psychology minor consists of fifteen credit hours in psychology beyond the introductory course (Psy 1, 21). At least one of these courses must be at the 300 level. The student should consult the department chairperson no later than the fifth semester regarding course selection.

Undergraduate Courses
1. Introduction to Psychology (3)
Psychology as a science of behavior. Natural science aspects such as learning, sensation-perception, and physiological bases; and social science aspects such as human development, intelligence, and personality. Methodologies appropriate to these areas, and related societal problems. (SS)

2. Introduction to Psychology Directed Study (1)
Discussions and demonstrations related to the topics covered in Psy 1; supplemental readings and reports. Strongly recommended for students who plan to major in Psychology. Prerequisites: Concurrently enrolled in Psy 1 and consent of the department chairperson. Limited enrollment with preference given to freshmen and sophomores in the College of Arts and Sciences. (SS)

21. (SSP 21) Social Psychology (3)
Theories, methods of investigation, and results of research in social psychology with emphasis on psychological processes in social behavior, social attitudes, group behavior, and social interaction. (SS)

81. Psychology and Law (3)
Contributions of psychological research to understanding the legal system. Eyewitness testimony; jury selection and decision-making; the rights of mental patients; psychologists as expert witnesses. Barrett. (SS)

106. Child Development Directed Study (1)
Discussions and projects related to the topics covered in Psy 107; supplemental readings and written reports. Strongly recommended for students who plan to major in Psychology. Prerequisites: Concurrently enrolled in Psy 107 and consent of the department chairperson. Limited enrollment with preference given to freshmen and sophomores in the College of Arts and Sciences. (SS)

107. Child Development (3)
Survey of theories and research concerning perceptual, cognitive, social, and personality development through infancy and childhood. Prerequisite: Psy 1 or PsySSP 21. Barrett. (SS)

108. Adulthood and Aging Directed Study (1)
Discussions and projects related to the topics covered in Psy 109; supplemental readings and written reports. Strongly recommended for students who plan to major in Psychology. Prerequisites: Concurrently enrolled in Psy 109 and consent of the department chairperson. Limited enrollment with preference given to freshmen and sophomores in the College of Arts and Sciences. (SS)

109. (SSP 109) Adulthood and Aging (3)
Social science approaches to the latter two thirds of life. Cognitive and personality development; attitudes toward aging; social behavior of older adults; widowhood; retirement. Prerequisite: Psy 1 or Psy/SSP 21. Hyland. (SS)

110. Experimental Design and Statistical Analysis (4)
Principles of experimental design and statistical analysis: characteristics of data and data collection; descriptive statistics; hypothesis testing theory and practice; correlation, chi-square, t-test, analysis of variance. Three hours lecture and one hour computer lab. Richter. (ND)

117. Cognitive Psychology (4)
Information processing by human beings: attention, memory, language, and thought processes. Prerequisite: Psy 1 or Cogs 7. Malt, O'Seaghdha. (SS)

125. (SSP 125) Psychology of Small Groups (3)
Theories and empirical research regarding interpersonal behavior in small groups. Classroom exercises and group simulations. Prerequisite: consent of instructor. Rosenwein (SS)

135. (SSP 135, Jour 135) Human Communications (3)
Processes and functions of human communication in relationships and groups. Rosenwein. (SS)

140. (Cogs 140, MFL 140) Introduction to Linguistics (3)
Relationship between language and mind; formal properties of language; language and society; how languages change over time. (SS)

142. (AAS 142) The Psychology of African Americans (4)
Presentation of a range of writings on the psychology of African Americans; exploration of significant perspectives in understanding the psychological dynamics, popular culture, current research and, cultural implications of Black Americans entering the twenty-first century. Lectures and discussion. Prerequisite: By the consent of the instructor. Bronough (SS)

153. (SSP 153) Personality (4)
Review and critique of theories of personality and their associated systems of psychotherapy. Prerequisite: Psy 1, Psy 21 or SSP 21, Newman. (SS)

154. Introduction to Clinical Psychology (3)
Survey of clinical psychology as a science and profession. Current psychological treatment approaches, assessment techniques, research strategies, and their empirical and theoretical foundations. Also discusses the training of clinical psychologists and ethical issues in clinical research and practice. Prerequisite: Psy 1. Williams. (SS)

160. Independent Study (1-3)
Readings on topics selected in consultation with a staff member. Prerequisite: Psy 1 and consent of the department chairperson. May be repeated for credit. (SS)

161. Supervised Research (1-3)
Apprenticeship in ongoing faculty research program. Literature review, experimental design, data collection and analysis, and professional writing under faculty sponsor supervision. May be repeated once for credit. Prerequisite: Psy 1 or Cogs 7 and consent of sponsor. (SS)

162. Psychological Field Work (1-3)
Work-Study practice including supervised experience in one of several local agencies. Development of familiarity with the operations of the agency and working with individual patients or students. Prerequisite: Psy 1 plus two additional psychology courses and consent of instructor. (SS)

176. Mind and Brain (4)
Perception and cognitive neuroscience as the link between mental processes and their biological bases. Visual and auditory perception; the control of action; neuropsychological syndromes of perception, language, memory and thought; neural network (connectionist) models of mental processes. Prerequisite: Psy 1 or Cogs 7. O'Seaghdha. (SS)

177. (Bios 177) Introduction to Behavioral Neuroscience (3)
Nervous system functioning with varying emphasis on neurophysiology, neuroanatomy, behavior genetics, information transmission, research techniques, sensory and motor functions. Prerequisite: Psy 1 or Introductory Biology. Nyby, Simon. (TVS)
201. Industrial Psychology (3)
Psychological concepts and methods applied to business and industrial settings. Personnel selection, placement and training, leadership, work motivation, job satisfaction and consumer behavior. Prerequisite: Psych 1. (SS)

210. Experimental Psychology (4)
Designing, conducting, and reporting psychological experiments, Laboratory exercises, report writing, and a group research project. Prerequisites: Psych 1 and 110 and consent of Department chairperson. (ND)

305. Abnormal Psychology (4)
Examines research and theory on the patterns, causes, and treatment of various forms of abnormal behavior. Prerequisite: Psych 153 or consent of the department chairperson. Williams. (SS)

307. Seminar in Cognition (4)
In-depth exploration of a selected area of higher cognition, for example, Thinking and Reasoning; Metacognition; Theories of Memory; Expertise; and Language and Thought. Topic varies by year. Readings, hands-on demonstrations, and a research paper. Prerequisite: Psych 117 or 176 or Cogs 7 or consent of instructor. O'Seaghdha, Malt (SS)

308. (SSP 308) Seminar in Social Psychology (3)
Intensive consideration of selected topics in current theory and research in social psychology. The subject matter varies from semester to semester, and includes such topics as the social psychology of education, the applications of perception and learning theory to social psychological problems, the social psychology of science, and the social environment of communication. May be repeated for credit. (SS)

312. (SSP 312) Interpersonal Behavior in Small Groups (3)
Intensive consideration of theoretical and methodological issues in the analysis of the development of small groups. Rosenwein. (SS)

314. (SSP 314) Attitudes, Attributes, and Actions (3)
Social perception and cognition as studied in current social psychology. Persuasion, conformity, prejudice, stereotypes, and other social processes in relation to attitude formation and change. (SS)

315. History of Modern Psychology (4)
Origin and development of major theories in modern psychology. Prerequisite: two 300-level Psych courses. Newman (SS)

318. (WS 318) Seminar in Gender and Psychology (4)
Gender as shaped by psychological and social psychological processes. Socialization, communication and power, gender, stereotypes, methodological issues in sex differences research. Prerequisite: Psych 210 completed or concurrent or permission of instructor. Hyland. (SS)

320. (Euc 320) Psychology of Language (4)
Psychological processes involved in language comprehension, production, and use. Topics include the relation of language to thought, word meaning; speech perception; language acquisition; sign language. Prerequisites: Psych 117 or 176 or Cogs 7 or consent of instructor. Malt. O'Seaghdha (SS)

323. (SSP 323) The Child in Family and Society (3)
Influences such as marital discord, family violence, poverty and prejudice on the development of the child from birth through adolescence. (SS)

329. Seminar in Advanced Social Research Methods (3)
Issues related to participant selection and recruitment, research design, measurement, and data collection. Readings, apprenticeship in ongoing faculty social and behavioral research projects, and an independent research proposal. Prerequisite: Psych 210 or SR 111 and permission of instructor. (ND)

331. Humanistic Psychology (4)
The literature of and metaphors underlying the humanistic point of view in psychology. These “models of man” are contrasted with models underlying other modes of psychological inquiry. Prerequisite: Psych 153 and consent of department chairperson. Newman. (SS)

333. (SSP 333, Govt 333) Social Psychology of Politics (3)
Political behavior viewed from a psychological and social psychological perspective. Rosenwein. (SS)

335. (Bios 335) Animal Behavior (3)
Discussion of the behavior of invertebrates and vertebrates and analysis of the physiological mechanisms responsible for behavioral actions. Emphasis on perception, environmental stimuli, and adaptive value of special behavior patterns. Prerequisite: Bios 31 or EES 31 or MBio 101. Izikowitz. (NS)

351. Cognitive Development in Childhood (4)
Piaget and alternative theoretical approaches. Research on development of memory, comprehension, communication, classification, and social cognition. Prerequisite: Psych 107, 117, or Cogs 7. Barrett. (SS)

352. (SpEd 331) Emotional and Behavioral Disorders (3)
Definition, classification, etiology, treatment, and historical perspective of individuals with emotional and behavioral disorders. (SS)

354. Personality Assessment (4)
Methods of describing and measuring personality. Observational techniques, interviews, self-report inventories, intelligence tests, and projective tests. Prerequisite: Psych 153. (SS)

356. (SSP 356) Seminar in Personality Psychology (4)
Topics in personality psychology: the self, personality consistency, motivation, psychological adjustment. Prerequisite: Psych 153 or consent of instructor. Williams. (SS)

358. Seminar in Infant Development (4)
Theories and current research focusing on development in the first two years of life. Topics include cognitive, perceptual, language, social, emotional development, and methods used in infancy research. Prerequisite: Psych 107 and consent of department chairperson. Barrett. (SS)

361. (SSP 361) Personality and Social Development in Adulthood (4)
Theories and current research. Prerequisite: Psych 109 or consent of department chair. Hyland. (SS)

363. (SSP 363) Personality and Social Development in Childhood (4)
Issues related to social development (e.g., attachment, social competence), social contexts (e.g., family, day care), and personality development (e.g., sex roles, aggression, temperament) from infancy through adolescence. Prerequisite: Psych 107 or consent of instructor. (SS)

365. Cross-cultural Perspectives on Aging (4)
Social development and cross-cultural aging; psychological and sociological theories of ethnic aging: stratification across the life course, health, family issues, economics, legal and political status of ethnic elderly; focus on Hispanic, Asian, Native, and African Americans. Prerequisite: Psych 109. Jackson. (SS)

366. Seminar in Cognitive Aging (4)
Information processing by older adults: perception, attention, memory, speech and text processing and comprehension. The course will also
examine the effects on cognitive processing of such diseases as Alzheimer’s and Parkinson’s. Prerequisite: Psy 109; Psy 117 not required but strongly recommended. Jackson (SS)

375. (Bios 375) Sensation and Perception (3)
Sensory processes of vision, audition, touch, taste, and smell. Psychological dimensions of such processes leading to consideration of perception as characteristic of organisms. Prerequisite: Psy 117 or 176 or 177 or CogS 7. (SS)

375. (Bios 375) Neuroanatomy of Behavior (3)
Neuroanatomy and neurophysiology of animal and human behavior. Feeding, thirst, sleep, emotions, learning, and psychopathology. Prerequisite: Psy 177 or Bios 220 or 223 or 355. Simon, Nyby. (ND)

382. (Bios 382) Endocrinology of Behavior (3)
Hormonal effects upon animal and human behavior. Emphasis on endocrinology of steroid hormone involvement in reproductive behaviors. Prerequisite: Psy 177 or Bios 220 or 223 or 355. Nyby, Schneider, Simon (NS)

393. Independent Research (1-3)
Individual research projects designed and executed in collaboration with college advisor. Repeated meetings with advisor to give progress reports and receive feedback. Should read relevant literature and write a report in APA format. May be repeated once for credit. Prerequisite: Psy 210 or 161 and consent of advisor. (ND)

395. Thesis (3)
Written report: Literature review and design of study in selected area of psychology. Intended for senior majors in psychology only. Prerequisite: consent of the chairperson. (ND)

396. Thesis (3)
Execution of project designed in Psych 395. Final report and oral presentation. Prerequisite: Psy 395 and consent of department chairperson. (ND)

For Graduate Students
The department of psychology offers the doctorate of philosophy degree with specializations in cognition, development, and personality. The program emphasizes a commitment to research and the fostering of teaching skills. Students are trained primarily for positions at universities and those involving basic or applied research.

Requirements for a doctoral degree at Lehigh: The Graduate School requires 72 credit hours for a doctoral degree for those entering with a bachelor of arts or bachelor of science degree; 48 credit hours are required for those entering with the master of arts or master of science degree. All doctoral candidates are required to spend at least one year in residence, i.e., in full-time work toward the degree.

Requirements for a Ph.D. in the Department of Psychology:

Research
All graduate students are expected to be involved in research throughout their graduate careers. There are also several formal research requirements of the program.

First Year Project. First year students are expected to choose an adviser and begin to work on a research project as early as possible. A written and oral report of the student’s research activities is made to the department.

Master’s thesis. A master’s thesis (usually empirical or data-based) is required. An oral presentation of the thesis is made to the department. Students entering with a master’s degree may submit their thesis in fulfillment of the departmental thesis requirement with faculty approval.

Doctoral dissertation. This is an original piece of scholarly work usually empirical research, although original theoretical or historical research is possible with faculty approval.

Coursework
Core courses. All students are required to take one-semester graduate core courses in Cognitive Psychology and Developmental Psychology.

Psych 421 and 422. Analysis and Design of Experiments. These courses represent a two-semester sequence of theoretical and applied statistics and research methodology.

Psych 400+, Graduate Seminar. Students must take four graduate psychology seminars beyond the two core courses.

Psych 409, Professional Seminar. A one-credit, one-semester course taken in the first semester of graduate study that covers research ethics, proposal writing, and instructional issues.

Graduate Electives. All students must take three additional elective courses appropriate to their area of specialization. These may be selected from inside or outside the department and must be approved by the student’s advisor.

Teaching
Students are encouraged to participate in teaching as appropriate for their training throughout their graduate years. Normally, students begin as teaching assistants and progress to teaching independently.

General Examination
This is required for all doctoral candidates and must be passed at least seven months prior to the awarding of the degree. The student may opt for a major/minor or a major only exam; subareas to be covered on the exam are selected by the student in consultation with the student’s general exam committee.

Evaluation
Graduate students are evaluated on their performance in course work, research, teaching, assistantship assignments, and the general examination. The faculty provides each student with a written evaluation of progress in the graduate program annually.

Financial Support
Support is available in the form of teaching and research assistantships, fellowships, and scholarships. There are special fellowships for minority students. While a good undergraduate background in psychology is desirable, promising students with majors other than psychology are encouraged to apply.

How to apply
Applications for admission and financial aid may be obtained from the Department of Psychology. Completed application forms plus transcripts, letters of recommendation, and a report of scores on the Graduate Record Examination and advanced tests in psychology should be submitted not later than February 1 of the year of admission. New students are normally accepted for entrance into the program only for the fall semester.

Graduate-Level Courses
402. (SchP 402, SpEd 402) Behavior Modification (3)
Theory and applications of behavior modification methods in classroom and clinical settings. Methods derived from operant, classical, and cognitive models. Topics include behavior analysis, behavior modification, outcome research, and ethical and philosophical issues. Prerequisite: HD 400 or its equivalent.

403. Cognitive Psychology (3)
Theoretical and empirical issues in cognitive psychology. Prerequisite: Graduate standing or consent of instructor.

404. Biopsychology (3)
Theoretical and empirical issues in biopsychology. Prerequisite: Graduate standing or consent of instructor.
405. Developmental Psychology (3)
Theoretical and empirical issues in developmental psychology. Prerequisite: Graduate standing or consent of instructor.

406. Personality Psychology (3)
Theoretical and empirical issues in personality psychology. Prerequisite: Graduate standing or consent of instructor.

409. Professional Seminar (1)
Two hours of class meetings per week of first-and second-year graduate students to discuss teaching psychology and preparing for the profession.

421. Analysis and Design of Experiments (3)
First of a two-semester sequence covering a variety of issues in theoretical and applied statistics with emphasis on inferential statistics and analysis of variance. Richter

422. Analysis and Design of Experiments (3)
Continuation of Psyc 421. Prerequisite: Psyc 421. Richter

423. (Cog 423) Foundations of Cognitive Science (3)
Survey of fundamental theory and methodologies from artificial intelligence, linguistics, cognitive psychology, philosophy, and neuroscience, as well as salient research problems such as knowledge acquisition and representation, natural language processing, skill acquisition, perception and action, and the philosophical question of intentionality.

434. Seminar in Personality (3)
Selected topics in personality theory and research, including personality change, the self, personality consistency, and the relationships among thought, emotion, and behavior. Prerequisite: Psyc 406. Williams.

435. Abnormal Psychology (3)
Theoretical and empirical analysis of issues regarding the nature, measurement, causes, and treatment of various forms of abnormal behavior. Williams

448. Seminar in Psychology of Language (3)
Topics in language comprehension and production. Content will vary from year to year. Prerequisite: Psyc 403 or consent of instructor. Malt, O’Seaghdha

450. Special Topics in Mathematical Models and Statistics (3)
Selected topics in the application of mathematics to psychological research. May be repeated for credit. Richter

451. (Educ 451) Theories of Learning (3)
In-depth study of major classical and contemporary learning theories. Review of experimental research relevant to theories. (Intended for graduate students in the College of Education.)

453. Advanced Topics in Learning (3)
An intensive study with emphasis on current research of discrimination learning, avoidance learning, concept learning, problem solving, or verbal learning. May be repeated for credit. Prerequisite: Psyc 403 or consent of instructor.

460. Special Study (1-3)
Study of some special topic not covered in the regular course offerings. May be repeated for credit.

461. Research Seminar (1-3)
Original research projects not connected with master’s or doctoral theses are designed and executed in collaboration with the faculty. Students meet with the seminar director to critique each other’s projects.

471. Applied Psychology Internship (1-6)
Supervised, independent field work experience in e.g., industry, a medical setting, or a mental health setting. May be repeated for up to six hours credit.

473. (Coun 457) Personality and Adjustment (3)
Theories of personality and adjustment with emphasis on the adjustment processes in an educational setting. Prerequisite: consent of the program director. Hyland, Williams

474. (Educ 474) Psychological Development in Childhood (3)
Survey of theories and research concerning perceptual, cognitive, social, and personality development through infancy and childhood.

475. (Coun 460) Theories of Psychological Counseling (3)
Analysis and synthesis of concepts drawn from counseling theorists. Research and current trends in counseling concerning educational, social and vocational problems. Prerequisite: admission to program in counseling.

476. Seminar in Cognition (3)
Selected topics in human information processing, including such areas as attention, memory, language and comprehension, and decision-making. Area of emphasis will vary from year to year. Prerequisite: Psyc 403 or consent of instructor. Malt, O’Seaghdha

478. (Cog 478) Ontological Psychology (3)
Principles and constraints for the modeling of psychological phenomena: perception, memory, knowing, emotions, consciousness, language, and rationality. Bickhard

480. Seminar in Cognitive Development (3)
Selected topics in cognitive development in infancy and childhood, including such areas as conceptual development, memory development, the development of reasoning abilities, and language acquisition. Emphasis will vary from year to year. Prerequisite: Psyc 405 or consent of instructor. Barrett

481. Selected Topics in Social and Personality Development (3)
Topics include emotional and sex-role development, peer relations, and social competence. Emphasis will vary from year to year. Prerequisite: Psyc 405 or 474 or consent of instructor.

482. Seminar in Adult Development (3)
Application of lifespan developmental theory and methodology to personality, social, and cognitive development in adulthood. Prerequisite: Psyc 405 or consent of instructor. Hyland

486. Seminar in Clinical Psychopharmacology (3)
Examination of diagnostic issues and pharmacological intervention strategies in the treatment of neuroses, psychoses, and other psychological/psychiatric problems. Emphasis on consideration of current primary references with evaluation through student presentations. Prerequisite: Psyc 404 or consent of instructor. Simon

Public Relations

See listings under Journalism and Communication.

Quality Engineering

Faculty. The Quality Engineering program is offered by the department of Industrial and Manufacturing Systems Engineering. A list of the faculty can be found in section V of this catalog, under the heading: Industrial and Manufacturing Systems Engineering.
Religion Studies

Professors. Norman J. Girardot, Ph.D. (Chicago); Michael L. Raposa, Ph.D. (Pennsylvania), Chairperson; Laurence J. Silberman, Ph.D. (Brandeis), Philip and Muriel Berman Professor of Jewish Studies, and Director of the Philip and Muriel Berman Center for Jewish Studies.

Associate professors. Kenneth L. Kraft, Ph.D. (Princeton); Lloyd H. Steffen, Ph.D. (Brown); Lenore E. Chava Weissler, Ph.D. (Pennsylvania), Philip and Muriel Berman Chair of Jewish Civilization; Benjamin G. Wright, III, Ph.D. (Pennsylvania).

The Religion Studies Department is committed to the academic investigation of religion as an intrinsic and vital dimension of human culture. The scholarly study of religion is an integral facet of a liberal arts education. The student of religion is engaged in the critical and interpretive task of understanding patterns of religious thought and behavior as aspects of the human cultural experience.

Religion studies is interdisciplinary in that it draws upon humanistic (involving historical and philosophical perspectives) and social scientific (involving sociological, anthropological, and psychological perspectives) modes of inquiry. Religion studies is a cross-cultural, comparative discipline concerned with the character and significance of the major religious traditions of the world. The student of religion confronts ethical problems and basic issues of values and meaning raised by modern multicultural and technological society.

Major in Religion Studies

The major in Religion Studies consists of 32 credit hours of coursework (8 courses). Requirements include:

1. At least one introductory course (any course numbered below level 10).
2. At least one course on a Western religious tradition, and at least one course on an Eastern religious tradition.
3. At least four courses at the 100 level or above.

In addition to this minimum distribution, we recommend a concentration in one of the major religious traditions, or in a comparative or thematic approach to the study of religion. The concentration should include at least four courses, where that is possible. Language study appropriate to the concentration is also desirable.

Students are particularly encouraged to consider a joint or double major with another major field from any of the three colleges at the university.

Departmental Honors

Religion Studies majors are admitted to honors by invitation of the departmental faculty toward the end of the student’s junior year. To be eligible, a student must have maintained a 3.25 average in his or her major program by the end of the junior year. Upon acceptance to honors, the student will work out a special program of studies for the senior year with the major advisor, culminating in the writing of a senior essay.

Minor in Religion Studies

The minor in religion studies consists of a total of sixteen credits. The specific courses to be taken by each student are to be decided upon jointly by the student and the departmental advisor. Ordinarily, the student will be expected to take one introductory course unless specifically exempted by the departmental chairperson.

Course Offerings

1. Sacred Scriptures from Around the World (4)

An encounter with the different sacred books of the world’s major religions. Both the books and differing attitudes in these traditions towards sacred books are examined. Books investigated include the Bhagavad Gita, the Analects of Confucius, the Qur’an and the Jewish and Christian Bibles. Wright
2. Life and Death in Religious Traditions (4)
Explores ways in which Eastern and Western religions conceptualize the
great life passages, birth, maturation, marriage, parenting and death.
Weissler. (HU)

3. (Phil 3) Religion and Ethics in Religious Traditions (4)
Introduction to philosophical and religious modes of moral thinking,
with consideration given to ethics in the world religious traditions
(family life and role of women, social justice, environment, work,
models of ethical ideal). Particular issues examined include abortion,
corporal punishment (such as the death penalty), problems in medical
ethics, and heavy drinking as a behavioral problem. Steffen (HU)

4. How to Study Religion (4)
How do sociologists, psychologists and philosophers answer such
questions as: Why and how do religions arise? Why and how do people
develop beliefs in God? Where do religious scriptures come from? Why
do people ascribe authority to religious traditions? Why has religious
faith declined in modern society? Silberstein (HU)

5. Spiritual Exercises East and West (4)
Explores a variety of religious disciplines developed in both eastern and
western religious traditions, ranging from the practice of yoga and
the martial arts to various forms of prayer, meditation and asceticism.
Raposa. (HU)

6. Religion and the Ecological Crisis (4)
Past and present responses to nature in world religions. Contemporary
topics include the animal rights debate, ecofeminism, and the
development of environmental ethics. Is “the end of nature” at hand?
Why is the environment a religious issue? Kraft. (HU)

7. Jesus, Buddha, Confucius, and Elvis (4)
Comparative and cross-cultural exploration of the nature and meaning of
“religious founders” in the history of religions. Girardot. (HU)

8. Prehistoric Religion and Technology (4)
Origins and early development of religions, with focus on interactions of
religion, magic, and technology, especially as these correlate with
hunting, agriculture, and pastoral modes of subsistence. Girardot. (HU)

62. (Asia 62) Religions of India (4)
Origin, development and meaning of the major forms of Indian religious
traditions. Attention to elite and popular forms of Hinduism, Yoga,
early Buddhism. (HU)

64. (Asia 64) Religions of China (4)
History and meaning of the major forms of Chinese religion- especially
Confucianism and Neo-Confucianism, Taoist mysticism, Buddhism
(Ch’an/Zen), and popular religion. Girardot. (HU)

65. (Asia 65) Religions of Japan (4) A survey of Japan’s diverse
religious heritage and its impact on contemporary culture. Japanese
approaches to the self, the world, and the sacred are considered in
comparative perspective. Topics covered include: Shinto, Buddhism,
Zen, Confucianism, the way of the warrior, folklore, and postwar
movements. Kraft. (HU)

67. (Asia 67) Japanese Civilization (4)
The history and culture of Japan from its origins to the present. Special
consideration will be given to the rise and fall of the warrior class,
developments in art and religion, the dynamics of family life, and
Japan’s “economic miracle.” Kraft. (HU)

68. Practical Justice: From Social Systems to Responsible
Community (4)
Examination of the role of moral and religious values in social systems,
including education, the economic system, criminal justice, with
particular attention to the problems of poverty, literacy, homelessness
and domestic violence. Students engage in volunteer efforts to gain
practical experience with those who deliver and receive services in these
systems. An action-reflection model (with reference to liberation
theology and religious thinkers like M.L. King, Dorothy Day, and
Walter Rauschenbusch) is employed to urge reflection on how social
systems can be affected and transformed by visions of justice, ethics,
religion and social responsibility. Steffen. (HU)

73. The Jewish Tradition (4)
Development of traditional Judaism; readings in the Bible, the Talmud,
and selected mystical texts. Discussions will focus on the diverse ways
in which Judaism has been understood and interpreted up until the end
of the 18th century. Silberstein, Weissler. (HU)

75. The Christian Tradition (4)
Introduction to the Christian tradition from its early variety and
subsequent classical definition in the church councils up to the
enlightenment. Special emphasis will be placed on the multiform
interpretations of the Christian message. (HU)

76. Reading the Bible in the Contemporary World (4)
Reading passages from the Bible with an eye toward distinguishing and
understanding different sorts of questions that can be asked of them and
various perspectives that can be adopted when reading them. What are
these stories about? What do they mean, when, and to whom? Wright
(HU)

77. The Islamic Tradition (4)
Origin and development of classical Islam. Topics include Muhammad
and the Koran; legal, theological, and ritual institutions; the Caliphate;
Islamic mysticism; Islamic cosmology and Islamic science. (HU)

111. Jewish Scriptures/Old Testament (4)
The religious expression of the Hebrews, Israelites, and Jews as found
in the Jewish Scriptures (TANAK/Christian Old Testament). Near
Eastern context of Hebrew religion, the Patriarchs, the Exodus, the
monarchy, prophecy, Exile and Return. Emphasis on historical, literary,
critical problems, and newer socio-historical methods. (HU)

112. The Beginnings of Judaism and Jewish Origins: Jewish
Diversity in the Greco-Roman World (4)
The variety of approaches to Judaism in the period following the
Babylonian exile through the second century C.E. The literature studied
will include Apocrypha, Pseudepigrapha, and the Dead Sea Scrolls.
Wright. (HU)

of Christianity (4)
Early Christianity from its beginnings until the end of the second
century. Coverage includes the Jewish and Hellenistic matrices of
Christianity, traditions about the life of Jesus and his significance,
and the variety of belief and practice of early Christians. Emphasis on
encountering primary texts. Wright. (HU)

121. Sources for the Life of Jesus: the Jewish and Christian
Context (4)
Ancient sources that claim to provide information about Jesus of
Nazareth. Approaches taken to Jesus’ life and career; early Christian
interpretations of the significance of Jesus; methodology in assessing
evidence for the historical Jesus and his message. Wright. (HU)

124. (Phil 124) Reason and Religious Experience (4)
A critical look, from a philosophical perspective, at some fundamental
problems of religion: The nature of religious experience and belief,
reason and revelation, the existence and nature of God, the problem of
evil, and religious truth. Raposa. (HU)
125. Heresy and Orthodoxy: Varieties of Christianity in the First Three Centuries (4)
Examines the development of Christianity until the end of the third century. Compares the views of different groups about the significance of Jesus. Who were the proto-orthodox? Jewish Christians? Gnostics? What did they think? Why were some branded heretics by others? Wright (HU)

129. (Phil 129) Jewish Philosophy (3)
How major Jewish thinkers from the 1st to the 20th centuries confronted questions at the intersection of religion and philosophy: the existence and nature of God, free will, evil, divine providence, miracles, creation, revelation, and religious obligation. (HU)

130. The Mystical Tradition: Judaism (4)
Explores the history of the quest to know God, through mystical experience or theosophical speculation, as found in Jewish tradition. Examines such issues as the tensions between institutional religion and personal religious experience, between views of God as immanent in the world or transcending it, and between imagery for God and religious experience of God. Weissler. (HU)

132. Hasidic Tales (4)
Examines the mysterious and beautiful tales told by Hasidim, participants in the movement of spiritual revival which arose within 18th century Judaism. Compares hasidic tales to European fairy tales, and shows how later writers transformed hasidic narratives to express their own religious or literary meanings. Weissler. (HU)

133. New Age Spirituality (4)
An exploration of alternative religious beliefs and practices in the late 20th century. Topics include goddess religion, channeling, UFOs, adaptations of Asian and Native American traditions, and spiritual environmentalism. How "new" are New Age religions? How does a genuine religious movement differ from a cult? Kraft. (HU)

138. (WS 130) Women in Jewish History (4)
Contributions of, and limitations on, women at different stages of Jewish history, using both primary sources and secondary material. Experience of modern Jewish women, and the contemporary feminist critique of traditional gender roles. Weissler. (HU)

139. Jewish Folklore (4)
Traditional culture and lore of European Jews from 18th century Central Europe to 19th century Eastern Europe. Shift from folk to ethnic culture as Eastern European Jews emigrated to North America in the 20th century. Nature of tradition and ethnicity; difference made by gender in experiencing traditional culture; relationship between "official" religion and popular traditions. Readings supplemented by films, field trips, and student field work. Weissler. (SS)

150. Forms of Jewish Identity in the Modern World (4)
Fundamental themes in the experience of modern Jewry: confrontation with secular culture; crisis of religious faith; Zionism and the renewal of Jewish nationalism; the problem of Jewish identity in America; and the impact of the Holocaust. Silverstein, Weissler. (HU)

152. American Judaism (4)
Diverse cultural and social forms through which American Jews express their distinct identity. Is American Jewry an example of assimilation and decline or creative transformation? What, if anything, do American Jews share in common? Compatibility of Judaism with individualism, pluralism, and voluntarism. How have the Holocaust and the State of Israel shaped the self-understanding of American Jewry? Silverstein. (HU)

154. (Hist 154) The Holocaust: History and Meaning (4)
The Nazi holocaust in its historical, political and religious setting. Emphasis upon moral, cultural and theological issues raised by the Holocaust. (HU)

155. Jewish Thought since the Holocaust (4)
Reactions to the Holocaust by major Jewish thinkers such as Wiesel, Rubenstein, Fackenheim, Buber, Heschel, Schultze, and Berkovitz. Focus on the problem of evil and its relationship to religious faith. Silverstein. (HU)

156. Israel, Zionism, and the Renewal of Judaism (4)
New interpretations of Judaism, the Jewish community and Jewish history developed by Zionist thinkers. Diverse currents within Jewish nationalism thought and critical responses to Zionist ideology. Silverstein. (HU)

157. (Hist 157) The Renaissance and Reformation (4)
The transition from medieval to modern society. Consideration of political, economic, and social forces produced by the Renaissance and their influence upon the dominant religious theme of the Reformation era. Baylor. (HU)

158. (WS 185) Sex and Gender in Judaism: The Feminist Critique (4)
Writings by Jewish feminists reflecting the encounter between Judaism and feminism: prayer and ritual, women rabbis, God, and God language, communal power, the marriage and divorce. Silverstein. (HU)

159. Roman Catholicism in the Modern World (4)
A survey of the various intellectual, cultural, political and ecclesiastical developments that have shaped contemporary Roman Catholic life and thought. Raposa. (HU)

160. (Asia 160) The Taoist Tradition (4)
Consideration of the religious and cultural significance of Taoism in its various historical forms. Primary attention will be given to a close reading of some of the most important texts of the early philosophical tradition (e.g. Tao Te Ching, Chuang Tzu) and of the later religious tradition (e.g. Pao P' u Tzu and other selections from the Tao Tsang). Contemporary implications of Taoist thought will also be considered (e.g. "The Tao of Physics", "a Taoist on Wall Street"); and "the Tao of Japanese Management"). Girardot (HU)

162. (Asia 162) Zen Buddhism (4)

164. (Asia 164, IR 164) Japan's Response to the West (4)
A survey of Japanese history and culture from 1500 to the present, following the theme of Japan's contact with the West. What enabled Japan to modernize and Westernize so successfully? Topics covered include: the expulsion of Christianity, the first samurai mission to the U.S., the postwar American occupation, and contemporary issues. Readings include Japanese novels and short stories (in translation). Kraft. (HU)

168. (Asia 168) Buddhism in the Modern World (4)
Explores contemporary Buddhism in Asia, America, and Europe. Topics include the plight of Tibet, Buddhist environmentalism, and the emergence of a socially engaged Buddhism. How are Westerners adapting this ancient tradition to address present-day concerns? Kraft. (HU)

169. (Asia 169) Classics of Asian Religion (4)
Sacred scriptures of Asia and an introduction to the religions they represent. What do these texts teach about reality, humanity, divinity, and society? How is the path of spiritual practice presented in the different traditions? Kraft, Girardot. (HU)

174. Contemporary Theology (4)
Major twentieth century movements within Christian and Jewish theology understood as responses to the problems of modern times. May be repeated for credit as the subject matter varies. Raposa. (HU)
180. (Hist 180) Religion and the American Experience (4)
The historic development of major American religious groups from
colonial times to the present; their place in social and political life, and
the impact of the national experience upon them. Raposa. (HU)

184. (WS 184) Religion, Gender, and Power (4)
Gender differences as one of the basic legitimations for the unequal
distribution of power in Western society. Feminist critiques of the basic
social structures, cultural forms, and hierarchies of power within
religious communities, and the ways in which religious groups have
responded. Silberman (HU)

186. Judaism in Israel and the United States (4)
Explores the differences/similarities in the ideologies, myths and
symbols that shape the views of Jews in Israel and the United States
on such issues as: the meaning of Judaism, the interpretation of Jewish
history, the relationship of religion and peoplehood, and the relationship
of democracy and Jewish values. Readings include Amos Oz, A.B.
Yehoshua, Haim Hazaz, Leonard Fein, Mordecai Kaplan. Silberman
(HU)

Impact of the scientific and technological culture on the Western
religious imagination. Roots of science and technology in religious ideas
and images. Ways of knowing and concepts of experience in religion and
science. Raposa (HU)

188. Religion and Literature (4)
Religious themes in the modern novel or the spiritual autobiography.
Melville, Tolstoy, Camus, Updike, Walker, and Morrison; or Woolman,
Tolstoy, Malcolm X, Wiesel, Frederick Douglass, Sojourner Truth,
Kukai. Steffen. (HU)

189. Religion and the Visual Arts (4)
To what extent does the process and production of artistic images relate
to visionary experience in the history of world religions, and expose a
religious dimension in life? In what sense is an artistic vocation similar
to the religious vocation of a shaman, prophet, or saint? In what way do
artists and religious figures respond to change, and create the "real"
world? Girardot. (HU)

204. (MFL 204) The Myths of the Slavs: Folklore and
Literature (4)
Distinction between "folklore" and "literature". Study of Russian,
Ukrainian, and Belarussian tales, legends, riddles, sayings and heroic
poems. Manouelian. (HU)

213. (Clst 213) Ancient Roman Religion (3)
Religious experience of the Roman people from prehistory to end of
the Empire. Nature of polytheism and its interactions with monothelitism
(Christianity, Judaism). Theories of religion. Emphasis on primary
source materials. (HU)

221. (Asia 221) Topics in Asian Religions (4)
Selected thematic and comparative issues in different Asian religious
traditions. May include Buddhism and Christianity, religious and martial
arts, Asian religions in America, Taoist meditation, Zen and Japanese
business, Buddhist ethics. May be repeated for credit. Girardot, Kraft
(HU)

222. Topics in Western Religions (4)
Selected historical, thematic, and comparative issues in Judaism,
Christianity, and Islam. May be repeated for credit as the subject matter
varies. (HU)

224. (Phil 224) Topics in the Philosophy of Religion (4)
Selected problems and issues in the philosophy of religion. May be
repeated for credit as the subject matter varies. Prerequisite: Rel 181 or
consent of the department instructor. Raposa. (HU)

225. Topics in Religion and Ethics (4)
Analysis of various moral problems and social value questions. Possible
topics include: environmental and non-human animal ethics; medical
ethics; drug and alcohol abuse; spiritual meaning of anorexia. (HU)

251. (Clst 251) Classical Mythology (3)
Myth, religion and ritual in ancient Greece and Rome. Emphasis on
primary sources; introduction to ancient and modern theories of myth.
Cross-cultural material. (HU)

335. (Anth 335) Religion, Symbolism and Cosmology (3)
How human experience is mediated through the use of symbols.
Religious and cosmological systems in cross-cultural perspective.
Frankel. (SS)

355. (Hist 355) European Intellectual History (4)
Political and religious thought and other aspects of the history of ideas
in Europe from the Middle Ages to about 1700. Baylor. (HU)

359. (SSp 359) Sociology of Religion (3)
Religion as a central institution in society. Social functions provided by
religion, for individuals and for the society as a whole. Social correlates
of interindividual differences in religiosity. Religious sects and cults and
why they exist in modern society. Thomas. (SS)

361. Fieldwork (1-4)
Opportunity for students to work, or observe under supervision,
religious organizations or institutions. Consent of chair required. (HU)

371. Directed Readings (1-4)
Intensive study in areas appropriate to the interests and needs of
students and staff. (ND)

391. Honors Thesis in Religion (4)

Russian

See listing under Modern Foreign Languages.

Russian Studies

Rajan Menon, Ph.D. (Illinois), Monroe J. Rathbone professor of
international relations, program director,
Professors. Donald D. Barry, Ph.D. (Syracuse); Oles M. Smolansky,
Ph.D. (Columbia).
Associate Professor. Mary A. Nicholas, Ph.D. (Pennsylvania).
Adjunct Professor. Winfred Kohls, Ph.D. (Berkeley).
Assistant Professor. Edward Manouelian, Ph.D. (Harvard).

Russian Studies Major
The major in Russian Studies is an interdisciplinary program designed to
provide students with a broad exposure to the Russian language and to
Russian and Soviet culture. Courses in language, literature, history,
politics, foreign policy, and economics, as well as the possibility of
study in the USSR, are part of the curriculum for this major. The
required and elective courses fit in well with a traditional liberal arts
education. At the same time, the emphasis on area studies provides
students with a focus for their intellectual efforts and a specialization
that can be pursued, in graduate school or in a variety of public and
private sector careers, after graduation.

The major in Russian studies require 36 credit hours, distributed as
follows:
Science, Environmental and Technical Writing

See listings under Journalism and Communication.

Science, Technology and Society

Stephen H. Cutcliffe, Ph.D. (Lehigh), program director.
Steven Louis Goldman, Ph.D. (Boston), Andrew W. Mellon Professor in the Humanities.

The Science, Technology and Society (STS) Program is the product of a continuing intercollege effort to create a common ground from which to explore the relations between science, technology and society: between ideas, machines and values.

The STS Program serves as a focal point for a wide range of courses that study the nature of science and of technology, and analyze their social and personal implications. It lends coherence and visibility to offerings otherwise dispersed throughout the catalog.

STS Studies Major

The major in Science, Technology and Society Studies prepares students for graduate study or for a wide variety of career opportunities including policy analysis, planning, or community relations with public or private sector agencies concerned with the social relations of scientific research and technological innovation. The intrinsically cross-disciplinary character of science-technology-society interactions is reflected in the B.A. requirements. Majors must complete a minimum of 31 credit hours in STS courses, listed below, together with at least 15 credit hours in any traditional academic discipline: engineering, physical or life science, the humanities, or the social sciences. This collaborative set of courses should be chosen in consultation with the Program Director to provide the foundation needed to engage STS Studies issues in which that discipline is implicated. The senior seminar and project provide an opportunity for students to integrate the knowledge they have gained and the skills they have acquired, in the course of guided research on a topic of special interest to them. Additional opportunities for student research are available, especially through STS 181: Independent Study.

STS Studies is a social science major in the College of Arts and Science, and majors must fulfill the College's B.A. distribution requirements. A detailed description of the STS Studies major requirements follows.

Detailed Description of STS Major Requirements

A. Required STS Courses (minimum of 31-32 hours)
   - STS 11: Technology and Human Values (4)
   - STS 12: Engineering and Society (4)
   - Hist 7: The Machine in America (3)
   - STS/Jour 124: Politics of Science (3) or Poli 115: Technology as Politics (4)
   - Phil 128: Philosophy of Science (3) or Phil 228: Topics in Philosophy or Science (3)

   STS 381: Senior Seminar and Methods (4)

   STS 382: Senior Project (4)

Two additional advanced courses (100 level or higher) from the list of approved STS Studies courses (6-8)

B. Concentration in a complementary discipline (minimum of 15 hours to be chosen in conjunction with STS Studies advisor); or approved departmental or interdisciplinary program minor; or double major.

C. Science and Mathematics Requirement: Students must fulfill the College's regular B.A. distribution requirements of at least 8 credits in the Natural Sciences; and at least 3 credits in Mathematical Sciences. At least one of the courses in the Natural Sciences must also include the associated laboratory course. These courses should be chosen in consultation with the advisor.

School Psychology

See listings under Education.
Science, Technology and Society Courses

11. Technology and Human Values (4)
Impact of technology on society in relation to ethical problems raised by the exploitation of technological innovations. Illustrations from history, social studies, philosophy, literature, and film. Cutcliffe. (SS)

12. Engineering and Society (4)
An examination, from the perspective of its social context, of engineering as a distinctive problem-solving discipline. The roles of design, modeling, testing, safety analysis, product and client in defining engineering problems and acceptable solutions to them. Goldman, Nagel. (SS)

124. (Jour 124) Polities of Science (3)
Organization of the U.S. scientific community and how it interacts with government, the mass media and the public. Friedman. (SS)

141. Asia (141) Science and Technology Studies in East Asia (4)
The development of science and technology in East Asia with emphasis on Japan and China. Cultural and religious influences, both internal and external, and interactions with the West, as illustrated by the development of bronze technology, ceramics and architecture. Factors in Western and Japanese society that have contributed to the rapid growth of Japanese technology as well as limits to future growth of technology in East Asia. Notis. (SS)

145. (Hist 145) Introduction to the History of Science (4)
The history of modern science, primarily physical and biological, with emphasis on the development of major theoretical models since the seventeenth century. Goldman (SS)

181. Independent Study (1-4) fall-spring
Prerequisite: consent of the program director. (ND)

221. (MAT 221) Materials in the Development of Man (3)
Development of materials technology and engineering from the stone age to atomic age as an example of the interaction between technology and society. In-class demonstration laboratories on composition and structure of materials. Term projects using archaeological materials and alloys. Course intended for, but not limited to, students in the humanities and secondary science education. Engineering students may not use this course for engineering science or technical elective credit. Notis. (SS)

323. (Jour 323) Scientific and Environmental Controversies (4)
Exploration of media coverage of controversial scientific and environmental topics. Includes discussion of the social responsibilities of the media. Topics will vary with the semester but usually include several issues of the following: genetic engineering, environmental risks such as dioxin or electromagnetic fields, viruses, or various technology applications. S. Friedman (SS)

341. Issues in American Competitiveness: At Home and Abroad (4)
Issues affecting American commercial competitiveness focusing on topics associated with the recent emergence of a new commercial environment in all First World societies. Team taught in a highly interactive setting with industry, public sector, and government experts, in addition to academics from various disciplines and institutions. Students read topical articles and books, participate in team projects and debates, and conduct team research on competitiveness issues they have chosen for a term report. Goldman, Nagel. (SS)

381. Senior Seminar (4)
In-depth study of selected topics in science, technology and society with special attention to methodological issues. Subject matter may vary from semester to semester. Intended for STS majors and minors, but open to others. Prerequisite: STS 11 or consent of program director. Cutcliffe. (SS)

382. Senior Project (4)
Continuation of STS 381. Students conduct and present independent research projects on STS topics of special interest. Prerequisite: STS 381. Cutcliffe. (SS)

Other STS courses.
The following courses, appropriate to STS Studies, are offered by various departments. Course descriptions may be found under the catalog entry for the individual department. New courses are frequently added to this list and announced in bulletins published by the STS Program. For further information, please contact the program director.

Anth 151 Utopias and Alternative Communities - Staff
Arch 107 History of American Architecture—Thomas
Arch 210 20th Century Architecture—Zakari
Arch 361/3 Hist 361 Evolution of Highrise Building
Construction—Peters
Arch 363/3 Hist 363 Evolution of Long-Span Bridge
Building—Peters
Arch 365/3 Hist 365 Evolution of the Modern Building Process
—Peters
Asia 141 Science and Technology Studies in East Asia
—Notis
Chm 5 Chemistry and National Issues—Schnay
CIS 108 Ancient Technology—Small
CIS 239/24 Arc 204 Ancient City and Society—Small
CIS 252 Computers and Society—Staff
Eco 311 Environmental Economics—Mulaney
Eco 314 Energy Economics—McNamar
EES 3 Global Environmental Change—Meltzer & Zeitler
EES 11 Environmental Geology—Evenson
Engl 122 Speculative Fiction—Kbur
Engl 187 Themes in Literature: Utopian Literature—Staff
Pols 111 The Politics of Environment and Natural Resources—Wurth
Pols 115 Technology as Politics—Wurth
Hist 7 Machine in America—Smith
Hist 31/Asia 31 History of Japanese Industrialization
Since 1800—Cooper
Hist 32 Japanese Industrialization: laboratory
—Cooper
Hist 107 Technology and World History—Smith
Hist 111 Engineering in the Modern World—Smith
Hist 145 Introduction to the History of Science
—Goldman
Hist 307 History of American Industrial Technology
—Smith
Hist 315 American Environmental History—Cutcliffe
Jour 124 Politics of Science—Friedman
Jour 125 Environment, Public, and Mass Media
—Friedman
Jour 323 Scientific and Environmental Controversies
—Friedman
Mat 221 Materials in the Development of Man—Notis
Phil 116 Bioethics—Staff
Phil 128 Philosophy of Science—Beam
Phil 228 Topics in the Philosophy of Science
—Goldman
Phil 250 Minds of People and Robots—Staff
Rel 6 Religion and the Ecological Crisis—Kraft
Rel 8 Prehistoric Religion and Technology
—Girardot
Internship Opportunities. The department maintains close, working relationships with a variety of social agencies and institutions in the area. Majors can earn course credit by carrying out supervised work in field settings, e.g., hospitals, private and public agencies devoted to social services, courthouses, prisons, etc. This useful experience allows a student to apply the concepts learned in the classroom to a field setting and to evaluate vocational aspirations and interests.

Senior Thesis. All majors are encouraged to do independent research culminating in a Senior Thesis, and this is especially recommended for students intending to go on to graduate or professional school. The best time to begin discussing possible projects with faculty is during the second semester of the junior year. The department chairperson should be consulted for further details.

Departmental Honors. To be eligible for departmental honors, students must have at least a 3.3 GPA in the major. In addition, students pursuing honors must take SR, Anth, or SSP 399 and write a thesis during their senior year. Awarding of departmental honors is contingent on both the quality of the thesis, as judged by a department committee, and the candidate’s GPA at time of graduation.

B.A. Major Programs

Social Relations

Introductory (6 credits, from two of the disciplines)
Anth 11 Sociocultural Anthropology (3) spring
Anth 12 Human Evolution and Prehistory (3) fall
SSP 5 Introductory Sociology (3) fall
SSP 21 Social Psychology (3) spring

Theory and Methodology (11 credits)
SR 111 Research Methods and Statistics (4) fall
SR 112 Computer Applications in Social Relations (4) spring
SR 381 Development of Social Theory (3) fall

Major Electives (21 credits)
Seven additional courses in social relations, with at least four at the 300-level or above. These must be chosen in such a way that, in conjunction with the introductory courses, the student completes at least two courses in each of anthropology, sociology, and social psychology. No more than 6 credits of individualized study—371, 393, or 399 courses—can be applied toward this requirement.

Anthropology

Introductory (6 credits)
Anth 11 Sociocultural Anthropology (3) spring
Anth 12 Human Evolution and Prehistory (3) fall

Theory and Methodology (11 credits)
SR 111 Research Methods and Statistics (4) fall
SR 112 Computer Applications in Social Relations (4) spring
SR 381 Development of Social Theory (3) fall

Major Electives (21 credits)
Seven additional courses in anthropology, with at least four at the 300-level or above. (One of these seven may be a SR, or SSP course.) No more than 6 credits of individualized study—371, 393, or 399 courses—an be applied toward this requirement.

Sociology/Social Psychology

Introductory (6 credits)
SSP 5 Introductory Sociology (3) fall
SSP 21 Social Psychology (3) spring

Theory and Methodology (11 credits)
SR 111 Research Methods and Statistics (4) fall
SR 123 Computer Applications in Social Research (4) spring
SR 381 Development of Social Theory (3) fall

The disciplines of sociology and anthropology are concerned with the study of human beings in relationships with others, i.e., with social relations. As such, these disciplines encompass the study of the broadest range of human social activities, from the comparative examination of widely divergent cultures and societies, to the inner life of individuals as this influences social behavior, to an examination of the most pressing social issues of our time. To study social relations is to develop an understanding of the influences that have shaped one’s past and that pattern one’s future.

The common goals of the department’s diverse offerings are to foster both self- and societal-awareness and to provide students with the analytic skills necessary to understand and conduct social research. Central to the department’s major programs is training in research methods, statistics, and the use of computer applications in social science.

Math 12, Basic Statistics, is highly recommended for students contemplating a major [and/or minor] in this department. While not required, this course should be taken instead of another math course, if possible, to fulfill the college’s distribution requirements. Math 12 will help prepare students for research requirements for this major.

The department offers three Bachelor of Arts majors: Social Relations, Anthropology, and Sociology/Social Psychology. The three programs are parallel in structure and requirements. Each consists of 38 credit hours of course work: 17 credits of core courses (6 in introductory level courses and 11 in theory and methodology) and 21 credits of major electives. The Social Relations major is an interdisciplinary program for students desiring a wider familiarity with social science fields, whereas the Anthropology and Sociology/Social Psychology majors are for students desiring more traditional, disciplinary programs of study.

Research Opportunities. It is the explicit aim of the department to involve majors, minors and other interested students in the ongoing research activities of faculty members. Second-semester sophomore, junior and senior students interested in a supervised research experience are encouraged to consult with the department chair or talk with the appropriate faculty member. Course credit can be received for research experience.
Major Electives (21 credits)
Seven additional courses in sociology and/or social psychology, with at least four at the 300-level or above. (One of these seven may be a SR or Anth course.) No more than six credits of individualized study—371, 393, or 399 courses—can be applied toward this requirement.

Note: Students majoring in anthropology or in sociology/social psychology can use the following SR courses to fulfill the major electives requirement as if these were Anth or SSP courses, respectively:
SR 365 Internship in Social Relations (1-4)
SR 395 Methods in Observation (3)
SR 416 Quasi-Experimentation and Program Evaluation (3)
SR 461 Seminar in Social Relations (1-4)

Minor Programs
Anthropology: Anth 11 or 12 and twelve additional credits at the 100level or above in anthropology.
Social Psychology: SSP 21 and twelve additional credits at the 100-level or above, selected from the following courses (as available): 100, 109, 125, 135, 153, 308, 312, 314, 323, 327, 333, 356, 361, 363, 371, 391, 393.
Social Relations: One introductory course (Anth 11 or 12, SSP 5 or 21) and twelve additional credits at the 100-level or above, with at least three credits in each of anthropology, sociology, and social psychology.
Sociology: SSP 5 and twelve additional credits at the 100-level or above, selected from the following courses (as available): 100, 103, 141, 152, 160, 162, 165, 325, 326, 341, 351, 355, 359, 364, 366, 370, 371, 373, 374, 379, 393.

Undergraduate Courses
SR 41. (WS 41) Human Sexuality (3)
Sexuality and gender roles across the life cycle, including human reproduction, decision-making, and the societal regulation of sexual behavior. Green. (ND)

SR 42. (WS 42) Sexual Minorities (3)
How minority sexual identities have been the subject of speculation, misunderstanding, and sometimes violent attempts at correction or elimination. Sexual orientation, gender role, including transvestism and “drag,” transsexualism, sexism, heterosexism, and homophobia. Emphasis on critical thinking, guest speakers, and discussions. Green. (SS)

SR 100. Seminar in Social Relations (1-4)
Topics in social relations. May be repeated for credit. (SS)

SR 111. Research Methods and Statistics (4) fall
Research skills in anthropology, sociology and social psychology. Problem formulation; research design; methods and measures; analysis and interpretation of data. Emphasis on the use of statistics in the research process. (ND)

SR 112. Computer Applications in Social Relations (4) spring
Uses of micro- and mainframe computers in the social sciences. Data management; statistical analysis; simulations. Weekly laboratory sessions. Prerequisite: SR 111 or consent of department chair. (ND)

SR 118. Close Personal Relationships (3)
Dynamics of development, maintenance and dissolution of relationships with family, close friends, lovers and spouses. Life cycle of relationships, attraction, communication. (SS)

SR 331. Social Perspectives on Death and Dying (3)
The meaning of the end of life in various societies, especially the United States. Sociological, anthropological, and psychological perspectives on dying as a process, and on death as an event, combined with philosophical and ethical considerations. Topics to be considered include euthanasia and “extraordinary means” to maintain life from neonate to elderly, funeral practices, stages of dying, hospices, and the social milieu and family relationships of the dying person. Prerequisite: Any one of the following introductory courses: Anth 11, Anth 12, SSP 5, SSP 21, or department permission. (SS)

SR 363. Seminar in Social Relations (1-4)
Selected social science topics. May be repeated for credit. Prerequisite: Any one of the following introductory courses: Anth 11, Anth 12, SSP 5, SSP 21, or department permission. (SS)

SR 365. Internship in Social Relations (1-4)
Supervised work experience and observation in a variety of field settings, e.g., hospitals, social services, public agencies, private organizations. May be repeated once for credit. Prerequisite: open only to the department’s majors. McIntosh. (SS)

SR 381. Development of Social Theory (3) fall
Comparative study of social theory. Prerequisite: Any one of the following introductory courses: Anth 11, Anth 12, SSP 5, SSP 21, or department permission. (SS)

SR 395. Methods in Observation (3) alternate years
Naturalistic and participant observation in uncontrolled field settings. Prerequisite: Any one of the following introductory courses: Anth 11, Anth 12, SSP 5, SSP 21, or department permission. Tannenbaum. (SS)

SR 399. Senior Thesis (3)
Research during senior year culminating in senior thesis. Required for social relations majors seeking departmental honors. Prerequisite: consent of the department chairperson. (SS)

Anthropology

Anth 11. Sociocultural Anthropology (3) spring
Human behavior in cross-cultural perspective. Variations in kinship reckoning, political organization, economic and religious life in comparative perspective. Particular non-Western peoples: films and readings. (SS)

Anth 12. Human Evolution and Prehistory (3) fall

Anth 100. Seminar in Anthropology (1-4)
Topics in anthropology. May be repeated for credit. (SS)

Anth 112. (Clst 112) Doing Archaeology (3)
Principles of archaeological method and theory. Excavation and survey methods, artifact analysis, dating techniques, and cultural reconstruction. Course includes field project. Small. (SS)

Anth 121. (Clst 121) Environment and Culture (3)
Impact of environment upon cultural variability and change. Comparative study of modern and past cultures and their environments as well as current theories of human/ environmental interaction. Small. (SS)

Anth 123. (WS 123) The Cultural Construction of Gender (3)
Comparative study of the meanings and social roles associated with gender. Psychological, symbolic, and cultural approaches. Tannenbaum. (SS)

Anth 125. Anthropology of Peasant Peoples (3)
Comparative study of peasants—people who depend on small-scale agriculture and comprise 80% of the world population. Cultural, political, and economic bases of peasant societies and their future prospects. Tannenbaum. (SS)
Anth 127. (Clss 127) Early Civilization (3)
Introduction to early civilizations in the Near East, Mediterranean, Africa, Europe, and New World. Similarities and differences in economics, politics, social organization, and religion. Small. (SS)

Anth 128. Urban Ethnology (3)
Cross-cultural study of the city as a social milieu. Comparison of methods and strategies for research in urban settings, and the explicit and implicit theories of urban life associated with these. Field projects will use Bethlehem’s South Side as an ethnographic laboratory. (SS)

Anth 132. Analysis of Archaeological Materials (4) fall
Analysis of archaeological materials emphasizing technological, stylistic, and functional aspects of lithic and ceramic artifacts; background to classification, measurement techniques, generating data bases, and classic analytic procedures. Teltsler. (SS)

Anth 139. (Rel 139) Jewish Folklore (4)
Traditional culture and lore of European Jews from 18th century Central Europe to 19th century Eastern Europe. Shift from folk to ethnic culture as Eastern European Jews emigrated to North America in the 20th century. Nature of tradition and ethnicity; differences in gender roles and family roles. Traditions supplemented by films, field trips, and student field work. Weisler. (IHU)

Anth 140. (Cogs 140, Psy 140, MFL 140) Introduction to Linguistics (3)
Relationship between language and mind; formal properties of language; language and society; how language changes over time. (SS)

Anth 142. Prehistoric Religion and Technology (4)
Origins and early development of religions, with focus on interactions of religion, magic, and technology, especially as these correlate with hunting, agriculture, and pastoral modes of subsistence. Girardot. (IHU)

Anth 151. Utopias and Alternative Communities (3)
Present and past searches for new forms of community in fact and fiction. (SS)

Anth 172. North American Archaeology (3) fall
Development of prehistoric North American indigenous population north of Mexico, beginning with earliest evidence of people in the New World continuing up through European contact. Teltsler. (SS)

Anth 174. (Chs 174, Art 174, Arch 174) Greek Archaeology (3)
Ancient Greek culture from the Neolithic to Hellenistic periods. Reconstructs of Greek social dynamics from study of artifacts. Small. (SS)

Anth 176. (Chs 176, Art 176, Arch 176) Roman Archaeology (3)
Cultures of the Roman Empire. Reconstructs of social, political, and economic dynamics of the imperial system from study of artifacts. Small. (SS)

Anth 178. Mesoamerican Archaeology (3)
Ancient civilizations of Mesoamerica: Olmec, Zapotec, Maya, Toltec, and Aztec. Reconstructs of urban centers, political and economic organizations, and theories of the Mayan collapse. Small. (SS)

Anth 180. (Chs 180) Cultures of the Greeks and Romans (3)
Analysis of Greek and Roman Cultures. Focus on kinship, political and economic organization, sexual practices, burial practices, gender construction, religions, art, literature, and warfare. Small. (SS)

Anth 182. North American Indians (3)
Culture areas of native North America prior to substantial disruption by European influences north of Mexico. Environmental factors and cultural forms. Gatewood. (SS)

Anth 184. (Asian Studies 184) Cultures of the Pacific (3)
Cultures of the Pacific Islanders prior to substantial disruption by European influences. Culture histories, language families, social organizations, and religions of Australian, Melanesian, Polynesian, and Micronesian peoples. Gatewood. (SS)

Anth 187. (Asian Studies 187) Peoples of Southeast Asia (3)
Peoples and cultures of Burma, Laos, Cambodia, Thailand, Malaysia, Singapore, Indonesia, and the Philippines. World view, religion, economy, politics, and social organization. Tannenbaum. (SS)

Anth 305. Anthropology of Fishing (3)
Comparative study of fishing peoples and their technologies. Fishing strategies, control of information, and social organization of marine exploitation in subsistence and modern industrial contexts. Theory of common-property resources and the role of social science in commercial fisheries management. Prerequisite: Any one of the following introductory courses: Anth 11, Anth 12, SSP 5, SSP 21, or department permission. Gatewood. (SS)

Anth 321. Anthropology of Physical and Mental Health (3)
Definition and treatment of physical and mental health in cross-cultural perspective. Strategies for coping with illness in literate and nonliterate, Western and non-Western societies. Prerequisite: Any one of the following introductory courses: Anth 11, Anth 12, SSP 5, SSP 21, or department permission. (SS)

Anth 325. Economic Anthropology (3)
Cross-cultural perspectives on the ways people produce, distribute, and consume goods; how these systems are organized, and how they are connected with other aspects of society, particularly political and ideological systems. Prerequisite: Any one of the following introductory courses: Anth 11, Anth 12, SSP 5, SSP 21, or department permission. Tannenbaum. (SS)

Anth 330. Food for Thought (3)
Symbolic and cultural analyses of foods and cuisines. Examines what people eat, who prepares it, what it means, and the social and religious uses of foods historically and cross-culturally. Tannenbaum. (SS)

Anth 335. (Rel 335) Religion, Symbolism and Cosmology (3)
How human experience is mediated through the use of symbols. Religious and cosmological systems in cross-cultural perspective. Prerequisite: Any one of the following introductory courses: Anth 11, Anth 12, SSP 5, SSP 21, or department permission. (SS)

Anth 339. Seminar in Anthropology (3)
Topics in anthropology. Varying semester to semester: human evolution, politics and law, introduction to linguistics, human use of space, anthropology of deviance. May be repeated for credit. Prerequisite: Any one of the following introductory courses: Anth 11, Anth 12, SSP 5, SSP 21, or department permission. (SS)

Anth 345. (Clis 345) Evolution of the State (3)
Theories of state formation. Comparison of evolutionary trajectories of early states in the Near East, Mediterranean, and New World. Prerequisite: Any one of the following introductory courses: Anth 11, Anth 12, SSP 5, SSP 21, or department permission. Small. (SS)

Anth 363. Kinship, Marriage and Descent (3)
Kinship as the central institution in primitive social organization. Variations in definition and regulation of marriage and descent in cross-cultural perspectives. Critiques of Murdock, Levi-Strauss, and Fortes. SSP 364 recommended in conjunction with this course. Prerequisite: Any one of the following introductory courses: Anth 11, Anth 12, SSP 5, SSP 21, or department permission. Gatewood. (SS)

Anth 371. Special Topics (1-3)
Advanced work through supervised readings. May be repeated for credit. Prerequisite: consent of the department chairperson. (SS)
Sociology and Anthropology 253

Anth 376. Culture and the Individual (3)
Concepts and methods of studying relations between the individual and the sociocultural milieu. Culture and personality language and thought, cross-cultural studies of cognition. Prerequisite: Any one of the following introductory courses: Anth 11, Anth 12, SSP 5, SSP 21, or department permission. (SS)

Anth 382. Theory and Method in Archaeology (3) spring
Archaeological approaches to behavioral reconstruction and explanation of cultural change as manifest in the archaeological record. Overview of the major schools of thought in Europe and North America during the 20th century. Prerequisite: Anth 112. Small and Teltser. (SS)

Anth 392. Field School in Archaeology (6) summer
Methods and techniques in the recovery of archaeological information including sampling, survey, controlled surface collection, interpretation of aerial photographs, and excavation. Location varies according to research project of instructor. Prerequisites: permission of instructor. Small and Teltser. (SS)

Anth 393. Research Apprenticeship (3-4)
Conducting anthropological research under the supervision of a faculty member. May be repeated for credit. Prerequisite: consent of the department chairperson. (SS)

Anth 399. Senior Thesis (3)
Research during senior year culminating in senior thesis. Required for anthropology majors seeking departmental honors. Prerequisite: consent of the department chairperson.

Sociology/Social Psychology

SPP 141. Social Deviance and Social Control (3)
Analysis of deviant social systems, supporting factors maintaining them, and societal responses to deviant roles and collectivities. McIntosh. (SS)

SPP 152. Alcohol, Science and Society (3)
Alcohol use and abuse, its historical function in society, moral entrepreneurship, status struggles and conflict over alcohol. Current problems with attention to special population groups and strategies for prevention of alcohol abuse. McIntosh. (SS)

SPP 153. (Psyc 153) Personality (4)
Review and critique of theories of personality and their associated systems of psychotherapy. Prerequisite: Psyc 1 or SSP/Psyc 21. (SS)

SPP 160. Medicine and Society (3)
Health, illness, and the health professions from the sociological perspective. Social epidemiology, social psychology of illness, socialization of health professionals, organization of health care, patient-professional relationships and ethical issues in medical care. Laske. (SS)

SPP 162. AIDS and Society (3)
Impact of the AIDS epidemic on individuals and on social institutions (medicine, religion, education, politics, etc.); social and health policy responses; international experience; effect of public attitudes and policy on people affected directly by AIDS. Green. (SS)

SPP 165. Contemporary Social Problems (3)
Studies of major problems facing contemporary society. (SS)

SPP 166. (AAS 166) Who Gets What?: The Social Problems of Wealth and Inequality (3)
Considers the existence of poverty amid affluence in the United States. Comparative studies of wealthiest and poorest among us, focusing on social values and social conditions. Sociological and historical analysis through debate on the causes of social problems related to the gap between the “Haves” and “Have-nots.” Washington. (SS)

SPP 308. (Psyc 308) Seminar in Social Psychology (3)
Intensive consideration of selected topics in current theory and research in social psychology. The subject matter varies from semester to semester, and includes such topics as the social psychology of education, the applications of perception and learning theory to social psychological problems, the social psychology of science, and the social environment of communication. May be repeated for credit. Prerequisite: Any one of the following introductory courses: Anth 11, Anth 12, SSP 5, SSP 21, or department permission. (SS)

SPP 312. (Psyc 312) Interpersonal Behavior in Small Groups (3)
Intensive consideration of theoretical and methodological issues in the analysis of the development of small groups. Prerequisite: Any one of the following introductory courses: Anth 11, Anth 12, SSP 5, SSP 21, or department permission. Rosenwein. (SS)

SPP 314. (Psyc 314) Attitudes, Attributions, and Actions (3)
Social perception and cognition as studied in current social psychology. Persuasion, conformity, prejudice, stereotypes, and other social processes in relation to attitude formation and change. Prerequisite: Any one of the following introductory courses: Anth 11, Anth 12, SSP 5, SSP 21, or department permission. (SS)

SPP 323. (Psyc 323) The Child in Family and Society (3)
Influences such as marital discord, family violence, poverty and prejudice on the development of the child from birth through adolescence. Prerequisite: Any one of the following introductory courses: Anth 11, Anth 12, SSP 5, SSP 21, or department permission. Herrenkohl. (SS)
SSP 325. (Hist 325, WS 325) History of Sexuality and the Family in the U.S. (4) fall
Social change from early agrarian communities to beginnings of industrialism, emphasizing socio-economic class, family structure, and treatment of women and minority groups. Shade, Soderlund. (SS)

SSP 326. (Hist 326, WS 326) Social Class in American History (4) spring
Changing role of women, minority groups, and the family during the industrial era. Development of the modern class structure and the impact of the welfare state. Prerequisite: any one of the following: Hist 10, 137, 138, or 139, or consent of history department chair. Simon. (SS)

SSP 327. (Jour 327) Mass Communication and Society (3)
A review of theories and research on the relationship of mass communication to social processes. Intensive analysis of selected media products (e.g., TV news, dramas, and sitcoms; films; print; music videos, etc.). Prerequisite: Any one of the following introductory courses: Anth 11, Anth 12, SSP 5, SSP 21, or department permission. Rosenwein (SS)

SSP 333. (PolS 333, Psyc 333) Social Psychology of Politics (3)
Political behavior viewed from a psychological and social psychological perspective. Prerequisite: Any one of the following introductory courses: Anth 11, Anth 12, SSP 5, SSP 21, or department permission. Rosenwein. (SS)

SSP 341. (WS 341) Women and Health (3)
Relationships of women to the medical system. Influence of medicine on women's lives and the impact of the women's movement on health care. Prerequisite: Any one of the following introductory courses: Anth 11, Anth 12, SSP 5, SSP 21, or department permission. Lasker. (SS)

SSP 351. (WS 351) Gender and Social Change (3)
Changes in gender roles from social psychological and structural perspectives. Comparative analyses of men and women (including people of color) in the social structure; their attitudes and orientations toward work, family, education, and politics. Prerequisite: Any one of the following introductory courses: Anth 11, Anth 12, SSP 5, SSP 21, or department permission. Spade. (SS)

SSP 355. Sociology of Education (3)
Education as a social institution. Statuses, roles, and relationships in the organization of schools; higher education as well as elementary and secondary schools. Prerequisite: Any one of the following introductory courses: Anth 11, Anth 12, SSP 5, SSP 21, or department permission. Spade. (SS)

SSP 356. (Psyc 356) Seminar in Personality Psychology (4)
Topics in personality psychology: the self, personality consistency, motivation, psychological adjustment. Prerequisite: SSP/Psyc 153 or consent of instructor. Williams. (SS)

SSP 359. (Rel 359) Sociology of Religion (3)
Religion as a central institution in society. Social functions provided by religion, for individuals and for the society as a whole. Social correlates of interindividual differences in religiosity. Religious sects and cults and why they exist in modern society. Prerequisite: Any one of the following introductory courses: Anth 11, Anth 12, SSP 5, SSP 21, or department permission. (SS)

SSP 361. (Psyc 361) Personality and Social Development in Adulthood (4)
Theories and current research. Prerequisite: SSP/Psyc 109 or consent of Psychology department chair. Hyland. (SS)

SSP 363. (Psyc 363) Personality and Social Development in Childhood (4)
Issues related to social development (e.g., attachment, social competence), social contexts (e.g., family, day care), and personality development (e.g., sex roles, aggression, temperament) from infancy through adolescence. Prerequisite: 107 or consent of instructor (SS)

SSP 364. (WS 364) Sociology of the Family (3)
Sociological analysis of families in the United States, including investigations of historical and contemporary patterns. Issues addressed include parenting, combining work and family, divorce and remarriage, family policies. Anth 363 is recommended in conjunction with this course. Prerequisite: Any one of the following introductory courses: Anth 11, Anth 12, SSP 5, SSP 21, or department permission. Spade. (SS)

SSP 366. Sociology of Aging (3)
Residential patterns, social policies and services for the aged. Alternative political strategies, health programs, living arrangements and workplace choices considered. The changing roles of the elderly in American and other societies, and the special problems they face. Impact of changing age structure. Prerequisite: Any one of the following introductory courses: Anth 11, Anth 12, SSP 5, SSP 21, or department permission. Lasker. (SS)

SSP 367. Sociology of Science (3)
Review of sociological, social psychological, and anthropological perspectives on science as a cognitive and social enterprise. Analysis of past and contemporary case studies as well as experimental/simulation research. Rosenwein. (SS)

SSP 370. Juvenile Delinquency (3)
The development of delinquent behavior within its social context; an analysis of delinquent gangs and subcultures and the variable patterns of antisocial activity; and the evaluation of institutional controls and treatment of the problem. Prerequisite: Any one of the following introductory courses: Anth 11, Anth 12, SSP 5, SSP 21, or department permission. Bell. (SS)

SSP 371. Special Topics (1-3)
Advanced work through supervised readings. May be repeated for credit. Prerequisite: consent of the department chairperson. (SS)

SSP 373. Seminar in Sociology (3) (SS)
Intensive consideration of selected topics in contemporary theory or research in sociology. The subject matter varies from semester to semester. May be repeated for credit. Prerequisite: Any one of the following introductory courses: Anth 11, Anth 12, SSP 5, SSP 21, or department permission.

SSP 374. Social Stratification (3)
Social inequality as an organizing principle in complex societies. Theories of wealth, class, and power. Sociological impact of education, occupation, and income on social status and social class. Prerequisite: Any one of the following introductory courses: Anth 11, Anth 12, SSP 5, SSP 21, or department permission. (SS)

SSP 379. (AAS 379) Race and Class in America (3)
This course focuses on the ways in which various categories and groupings within the social concepts of “race” and “class” have organized the American social, economic and political structure and shaped national and international policy. An overview of the distribution of wealth and political power in the United States provide the student with the opportunity to consider how and why “race” and “class” both together and separately can be used to explain racism, residential segregation, poverty, working class identity and the existence of a wealthy power elite in the United States. Washington. (SS)
SSP 391. (Psy 391) Evaluation Research (3)
Application of social research methods of evaluation of the effectiveness of social programs. Measurement, research design, criteria of effectiveness and decision making. Prerequisite: SR 111 or SR 112 or consent of department chairperson. Herrenkohl. (SS)

SSP 393. Research Apprenticeship (3-4)
Conducting sociological or social psychological research under the supervision of a faculty member. May be repeated for credit. Prerequisite: consent of the department chairperson. (SS)

SSP 399. Senior Thesis (3)
Research during senior year culminating in senior thesis. Required for sociology/social psychology majors seeking departmental honors. Prerequisites: declared major in sociology/social psychology and consent of the department chairperson.

For Graduate Students
The department offers a master's (MA) degree program in social relations. This thirty-credit program provides further preparation for an advanced degree and training for nonacademic careers. Students may concentrate in (1) health, family, and human development; (2) human ecology and social structure; (3) analysis of interaction processes, or (4) a program tailored to individual educational needs. All graduate students complete the program with a thesis. In conjunction with the Center for Social Research, the department offers many opportunities for research experience. For further information, students should contact the department chair or graduate program director.

SR 401. Proseminar in Applied Social Research
Specialized topics including advanced statistical and measurement techniques, computing methods, data base management, research design and specialized areas of research activity. Can be repeated for credit. Permission of instructor required.

SR 411. Advanced Research Methods (3) fall
A basic course given in research theory and methods. Consideration given to the nature of theory, hypotheses testing, the definition of variables and methods of measurement.

SR 412. Practicum in Research Methods (3) spring
Laboratory in the design and execution of research. Includes class project. Prerequisite: SR 411.

SR 413. Fieldwork in Social Relations (3)
Supervised work experience in a variety of field settings, e.g., hospital, public and private social service agencies and organizations.

SR 414. Survey Research (3)
Examination of survey methods, sample design, interview design, training of survey personnel, data management and analysis.

SR 416. (Educ 416) Quasi-Experimentation and Program Evaluation (3)

SR 461. Seminar in Social Relations (1-4)
Topics in social relations: anthropology, sociology and social psychology. Topics vary.

SR 470. Social Theory (3) fall
Major trends in social science theory in historical context. Comparison of the major theoretical perspectives with an emphasis on underlying philosophy and the development of critical capacities in students.

SR 471. Special Topics (1-3)
Intensive study in an area of social relations that is appropriate to the interests and needs of staff and students.

SR 472. Special Topics (1-3)
Continuation of SR 471.

SR 473. (Educ 473) Social Basis of Human Behavior (3)
Development of human behavior from a social psychological perspective. Emphasis placed on the impact of society upon school-age children and adolescents.

SR 477. Advanced Computer Applications (4) spring
Uses of computers in social sciences, including data collection, management, and analysis, simulations, and decision-making; includes weekly lab.

Spanish

See listings under Modern Foreign Languages.

Special Education

See listings under Education.

Speech

See listings as Communication under Journalism and Communication.

Technology, Interdisciplinary Courses

See listings under Science, Technology and Society.

Theatre

Professor: Jeffrey Milet, M.F.A. (Yale); Augustine Ripa, M.F.A. (Northwestern).
Associate professor: Pam Pepper, M.F.A. (Ohio), chairperson.
Instructor: Ardenic Hall-Karambe, M.A. (Southwest Texas State)
Assistant professors: Drew Francis, M.F.A. (Brandeis); Erica Holscher, M.F.A. (Northwestern)
Adjunct assistant professor: Jennie Gilrain, B.S. (Allegheny College), (Western Michigan University);
E. Laura Hausmann, B.F.A. (Boston Conservatory)

To study theatre is to examine its many internal disciplines. Acting and directing combine with design, technical theatre, dramatic literature and theatre history to form the body of our art. Students may pursue general theatre studies or focus on particular areas such as performance, design or history and literature. They may major in theatre, minor in theatre or participate strictly in our production program. Students may even complete a minor in theatre from outside the College of Arts and Science.

The bachelor of arts degree in theatre is granted after at least thirty-nine credit hours of study. Because we believe that undergraduate theatre education should be broad based with an emphasis on diversity of experience, students are encouraged to take a variety of courses outside the major. Many students complete double majors. Those with the talents and aspirations for a career in theatre have gone to graduate schools offering intense, pre-professional training. Other majors who have not pursued a theatrical career have gone from our program directly into careers in business, social services, sales. Theatre study is an excellent preparation for vocations in which self presentation is
important, such as law. The problem solving, analytical and interpersonal skills gained from this discipline are applicable across a wide range of careers. An understanding and appreciation of the complex art of the theatre will enrich a lifetime.

In addition to its academic courses, the department sponsors an active production program in which students, faculty and guest artists collaborate. Our main performance facility is the Diamond Theatre, a three-hundred seat thrust theatre housed in the Zoellner Arts Center. The core of our work in this space is dedicated to productions featuring primarily student actors directed by faculty or guest artists. When possible, a highly qualified student may direct or design in the main space. In addition to our own productions, we regularly invite outside professional performers and ensembles to work with us and perform. We also operate a lab theatre (Zoellner's Black Box Theatre) for student and faculty experimentation. The availability of valuable hands-on experience and the very close working relationships developed between students and faculty uniquely characterize the department of theatre.

The department enjoys a special relationship with Bethelheim's professional theatre company, Touchstone Theater. Performance and administrative internships with the company are available to qualified students and the department and Touchstone often collaborate on workshops and seminars.

Students interested in designing a major or minor in theatre should consult with the department chairperson. Experienced theatre students with questions regarding accurate placement in any theatre course should, likewise, consult with the Chairperson.

The department of theatre is accredited by the National Association of Schools of Theatre.

**Theatre Major**

Through the selection of appropriate electives, students may concentrate their major in one of these areas:

- ACTING/DIRECTING
- DESIGN/TECHNICAL THEATRE
- THEATRE HISTORY/DRAMATIC LITERATURE
- GENERAL THEATRE STUDIES

The major in theatre consists of 39-44 hours distributed as follows:

**Coursework required of all majors, 19-20 hrs**

- Thtr 55 Drama and (4)
- Thtr 127 Development of Theatre and Drama from Antiquity to Renaissance (4)
- Thtr 128 Development of Theatre and Drama from Renaissance to Present (4)
- Thtr 302 Acting, any appropriate level (3-4)
- Thtr 315 Senior Study (0)

**Production Requirement, 8 hrs**

Four active semesters of approved production activity, including Thtr 68, Costume Construction (2) and Thtr 67, Stagecraft (2), Thtr 61, Theatre Production (2) and or other approved production-related course will complete this requirement.

**Electives, 12-16 hrs**

Four courses carefully selected with an advisor, emphasizing Acting/Directing, Design/Technical Theatre, Theatre History/Dramatic Literature or General Theatre Studies.

**Recommanded electives from other departments:**

The departments of Art and Architecture, English, Modern Foreign Languages, Music and others all offer courses of value to a theatre major or minor. Consult with your advisor about enriching your academic career outside the theatre department.

**Theatre Minor**

The minor in theatre consists of at least 22 hours of course work selected in consultation with a departmental advisor. This includes at least 5 courses (18-20 hrs) AND two active semesters in theatre production totaling at least 4 credits. Fulfill the production requirement through Thtr 68, Costume Construction (2) AND/OR Thtr 67, Stagecraft (2), or another approved production-related course such as Thtr 61, Theatre Production (2). An approved minor in theatre will include some academic diversity beyond a single curricular area.

**Departmental Honors**

The exceptional student may elect to pursue departmental honors in the senior year. This student must have a GPA of 3.3 in all theatre courses presented for the major. No later than the fall of the senior year the student, with faculty supervision, elects a special project in a particular area of theatre. This may take the form of preparing to direct a play, researching a role to be performed, preparing a design presentation or researching in an area of theatre scholarship in preparation for the writing of a substantial report. In the next semester, usually the spring of the senior year, the report or project would be executed. The student would enroll in two, four-credit independent study courses, one each senior semester.

**The Acting Sequence**

Students with little or no prior acting experience should elect Theatre 11, Introduction to Acting, as their first course. Students with some prior acting experience should consult with the department chairperson for accurate placement and waiver of the Theatre 11 prerequisite.

**Courses in Theatre**

- **Thtr 1. Introduction to Theatre** (3)
  - Foundations of theatre: historical, literary and practical. (HU)

- **Thtr 2. Introduction to Theatre Lab** (1)
  - Open only to those concurrently enrolled in Theatre 1. Practical experience in various aspects of play production and theatre management. (HU)

- **Thtr 11. Introduction to Acting** (3)
  - Preparation for scene study and characterization. Recommended for students with little or no prior experience. (HU)

- **Thtr 12. Introduction to Acting Lab** (1)
  - Open only to those concurrently enrolled in Theatre 11. Practical experience in performance. (HU)

- **Thtr 54. (Ciss 54) Greek Tragedy** (3)
  - Aspects of Greek theatre and plays of Aeschylus, Sophocles, and Euripides in their social and intellectual contexts. Pavlock (HU)

- **Thtr 55. Dramatic Action** (4)
  - How plays are put together, how they work and what they accomplish. Examination of how plot, character, aural and visual elements of production combine to form a unified work across genre, styles and periods. Recommended as a foundation for further studies in design, literature or performance. (HU)

- **Thtr 56. Jazz Dance** (2)
  - Jazz dance styles and combinations. May be repeated for credit. Prerequisite: fee, and consent of chairperson. (HU)

- **Thtr 57. Modern Dance** (2)
  - Modern dance styles and combinations. May be repeated for credit. Prerequisite: fee and consent of chairperson (ND)

- **Thtr 58. (Ciss 58) Greek and Roman Comedy** (3)
  - Study of comedy as a social form through plays of Aristophanes, Menander, Plautus, and Terence. Pavlock (HU)

- **Thtr 61. Theatre Production** (2)
  - Selected or auditioned production positions of responsibility and/or leadership. May be repeated for credit. Prerequisite: consent of chairperson.
Thtr 67. Stagecraft (2)
Drafting, problem solving, stagecraft, rigging, materials and techniques. Practical experience in executing scenery for the stage. (HU)

Thtr 68. Costume Construction (2)
Techniques of sewing, pattern drafting and fitting. Practical experience in executing costumes for the stage. (HU)

Thtr 111. Theatre Sound (2)
Techniques, materials, and methods of designing sound for theatrical production. (HU)

Thtr 113. Lighting Design (4)
An introduction to the art and practice of lighting design for the stage. History of theatrical lighting design. Recommended prior or concurrent course: Thtr 55, Dramatic Action. (HU)

Thtr 115. Scene Design (4)
An introduction to the art and practice of scenic design for the stage. History of theatrical scenic design. Recommended prior or concurrent course: Thtr 55, Dramatic Action. (HU)

Thtr 127 (Engl 127). The Development of Theatre and Drama from Ritual to Renaissance (4)
Survey of Western theatre and dramatic literature from ritual origins to the Renaissance. (HU)

Thtr 128 (Engl 128). The Development of Theatre and Drama from Renaissance to Present (4)
Survey of Western theatre and dramatic literature from the Renaissance to the present. (HU)

Thtr 140 (AAS 140). African American Theatre (4)
Studies of African American theatre: literary, and practical and historical. May be repeated for credit. (HU)

Thtr 144. Directing (4)
Introduction to the director's craft. Research, rehearsal techniques, scene work. Prerequisite: Thtr 55, Dramatic Action, AND acting experience as determined by the department, or consent of chairperson. (HU)

Thtr 147. Characterization in Realism (4)
Elements of characterization through scene study in realistic drama. Recommended for students with some prior acting experience, or Thtr 111. (HU)

Thtr 148. Characterization in Expressionism (4)
Elements of characterization through scene study in expressionistic drama. Recommended for students with some prior acting experience, or Thtr 111. (HU)

Thtr 151. Costume Design (4)
The history and development of theatrical costume. Wardrobe and its relationship to art and culture. (HU)

Thtr 161. Theatre Design and Technology (4)
Theatre environments, equipment systems and acoustics. Functions and ethics. (HU)

Thtr 175. Special Projects (2-4)
Theatrical topics of current or special interest. Can be repeated for credit. (HU)

Thtr 181. Theatre Management (4)
Concepts, techniques and practices related to managing the theatrical enterprise. (HU)

Thtr 185. Production Seminar (4)
Practicum in various approaches to theatre production, e.g., performance ensemble. Prerequisite: audition, or consent of the chairperson. Can be repeated for credit. (HU)

Thtr 211 (Ger 211). Introduction to German Drama (4)
Drama as a literary genre; plays from various periods of German literature. (HU)

Thtr 214. Advanced Lighting Design (4)
Continuation of Theatre 113. Advanced lighting design problems and techniques. Prerequisite: Thtr 113. (HU)

Thtr 216. Advanced Scene Design (4)
Continuation of Theatre 115. Advanced design problems and techniques. Practical experience. Prerequisite: Thtr 115. (HU)

Thtr 218 (Ger 218). Goethe's "Faust" (4)
Study of Goethe's play with an introduction to the Faust tradition. (HU)

Thtr 236. Acting Presentational Styles (4)
Elements of characterization and scene study in presentational dramatic literature from classical through post-modern periods. Prerequisite: 100-level acting course, or consent of chairperson. (HU)

Thtr 244. Acting Shakespeare (4)
Monologue, scene study and ensemble work from Shakespeare's dramatic and poetic canon. Prerequisite: 100-level acting course, or consent of chairperson. (HU)

Thtr 245. Advanced Directing (4)
Continuation of Theatre 144. The director's voice. Supervised practical experience. Prerequisite: Thtr 144. (HU)

Thtr 271. Playwriting (4)
The art and practice of writing plays for the stage. (HU)

Thtr 275. Internship (2-4)
Professionally supervised work in the areas of performance, design, technical theatre, administration, and management. May be repeated for credit. Prerequisite: consent of chairperson.

Thtr 315. Senior Study (0)
Seminar for senior theatre majors. Enhancement of current theatre studies while preparing for further theatre studies or activity. Fall only.

Thtr 318. (Fren 318). Drama in the Twentieth Century (3)
Contemporary French drama with an analysis of its origins and movements. Armstrong. (HU)

Thtr 328. (Eng 328). Shakespeare (4)
An introduction to Shakespearean drama including comedies, histories, tragedies, and romances. Emphasis on textual study, cultural contexts, and performance strategies. Hawkes, Traister (HU)

Thtr 351. Advanced Special Projects (4-8)
Independent study in theatre. Prerequisite: consent of the chairperson. Can be repeated for credit. (HU)

Thtr 361. Research in Theatre Technology (2-4)
Solving technological problems in theatre. Application of new technologies. May be repeated for credit. Prerequisite: consent of chairperson. (HU)
Urban Studies

Urban Studies Committee. David Curtis Amidon, Jr M.A. (Penna State), associate professor of urban studies and director, urban studies program: Richard W. Barron, Ph.D. (Boston), professor of management; Frank T. Colon, Ph.D. (Pittsburgh), professor of government; Thomas J. Hylak, Ph.D. (Notre Dame), professor of economics; Roger D. Simon, Ph.D. (Wisconsin), professor and chairman of history; J. Bruce Thomas, Ph.D. (Berkeley), associate professor and chairman of architecture; Ivan Zaknic, M.Arch. and Urban Planning (Princeton), professor of architecture.

This is an interdepartmental major program intended for students who seek a broad background in the social sciences and for those with career interests in such fields as business or law, and such specialized areas as city management, architecture and urban planning, human relations, and the helping professions.

Instruction focuses on the process of urbanization, the problems and opportunities arising therefrom, the relationship between cities and economic growth, and public policies relating to cities.

A minimum of 36 credit hours is required, apportioned among two levels of study. Substitutions are possible with approval of the director, who advises all those with majors and minors in urban studies. The director's office is located at 232 Chandler-Ullmann Hall.

Undergraduate Major

I. required preliminary courses (11-12 credit hours)
US 61 The Study of Urbanization (4)
US 62 Contemporary Urban Issues (4)

one of the following research methods courses
Pols 221 Research in Political Science (4)
Eco 145 Statistical Methods (4)
Hist 202 Introduction to Historical Research (4)
Math 12 Basic Statistics (4)
SR 111 Research Methods of Social Relations (4)

Ill. elective courses (25 credit hours)
Any course may be elected from the following:
Eco 312 Urban Economics (3)
Eco 337 Transportation and Spatial Economics (3)
Pols 177 Urban Politics (4)
Pols 260 Public Administration (4)
Hist 334 American Urban History (4)
Soc 370 Juvenile Delinquency (3)
US 363 Philadelphia: Development of a Metropolis (4)
Up to two Architectural History courses numbered 100 or higher
Up to two courses may be elected from the following:
Eco 354 Public Finance: State and Local (3)
Pols 231 Government and Law Internship (4)
(Pols 232 may be offered instead of Pols 231)
Hist 326 Social Class in American History (4)
US 125 American Ethnic Groups (4)
US 371/372 Special Topics (1-8)

Participants in off-campus programs, such as the Philadelphia or Washington semesters, may receive credit for up to three elective courses, depending upon the content of those courses, but they must also complete at least four courses in the first group of electives above.

Urban studies minor. The minor consists of US 61 and four or five additional courses from an approved list for a total of eighteen credit hours.

Undergraduate Courses

61. The Study of Urbanization (4) spring, 1998
Introduction to the study of cities. Emphasis on sources of economic vitality, especially entrepreneurialism, and on causes of social and material decay. Amidon. (SS)

62. Contemporary Urban Issues (4) spring, 1999
Analysis of problems, typically including planning, housing, crime, and racial conflict, with strong emphasis on twentieth-century New York City. Amidon. (SS)

75. Culture Wars (3) fall
Conservative perspectives on the most divisive issues in American life today including, among others, race, crime, homelessness, family life, feminist and gay/lgbtqq agendas, and the role of government in the economy. Political bias in the media and the academy. Extensive analysis of feature films. Amidon. (SS)

81. Americans from Italy (3) summer
The immigrant generation seen through autobiographies and fiction. Attitudes of and toward Ilotile Americans in recent times, especially as reflected in feature films and in politics. Struggles to preserve traditional values. Amidon. (SS)

Jewish influences on American higher education and popular culture, with special attention to the movie industry. Sources of Jewish liberalism and Leftism. Neo-conservatism and other adjustments to the wielding of serious power in American life. Mutual hostilities between secularized Jews and Orthodox Jewry, conservative Catholics, evangelical Christians, and African-Americans. Jewish roles in party politics and journalism. Amidon. (SS)

88. The Lost World of Protestant America (3)
Decline of the once-dominant American cultural group in relative size, self-confidence, cohesiveness, and religious conviction. Myth and reality in the work of such figures as Horatio Alger, Zane Grey, Norman Rockwell, and Walt Disney. Individualism, communalism, and constitutional conflict. Seminar format with limited enrollment. Amidon. (SS)

125. American Ethnic Groups (4) spring, 1999
Immigration to the United States; patterns of conflict and accommodation; emphasis on recent confrontations in New York and Los Angeles. Amidon. (SS)

363. Philadelphia: Development of a Metropolis (4) fall
Philadelphia as an experiment in the deliberate creation of a new community; the rise and fall of the Protestant elite; immigration, industrialization, and vigorous growth, 1681-1929; liberalism and the collapse of a great city. Amidon. (SS)

371/372. Special Topics (1-8)
A seminar on a topic of special interest in urban studies. Prerequisite: consent of the program director. (SS)

Women's Studies

Robin S. Dillon, Ph.D. (Pittsburgh), Director of Women's Studies and associate professor of Philosophy.

Professors. Rosemarie Arbour, Ph.D. (Illinois), professor of English; Elizabeth N. Fifer, Ph.D. (Michigan), professor of English; Edward J. Gallagher, Ph.D. (Notre Dame), professor of English; Thomas J. Hylak, Ph.D. (Notre Dame), professor of Economics; Judith N. Lasker, Ph.D. (Harvard), professor of Sociology and Anthropology; Laura Katz Olson, Ph.D. (Colorado), professor of Government; C. Robert Phillips, Ph.D. (Brown), professor of History; William G.
Shade, Ph.D. (Wayne State), professor of History: Laurence J.
Silberstein, Ph.D. (Brandeis), Philip & Muriel Berman Professor of Jewish Studies and professor of Religion Studies; Jean R. Soderlund, Ph.D. (Temple), professor of History: Jan S. Fergus, Ph.D. (C.U.N.Y.), professor of English.

Associate professors. Colleen M. Callahan, Ph.D. (North Carolina), associate professor of Economics; Lucy C. Gans, M.F.A. (Pratt), associate professor of Art and Architecture; Diane T. Hyde, Ph.D. (Syracuse), associate professor of Psychology; Jill E. Schneider, Ph.D. (Wesleyan), associate professor of Biological Sciences; Joan Z. Spade, Ph.D. (SUNY, Buffalo), associate professor of Sociology and Anthropology; Lloyd H. Steffen, Ph.D. (Brown), University Chaplain and associate professor of Religion Studies; Hannah W. Stewart-Gambino, Ph.D. (Duke), associate professor of Government; Nicola B. Tannenbaum, Ph.D. (Iowa), associate professor of Sociology and Anthropology; Lenore E. Chava Weissler, Ph.D. (Pennsylvania), Philip and Muriel Berman Chair of Jewish Civilization and associate professor of Religion Studies; Marie-Helene Chabut, Ph.D. (U.C. San Diego), associate professor of French; Gail A. Cooper, Ph.D. (California-Santa Barbara), associate professor of History.

Assistant professors. John Pettigrew, Ph.D. (Wisconsin); Patricia Turner, Ph.D. (Michigan).

Lecturer. Ernest Green, Jr., Ph.D. (Pennsylvania), lecturer in Sociology and Anthropology.

The minor in Women's Studies engages students in the study of two interrelated subjects. The first is an examination of the cultural, historical, and social experiences and contributions of women. The second is an exploration of gender (i.e., the social construction of differential identity for males and females) and of the many ways in which gender distinctions have shaped human consciousness and human society.

Nearly all academic disciplines have defined human nature and significant achievement in terms of male experience and have underestimated the impact of gender on social structures and human lives. By contrast, Women's Studies courses attend to the diverse experiences and perspectives and acknowledge the critical significance of gender. By shifting the focus to women and gender, Women's Studies seeks to provide an alternative paradigm for understanding human experience. Students in Women's Studies courses are encouraged to reevaluate traditional assumptions about human beings, human knowledge, and human culture and society, and to explore non-sexist alternatives for a more fully human social order.

The Women's Studies Program has several major goals: to expand students understanding of women's present status and rich history; to stimulate a critical examination of the impact of gender roles and stereotypes on social structures and individual lives; to evaluate proposals for alternative arrangements; and to connect issues addressed in the classroom with those raised in personal, political, and cultural contexts. The program challenges students to think beyond the boundaries of traditional gender roles, traditional disciplines, and established institutions. In the best tradition of a liberal arts education, Women's Studies encourages women and men to think critically and constructively, to redesign knowledge, and to gain a better understanding of themselves and their world. The minor in Women's Studies consists of a minimum of 18 credit hours (6 courses). Students pursuing the minor are required to take the introductory course (WS 101) and one upper-level course from among those concerned with the theory and practice of Women's Studies. The remaining 4 courses must include at least one course in the arts and humanities and one course in the natural and social sciences. Students arrange their program in consultation with the Program Director, Professor Robin Dillon, Department of Philosophy.

Elective Courses (12 credit hours)
WS 41/541 Human Sexuality (3)
WS 428R 42 Sexual Minorities (3)
WS 121/Art 121 Women in Art (3)
WS 123/Anth 123 Cultural Construction of Gender (3)
WS 124/Hist 124 Women in America (4)
WS 130/Eco 130 Economics of Race and Gender (2)
WS 138/Rel 138 Women in Jewish History (4)
WS 152/Clsl 152, Hist 152 Women in Antiquity (4)
WS 158/Rel 158 Sex and Gender in Judaism: The Feminist Critique (4)
WS 179/Pols 179 Politics of Women (4)
WS 184/Rel 184 Religion, Gender, and Power (4)
WS 226/Phil 226 Feminism and Philosophy (3)
WS 311/Eng 311 Literature of Women (3)
WS 318/Psych 318 Seminar in Gender Psychology (4)
WS 325/Hist 325 History of Sexuality and the Family in the U.S. (4)
WS 326/Clsl 326, Hist 326 Social Class in American History (4)
WS 327/Fren 327 Women Writing in French (4)
WS 341/Soc 341 Women and Health (3)
WS 351/Soc 351 Gender and Social Change (3)
WS 353/Hist 353 Women in European History, 1500-Present (4)
WS 364/Soc 364 Sociology of the Family (3)
WS 91, 191, 272, 291, 371, 381, 391, 392 Special Topics (1-4)

In addition, new courses may be offered annually. Students should check with the Director for an updated list.

Undergraduate Courses in Women's Studies
Description of Required Courses (6 credit hours)

WS 101. Introduction to Women's Studies (4)
Placing women's experience at the center of analysis, the course introduces students to the key concepts, theoretical frameworks, and interdisciplinary research in the new scholarship on women. Examines how gender interacts with race, age, and class to shape human consciousness and determine the social organization of human society. (HU)

WS 271. Independent Reading and Research (1-3)
Independent study of selected topics designated and executed in close collaboration with member of Women's Studies faculty. Students taking this course as a requirement for the minor must elect the three-credit option. Prerequisite: consent of program director. (SS)

WS 330. Internship in Women's Studies (3)
Supervised work in women's organizations or settings, combined with an analysis, in the form of a major paper, of the experience using the critical perspectives gained in Women's Studies courses. Placements arranged to suit individual interests and career goals; can include social service agencies, women's advocacy groups, political organizations, etc. May be repeated for credit. Prerequisite: WS 101 and consent of program director. (SS)

WS 350. Senior Seminar (3)
An upper-level seminar that challenges students to systematize insights gained from introductory and elective courses by applying the interdisciplinary methodology of Women's Studies to a focused topic. Subject matter varies semester to semester. Offered by Women's Studies faculty on a rotating basis. May be repeated for elective credit. Prerequisite: WS 101, or consent of program director. (SS)
Undergraduate Elective Courses in Women’s Studies

Description of Elective Courses (12 credit hours)

**WS 41. (SR 41)** Human Sexuality (3)
Sexuality and gender roles across the life cycle, including human reproduction, decision-making, and the societal regulation of sexual behavior. (ND)

**WS 42. (SR 42)** Sexual Minorities (3)
How minority sexual identities have been the subject of speculation, misunderstanding, and sometimes violent attempts at correction or elimination. Sexual orientation, gender role, including transvestism and "drag", transsexualism, sexism, heterosexism, and homophobia. Emphasis on critical thinking, guest speakers, and discussions. Green. (SS)

**WS 121. (Art 121)** Women in Art (3)
Women artists from Renaissance to present. Attitudes toward women artists and their work; changing role of women in art world. Visits to museums and artists' studios. May be repeated for credit, as topic varies. Gans. (HU)

**WS 123. (Anthr 123)** Cultural Construction of Gender (3)
Comparative study of the meanings and social roles associated with gender. Psychological, symbolic, and cultural approaches. Tannenbaum. (SS)

**WS 124. (Hist 124)** Women in America (4)
Roles of women in American society from colonial to present times; attitudes toward women, female sexuality, women's work, and femininity. Cooper, Shade. (SS)

**WS 130. (Eco 130)** Economics of Race and Gender (2)
The question of the role of race and gender in economic decision-making is explored. Various sorts of discrimination are discussed in an economic framework and possible remedies are evaluated. The historical role of race and gender in the economy is also discussed. Prerequisite: Eco 11 or Eco 1. Department permission required. (SS)

**WS 138. (Rel 138)** Women in Jewish History (4)
Contributions of, and limitations on, women at different stages of Jewish history, using both primary sources and secondary material. Experience of modern Jewish women, and the contemporary feminist critique of traditional gender roles. Weissler. (HU)

**WS 152. (Chs 152, Hist 152)** Women in Antiquity (4)
Interdisciplinary study of women in Greece and Rome. Literary, archaeological and historical evidence and approaches. Cross-cultural material. Phillips. (HU)

**WS 158. (Rel 158)** Sex and Gender in Judaism: The Feminist Critique (4)
Writings by Jewish feminists reflecting the encounter between Judaism and feminism: prayer and ritual, women rabbis, God and God language, communal power, and marriage and divorce. Silberman. (HU)

**WS 179. (Pols 179)** Politics of Women (4)
Major social and political issues relating to the role of women in American society. Study of other countries will be included for comparative analysis. Olson. (SS)

**WS 184. (Rel 184)** Religion, Gender and Power (4)
Gender differences as one of the basic legitimations for the unequal distribution of power in Western society. Feminist critiques of the basic social structures, cultural forms, and hierarchies of power within religious communities, and the ways in which religious groups have responded. Silberman. (HU)

**WS 226. (Phil 226)** Feminism and Philosophy (3)
Analysis of the nature, sources and consequences of the oppression and exploitation of women, and justification of strategies for liberation. Topics include women’s nature and human nature, sex roles and gender differences, sexism, femininity, sexuality, reproduction, mothering. Dillon. (HU)

**WS 311. (Engl 311)** Literature of Women (3)
Women's works about women: is literary creativity gender-identified? Are there specifically “feminine” subjects or themes? Besides re-reading some familiar fiction, drama, and poems, introduction to contemporary and often experimental works by less famous writers. Arbur. (HU)

**WS 318. (Psych 318)** Seminar in Gender Psychology (4)
Gender as shaped by psychological and social psychological processes. Socialization, communication power, gender stereotypes, methodological issues in sex differences research. Prerequisite: Psych 210 completed or concurrent or permission of instructor. Hyland. (SS)

**WS 325. (Hist 325, SSP 325)** History of Sexuality and the Family in the U.S. (4)
Changing conceptions of sexuality and the role of women, men, and children in the family and society from the colonial to the post-World War II era. Emphasis on the significance of socio-economic class and cultural background. Topics include family structure, birth control, legal constraints, marriage, divorce, and prostitution. Soderlund, Shade. (SS)

**WS 326. (Hist 326, SSP 326)** Social Class in American History (4)
Emphasis on the 19th and 20th centuries, focusing on: emergence of a white collar middle class; conditions and treatment of the poor and growth of the welfare state; conditions of industrial workers, struggle to organize unions and their later decline; indicators of social status and exclusion among the rich; changing distribution of income and wealth over time; and the extent of social mobility. Simon. (SS)

**WS 327. (Fren 327)** Women Writing in French (4)
Reading and discussion of works written by women in French. The emphasis is on 19th and 20th Century writers, such as G. Sand, Colette, S. de Beauvoir, M. Duras, Andree Chedid. (HU)

**WS 341. (Soc 341)** Women and Health (3)
Relationships of women to the medical system. Influence of medicine on women's lives and the impact of the women's movement on health care. Prerequisite: an introductory department course (Anth 11, Anth 12, SSP 5, or SSP 21), or consent of the department chair. Lasker. (SS)

**WS 351. (Soc 351)** Gender and Social Change (3)
Changes in gender roles from social psychological and structural perspectives. Comparative analyses of men and women (including people of color) in the social structure; their attitudes and orientations toward work, family, education, and politics. Prerequisite: an introductory department course (Anth 11, Anth 12, SSP 5, or SSP 21), or consent of the department chair. Spade. (SS)

**WS 353. (Hist 353)** Women in European History, 1500-present (4)
Examines the position of women in Europe since the Renaissance. Particular attention to changing conceptions of women and their roles in society, the evolution of “women’s work”, the origins, growth and impact of feminism, and gender distinction as reflected in law, politics, popular culture, and leisure. Turner. (SS)

**WS 364. (Soc 364)** Sociology of the Family (3)
Sociological analysis of families in the United States, including investigations of historical and contemporary patterns. Issues addressed include parenting, combining work and family, divorce and remarriage, family policies. Anth 363 recommended in conjunction with this course. Prerequisite: Any one of the following introductory courses: Anth 11, Anth 12, SSP 5, SSP 21, or departmental permission. Spade. (SS)

**WS 91, 191, 272, 292, 371, 381, 382, 391, 392. Special Topics (1-4)**
Intensive study of a topic of special interest not covered in other courses. May be cross-listed with relevant offerings in major department or other programs. May be repeated for credit as topic varies. Prerequisite: consent of program director. (ND)
VI.

An Overview from Past and Present

Lehigh University is independent, nondenominational, and coeducational.

Founded in 1865 as a predominantly technical four-year school, the university now has approximately 4,400 undergraduates within its three major units—the College of Arts and Science, the College of Business and Economics, and the College of Engineering and Applied Science—and approximately 2,000 students enrolled in graduate programs offered through the Graduate School in these colleges and in the College of Education. There are undergraduates from nearly every state and U.S. territory and more than forty foreign nations.

The university is primarily situated on the Asa Packer Campus on the north slope of South Mountain overlooking Bethlehem, Pennsylvania. Sayre Park, the wooded refuge located toward the top of the mountain, is the setting for many living groups. The residences are reached via winding private roads. Many residential units on campus command a panoramic view of the Lehigh Valley. The Appalachians are visible to the west, with an especially good view from The Lookout on the Packer Campus. Both the tower and dining room in Jacaranda Hall on the new Mountaintop Campus afford panoramic views of the Lehigh Valley. The campus at its highest point is 971 feet above sea level.

A substantial portion of the upper level of Lehigh’s Campus is maintained as a nature preserve. The preserve supports deer, squirrels, chipmunks, raccoons, wild turkeys and other birds.

Besides the Asa Packer Campus, the university has extensive athletic fields and facilities on the Murray H. Goodman Campus, two miles to the south in Saucon Valley. The university acquired the Mountaintop Campus at the end of 1986. It links the Asa Packer and Murray H. Goodman campuses and brings total land holdings in Bethlehem to 1,600 acres, nearly double the former total.

The board of trustees and university officers have established and enforce policies designed to preserve Lehigh’s natural beauty. It is their contention that the environment in which the young adult university student pursues knowledge can make the total educational experience more meaningful, and that the ideal environment is separate and unique from the distractions of the non-academic community.

There are approximately 400 members of the faculty, teaching a total of more than 2,000 course titles (not all of which are offered every semester). Among faculty members who are tenured and to whom the university has a permanent commitment, nearly all hold the doctorate degree (typically Ph.D. or Sc.D.).

In total, there are more than 2,000 employees of the university, making it the second-largest employer in the community.

History and Purpose

The principal author of the brief history of Lehigh University that follows, Dr. W. Ross Yates, holds the bachelor of arts and master of arts degrees from the University of Oregon, in his native state. He received the doctor of philosophy degree from Yale University and studied in France on a Fulbright Scholarship. He joined the Lehigh staff in 1955 and served as dean of the College of Arts and Science from 1963 to 1972. Today he is professor emeritus of government, and lives in Oregon.

When the sound of the last cannon of the Civil War died away, statesmen, educators, and industrial pioneers marshalled the victorious forces of the North and turned their attention to education. They wanted to increase the number of trained scientists, engineers, and other skilled people so they could transform the vast natural resources of the country into a strong and independent national economy.

Asa Packer was one of the industrial pioneers. He built the Lehigh Valley Railroad and controlled a coal-mining empire in the mountains of eastern Pennsylvania. He knew, as did many others, that a strong national economy depended on more than technical skills. It needed above all people broadly educated in the liberal arts and sciences—people who could combine practical skills with informed judgments and strong moral self-discipline. He kept this in mind when founding and endowing Lehigh University.

The site that Packer chose for his university was a railroad junction across the Lehigh River from Bethlehem, a community founded in 1741 by Moravian missionaries. William Bacon Stevens, Episcopal bishop of the Diocese of Pennsylvania and the first president of the university’s board of trustees, in 1869 described the origin of the university as follows:

“In the fall of 1864 an interview was requested of me by the Hon. Asa Packer, of Mauch Chunk (now Jim Thorpe), Pa. He came to my house in Philadelphia, and said that he had long contemplated doing something for the benefit of his State, and especially of the Lehigh Valley. From that valley he said he had derived much of the wealth which GOD had given to him, and to the best interests of that valley he wished to devote a portion of it in the founding of some educational institution, for the intellectual and moral improvement of the young men of that region.

“After conversing with him a little while, and drawing out his large and liberal views, I asked him how much money he purposed to set aside for this institution, when he quietly answered that he desired to give $500,000. At the time of this interview no one in this country, it is believed, had offered in a single sum such an endowment for a literary institution. It was the noblest offering which an American had ever laid on the altar of learning, and more than equaled many royal donations which have carried down the names of kings as patrons of European universities.

“Filled with profound emotions at the mention of such a gift for such an object, I asked the noble donor what specific plans he had dreamed in his own mind in reference to it. His reply was, ‘I am not much acquainted with these matters, but you are, and I want you if you will to devise a plan which I can put into effective operation.’ I told him that I would make the attempt. I did so. I drew up the outline sketch of such an institution as I thought would give the largest results for the means used, and submitted it in a few weeks to his inspection.

“He examined it with the practical judgment and business habits with which he deals with all great questions, and adopted the scheme as the basis of his future university.

“The first meeting of the Board of Trustees, selected by Judge Packer, met at the ‘Sun Hotel,’ in Bethlehem, July 27th, 1865, and began to organize the work before them.”

The trustees followed several principles in setting up the university. One was that of combining scientific and classical education. They considered both to be practical. The principle carried forward an ideal of the great 17th-Century Moravian educator, John Amos Comenius. A motto taken from the works of Francis Bacon was used to summarize this principle, namely, Homo minister et interpretes naturae—man, the servant and interpreter of nature, to use a free translation. That motto lives on at Lehigh, being an element in the university seal.

The trustees chose as first president a man whose education and habits expressed this principle, Henry Coppee. They established five schools, including a school of general literature in addition to four scientific schools of, respectively, civil engineering, mechanical engineering, mining and metallurgy, and analytical chemistry.
Another principle upon which the trustees insisted was that of keeping the size of the student body proportionate to the abilities of the faculty to teach them well. The university would admit only as many freshmen each year as it could be assured of providing with the highest quality of education. In the 19th Century the total enrollment never exceeded several hundred students; the size has increased significantly in recent decades, along with the number of faculty members.

The trustees also insisted that Lehigh was to be non-denominational and would have an admission policy based on merit. Competitive examinations were held for applicants for admission. From 1871 to 1891 no tuition was charged, but the national financial crisis at the turn of the century decimated the value of the Lehigh Valley Railroad stock that Packer had given to Lehigh, which was the principal source of income.

At first the student body was entirely male. The contemporary ideological climate would permit nothing else. But around 1916, women were admitted to graduate programs. In 1917, the university opened its undergraduate program to them as well. Today men and women applicants are considered on equal basis, and in the class that entered in 1986 more than 35 percent of the students were female.

From the first, the students were serious-minded. In 1924, Catherine Drinker Bowen, daughter of president Drinker and later a famous biographer, published a brief History of Lehigh University, in which she commented:

"Ask any college professor which brand of boy he would prefer to teach, the cigarette brand or the flannel shirt variety. Right here we offer ten to one the flannel shirts... Lehigh still holds to the emblem of the flannel shirt—long may it wave! Engineers come to college to work. A writer in the Syracuse Post in 1895 spoke truthfully when he said, 'From the first, Lehigh's characteristic has been her earnestness. It is the boast of her graduates, the inspiration of her students. Men go there to learn to take a useful part in the economy of life'."

The university community was constantly infused with new faculty and students determined to renew and rework the original principles in the light of changing times. The students' ambition and zeal bore fruit; as alumni they carried the university's educational goals into the work of nation-building. And, having received, they gave to perpetuate Lehigh's work of service.

Today, Lehigh University still adheres to Assa Packer's goal of a liberal and scientific education for practical service. Faculty and students work to maintain high quality in instructional programs. Generous support from individuals, foundations, industry, and government help Lehigh to retain high quality of education and faculty while keeping tuition as low as possible. (Tuition covers only a part of the cost of a Lehigh education.)

**Presidents of the University**

The presidents of Lehigh University are described and their achievements cited in the following paragraphs. The years in parentheses are those served in the presidency.

**Henry Coppee (1866-1875).** Coppee served as a railroad engineer in Georgia, a captain in the Army during the Mexican War, and taught at West Point and at the University of Pennsylvania before becoming first president in 1866.

Much building was done on the new university campus. A Moravian church on Packer Avenue was remodeled into Christmas Hall; a house for the president was erected on campus; and Packer Hall, the university center, was built.

Coppee lectured in history, logic, rhetoric, political economy, and Shakespeare.

**John McDowell Leavitt (1875-1880).** Leavitt was an Episcopal clergyman who graduated from Jefferson College and taught at Kenyon College and Ohio University. During his incumbency, the university was divided into two schools, General Literature and Technology. As of 1876, a student could receive two engineering degrees by taking a longer course, and beginning in 1877 the master of arts, doctor of philosophy, and doctor of science degrees were established.

Linderman Library rotunda was completed in 1877. Assa Packer died in May, 1879; and Founder's Day was held in his honor the following October.

**Robert Alexander Lamberton (1880-1893).** Lamberton, a graduate of Dickinson College, practiced law in Harrisburg, Pa., and was a university trustee when asked to become president. During his administration, students and the community witnessed the first Mustard and Cheese dramatic presentation.

A gymnasium (now Coppee Hall) was erected, and Chandler Chemistry Laboratory was built, now known as Chandler-Ullmann Hall. Lehigh was also building its reputation for academic excellence; the mechanical engineering department was established in 1881 and the Lehigh chapter of Phi Beta Kappa was founded in 1887.

**Thomas Messenger Brown (1893-1904).** Brown studied medicine at the University of Pennsylvania and went abroad to study chemistry. Thereafter he was professor of chemistry at Lafayette College. In 1895 he presided the presidency of Lehigh and was greatly interested in furthering the university's development as a technical school.

His first years were difficult ones because the Panic of 1893 decimated the university's stock holdings in the Lehigh Valley Railroad. Nevertheless, Lehigh managed to grow in enrollment, academics, and in physical plant. Williams Hall was completed. The curriculum leading to a degree in arts and engineering was established, as was the department of zoology and biology. New curricula were adopted in metallurgical engineering, geology, and physics.


**Henry Sturgis Drinker (1905-1920).** Drinker, an 1871 Lehigh graduate, was the only university alumnus ever to become president. In 1907, the alumni endowment fund began, the Lehigh Alumni Bulletin was first published in 1913, and the Alumni Association was incorporated in 1917.

Drinker, besides being a lawyer, was a mechanical engineer and had been largely instrumental in solving the problems of constructing the two-mile-long Musconetcong Tunnel, an engineering feat that made possible a railroad line between Easton, Pa., and New York City. He started a tradition of businesslike management of university affairs.

During Drinker's years, more buildings were completed: the original section of Fritz Engineering Laboratory, Brown Hall, Coxe Mining Laboratory, Taylor Hall, Taylor Gymnasium and Field House, Taylor Stadium and Lamberton Hall. Drinker's interest in horticulture led to the planting of many rare trees and plants.

A teacher's course and business administration course were begun in 1909, and in 1918 the university was divided into three colleges, liberal arts, business administration, and engineering—the roots of the colleges of today. Army ROTC was established in 1919.

Drinker's daughter, Catherine Drinker Bowen, went on to become a historical writer of note. Her experiences as the daughter of a Lehigh president and occupant of the President's House are recorded in Family Portrait (Atlantic Little-Brown).

Drinker resigned in 1920 and Natt M. Emery, vice president, served as chief executive officer until 1922.

**Charles Russ Richards (1922-1935).** Richards took office in 1922. During his presidency, the first graduate degrees were awarded to women. Lehigh faced a shortage of students from 1929 to 1936 as a result of the Depression, but the newly established office of admission, as well as university scholarships, fellowships, and deferred tuition payments, helped to ease the shortage.

Changing concepts of education were evident in several newly organized academic offerings: philosophy, music, psychology, journalism, history, and fine arts. The majors system was instituted as were the senior comprehensive examinations in the Arts College. The placement bureau, a public relations office, and a student health service were organized.
The Alumni Memorial Building—a memorial to the Lehigh alumni who served in World War I—and Packard Laboratory both were completed in 1925. In the same decade, a major addition to Linderman Library also was completed.

Clement C. Williams (1935-1944). Williams, a civil engineer, was president during an era of unprecedented alumni support. Undergraduate enrollment rose to an all-time high, passing 2,000 in 1938. Richards and Drinker residential houses, and the Ulmann wing adjoining the Chandler Chemistry Laboratory, were built. Grace Hall, the first arena-type facility of any size on campus, was completed in 1940, the gift of Eugene G. Grace, an 1899 graduate, who headed the board of trustees. A Graduate School implemented the programs in the three colleges. Williams retired in 1944, and the university was without a president for approximately two years.

Martin Dewey Whitaker (1946-1960). Dr. Whitaker, who had been director of the Atomic Energy Commission Laboratory at Oak Ridge, Tenn., and had worked in developing the atomic bomb, faced the responsibility of helping the university community readjust to peacetime conditions after World War II.

During his time as president, Lehigh’s assets nearly tripled; the endowment more than doubled to $18 million. Many buildings were renovated, and the Dravo House and McClintic-Marshall House residence halls were built. The faculty increased in number by 75 percent and the first endowed distinguished professorships were established.

The Centennial development program was begun in 1959. It raised more than $22 million for faculty salaries and construction that later included Whitaker Laboratory.

An extensive renovation and enlargement project associated with Packer Hall was undertaken in 1957, and, upon completion in 1958, the building became a university center.

Academically, during the Whitaker years 120 departments offered the master’s degree and twelve the doctor of philosophy.

Whitaker died in office.

Harvey A. Neville (1961-1964). Dr. Neville was the only faculty member ever elected president. His association with the university began in 1927 as an assistant professor of chemistry. During his three-year term as president, the first phase of the Saucon Valley athletic complex was completed, and Sayre Field was opened atop South Mountain. The Center for Information and Computing Science was established.

Dr. Neville, a strong supporter of research who fostered its growth on the campus, died in 1983.

Deming Lewis (1964-1982). Willard Deming Lewis became president after a distinguished career as a space engineer and research administrator.

Dr. Lewis comes from a remarkable family that traces its American roots to William Lewis, an Englishman who settled in the Massachusetts Bay Colony in 1640. His great-grandfather and grandfather were presidents of the Lewis Manufacturing Co., a textile firm in Walpole, Mass. Willard Lewis, Deming’s father, moved to Augusta, Ga., and eventually became owner of Riverside Mills there.

Deming was admitted to Harvard at age fifteen, but his mother thought him too young to attend. So he waited and entered Harvard at age sixteen, eventually receiving three degrees there, as well as two degrees from England’s Oxford University, where he was a Rhodes Scholar in advanced mathematics. At Harvard, Lewis worked with Ted Hunt, the father of high fidelity, writing the equations describing a stylus sliding through a warped groove.

In 1941, Lewis joined Bell Telephone Laboratories, and in 1962 he was one of four executives who initiated Bellcomm, Inc., in Washington, D.C., which engineered systems for the Apollo project that placed the first man on the moon.

Lewis, who died in 1989, holds thirty-three U.S. patents on such devices as microwave antennas and filter and digital error detection systems.

During the Lewis administration, undergraduate women were admitted in 1971, and the university’s visiting committees were established in 1964. New programs included majors in natural science, biology, social relations, geological sciences, environmental science and resource management, and religious studies. Minors for engineering students in such fields as business, history, and social sciences were begun. Interdisciplinary majors such as computer engineering, computing and information science, applied mathematics, management science, American studies, and many others were instituted. Six research centers and seven institutes were established, including the Biotechnology Research Center.

The first phase of the New Century Fund capital campaign yielded $1.1 million more than its goal of $30 million; the second phase, which brought the campaign to a conclusion in 1985, raised more than $100 million.

Construction included the following: Maginnes Hall; Whitaker Laboratory; Mart Science and Engineering Library; the Central Heating and Refrigeration building; Sinclair Laboratory; the Seeley G. Mudd Buildings, and Neville Hall, Rathbone Hall dining room; thirteen fraternity houses, the Centennial I and Centennial II residential complexes; the Trembley Park student apartment complex; the Saucon Village Apartments complex, completion of the acquisition of the Saucon Valley athletic lands and the construction there of the Varsity House, the squash courts, the Philip Rauch Field House and Stabler Athletic and Convocation Center, and Broadhead House, a six-story residence hall. In addition, the restoration of Packer Memorial Church was completed, as well as a million-dollar renovation of Packard Laboratory. Plans were made for the E. W. Fairchild-Martindale Library and Computing Center.

The original Physics Laboratory is now named in Dr. Lewis’s honor.

Dr. Peter Likins (1982-present). Dr. Likins became eleventh president in 1982. Under his guidance Lehigh continues to seek balanced excellence in undergraduate programs while pursuing focused objectives in graduate study and research.

The Likins presidency has been characterized by achievement and action. In 1986, for example, Lehigh completed construction and implementation of its state-of-the-art telecommunications system, a $20-million-plus project. As a result, all university buildings and residential facilities are wired to allow students and faculty maximum access to information and each other via the voice-and-data telecommunications network. Completion of the network approximately coincided with the dedication in 1985 of the E.W. Fairchild-Martindale Library and Computing Center, which affords to the campus community one of the most automated library facilities available anywhere.

In 1986, a building adjoining the campus, at 200 W. Packer Ave., was named the Harold S. Mohler Laboratory, honoring the former chairman of the board of trustees. The building has been renovated to accommodate the Lehigh Industrial and Manufacturing Systems Engineering program.

In the fall of 1986, a dedication was held for the Sherman Fairchild Center for the Physical Sciences, an outstanding facility encompassing the renovated 1890s-era Physics Building (renamed Lewis Lab in 1994), the contemporary Sherman Fairchild Laboratory, and a new structure linking the two and providing an imposing entrance to physics facilities. The new building includes a 260-seat auditorium.

Also in 1986, the university purchased research facilities and land from Bethlehem Steel Corp. to establish what is now called the Mountaintop Campus, an area southeast of the Packer Campus and north of the Murray H. Goodman Campus, that links both campuses. The acquisition of five buildings and 742 acres at a cost of $18.75 million was the largest real estate transaction in the history of the university. Campus acreage virtually doubled.

Likins led the way in the establishment of the Colonial League, now the Patriot League, in football, effective with the 1986 season. Other schools belonging to the league are Bucknell, Colgate, Davidson, Holy Cross, Lafayette, the United States Military Academy and Fordham University. The league represents a commitment by participating
schools to the principle of "scholar-athletes," students who are primarily concerned with academic work but also play football. This principle has been a Lehigh tradition. Eventually, the member schools all will play each other every year, while also including all Ivy League schools in their schedules.

The university completed in 1989 a new stadium for football and other sports on the Murray H. Goodman Campus. Taylor Stadium has been razed to make way for the Rauch Business Center and the Zoellner Arts Center and garage.

Under Likins, financial support of the university has grown from around $10 million annually to more than $24 million in both 1986-87. In the years 1986 through 1990, 60 percent of alumni made gifts to Lehigh, placing Lehigh just behind first-place Dartmouth and just ahead of Princeton in percentage of alumni making gifts. The three schools are the leaders among Ph.D.-granting institutions for which records are kept on a national basis.

Likins was a prime mover in the establishment in 1984 of the Lehigh Valley Center for Jewish Studies, headquartered at Lehigh and serving private colleges in the area, and the establishment of a chair in Judaica based at Lehigh supported by a major gift from Philip and Muriel Berman.

In recent years, Lehigh established a center in the field of integrated circuits, the Center for Innovation Management Studies, the Chemical Process Modeling and Control Research Center, and the Center for International Studies.

A native of California, Likins is relaxed and informal in his interpersonal dealings and has regular personal contact with undergraduates. A former collegiate wrestler of some note (in 1982 he was named to the National Wrestling Hall of Fame), he and members of his family regularly attend Lehigh athletic events.

Likins was substantially involved in the university's designation as a National Historic Landmark in 1981. He is, one of four such centers established by the Pennsylvania legislature. The North East Tier center has assisted dozens of fledgling businesses involved in high-technology fields.

Dr. Likins is a distinguished academic administrator, a seasoned educator in engineering, an expert in spacecraft dynamics and control, an author of textbooks in engineering mechanics, a researcher who continues to add to his substantial list of publications, and a consultant to governments and industry. He was one of 13 science advisors to President George Bush, serving on the president's science advisory committee.

He earned the B.S. in civil engineering from Stanford University in 1957, the master of science in civil engineering from Massachusetts Institute of Technology the following year, and the Ph.D. in engineering mechanics from Stanford in 1965. He joined Columbia as dean of the School of Engineering and Applied Science in 1976 and was named provost in 1980. Earlier, he was a development engineer at the Jet Propulsion Laboratory of the California Institute of Technology, and subsequently served as professor and later as associate dean of engineering at the University of California, Los Angeles. He is a fellow of the American Institute of Aeronautics and a member of the National Academy of Engineering.

Dr. Likins and his wife, Patricia, have six children and reside in the President's House.

University Campuses
Lehigh University's three campuses are located in Bethlehem, Pa., and comprise 1,600 acres.

Ass Packer Campus. Lehigh's main academic campus, encompassing approximately 360 acres on the north slope of South Mountain overlooking Bethlehem, is a wooded area where most students attend class and live. This contains the original campus of the university.

Murray H. Goodman Campus. During the 1960s, the university acquired extensive acreage in the Saucon Valley just south of South Mountain. Development of one of the nation's finest collegiate athletic complexes has continued since that time. The 500-acre campus now includes the new Murray H. Goodman Stadium (dedicated in 1988) and other athletic fields, as well as the 6,000-seat Stabler Athletic and Convocation Center, the North East Tier Ben Franklin Advanced Technology Center, the Philip Rauch Field House, the Varsity House locker facility, and an indoor tennis facility. The campus is named for a major benefactor, Lehigh alumnus Murray H. Goodman, of West Palm Beach, Fla.

Mountaintop Campus. Lehigh bought this campus from Bethlehem Steel Corp. in 1986. It contains 670 acres of woods and a 72-acre research site with 8 buildings, five of which are owned by the University, including a landmark tower building visible for miles around. Acquisition of the facilities—the largest single transaction in Lehigh history—connects the two older campuses. The Mountaintop Campus houses the Iacocca Institute Offices and the College of Education; the departments of Biological Sciences and Chemical Engineering; programs in biochemistry, biotechnology, ATLLS (Advanced Technology for Large Structural Systems) center, Energy Research Center, and Ben Franklin incubator companies.

University Buildings
Lehigh has a major collection of 19th-century buildings designed by such prominent architects as Addison Hutton (1834-1916), Edward T. Potter (1831-1904) and the firm of Furness and Evans (Frank Furness, 1839-1912).

The university's newer structures include the Goodman Stadium (1988), the Sherman Fairchild Center for Physical Sciences (1976, 1986), the E. W. Fairchild-Martindale Library and Computing Center (1985), the Stabler Athletic and Convocation Center (1979), the Broadhead House residential facility (1979), the Seeley G. Mudd Building and Neville Hall in the chemistry complex (1975), the Philip Rauch Field House (1975), the Rauch Business Center (1990), the Lewis Tennis Center (1994), and the new Ulrich Student Center in Grace Hall.

Recently completed just east of the Rauch Business Center is the new Zoellner Arts Center, which houses a 1,000-seat music auditorium, a 300-seat theatre, a permanent art gallery and museum store, and the Departments of Music and Theatre. A 350-car parking garage on the same site.

Altogether, the three campuses contain 130 buildings with more than 3 million square feet of floor space.

In the following list, the first date after the name of each building indicates the year of completion. The second date indicates the year of a major addition.

Campus Landmarks
Alumni Memorial Building (1925). This edifice of Gothic design, housing Admissions and other administrative offices and those of the Alumni Association, represents a memorial to the 1921 Lehigh alumni who served in World War I and the 46 who died. The building was designed by Theodore G. Visscher, Class of 1899, and James Lindsey Burley, 1894.

E. W. Fairchild-Martindale Library and Computing Center (1985). The high-technology building houses science and engineering holdings and a computer center. Construction was made possible by a major gift from Harry T. Martindale, a 1927 Lehigh graduate, and his wife, Elizabeth, daughter of the late Edmund W. Fairchild, founder of a business-publications and communications empire.

Linderman Library (1877). The rotunda, designed by Addison Hutton, was built as a gift to the university by founder Assa Packer as a memorial to his daughter, Lucy Packer Linderman. The rotunda is surrounded except on the south by a major addition constructed in 1929. The building houses more than 20,000 rare books and volumes related to the humanities and social science. The Bayer Gallery of Rare Books, made possible by a gift from Curtis F. Bayer, '35, was dedicated in 1985.
Packer Memorial Church (1887). The church was the gift of Mary Packer Cummings in memory of her father, founder Asa Packer. It was dedicated on Founder's Day, October 13, 1887. The building was designed by Addison Hutson; the stained-glass window over the main door is attributed to Louis Comfort Tiffany.

Observance of the centennial year took place in 1987.

President's House (1868). This 21-room residence, designed by Edward Potter, is the home of university presidents. Dr. and Mrs. Peter Likins and family have occupied the dwelling since 1982.

Packer Hall, The University Center (1868). When construction of the building began in 1865, a railroad was built to transport stone to the site. The building, designed originally by Potter, was extensively renovated and enlarged in 1958.

The building was constructed at the expense of the founder, who vetoed a plan to erect it of brick. "It will be built of stone," Asa Packer responded.

Today the building houses students and faculty dining facilities, a food court, deans' offices, the Journalism and Communications Department, the student radio station (WVLR), and conference facilities.

Academic and Research Facilities

Chandler-Ullmann Hall (1883, 1938, respectively). These adjoining buildings formerly were the William H. Chandler Chemistry Building (designed by Hutson) and the Harry M. Ullmann Chemistry Laboratory. Chandler served as acting university president, 1904 and 1905, and taught chemistry from 1871 to 1906. Ullmann served as chairman of the chemistry department. The building has been named a National Historic Chemical Landmark by the ACS.

The Department of Art and Architecture, division of Urban Studies, and Department of Psychology are located in Chandler-Ullmann.

Christmas-Saucon Hall (1865 and 1872, respectively). Christmas Hall is the university's oldest building. When Asa Packer acquired the South Mountain site for the university in 1865, a Moravian church was being constructed. The newly formed university took over the building and completed it for use in recitations and as a dormitory and chapel. The name Christmas Hall was chosen in keeping with Moravian religious tradition. In 1872, Saucon Hall was constructed a few feet to the east of Christmas Hall. The buildings were connected with the construction of a "hyphen" in 1926. The building houses the Department of Mathematics and classrooms.

Coppe Hall (1883). The building originally housed classrooms and a gymnasium. It is named in honor of Henry Coppee, first president. The building is used for classes and offices while awaiting renovations for the Department of Journalism.

Coxe Laboratory (1910). Originally a mining laboratory, the structure is named for Eckley B. Coxe, pioneer mining engineer and trustee of the university. The building is now the headquarters of Military Science ROTC program.

Drown Hall (1908). The building, designed by Furness and Evans, is a memorial to Thomas M. Drown, president from 1895 to 1904. It is headquarters for the English Department and the Learning Center.

Fritz Engineering Laboratory (1909, 1955). The laboratory is named for John Fritz, pioneer in the steel industry in the United States and a member of the university's original board of trustees. Fritz provided funds for the original section; a seven-story addition accommodates the university's testing machine, which is capable of applying a five-million-pound load to tension or compression members up to forty feet in length. The hydraulic testing machine is the largest facility of its kind currently in operation in the world. The laboratory is used primarily by the Department of Civil Engineering.

Iacocca Hall. Known as the tower building, it houses the College of Education, the Chemical Engineering Department, the Biological Sciences Department, as well as a dining room and food service facilities, plus a teleconferencing classroom. The headquarters of the Iacocca Institute is housed in the former library wing. The Cities in Schools, Inc. hypermedia lab training facility is also located here.

Imbit Laboratories. This is primarily a high-bay research lab space where the ATLOSS project was constructed, and where Chemical Engineering and Energy Research Center have major research facilities. It is also the headquarters of the "Fleet of the Future" program and the Energy Research Center.

Johnson Hall (1955). The building houses the university health service, the counseling service, the chaplain's office, campus police, and the parking services office, as well as the Women's Resource Center and the Office of Continuing, Distance and Summer Studies. Earl F. "Coxy" Johnson, '07, a director of General Motors Corp. and university trustee, provided funding for the structure.

Lamberton Hall (1907). The structure served as the university commons and dining room until the renovation of Packer Hall in 1958. The building honors the memory of Robert A. Lamberton, third president. It most recently housed the Music Department until its move to the Zoeller Arts Center, and plans are being made to convert the building to a Campus Pub.

Maginnes Hall (1970). The multilevel structure is headquarters for the College of Arts and Science and also houses the departments of Modern Foreign Languages, History, International Relations, Political Science, and Religion Studies, as well as the Science, Technology, and Society Program, the Lehigh Valley Center for Jewish Studies, and the Center for International Studies. The university bookstore is located on the ground floor. The building is named for Albert B. Maginnes, '21, who was a lawyer and university trustee.

Mart Science and Engineering Library (1968). This structure honors the memory of Leon T. Mart, '13, and his son, Thomas, '51. It operates in conjunction with the E. W. Fairchild-Martindale Library and Computing Center.

Seeley G. Mudd Building (1975). This seven-story building houses the chemistry department. The late Seeley G. Mudd was a California medical doctor. The Seeley G. Mudd Foundation, of Los Angeles, made a major gift toward the building.

Neville Hall (1975). This building in the chemistry complex has three auditoriums used for lectures and events. The building is named for Dr. Harvey A. Neville, president from 1961 to 1964, who was a chemist.

Newman Association Center. This Victorian structure, until the mid-1970s used as a private residence, was renovated by the Newman Association and serves as a center for students and as a residence for its director, a Roman Catholic chaplain.

Packard Laboratory (1929). The structure was the gift of James Ward Packard, Class of 1884, the electrical pioneer and inventor of the Packard automobile who served as a university trustee. The first Packard automobile (1898) is displayed in the lobby. The building is the headquarters for the College of Engineering and Applied Science. It also houses classrooms and laboratories for Mechanical Engineering and Mechanics and for Electrical Engineering and Computer Science. An auditorium accommodates large classes and various events.

Philosophy Building (1879). This small building just below Packer Memorial Church was constructed as a porter's lodge. Today it houses the Philosophy Department.
Price Hall. This structure formerly was a brewery named Die Alte Brauerei. In 1912 it was remodeled to serve as a dormitory, and it was named in honor of Henry Reece Price, president of the university board of trustees. It serves as the home of the Sociology and Anthropology Department.

Rathbone Hall (1971). This building’s upper level is a major student dining facility, with window walls affording a panoramic view of the Lehigh Valley. The building bears the name of its donor, Monroe Jackson Rathbone, ’21, president of the university board of trustees from 1957 to 1973. Rathbone was chairman of the board, Standard Oil Co. (New Jersey), now Exxon Corp., and was a major innovator in the oil industry. The lower level houses the Residential Services Office.

Rauch Business Center (1990). Philip Rauch ‘33, L.L.D. ’79, retired Chairman of the Board and Director of the Parker-Hannifin Corp., made the principal contribution to build this facility. Lehigh’s Rauch Business Center was dedicated in 1990 as the state-of-the-art home of the university’s College of Business and Economics. The $17.8-million facility has 115,000 square feet of floor space on five stories and features a diverse array of classrooms, auditoria, and conference rooms, and is also new home to the Career Services and Corporate Relations Office.

Sayre Building (1899). Originally known as the Sayre Observatory, the dome that once housed the telescope can still be seen. The Graduate Student Council is headquartered here.

Sherman Fairchild Center for the Physical Sciences (1892, 1976, 1986). The center, completed with help from the Sherman Fairchild Foundation, houses classrooms and laboratories for undergraduate and graduate students in physics, chemistry and biology, and a 260-seat auditorium. The complex includes the Lewis Laboratory, the original five-story stone structure built in 1892, the Sherman Fairchild Laboratory for Solid-state Studies built in 1976, and the 1986 addition comprising of the Oberkotter Auditorium and research laboratories.

Sinclair Laboratory (1970). This facility houses the Zetllemoyer Center for Surface Studies, and other research laboratories. It is named for Francis MacDonald Sinclair, and was the gift of his widow, Jennie H. Sinclair.

Whitaker Laboratory (1965). This five-story structure with an adjoining two-level classroom-auditorium section honors the memory of Martin Dewey Whitaker, university president from 1946 to 1960. The building serves the Department of Materials Science and Engineering and the Materials Research Center. There are laboratories for high-pressure research and reaction kinetics, nuclear studies, analog computation, process control, high-temperature thermodynamics and kinetics, and fine structures and metallurgy. The Office of International Education is also located in the building.

Williams Hall (1903). This brick structure was the gift of Edward H. Williams, Jr., Class of 1875. Dr. Williams was apfessor of mining and geology. The building contains classrooms and laboratories for the Departments of Biological Sciences and of Earth & Environmental Sciences. A small greenhouse adjoins the building. The building was extensively renovated and a fourth story added in 1956 following a fire.

Zoeller Arts Center (1997). With major gifts from Vickie and Robert Zoeller ’54, Dorothy and Dexter Baker ’50, and Claire and Theodore Diamond ’37, Dagley-Saylor Architects created a 105,000 sq. ft. structure designed to showcase Lehigh’s rapidly growing programs in the performing and visual arts as well as the departments of music and theater and 5,000 sq. ft. of exhibition space for the Lehigh University Art Galleries. Baker Hall, with a seating capacity of more than 1,000, is the finest acoustically appropriate theater for music performance in the Eastern Pennsylvania region; Diamond Theatre features a thrust stage and seating for 307, and a “black box” theater provides flexible space for experimental productions. Major sculptures outside the building include “Totem Head” by Henry Moore, a gift from Philip and Muriel Berman, and “In a State of Rejuvenescence” by contemporary American sculptor David Cerelli, a gift of the Bakers.

Athletic and Convocational Facilities

Murray H. Goodman Stadium (1988). Joanie and Murray Goodman ’48, L.L.D. ’88, were the principal benefactors. Mr. Goodman is the owner and chairman of The Goodman Company, a commercial real estate developer. On October 1, 1988, Lehigh opened the gates to the Murray H. Goodman Stadium, located on the Goodman Campus. Capacity is 16,000, and the stadium features a three-tiered press box, and limited chair back seating, with a picturesque South Mountain in the background.

Grace Hall (1940). The building is named for its donor, Eugene G. Grace, Class of 1899, who was chairman of Bethlehem Steel Corp. and president of the university’s board of trustees, 1924 to 1956. The building’s lower level seats 3,200 and is used for intramural sports, wrestling, and women’s varsity volleyball as well as concerts and lectures. Grace Hall serves as the Headquarters and Offices for Lehigh Intramural and Club Sports. The upper level houses the newly renovated Ulrich Student Center, including movie theatre, game room and mailboxes.

Lewis Indoor Tennis Facility (1994). An anonymous donor made possible the construction of four indoor tennis courts for recreational use as well as team practice, and is named for former Lehigh President W. Deming Lewis.

Philip Rauch Field House (1976). Philip Rauch, ’33, L.L.D. ’79 made a gift toward the facility. The building has 62,000 square feet of uninterrupted floor space — the equivalent of two football fields — for a variety of athletic activities. It has a six-lane, one-eighth-mile flat track.

Sayre Field (1961). Located atop South Mountain, the field is used for intramural sports.

Stabler Arena (1979). This arena provides seating for 6,000 persons for concerts, spectator sports, including Lehigh’s basketball teams, and other events. University trustee Donald B. Stabler, ’30, made a major financial contribution toward the facility.

Taylor Gymnasium (1913 and 1964). This structure was the gift of Charles L. Taylor, Class of 1876, who was a friend and business associate of steel magnate Andrew Carnegie. There are two indoor swimming pools, two basketball courts, the Welch Fitness Center, a men’s & women’s locker room, two racquetball and two squash courts, a steam room, a multi purpose dance/aerobics room, and a Sports Medicine Complex. The Athletic Department Offices are also housed in the Warren (Pete) Musser wing. A newly constructed Hall of Fame area opened in the spring of ’96.

Varsity House (1963). The building houses lockers for varsity teams. It is located on the Murray H. Goodman Campus.

Wilbur Drama Workshop (1908). During most of its life, the building served as a power plant. Renovated during the 1970s, it provided performing space for student theatrical productions, and is now the student shop and project lab for the IPD (Innovations in Product Design) program.

Central Heating/Cooling Plant
Central Heating and Refrigeration (1969). This glass-walled building houses three boilers that can be fired by either oil or gas. Other equipment provides chilled water for air conditioning.

Technology Center
Ben Franklin Building (1972). Situated on the Murray H. Goodman Campus in Saucon Valley, the building houses the Lehigh-based North East Tier Ben Franklin Advanced Technology Center, the Manufacturers Resource Center, and the Agility Forum.
Residential Facilities

The university is primarily residential in character, with about 85 percent of undergraduates living in facilities on the campus, including university-operated residence halls and independently managed fraternity and sorority houses.

Approximately 1,850 students live in on-campus residence halls and apartments.

A new residential complex is under construction in Sayre Park and will be ready for occupancy in August of 1998. It will house 150 students in three apartment buildings and include a fourth multipurpose, community building with outdoor recreation facilities.

Residence Halls

Brodhead House (1979). This structure is the university’s first high-rise residential facility. The six-story building includes 4-person suites on the five upper floors, with a dining facility and lobby on the entrance level. The building is named in memory of Albert Brodhead, a member of the Class of 1888 who died in 1933, leaving 51 Bethlehem properties to his alma mater.

Dravo House (1948). This 5-story stone edifice is the university’s largest residential facility. It bears the name of two brothers, Ralph M. Dravo, Class of 1889, and Francis F. Dravo, Class of 1887, who founded the Dravo Corp., a Pittsburgh-based international construction company. Both men served as university trustees.

Drinker House (1940). This stone building honors the memory of Henry S. Drinker, Class of 1871, university president from 1905 to 1920.

McClintic-Marshall House (1957). This U-shaped stone structure was built in memory of Howard H. McClintic and Charles D. Marshall, both Class of 1888, who founded the McClintic-Marshall Construction Co. The firm was the world’s largest independent steel fabricating firm before its acquisition by Bethlehem Steel Corp. in 1931. It built locks for the Panama Canal and constructed the Golden Gate Bridge in San Francisco Bay.

Richards House (1938). The building honors the memory of Charles Ross Richards, president of the university from 1922 to 1935. The building is constructed of stone in modified Gothic design.

Taylor Residential College (1907, 1984). The U-shaped building is one of the earliest concrete structures ever built. It was the gift of industrialist Andrew Carnegie in honor of his friend and associate, university trustee Charles L. Taylor, Class of 1876. The interior of the building was reconstructed and the exterior refurbished prior to the facility becoming Lehigh’s first residential college in 1984.

Trembley Park (1975). This seven-building undergraduate apartment complex is named in memory of Francis J. Trembley, Lehigh professor and pioneer ecologist.

Warren Square Complex. This cluster of five residence halls is located on Warren Square and Summit Street. They are upperclass facilities and some are used as special-interest houses.

Centennial II Complex (1970)

Beardslee House. Dr. Claude G. Beardslee was chaplain from 1931 to 1947.

Carothers House. Dr. Neil Carothers was dean of business.

Palmer House. Dr. Philip M. Palmer was dean of the arts.

Stevens House. The Rt. Rev. William Bacon Stevens of Philadelphia, was Protestant Episcopal bishop of the Diocese of Pennsylvania and first president of the university board of trustees. He was the principal architect of the university’s original academic plan.

Stoughton House. Dr. Bradley Stoughton was dean of the engineering college, 1936 to 1939.

Williams House. Dr. Clement C. Williams was president of the university, 1935 to 1944.

Saucon Village Apartments (1974)
The five-building garden apartment complex includes housing for married, graduate, and undergraduate students.

Diamond. Dr. Herbert M. Diamond, professor emeritus of economics, retired in 1964.

Gipson. Dr. Lawrence Henry Gipson, research professor of history, bequeathed his estate to the university to establish the Lawrence Henry Gipson Institute for Eighteenth-Century Studies. Dr. Gipson wrote a monumental 15-volume history, The British Empire Before the American Revolution. He won the Pulitzer Prize for volume 10, The Triumphant Empire: Thunderclouds Gather in the West, 1763-1766.

Hartman. Dr. James R. Hartman was chairman of the department of mechanical engineering and mechanics.

More. Dr. Robert P. More, '10, dean of the College of Arts and Science, who also taught German for forty years, bequeathed the university his $746,000 estate, amassed after investing $3,000 in IBM stock. The university child care center is located in this building.

Severs. Dr. J. Burke Severs, of Bethlehem, is distinguished professor emeritus of English. He is a Chaucerian scholar.

Fraternities and Sororities

The university has a strong fraternity tradition, dating back to 1872. Since the admission of undergraduate women in 1971, several sororities have come into being. Some 900 men live in fraternities.

Most of the fraternities have houses located in Sayre Park, while a few others are situated off campus. All are chapters of national fraternities.

An alphabetical listing follows. The date of the founding of the chapter is given in the first column. The second column lists the date the chapter occupied its present house; any additional date indicates the most recent addition or major renovation.

Alpha Chi Rho 1918 1968
Alpha Sigma Phi 1929 1966
Alpha Tau Omega 1966
Beta Theta Pi 1891 1968
Chi Phi 1872 1922 1968
Chi Phi 1895 1910 1955
Delta Chi 1952 1968
Delta Phi 1884 1963
Delta Sigma Phi 1931 1971
Delta Tau Delta 1874 1985 1959
Delta Upsilon 1885 1968
Kappa Alpha 1894 1961
Kappa Alpha 1900 1973
Lambda Chi Alpha 1926 1973
Phi Delta Theta 1876 1919 1963
Phi Gamma Delta 1921 1968
Phi Kappa Theta 1904 1970
Phi Sigma Kappa 1901 1957 1970
Pi Kappa Alpha 1929 1953 1995
Psi Upsilon 1884 1969 1966
Sigma Alpha Mu 1953 1966
Sigma Chi 1885 1970
Sigma Phi 1887 1950 1961
Sigma Phi Epsilon 1907 1963
Theta Chi 1942 1964
Theta Delta Chi 1884 1937 1967
Theta Xi 1904 1967
Zeta Psi 1973 1973
There are seven sororities. All are nationally affiliated. Six reside in the Centennial I Complex and one, Alpha Phi, resides in Sayre Park. Some 300 women live in sororities, and an eighth sorority is being colonized this year.

The sororities are listed with year of establishment at Lehigh in the first column and year of moving into their present house in the second column.

Alpha Chi Omega 1988 1997
Alpha Gamma Delta 1975 1985
Alpha Omicron Pi 1983 1986
Alpha Phi 1975 1996
Delta Gamma 1982 1987
Gamma Phi Beta 1975 1985
Kappa Alpha Theta 1984 1986

**Centennial I complex (1965)**

**Congdon House.** Located at the east end of the Centennial I complex. Dr. Wray H. Congdon served as dean of students, dean of the graduate school, and special assistant to the president. Alpha Chi Omega sorority is housed in congdon.

**Emery House.** It is named for Dr. Natt M. Emery, who was vice president and controller. Gamma Phi Beta sorority is housed in Emery.

**Leavitt House.** The Rev. Dr. John McD. Leavitt was the second president, 1873 to 1879. Alpha Gamma Delta sorority is housed in Leavitt.

**McConn House.** C. Maxwell McConn was dean of the university from 1923 to 1938. Alpha Omicron Pi sorority is housed in McConn.

**Smiley House.** Dr. E. Kenneth Smiley served as vice president from 1945 to 1964. Kappa Alpha Theta sorority is housed in Smiley.

**Thornburg House.** Dr. Charles G. Thornburg was professor and head of the department of mathematics, 1895 to 1923. His grandson, Dick Thornburg, completed his second term as governor of Pennsylvania at the end of 1986. Delta Gamma sorority is housed in Thornburg.

Alpha Phi sorority is housed in the former Pi Lambda Phi fraternity house.

The leader of the Moravians was Count Nicholas von Zinzendorf of Dresden. He arrived in the settlement in time for their observance of Christmas Eve in 1741 and gave the settlement the name Bethlehem—"house of bread".

The settlers built high-quality structures of stone, demonstrating principles of engineering that were not generally used elsewhere. They were interested in music, and established the first symphony orchestra in America. In 1748, the settlement had a fourteen-man orchestra. The community's first organ was built in 1757 by John Gottlob Klemm. The musical tradition, including the trombone choir, continues today, perhaps most visibly in the Bach Choir of Bethlehem, whose yearly Bach Festival is held in the university's Packer Memorial Church. In 1985, the 300th anniversary of the birth of Johann Sebastian Bach was observed.

Zinzendorf envisioned Bethlehem as the center for manufacturing; outlying Moravian settlements, such as Nazareth, Pa., would be primarily devoted to agriculture. On October 15, 1742, a large barn was "raised" with the help of most of the residents. Three months later a grist mill at the community spring produced the first flour. In 1758, the Sun Inn was built along Main St., a haven for travelers. Reconstruction of the picturesque inn was completed in 1982, and it now operates as a community center and restaurant.

Zinzendorf's determination that Bethlehem would be a major industrial center was assisted by the completion in 1755 of the water works, the first public utility in the New World.

The Moravian dedication to education was an extension of the philosophy of John Amos Comenius, who had written, "Everyone ought to receive a universal education." The Moravian educational institutions that continue today, including Moravian Academy and Moravian College, stem from this tradition.

The Moravians, although avowedly opposed to war, found their community pressed into service as a hospital when Washington's troops bivouacked at Valley Forge during the winter of 1777-78. Washington came to the community once, and many other Continental Army officers were visitors.

The Sun Inn was also used as a hospital during the war; among its patients was an aristocratic renegade from France, Marie Joseph Paul Ives Gilbert Motier, the Marquis de la Fayette. Lafayette had come to assist the Continental Army aboard his own ship, the "Victory." Fifty years later a college in Easton was named in his honor and it became Lehigh's traditional football rival.

The first bridge across the Lehigh River was built in 1794. It was replaced in 1816, but the latter was destroyed by a flood in 1841. In 1759, the turnpike (toll road) over South Mountain, generally along the route of the present Wyandotte St. hill, was opened. The present Hill-to-Hill Bridge was built some fifty years ago.

"Black gold." During the late 18th Century, anthracite was found in the mountains north of the Lehigh Valley. In 188, the Lehigh Coal Co. and the Lehigh Navigation Co. were formed, one to mine the anthracite on the upper Lehigh River, the other to transport it down river to metropolitan markets.

The Lehigh River was difficult to navigate. Consequently, in 1829 the Lehigh Canal was completed from Mauch Chunk (now Jim Thorpe), through Bethlehem to Easton, where it connected with the Delaware Canal. During the 1840s, iron mines were opened in the area, and several blast furnaces, fueled by coal, were in operation. Zinc ore, was found in neighboring Upper Saucon Township. In the 1850s Asa Packer built the Lehigh Valley Railroad. These origins eventually led to the heavy industry that continues in the Lehigh Valley today.

When Asa Packer founded Lehigh University in 1865, one of his objectives was to make possible broadly based education for young people of the region, combining the technical skills needed to run the flourishing industry of the Lehigh Valley with a liberal education.

In addition to its role as a steel-making center, Bethlehem today is a major tourist attraction. The Moravian community sets up an elaborate nativity scene and the entire city is decorated with lighting during the holiday period. The Moravian tradition of a single candle (now electric) in each window is widely observed.

**In Bethlehem, An Educational Tradition**

Lehigh University shares in the historical heritage of Bethlehem, even though, having been founded in 1865, it is a relative newcomer. The fact that Lehigh was established in Bethlehem reflects the tradition of education established by the community's first settlers thirty years before the founding of the nation.

The first Moravians were among the many German religious sects that came to the New World, and especially to Pennsylvania, during the early 1700s. But unlike William Penn, who established his "sylvania" as a new land where he might hold his Quaker beliefs away from England's oppression, the Moravians came as missionaries with the intent of converting the Indians to Christianity. For this purpose they settled the Lehigh Valley.

The early Moravians were industrious. Their first building, the Gemein Haus (community house) was completed in 1741. This building stands today, one of thirty-nine remarkably preserved pre-Revolutionary War buildings constructed by the Moravian settlers and in continuous use ever since by the Moravian community. Many of these buildings are located on Church St., west of the City Center; industrial buildings are located in the 18th Century Industrial Area in the Monocacy Creek valley west of the business district.
A top South Mountain is a steel tower known as the Star of Bethlehem. During the holiday period, the star's hundreds of bulbs create a 95-foot-high star that can be seen for many miles. The star was the gift to the community of Marion Brown Grace, wife of Eugene Gifford Grace, the steel magnate and president of the university board of trustees.

The community of Bethlehem has a population of approximately 78,000 persons with segments from a variety of nations who retain traditions of their country of origin.

There are five principal independent colleges in the Lehigh Valley besides Lehigh. They are Lafayette, Allentown College of St. Francis de Sales, Moravian, Muhlenberg, and Cedar Crest. A cooperative program is maintained that allows cross-registration for courses as well as shared cultural events. There are also two community colleges in the area.

In August 1984, Bethlehem held its first Musikfest, a 10-day annual festival that features a variety of musical performances and ethnic foods. An instant success, Musikfest was the brainchild of Jeffrey A. Parks, a lawyer and 1970 Lehigh graduate.
VII.

Administration, Faculty and Staff

This section lists the people whose talents and abilities constitute the university's most important resource. Members of the board of trustees contribute their expertise to establish the policies of the university. Also listed are the administration, members of the faculty and staff, and the members of the visiting committees who help to keep courses of instruction current and of maximum value to the students and prospective employers.

Board of Trustees

When the year of the degree is listed, the degree was awarded by Lehigh University.

Officers of the Board
Ronald J. Ulrich, chair
Eugene Mercy, Jr., vice chair
Denise M. Biew, corporate secretary and treasurer
Jill L. Sherman, executive secretary
Richard H. Sanders, assistant treasurer

Members of the Board

Curtis H. Barnett, J.D. Yale, chairman & CEO, Bethlehem Steel Corp.
Patricia M. Battin, B.A., Swarthmore; M.S., Syracuse, retired president, Commission on Preservation & Access
Peter B. Ridenbaugh, B.S. '52; M.S. '67; Ph.D. '68, MIT, Executive Vice President, Chief Technical Officer, Aluminum Co. of America
Charles W. Brown, B.S. '71, general manager, Lucent Technologies
Kevin L. Clayton, B.A. '84, M.B.A. St. Joseph's University, managing director, Oaktree Capital Management, LLC
William L. Clayton, B.S. '51, senior vice president, Smith Barney
William W. Crouse, III, B.A. '64, M.B.A. '71, Pace University, vice chairman, general partner, Healthcare Investment Corp.
Herbert E. Ehlers, B.A. '62, M.S. '64, managing director, Goldman Sachs & Co.
Phyllis A. Errico, B.A. '81, J.D. '84, assistant county attorney, County of Henrico, Richmond, VA
Oldrich Foucek, III, B.A. '72, J.D. '75, Case Western Reserve University, Tallman, Hudders & Sorrentino
Donald C. Garaventi, B.S. '58, President, Reombinant Biocatalysis, Inc.
Murray H. Goodman, B.S. '48, chairman, The Goodman Company
William F. Hecht, B.S. '64, M.S. '70, president and chief executive officer, Pennsylvania Power & Light
Jeffrey L. Kenner, B.S. '65, B.S. '66, President, Kenner & Co., Inc.
Suzanne J. Klein, B.A. '91, Assistant Meeting Planner, Merrill Lynch & Co., Inc.
Douglas C. Lane, B.S. '67, M.B.A. '68, University of Michigan, Lane Capital Management, Inc.
Paul N. Leitner, B.S. '76, M.B.A. '80, Chairman, The Leitner Thomas Group
George B. Lemmon, B.S. '55, B.A. '55, Chairman Emeritus, Owosso Corporation
Peter Likins, university president/trustee ex officio
Linda C. Linahan-Menna, B.S. '87
Martha E. Marcon, B.S. '74, National Technical Resource Partner-Insurance, KPMG Peat Marwick
William T. Marks, B.S. '70, M.B.A. '75, University of Missouri-Columbia, J.D. '75, University of Missouri-Columbia, Senior Vice President, Bank America Trust Company of Florida, N.A.
Gina H. McBeau, B.A. '82, Fundraising & Community Relations Officer, the State Museum of Pennsylvania
Eugene Mercy, Jr., B.S. '59, chairman, Granite Capital International Group
H. Edward Muehlen, B.A. '64, president, Stanton Chase International
Laura Penrod-Kronk, B.S. '82
Joseph R. Perella, B.S. '64, M.B.A. '72, managing partner, Morgan Stanley Group, Inc.
David L. Polakoff, B.S. '86, Director of International Finance, HBO
John W. Puth, B.A. '52, J. W. Puth Associates
James R. Rice, B.S. '62, M.S. '63, Ph.D. '64, professor engineering science and geophysics dept., Harvard University, Cambridge, MA
Edwin F. Scheetz, Jr., B.S. '54, chairman, Guayasita Investment Advisors, Inc.
Donald B. Stabler, B.S. '30, M.S. '32, LL.D. '74, president & board chairman, Stabler Companies Inc.
Karen L. Stuckey, B.S. '75, Partner, Price Waterhouse
James R. Tanenbaum, B.A. '71, M.A. '72, Tufts University, J.D. '75, University of Pennsylvania, Partner, Stroock, Stroock & Lavan
Ronald J. Ulrich, B.S. '67, M.B.A. '71, New York University, President, Equinox Capital Management
H. A. Wagner, B.S. Stanford University, M.B.A. Harvard, chairman of the board, president and chief executive officer, Air Products and Chemicals, Inc.
Frank E. Walsh, Jr., '63 B.S., vice chairman, Wesray Capital Corporation
Joseph F. Welch, B.S. '56, chairman, J.F. Welch Interests, Inc.
Susan C. Yee, B.S. '82, president, Regional Network Communications, Inc.
Robert E. Zoellner, B.S. '54, president, Alpine Associates

Trustees Emeriti

Morgan J. Cramer, '28, retired president, P. Lorillard and Co.
William B. Eagleston, Jr., B.S. '49, M.B.A., retired chairman emeritus, Mellon Bank
William C. Hittinger, B.S. '44, Eng.D. '83, retired executive vice president, research and engineering, RCA Corp.
Ronald R. Hoffman, B.S. '54 in Industrial Engineering, Executive Vice President-Human Resources, Aluminum Co. of American
Frank C. Rabold, B.S. '39, Eng. D. '70, retired manager of corporate services, Bethlehem Steel Corp.
S. Murray Rust, Jr., B.S., in M.E. '34, retired chairman of the board, Rust Engineering Co.
Richard M. Smith, B.S. '48, LL.D '83, retired vice chairman, Bethlehem Steel Corporation
James B. Swenson, B.B.A. '59, retired partner, Price Waterhouse
Principal Officers

Educational information (degrees earned and colleges and universities attended) may be found in the alphabetical listing that follows in this section. The highest degree earned is given here.

All offices, unless otherwise noted, are located at Bethlehem, Pa. 18015; the area code, unless otherwise noted, is (610).

Principal Officers
Peter Likins, Ph.D., president
758-3157
Nelson G. Markley, Ph.D., provost and vice president for academic affairs
758-3605
Rhonda I. Gross, M.B.A., vice president for finance and administration
758-3178
Jill L. Sherman, M.A., vice president for development and university relations
758-4711
Michael G. Bolton, M.B.A., vice president for public affairs
758-3121
Denise M. Blew, B.S., CMA, CPA, treasurer and secretary to the board
758-3179
James A. Tiefenbrunn, M.B.A., assistant vice president for resource management
758-4204
Patti T. Ota, Ph.D., vice provost and dean, College of Business and Economics
758-3165
758-3402
Harvey G. Stenger, Ph.D., dean, College of Engineering and Applied Science
758-5308
Bobb Carson, PhD, dean, College of Arts and Sciences
758-4570
Roland K. Yoshina, Ph.D., dean, College of Education
758-3221
Anthony L. Corallo, M.A., assistant vice president for facilities services and campus planning
758-3970
Joseph D. Sterrett, Ed.D, executive director of athletics
758-4320
Lorna J. Hunter, dean of admission and financial aid
758-3100
John W. Smeaton, PhD, vice provost for student affairs
758-3890
Arnold Hirschon, vice provost for information resources
758-3025
Roger N. Nagel, Ph.D., executive director, Iacocca Institute
758-6723

College Officers

College of Arts and Sciences
Bobb Carson, Ph.D., dean
Kenneth P. Kodama, Ph.D., associate dean (fall semester)
Gary G. DeLeo, Ph.D., associate dean
758-3300

College of Business and Economics
Patti T. Ota, Ph.D., dean
Therese A. Maskulka, D.B.A., associate dean
Kathleen A. Tresler, M.B.A., assistant dean and director, MBA program
758-3400

College of Engineering and Applied Science
Harvey G. Stenger, Ph.D., dean
Richard N. Weisman, Ph.D., associate dean

College of Education
Roland K. Yoshina, Ph.D., dean
758-3221

Offices and Resources
In this section, only the principal officers, are listed. For degree information, consult the alphabetical listing that follows.

Admission
27 Memorial Drive, West; 758-3100
Lorna J. Hunter, dean of admission and financial aid
Alumni Association
27 Memorial Drive, West; 758-3135
Barbara A. Turanchik, executive director
Art Galleries/Museum Operation
420 E. Packer Ave.; 758-3615
Ricardo Viera, director/curator
Athletics
641 Taylor Street; 758-4300
Joseph D. Sterrett, executive director of athletics
Ben Franklin Technology Center
125 Goodman Drive, Bethlehem, Pa. 18015; (610) 758-5200
Mark S. Lang, executive director
Bookstore
9 W. Packer Avenue; 758-3375
Michael J. King, director
Budget
428 Brodhead Avenue, 758-4204
James A. Tiefenbrunn, assistant vice president for resource management
Stephen J. Guttman, budget manager
Bursar
27 Memorial Drive, West; 758-3160
Craig F. Wood, bursar
Business Services
203 E. Packer Ave.; 758-3840
BARRY L. GAL, assistant vice president
Career Services and Corporate Relations
14 E. Packer Avenue; 758-3710
Donna L. Goldfinger, director of career services
Center for Writing, Math and Study Skills
35 Sayre Drive; 758-3098
Edward E. Lotto, director
Chaplaincy Services
36 University Drive; 758-3877
Rev. Dr. Lloyd H. Steffen, university chaplain and professor of religion studies
Community Relations and Government Affairs
422 Brodhead Ave.; 758-3885
Marcia Theodore, director
Computing Center (see Information Resources)
Conference Services
63 University Drive; 758-5306
Mary Kay Baker, manager
Controller’s Office
27 Memorial Dr., West; 758-3140
Robert E. Siegfried, controller
James Mahoney, associate controller
Counseling Service
36 University Drive; 758-3880
Ian T. Birk, director
Office of Dean of Students
29 Trembly Drive; 758-4156
Mark H. Erickson, dean of students
Sharon K. Basso, associate dean of students
Jennifer F. Volchok, associate dean of students
Sharon A. Brown, assistant dean of students
Susan Little Lantz, assistant dean of students
Suzanne Kilgannon Preston, assistant dean of students
Scott L. Walter, assistant dean of students
University Design
422 Brohead Avenue; 758-3015
Marvin Simmons, director of design
Steve Oblas, director of design resources
Developmen/University Relations
27 Memorial Dr., West; 758-4711
Jill L. Sherman, vice president for development and university relations
Robert M. Holcombe, assistant vice president for development
Ron D. Ticho, assistant vice president for university relations

Environmental Health and Safety
616 Brohead Ave; 758-4251
Barbara A. Plohoicki, Director
Facilities Services and Planning
461 Webster St.; 758-3970
Anthony L. Corallo, assistant vice president for facilities services and campus planning
Gary A. Falasca, director, office of facilities services
Patricia A. Chase, director, facilities planning and renovations

Financial Aid
218 W. Parker Avenue; 758-3181
William E. Stanford, director
University Forum Steering Committee
29 Trembley Drive; 758-3890
John W. Smeaton, vice provost for student affairs
Fraternity Management Association
219 Warren Square; 758-3888
Linda S. Guerrieri, executive director
Health Center
36 University Drive; 758-3870
Susan C. Kitei, M.D., director
Human Resources (Personnel)
428 Brohead Ave.; 758-3900
James A. Tiefenbrunn, assistant vice president for resource management

Information Resources
8A E. Parker Ave.; 758-3025
Arnold Hirshon, vice provost
Group leaders:
Susan A. Cady, Administrative, Planning & Advancement Services
Timothy J. Foley, Client Services
Roy A. Gruver, Technology Management Services
Joseph P. Lucia, Information Management Services
Christine Reysdon, Client Services, Collection Management
Kevin R. Weiner, Advanced Technology Group

Institutional Purchasing
203 E. Parker Ave.; 758-3840
Joseph F. Hardenberg, director
Internal Audit
27 Memorial Drive, West; 758-5012
Robert J. Eichenlaub, director

International Education
5 E. Parker Avenue; 758-4859
Anne H. Thomas, director
Gisela M. Nansteel, immigration specialist
Christine D. Smith, director, international advancement
Catherine M. Sowa, associate director
Libraries (see Information Resources)
Mailing and Printing Services
118 ATLAS Drive; 758-5402-Mailing; 758-5408-Printing
Nancy Mariano, director

Manufacturers Resource Center
125 Goodman Dr., Bethlehem, Pa., 18015; (610) 758-5599
Edith D. Ritter, executive director
Parking Services
36 University Drive; 758-3893
Patricia A. Potak, manager
Personnel
(See Human Resources)
University Police
36 University Drive, Room 221; 758-4200
Eugene Dux, chief

Public Affairs/Community Relations
111 Research Drive, 758-3121
Michael G. Bolton, vice president for public affairs
Marcia Theodorides, director of community relations and government affairs
Registrar
27 Memorial Drive, West; 758-3200
Bruce S. Correll, registrar
University Relations
436 Brohead Ave.; 758-3171
Ron D. Ticho, assistant vice president for university relations
Rita T. Malone, director of university communications
William J. Johnson, director of external relations
Office of Research and Sponsored Programs
526 Brohead Ave.; 758-3021
Richard H. Sanders, assistant vice president for research and sponsored programs
Thomas J. Meischeid, director
Mary Jo Hill, associate director
Residential Services
63 University Drive; 758-3500
David M. Joseph, director
Risk Management
616 Brohead Ave.; 758-3899
Richard Freeman, director
Special Academic Programs (Distance and Summer Studies)
36 University Drive; 758-3866; 758-6210
James A. Brown, director
Margaret A. Kerschmar, Manager Distance Education
Sports Communications
641 Taylor Street; 758-3174
Glenn A. Hofmann, director
Student Affairs
29 Trembley Drive; 758-3890
John W. Smeaton, vice provost for student affairs
Telecommunications (see Information Resources)
Transportation Services
126 Goodman Drive; 758-4410
Christopher J. Christian, director
Treasurer
27 Memorial Drive, West; 758-3180
Rhonda J. Gross, vice president for finance and administration
Denise M. Blew, treasurer and secretary to the board
Stephen P. Link, assistant treasurer

Faculty and Staff: Emeriti
The first date after the name is the date of appointment to continuous service on the Lehigh faculty or staff; the second date, when the first fails to do so, indicates the date of appointment to the present professional rank. Where the name of the institution awarding a high-level degree is not given, the institution is the same one that awarded the previous degree listed.

P.E. indicates certification as a professional engineer; CPA indicates certified public accountant. A.P.R. indicates accreditation by Public Relations Society of America. A.T. C., means certified athletic trainer.

A
David W. Ackland (1991), assistant research scientist, department of materials science & engineering.
Stacey M. Alderfer (1989); team leader, client services. B.S., Marwan, 1986.


Nicholas W. Balabkins (1957, 1994), professor emeritus of economics. Dipl.rer.pol., Gottingen (Germany), 1949; M.A., Rutgers, 1953; Ph.D., 1956.


John W. Bonbow (1992), assistant professor of chemistry. B.S., Lehigh University, 1982; Ph.D., Indiana University, 1990.
Arlan Benkocer (1987), research engineer, Energy Research Center.
Donald J. Bergeron (1978, 1994), associate director for engineering services.
Daniel Beuttenmuller (1990, 1993), asst. director, facilities services.
Rebecca A. Bowen (1968), employee relations and training manager. B.A., DePaul University, 1974; M.B.A., Lehigh, 1984.
Lawrence Breiner (1986, 1989), associate director, residential services.
Josef M. Brozek (1959, 1979), research professor emeritus of psychology. Ph.D., Charles (Prague), 1937.

C


B.S., Zagreb (Yugoslavia), 1974; M.S., 1980; Ph.D., 1985.


F


S.B., Hangchow, 1947; M.S., Purdue, 1957; Ph.D., West Virginia, 1966.


Gregory S. Ferguson (1990, 1996), associate professor, chemistry.

B.S., College of William and Mary, 1982; M.S., Cornell University, 1984; Ph.D., 1987.


Joseph C. Hartman (1997), assistant professor of industrial and manufacturing systems engineering. B.S., University of Illinois at Urbana-Champaign, 1992; M.S., Georgia Institute of Technology, 1994; Ph.D., 1996.
Richard G. Herman (1979, principal research scientist, Zellmeyer Center for Surface Studies. B.S., SUNY at Fredonia, 1966; Ph.D., Ohio, Athens, 1972.
Monica Herrera (1979, 1990), software support admin.
telecommunications.
Ladd E. Hoover (1960, 1967), associate director emeritus, university health services, B.S., Nebraska, 1924; M.D., 1926.
J

J
Margaret A. Kersmas (1992), program administrator, office of distance education.
Dean Krause (1975, 1982), media specialist.


Carol D. Lidie (1968, 1988), team leader, tech. management.


Peter Mueller (1980), associate professor of civil engineering. Dipl. Ing., ETH (Zurich), 1967; Dr. sc. tech., 1978.


N


O


P


P


Preston Parr (1949, 1982), dean emeritus and vice president emeritus for student affairs. B.S., Lehig, 1943; M.S., 1944.
Patricia A. Potak (1974, 1992), manager, parking services.
Kathryn M. Richards (1989), communications specialist, development.
James J. Ricles (1992), associate professor of civil engineering. B.S., The University of Texas, 1979; M.S., 1980; Ph.D., University of California, Berkeley, 1987; P.E., California.
S
John W. Sale (1994), research program development manager, energy research center. B.S., California State Polytechnic College, SLO, 1971; M.S., Univ. of California, Berkeley, 1976.
John H. Santee (1987), assistant director, facilities services.
Charles B. Solar (1968, 1990), professor emeritus of geological sciences. B.S., City College ofNew York, 1946; M.S., Yale, 1948; Ph.D., 1951.
Edward K. Shupp (1979, 1992), Lieutenant and associate director of campus police.


James E. Sturm (1956, 1995), professor emeritus of chemistry. B.A., St. John’s (Minnesota), 1951; Ph.D., Notre Dame, 1957.


T


Susan Terry (1985), assistant manager and textbook buyer.


Robert J. Trent (1993), assistant professor of management. B.S., Michigan State University, 1980; MBA, Wayne State University, 1982; Ph.D., Michigan State University, 1993.


Donald R. Trippe (1992), assistant professor of accounting. B.S., East Carolina University, 1983; M.S., Texas Tech University, 1985; Ph.D., University of South Carolina, 1993.


U

Fred J. Wehden (1977), senior computing consultant, information resources.
Research Organizations/
Directors and Staff

Directors and staff members of the university’s research centers and institutes are listed. Complete degree information may be found in the faculty and staff alphabetical listings. In some cases, areas of research interest are given.

All addresses are Bethlehem, Pa. 18015, and the area code is (610).

Biopharmaceutical Technology Institute
111 Research Drive; 758-5427

Building and Architectural Technology Institute
17 Memorial Drive, East; 758-4511
David C. Amidon, Jr., M.A.; Lynn S. Beedle, Ph.D.; George C. Driscoll, Ph.D.; Francis A. Harvey, Ed.D.; Roy C. Herrenkohl, Ph.D.; Donald J. Hillman, Ph.D.; Ti Huang, Ph.D.; Celal N. Katehm, Ph.D.; Le-Wu Lu, Ph.D.; Benjamin F. Marcune; Paul Mueller, Dr.sc.techn.; Tom F. Peters, Dr.sc.techn.; Warren A. Pillsbury, Ph.D.; Richard Roberts, Ph.D.; Roger D. Simon, Ph.D.; Steven Thode, D.B.A.; Bruce Thomas, Ph.D.; John L. Wilson, Ph.D.; Ivan Zaknic.

Center for Innovation Management Studies
621 Taylor Street; 758-3427
Al Bean, Ph.D., director; Theodore W. Schlie, Ph.D., associate director for research.

Center for Manufacturing Systems Engineering
200 W. Packer Avenue; 758-5157

Center for Polymer Science and Engineering
111 Research Drive; 758-3590
Mohamed S. El-Aasser, Ph.D., director; Manoj K. Chaudhury, Ph.D.; Gregory Ferguson, Ph.D.; Natalie Foster, Ph.D.; Christos Georgakis, Ph.D.; Richard W. Hertzberg, Ph.D.; Daniel C. Hong, Ph.D.; Andrew Klein, Ph.D.; John W. Larsen, Ph.D.; Marie C. Messmer, Ph.D.; H. Daniel Ou-Yang, Ph.D.; Raymond Pearson, Ph.D.; Steven L. Regen, Ph.D.; Maria Santore, Ph.D.; Keith J. Schray, Ph.D.; Cesar A. Silebi, Ph.D.; Leslie H. Sperling, Ph.D.; John W. Vanderhoff, Ph.D.; Emeritus professor; Arkady S. Voloshin, Ph.D.

Center for Social Research
516-520 Brodhead Ave.; 758-3800
Diane Hyland, Ph.D., director; Brenda P. Egolf, M.A., research scientist; John B. Gatewood, Ph.D.; Ellen C. Herrenkohl, Ph.D., research scientist; Roy C. Herrenkohl, Ph.D.; James Jackson, Ph.D.; Judith N. Lasker, Ph.D.; Carole Reese, M.A., research scientist; M. Jean Russo, Ph.D., research scientist; David B. Small, Ph.D.; Joan Z. Spade, Ph.D.; Lori Toedter, Ph.D.; S. Lloyd Williams, Ph.D.

Chemical Process Modeling and Control Research Center
111 Research Drive; 758-4781
Christos Georgakis, Ph.D., director; Dragana Brzakovic, Ph.D.; Laura I.

Diamond Center for Economic Education
621 Taylor Street; 758-3401
Jon T. Innes, director

Emulsion Polymers Institute
111 Research Drive; 610-758-3590
Mohamed S. El-Aasser, Ph.D., director; Eric S. Daniels, Ph.D., associate director; E. David Sudoil, Ph.D., director; Associate Victoria L. Dimonie, Ph.D.; Christos Georgakas, Ph.D., Andrew Klein, Ph.D.; Thomas B. Lloyd, Ph.D.; H. Daniel Ou-Yang, Ph.D.; Raymond A. Pearson, Ph.D.; James E. Roberts, Ph.D.; Leslie H. Sperling, Ph.D.; Cesar A. Silebi, Ph.D.; OlgaL. Shaffer, M.S.; John W. Vanderhoff, Ph.D., emeritus professor.

Energy Research Center
117 ATLLS Drive; 758-4090

Engineering Research Center for Advanced Technology for Large Structural Systems (ATLSS)
117 ATLLS Drive, Imb Laboratories, Mountain Top Campus; 610-758-3535, Fax 610-758-5553, Web http://www.lehigh.edu/~inatl/inatl.html

John W. Fisher, Ph.D., director; John E. Bower, Ph.D., deputy director; John W. Johnson, Ph.D., associate director; William D. Mihaich, (CT.I.) M.B.A., manager-industry liaison and technology transfer; Bruce A. Laub, M.B.A., business manager; Frank E. Stoeke, M.S., manager of structural laboratories; Le-Wu Lu, Ph.D., seismic design technology; Richard D. Granata, Ph.D., corrosion and coatings technology; Richard Sause, Ph.D., structural assemblies and materials; Eric J. Kaufman, Ph.D., metallurgy and fractography; Robert J. Drexler, Ph.D., condition assessment; James M. Riches, Ph.D., structural renewal technology.

Iacocca Institute
111 Research Drive; 758-6723
Dr. Roger Nagel, executive director & CEO; Dr. Emory W. Zimmers, Jr., deputy director; Lin L. Erickson, associate director and executive director of The Discovery Center for Science & Technology; Dr. Mark S. Lang, associate director and executive director, Ben Franklin Technology Center; Dr. Napoleon Devia, senior staff member; Mr. Rusty Patterson, industry president and CEO, The Agility Forum; Edith D. Ritter, director, Manufacturers Resource Center. Iacocca Professors: Mohamed El-Aasser, professor of chemical engineering; Sharon Friedman, professor of journalism and communications; John R. McNamara, professor of economics; Perry A. Zirkel, professor of education and human services.

Institute of Biomedical Engineering and Mathematical Biology
17 Memorial Drive, East; 758-3703
Eric P. Salathe, Ph.D., director; George A. Arangio, M.D., visiting research scientist; Russell E. Benner, Ph.D., research scientist.

Institute for Metal Forming
5E Packer Avenue; 758-4234
Betzadl Avizor, Ph.D., director

Institute of Fracture and Solid Mechanics
19 Memorial Drive, West; 758-4130
George C.M. Sih, Ph.D., director; Fazil Erdogan, Ph.D.; Ronald J. Hartman, Ph.D.; Robert A. Lucas, Ph.D.; Richard Roberts, Ph.D.; Robert G. Sarubbi, Ph.D.; Dean P. Updike, Ph.D.; Robert P. Wei, Ph.D.

Institute of Thermo-Fluid Engineering and Science
111 Research Drive; 758-4091

International Center for Democracy and Social Change
537 Maginness Hall, 9 W. Packer Avenue; 758-4745

Lawrence Henry Gipson Institute for Eighteenth-Century Studies
9 W. Packer Avenue; 758-3369/3360
Jan Forging, Ph.D., co-director; Jean R. Soederlund, Ph.D., co-director; Michael G. Bayler, Ph.D.; Marie Helene Chabot, Ph.D.; Stephen H. Coutelle, Ph.D.; Edward J. Gallagher, Ph.D.; Scott Paul Gordon, Ph.D.; Richard K. Matthews, Ph.D.; Philip A. Metzger, Ph.D.; James S. Saeger, Ph.D.; William G. Shade, Ph.D.; Joan Straunmanis, Ph.D.

Philip and Muriel Berman Center for Jewish Studies
9 W. Packer Avenue; 758-4869, fax 758-4858
Laurence J. Silberstein, Ph.D., director; Robert Cohn, Ph.D., Lafayette College; Chava Weissler, Ph.D., (Lehigh University). Associated faculty: David C. Amidon, Jr., M.A.; Daniela Cohen, M.A.; Alice Eckhardt, M.A., professor emerita; Oles M. Smolansky, Ph.D.; Roslyn Weiss, Ph.D.; Benjamin G. Wright III, Ph.D.

Martindale Center for the Study of Private Enterprise
621 Taylor Street; 758-4771
J. Richard Aronson, Ph.D., director; Robert J. Thornton, Ph.D., associate director; Thomas J. Hyclak, Ph.D., associate director and director of the Kalmich Institute for the Study of Regional Political Economy; Anthony P. O'Brien, Ph.D., head advisor to undergraduate students; Arthur E. King, Ph.D.; Richard W. Barness, Ph.D., director, Iacocca Institute; Melinda deBorreno, Ph.D.; Colleen Callahan, Ph.D.; Parveen Gupta, Ph.D.; Frank Gunter, Ph.D.; James M. Machikula, Ph.D.; Vincent G. Munley, Ph.D.; James Deardorff, Ph.D.; Judith McDonald, Ph.D., director, Canadian Studies Institute; James Rebele, Ph.D.; James W. Schmoller, Ph.D.; Mary Schrann, Ph.D., Roger Simon, Ph.D.; Raymond Wylie, Ph.D.

Materials Research Center
5 E. Packer Avenue; 758-3850
Martin P. Harmer, Ph.D., director; Katayun Barmak, Ph.D., thin films laboratory; Charles Booth, Ph.D., external consultant, materials liaison.
SMART Discovery Center
(See Iacocca Institute listing)

Science, Technology and Society Program and Technology Studies Resource Center
9 W. Packer Avenue; 758-3350
Stephen H. Cutchliffe, director, Science, Technology and Society Program and Technology Studies Resource Center; Rosemarie Arbus, English; Alden S. Bean, management and marketing; Gordon Beam, philosophy; Lynn S. Beadle, civil engineering; Gail Cooper, history; Jack A. DeBellis, English; Robin Dillon, philosophy; Edward B. Evenson, geological sciences; Sharon M. Friedman, journalism; Edward J. Gallagher, English; Norman G. Girardot, religion studies; Steven L. Goldman, philosophy and history; Mikkell P. Groover, industrial engineering; Robert Hanson, English; Francis A. Harvey, education; Ned D. Heindel, chemistry; Roy C. Herrenkohl, social relations; Kenneth L. Kraft, religion studies; Judith N. Lasker, social relations; Benjamin Litt, management and marketing; John R. McNamara, economics; Anne S. Meltzer, earth and environmental sciences; Philip A. Metzger, Linderman Library; Jeffrey Milet, speech and theater; Vincent G. Munley, economics; Roger N. Nagel, computer science and electrical engineering; Michael R. Notis, materials science and engineering; Anthony O’Brien, economics; Alan W. Penze, materials science and engineering; Tom F. Peters, art and architecture; Michael Raposa, religion studies; Christine M. Roysdon, Linderman Library; Paul F. Salerni, music; William E. Schiesser, chemical engineering; Keith J. Schray, chemistry; Roger D. Simon, history; Bruce M. Smackey, management and marketing; Robert E. Rosenwein, social relations and classical studies; David Small, social relations and classical studies; John K. Smith, history; Bruce Thomas, art and architecture; Ricardo Viera, art and architecture; Todd Watkins, economics; Albert H. Wurth, government; Raymond F. Wylie, international relations; Ivan Zaknic, art and architecture; Peter K. Zeitzler, earth and environmental sciences.

Zettlemoyer Center for Surface Studies
7 Asa Drive; 758-3600, FAX 758-6555
Richard G. Herman, Ph.D., executive director; Manoj K. Chaudhury, Ph.D., associate professor of chemical engineering; Gregory S. Ferguson, Ph.D., associate professor of chemistry; Natalie Foster, Ph.D., associate professor of chemistry; Richard D. Granata, Ph.D., director, corrosion prevention laboratory; James C.M. Iwag, Ph.D., professor of electrical engineering and computer science; Leonard E. Klebanoff, Ph.D., professor of chemistry and director, surface magnetism laboratory; Kamil Klotz, Ph.D., professor and director, catalysis laboratory; John W. Larson, Ph.D., professor of organic chemistry; Charles E. Lyman, Ph.D., professor of materials science and engineering; Marie Messmer, Ph.D., assistant professor of chemistry and director, nonlinear spectroscopy laboratory; Fortunato J. Micale, Ph.D., professor (retired) of chemistry and director, colloid laboratory; Albert C. Miller, Ph.D., director, XPS laboratory; Carl O. Moses, Ph.D., associate professor of earth and environmental sciences; Steven L. Regen, Ph.D., professor of organic and polymer chemistry; James E. Roberts, Ph.D., associate professor of chemistry; Gary W. Simmons, Ph.D., professor of chemistry and director, surface analysis laboratory; Israel E. Wachs, Ph.D., professor of chemical engineering and director, vibrational spectroscopy laboratory; Robert P. Wei, Ph.D., professor and director, environment-sensitive fracture laboratory.

Research Scientists: Ming Gao, Ph.D.; Richard D. Granata, Ph.D.; Richard G. Herman, Ph.D.; Thomas Lloyd, Ph.D.; Alfred C. Miller, Ph.D.; Kenneth T. Park, Ph.D.

Visiting Research Scientists: Laura Brind, Jiulin Dai, Jan Glueckstein, Chen-Char Hsu, Eugene S. Ilton, Roy Miron, Mahmoud Mouzavv-Madani, Chun-Bao Wang, Yarjing Yang
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<td>February 2 (Monday) - Last day to select or cancel pass/fail grading</td>
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<td>September 24 (Wednesday) - Four o’clock quizzes</td>
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<td>November 5 (Wednesday) - Four o’clock quizzes</td>
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<tr>
<td>Monday classes. Last day for January doctoral degree</td>
<td>May 15 (Friday) - Final exams end</td>
</tr>
<tr>
<td>December 9 (Tuesday) - Final exams begin</td>
<td>May 19 (Tuesday) - 8:30 a.m. Faculty grades due to</td>
</tr>
<tr>
<td>December 17 (Wednesday) - Final exams end</td>
<td>Registrar’s Office</td>
</tr>
<tr>
<td>December 22 (Monday) - 8:30 a.m. Faculty grades due to</td>
<td>May 20 (Wednesday) - Student grade rosters to be mailed to home address</td>
</tr>
<tr>
<td>Registrar’s Office</td>
<td></td>
</tr>
</tbody>
</table>
LEHIGH
University

Office of Admissions
Alumni Memorial Building
27 Memorial Drive West
Bethlehem, PA 18015-3094