Mechanical Engineering and Mechanics

OUR MISSION
The mission of the Department of Mechanical Engineering and Mechanics is to provide quality education and training to undergraduate and graduate students, to develop new knowledge and engineering methodology through research, and to provide service to industry and society at large.

STUDENT ENROLLMENT AND GRADUATION DATA
The Mechanical Engineering undergraduate program is accredited by the Engineering Accreditation Commission of ABET (http://www.abet.org) and is the largest undergraduate program within Lehigh's P.C. Rossin College of Engineering and Applied Science. Our enrollment and graduation figures can be found in this table. (http://www.lehigh.edu/engineering/academics/accredited/#mechanical)

PROGRAM OBJECTIVES
In harmony with the mission stated above, the department has adopted three Program Educational Objectives (PEOs) for the undergraduate program in Mechanical Engineering. Program graduates are expected, three to five years from graduation, to:

1. Successfully practice mechanical engineering and/or pursue advanced education, possibly towards other professions such as law, medicine, business, etc.
2. Participate at varying degrees in research and development, and other creative efforts in science, engineering, technology and/or technological entrepreneurship.
3. Engage in activities that demonstrate a commitment to professionalism and personal development and possibly demonstrate leadership qualities.

In order to achieve these objectives the ME program ensures that its graduates are capable of the eleven Student Outcomes (a-k) proposed by the accreditation organization ABET and adopted verbatim by the Lehigh University ME program. These outcomes are:

a. Ability to apply knowledge of mathematics, science and engineering.
b. Ability to design and conduct experiments, as well as to analyze and interpret data.
c. An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.
d. Ability to function on multi-disciplinary teams.
e. Ability to identify, formulate, and solve engineering problems.
f. Understanding of professional and ethical responsibility.
g. Ability to communicate effectively.
h. Broad education necessary to understand the impact of engineering solution in a global and societal context.
i. Recognition of the need for, and an ability to engage in lifelong learning.
j. Knowledge of contemporary issues.
k. Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Achievement of the aforementioned educational objectives is served first through a sound education in mathematics, physics, and engineering sciences; second, by exposure to the engineering process (creation, innovation, analysis, and judgment) through design courses, projects, laboratories, and a choice of technical electives that permits a degree of specialization; and third, by the development of cultural awareness through courses in humanities and social sciences. Students may also take elective courses that transcend traditional disciplinary lines, while still satisfying the requirements for mechanical engineering.

The undergraduate program provides students with the basic education they will need to function in an engineering environment, pursue graduate studies, continue their professional development, and establish an awareness of the culture and society in which we live. Because of technological innovations and the long term demands of global competition, the department seeks to prepare our students to adapt to the rapid advances and changes in technology, and to serve as agents and leaders in effecting these changes, while being cognizant of the needs and concerns of the society at large.

The graduate program bridges between the generalized undergraduate studies and the more focused research and remarkable accomplishments of our faculty. New graduate students participate in research by working closely with their faculty advisors; however, they are quickly encouraged to work and think independently, assuming greater responsibility for critical research functions. This learning process prepares the students for future research and development positions in industry or academia, where they can contribute toward the improvement and advancement of the community and society at large.

Professors. John P. Coulter, PhD (University of Delaware); John N. DuPont, PhD (Lehigh University); Patrick V. Farrell, PhD (University of Michigan Ann Arbor); Joachim L. Grenestedt, DSc (Royal Institute of Technology); D. Gary Harlow, PhD (Cornell University); Jacob Y. Kazakia, PhD (Lehigh University); Wojciech Z. Misiolek, DSc (AGH University of Science & Technology); Herman F. Nied, PhD (Lehigh University); John B. Ochs, PhD (The Pennsylvania State University); Tulga M. Ozsoy, PhD (Istanbul Technical University); Alparaslan Oztekin, PhD (University of Illinois Urbana); Donald O. Rockwell, Jr., PhD (Lehigh University); Eugenio Schuster-Rosa, PhD (University of California San Diego); Arkady Voloshin, PhD (Tel Aviv University)

Associate Professors. Meng-Sang Chew, PE (University of Virginia); Yaling Liu, PhD (Northwestern University); Noel Duke Perreira, PhD (University of California Los Angeles); Edmund B. Webb, III, PhD (Rutgers University)

Assistant Professors. Arindam Banerjee, PhD (Texas A&M University); Subhrajit Bhattacharya, PhD (University of Pennsylvania); Hannah Lee Dailey, PhD (Lehigh University); Justin Jaworski, PhD (Duke University); Brandon A. Krick, PhD (University of Florida); Keith W. Moores, III, PhD (University of Virginia); Nader Motiei, PhD (University of Pennsylvania); Natasha Vermaak, PhD (University of California Santa Barbara); Xiaohui Zhang, PhD (University of Miami)

Professors Of Practice. David C. Angstadt, PhD (Lehigh University); William Andrew Best, MS (Virginia Tech); Marc de Vinck, BFA (Parsons School of Design); Terry J. Hart, MS (Rutgers University); Michael Lehman, MD (Penn State College of Medicine); Murat Ozturk, PhD (Lehigh University)

Emeriti. Russell E. Benner, PhD (Lehigh University); Philip A. Blythe, PhD (University of Manchester); Forbes T. Brown, DSc (Massachusetts Institute of Technology); Terry J. Delph, PhD (Stanford University); Ronald J. Hartranft, PhD (Lehigh University); Stanley H. Johnson, PhD (University of California Berkeley); Arturs Kalnins, PhD (University of Michigan Ann Arbor); Edward K. Levy, SCD (Massachusetts Institute of Technology); Robert A Lucas, PhD (Lehigh University); Sudhakar Neti, PhD (University of Kentucky Lexington); Jerzy A Owczarek, PhD (University of London); Richard Roberts, PhD (Lehigh University); Robert G. Sarubbi, PhD (Lehigh University); Kenneth N. Sawyer, PhD (Brown University); George C. Sih, PhD (Lehigh University); Charles R. Smith, PhD (Stanford University); Gerald F. Smith, PhD (Brown University); Theodore A. Terry, PhD (Lehigh University); Dean P. Updike, PhD (Brown University); Eric Varley, PhD (Brown University)

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 motions 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 Integrated Product Development, combining state-of-the-art computer aided design and manufacturing methods in a business oriented framework. Several specific application fields are 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 a minimum of seven courses in humanities and social sciences (see humanities/social sciences), two free electives and five approved electives. The total graduation requirement is 129 credits.

### UNDERGRADUATE CURRICULUM IN MECHANICAL ENGINEERING

<table>
<thead>
<tr>
<th>First Year</th>
<th>Credits</th>
<th>Second Semester</th>
<th>Credits</th>
<th>Third Year</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGL 001 (Composition &amp; Literature)</td>
<td>3</td>
<td>ENGL 002 (Composition &amp; Literature II)</td>
<td>3</td>
<td>ME 021 (Mechanical Engineering Laboratory I)</td>
<td>1</td>
</tr>
<tr>
<td>MATH 021 (Calculus I)</td>
<td>4</td>
<td>MATH 022 (Calculus II)</td>
<td>4</td>
<td>ME 231 (Fluid Mechanics)</td>
<td>3</td>
</tr>
<tr>
<td>ENGR 005 (Introduction to Engineering Practice)</td>
<td>2</td>
<td>ECO 1 or HSS elective</td>
<td>4</td>
<td>MECH 102 (Dynamics)</td>
<td>3</td>
</tr>
<tr>
<td>Select one of the following:</td>
<td>5-6</td>
<td>Select one of the following:</td>
<td>5-6</td>
<td>HSS Electives</td>
<td>6-8</td>
</tr>
</tbody>
</table>

- ENGR 010 & CHM 030
- PHY 011 & PHY 012 (Introductory Physics I and Lab)

<table>
<thead>
<tr>
<th>Fourth Year</th>
<th>Credits</th>
<th>Second Semester</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME 111 (Professional Development (fall only))</td>
<td>1</td>
<td>Engineering Required/Technical-Elective courses</td>
<td>12-14</td>
</tr>
<tr>
<td>TE 212</td>
<td>2</td>
<td>HSS &amp; Free Electives</td>
<td>4</td>
</tr>
<tr>
<td>Engineering Required/Technical-Elective courses</td>
<td>6-8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HSS and Free Electives</td>
<td>4-6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Total Credits: | 124-135 |

- Total Credits Required for Graduation: 129
- **1** Required natural science courses, one taken fall semester and the other taken in spring.
- **2** For ME program the preferred course in this semester is ECO 001 Principles of Economics 4 credits.
- **3** Total credits for HSS and free electives must be at least 19 of which at least 13 must be HSS electives (for detailed description of HSS electives see the pages of RCEAS).

Required HSS courses 10 credits: ECO 001 Principles of Economics 4 credits

<table>
<thead>
<tr>
<th>Literature 3 credits</th>
<th>ENGL 001 Composition and</th>
</tr>
</thead>
<tbody>
<tr>
<td>Literature II 3 credits</td>
<td>ENGL 002 Composition and</td>
</tr>
</tbody>
</table>

Senior year Required/Technical-Elective courses total 20 credits according to the following schedule:

| ME 321 | Introduction to Heat Transfer | 3 |
| ME 207 | Mechanical Engineering Laboratory III | 2 |
| ME 322 | Thermodynamics II | 3 |
| ME 331 | Advanced Fluid Mechanics | 3 |
| ME 343 | Control Systems | 3 |

**Engineering Elective A:** Select one of the following for 3 credits:

- MECH 302 | Advanced Dynamics (Spring Semester) | 3 |
- MECH 305 | Advanced Mechanics of Materials (Fall Semester) | 3 |
- ME 304 | Thermodynamics II (Fall Semester) | 3 |
- ME 322 | Gas Dynamics (Spring Semester) | 3 |
- ME 331 | Advanced Fluid Mechanics (Fall Semester) | 3 |

**Engineering Elective B:** Select one of the following for 3 credits:

- Any ME or MECH three-hundred-level course, excluding ME 300 and ME 310 | 9 |
- Engineering Electives C: Select three courses for 9 credits | 9 |

| Total Credits | 20 |
**UNDERGRADUATE CURRICULUM IN ENGINEERING MECHANICS**

The curriculum in engineering mechanics is designed to prepare students for careers in engineering research and development, and it 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 role.

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 six 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. 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 a minimum of seven courses in humanities and social sciences (see humanities/social sciences). The total graduation requirement is 127 credits.

### UNDERGRADUATE CURRICULUM IN ENGINEERING MECHANICS

#### First Year

<table>
<thead>
<tr>
<th>First Semester</th>
<th>Credits</th>
<th>Second Semester</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGL 001 (Composition &amp; Literature)</td>
<td>3</td>
<td>ENGL 002 (Composition &amp; Literature II)</td>
<td>3</td>
</tr>
<tr>
<td>MATH 021 (Calculus I)</td>
<td>4</td>
<td>MATH 022 (Calculus II)</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 005 (Introduction to Engineering Practice)</td>
<td>2</td>
<td>ECO 1 or HSS elective</td>
<td>3-4</td>
</tr>
</tbody>
</table>

Select one of the following: 5-6

| ENGR 010 & CHM 030 | 6 | ENGR 010 & CHM 030 | 6 |
| PHY 011 & PHY 012 (Introductory Physics I and Lab) | 5 | PHY 011 & PHY 012 (Introductory Physics I and Lab) | 5 |

| Total Credits: 14-15 |

#### Second Year

<table>
<thead>
<tr>
<th>First Semester</th>
<th>Credits</th>
<th>Second Semester</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME 010 (Graphics for Engineering Design)</td>
<td>3</td>
<td>ME 104 (Thermodynamics I)</td>
<td>3</td>
</tr>
<tr>
<td>MECH 003 (Fundamentals of Engineering Mechanics)</td>
<td>3</td>
<td>MECH 012 (Strength of Materials)</td>
<td>3</td>
</tr>
</tbody>
</table>

| Total Credits: 15-17 |

#### Third Year

<table>
<thead>
<tr>
<th>First Semester</th>
<th>Credits</th>
<th>Second Semester</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME 021 (Mechanical Engineering Laboratory I)</td>
<td>1</td>
<td>ME 121 (Mechanical Engineering Lab II)</td>
<td>1</td>
</tr>
<tr>
<td>ME 231 (Fluid Mechanics)</td>
<td>3</td>
<td>ME 240 (Manufacturing)</td>
<td>3</td>
</tr>
<tr>
<td>MECH 102 (Dynamics)</td>
<td>3</td>
<td>MATH 208 (Complex Variables)</td>
<td>3</td>
</tr>
<tr>
<td>MATH 230 (Numerical Methods)</td>
<td>3</td>
<td>ECE 083 (Introduction to Electrical Engineering)</td>
<td>3</td>
</tr>
<tr>
<td>Electives</td>
<td>6-8</td>
<td>ECE 162 (Electrical Laboratory)</td>
<td>1</td>
</tr>
</tbody>
</table>

| Total Credits: 17-18 |

#### Fourth Year

<table>
<thead>
<tr>
<th>First Semester</th>
<th>Credits</th>
<th>Second Semester</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>ME 111 (Professional Development [fall only])</td>
<td>1</td>
<td>Engineering Required/Technical-Elective courses</td>
<td>9-11</td>
</tr>
<tr>
<td>Engineering Required/Technical-Elective courses</td>
<td>9-11</td>
<td>HSS and Free Electives</td>
<td>3</td>
</tr>
<tr>
<td>HSS and Free Electives</td>
<td>4</td>
<td>undefined</td>
<td></td>
</tr>
</tbody>
</table>

| Total Credits: 14-16 |

**Total Credits: 120-132**

**TOTAL CREDITS REQUIRED FOR GRADUATION 127**

1. Required natural science courses, one taken fall semester and the other taken in spring
2. For ME/MECH programs the preferred course in this semester is ECO 001 Principles of Economics 4 credits.
3. Total credits for HSS and free electives must be at least 19 of which at least 13 must be HSS electives (for detailed description of HSS electives see the pages of RCEAS).
4. Required HSS courses 10 credits: ECO 001 Principles of Economics 4 credits
5. Literature 3 credits
6. Literature II 3 credits

### Co-Op Program

To participate in the Co-op program students must rank in the top third of the engineering class after three semesters of study and attend a summer program between the sophomore and junior years. Students must see their advisor or contact the Co-op Faculty Liaison for further details.

B.S. IN ENGINEERING MECHANICS

For the flow chart of the program please follow the link: Flow Chart (http://catalog.lehigh.edu/coursesprogramsandcurricula/engineeringandappliedscience/mechanicalengineeringandmechanics/BSME_Flowchart_AY_2015-16.pdf)

*Co-op students must take ME 021 (http://catalog.lehigh.edu/search?P=ME%20021) sophomore year, second semester (18-19 credit hours). Co-op students will take a MATH elective (3), ME 231 (3), MECH 102(3), and a HSS elective (3-4) during the summer after the sophomore year (12-13 credit hrs.). See Co-op program for details.

### Co-Op Year

<table>
<thead>
<tr>
<th>Credits</th>
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<tr>
<td>12-13</td>
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</table>

### Senior year Required/Technical-Elective courses total 23 credits according to the following schedule:

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>ME 321</td>
<td>Introduction to Heat Transfer (For 3 credits; available Fall or Spring)</td>
</tr>
<tr>
<td>ME 207</td>
<td>Mechanical Engineering Laboratory III (For 2 credits; available Fall or Spring)</td>
</tr>
<tr>
<td>MECH 302</td>
<td>Advanced Dynamics (Spring Semester)</td>
</tr>
<tr>
<td>MECH 305</td>
<td>Advanced Mechanics of Materials (Fall Semester)</td>
</tr>
</tbody>
</table>

**Engineering Elective A:** Select two of the following for 6 credits

<table>
<thead>
<tr>
<th>Credits</th>
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<tbody>
<tr>
<td>6</td>
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</tbody>
</table>

**Engineering Elective B:** Select two of the following for 6 credits

<table>
<thead>
<tr>
<th>Credits</th>
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<tbody>
<tr>
<td>6</td>
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</table>
MINOR IN AEROSPACE ENGINEERING

The minor in aerospace engineering provides a foundation for students who intend to pursue a career in the aerospace industry. This minor will also provide sufficient technical background in aerospace studies for undergraduates who plan to enter graduate programs in this field. The minor requires a minimum of 15 credits from the following course selection:

**Required Courses**
- ME 255: Introduction to Aerospace Engineering
- MECH 326: Aerodynamics
- MECH 328: Fundamentals of Aircraft Design

**Elective Courses**
Select two of the following:
- ME 309: Composite Materials
- ME 322: Gas Dynamics
- ME 331: Advanced Fluid Mechanics
- ME 333: Propulsion Systems
- ME 343: Control Systems
- ME 348: Computer-Aided Design
- MECH 305: Advanced Mechanics of Materials

**Total Credits Required:** 127

*Co-op students must take ME 021 sophomore year, second semester (18-19 credit hours). Co-op students will take ME 231 (3), MECH 102(3), and two HSS electives (6-8) during the summer after the sophomore year (12-14 credit hours). See Co-op program for details.

Typical recommended options:

**Applied Mathematics and Computational Mechanics**
- MECH 305: Advanced Mechanics of Materials
- MECH 312: Finite Element Analysis
- MATH 309: Theory of Probability
- MATH 322: Methods of Applied Analysis I
- MATH 323: Methods of Applied Analysis II

**Solid Mechanics**
- MECH 305: Advanced Mechanics of Materials
- MECH 307: Mechanics of Continua
- MECH 312: Finite Element Analysis
- MECH 313: Fracture Mechanics
- MATH 322: Methods of Applied Analysis I

**Engineering Materials**
- MECH 305: Advanced Mechanics of Materials
- MECH 313: Fracture Mechanics
- MAT 218: Mechanical Behavior of Macro/Nanoscale Materials
- PHY 031: Introduction to Quantum Mechanics
- PHY 363: Physics of Solids

**Fluid Mechanics**
- ME 331: Advanced Fluid Mechanics
- ME 322: Gas Dynamics
- MECH 326: Aerodynamics
- MATH 322: Methods of Applied Analysis I

**MINOR IN MECHANICS OF MATERIALS**

The minor in mechanics of materials provides a view of mechanical strength and behavior of materials based on understanding a few basic concepts and using simplified material models. Courses selected for the minor will provide sufficient technical background in mechanics of materials for students having a major in the Department of Mechanical Engineering and Mechanics.

**Required Courses**
- MECH 360: Nuclear Reactor Engineering
- MECH 362: Nuclear Fusion and Radiation Protection
- MECH 364: Renewable Energy
- MECH 366: Engineering Principles of Clean Coal Technology

**Elective Energy Courses**
Select at least three of the following:
- ME 360: Nuclear Reactor Engineering
- ME 362: Nuclear Fusion and Radiation Protection
- MECH 376: Energy: Issues & Technology
- MECH 386: Process Control
- ME 322: Gas Dynamics
- ME 331: Advanced Fluid Mechanics
- ME 343: Control Systems

**Total Credits Required:** 127

*Additional Electives*
Select one of the following:
- CHE 373: Fundamentals of Air Pollution
- CHE/ME 376: Energy: Issues & Technology
- CHE 386: Process Control
- ME 322: Gas Dynamics
- ME 331: Advanced Fluid Mechanics
- ME 343: Control Systems

**Total Credits**

*Total Credits Required:* 15

**MINOR IN ENERGY ENGINEERING**

The minor in energy engineering touches upon the technologies associated with the transformation and use of energy in various forms. Since every sector of engineering and the economy require energies of one form or another, the courses included in this minor program will permit student exposure to fossil, nuclear and renewable energy technologies. The mechanical engineering curriculum provides the fundamental knowledge in thermodynamics, fluid mechanics and other related areas leading up to the courses for the energy engineering minor. The courses offer a wide variety of topics including fundamental, analytical and design aspects of energy conservation as well as various forms of energy used in power generation, transportation and industry.

The minor in energy engineering requires a minimum of 15 credits, which must be taken from MEM offerings. The minor in energy is primarily intended for ME Majors but students with other majors, particularly Chemical engineering will be able to take some or all the related courses. Four courses are required with some degree of choice and an additional course must be selected from a broader set.

**Required course**
- ME 304: Thermodynamics II

**Elective Energy Courses**
Select at least three of the following:
- ME 360: Nuclear Reactor Engineering
- ME 362: Nuclear Fusion and Radiation Protection
- ME 364: Renewable Energy
- ME 366: Engineering Principles of Clean Coal Technology

**Additional Electives**
Select one of the following:
- CHE 373: Fundamentals of Air Pollution
- CHE/ME 376: Energy: Issues & Technology
- CHE 386: Process Control
- ME 322: Gas Dynamics
- ME 331: Advanced Fluid Mechanics
- ME 343: Control Systems

**Total Credits Required:** 127

*Additional Electives*
Select one of the following:
- CHE 373: Fundamentals of Air Pollution
- CHE/ME 376: Energy: Issues & Technology
- CHE 386: Process Control
- ME 322: Gas Dynamics
- ME 331: Advanced Fluid Mechanics
- ME 343: Control Systems

**Total Credits**

*Total Credits Required:* 15

**MINOR IN ENERGY ENGINEERING**

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Select at least three of the following:
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**Total Credits Required:** 127

*Additional Electives*
Select one of the following:
- CHE 373: Fundamentals of Air Pollution
- CHE/ME 376: Energy: Issues & Technology
- CHE 386: Process Control
- ME 322: Gas Dynamics
- ME 331: Advanced Fluid Mechanics
- ME 343: Control Systems

**Total Credits**

*Total Credits Required:* 15

**MINOR IN MECHANICS OF MATERIALS**

The minor in mechanics of materials provides a view of mechanical strength and behavior of materials based on understanding a few basic concepts and using simplified material models. Courses selected for the minor emphasize concepts such as superposition of loadings; relation between external loads and internal stresses; factor of safety; safe design based on allowable stress or allowable loads; allowable deformation; and reliability of structures. Courses offer a wide variety of topics including analytical and numerical methods for solving mechanics problems; manufacturing and polymer processing.

The mechanics of materials minor requires a minimum of 15 credits, which must be taken from MEM offerings. Two courses are required; and three additional electives must be selected. The minor is not available for students having a major in the Department of Mechanical Engineering and Mechanics.

**Required courses**
- MECH 012: Strength of Materials

**Electives**
Select three of the following:
- ME 010: Graphics for Engineering Design
- ME 215: Engineering Reliability
ME 240 Manufacturing
ME 252 Mechanical Elements
ME/MAT/ISE 344 Metal Machining Analysis ¹
ME 385 Polymer Product Manufacturing
MECH 102 Dynamics
MECH 305 Advanced Mechanics of Materials
MECH 312 Finite Element Analysis
MECH 313 Fracture Mechanics

Total Credits 15

¹ This cross-listed course ME 344 counts as an elective.

GRADUATE PROGRAMS

The Department offers programs of study leading to the degrees of Master of Science, Master of Engineering, and Doctor of Philosophy in Mechanical Engineering and Master of Science and Doctor of Philosophy in Computational and Engineering Mechanics.

Subject to approval, courses from other engineering curricula, such as mathematics, may be included in the degree program.

MASTERS DEGREE PROGRAMS

The Department of Mechanical Engineering and Mechanics offers two Masters degree programs: the Master of Engineering degree (without a thesis) and the Master of Science degree (with a thesis). Both programs require 30 credit hours of graduate work (audit courses may not be used towards the degree) and must satisfy the following University course distribution requirements, as outlined in the RCEAS Graduate Student Handbook. The minimum program for all Masters degrees includes:

- Not less than 24 credits of 300- and 400-level coursework of which at least 18 hours is at the 400-level. Thesis credits count as part of the 400-level requirement.
- Not less than 18 credit hours in Mechanical Engineering and Mechanics.
- Not less than 15 credit hours of 400-level coursework in Mechanical Engineering and Mechanics.
- No course below the 300-level in Mechanical Engineering and Mechanics can be used towards the degree; however, two courses (6 credits) outside of the department, but in the engineering field, at level 200 and above, may apply, with approval from a student's advisor and the Departmental Graduate Committee.

Master of Science in Mechanical Engineering

The Master of Science degree in Mechanical Engineering requires 24 credit hours of courses and 6 credit hours of research, which culminates in a thesis, for a total of 30 credits. The University course distribution requirements, listed above, must be satisfied, as well as core course requirements. The core course requirement consists of: ME 452 and ME 453 or ME 413 (6 credits) and three additional core courses (9 credits). In addition, the student selects three electives (9 credits) and ME 490 thesis (6 credits), for the 30 credit total.

ME 452 Mathematical Methods In Engineering I 3
ME 453 Mathematical Methods In Engineering II 3
or ME 413 Numerical Methods in Mechanical Engineering 3

Select three of the following: 9

ME 423 Heat and Mass Transfer
ME 430 Advanced Fluid Mechanics
MECH 406 Fundamentals of Solid Mechanics
MECH 425 Analytical Methods in Dynamics and Vibrations
ME 401 Integrated Product Development
or ME 402 Advanced Manufacturing Science
ME 490 Thesis 6

Electives ¹ 9

Total Credits 30

¹ Electives: Three additional courses approved by the student's advisor and Departmental Graduate Committee. The courses selected, when considered with all other courses for the MS degree, must satisfy the University's course distribution requirement for the Master's degree.

Master of Engineering in Mechanical Engineering

The Master of Engineering degree requires 30 credit hours of graduate work. These 30 credit hours may include some or none of the core courses as described under the Master of Science degree. The University course distribution requirements, listed above, must be satisfied.

Master of Science in Computational and Engineering Mechanics

All students pursuing a master's degree in Computational and Engineering Mechanics must take a minimum of 30 credit hours of graduate level work, with not less than 24 of these hours being at the 400 level. The program must include the following courses and must satisfy the University's course distribution requirement for the Master's degree.

Required Courses

ME 452 Mathematical Methods In Engineering I 3
ME 453 Mathematical Methods In Engineering II 3
ME 413 Numerical Methods in Mechanical Engineering 3

Additional Requirements

Select two of the following: 6

ME 423 Heat and Mass Transfer
ME 430 Advanced Fluid Mechanics
MECH 406 Fundamentals of Solid Mechanics
MECH 425 Analytical Methods in Dynamics and Vibrations

Select any of the graduate courses in MEM and other approved electives. Both thesis and non-thesis options are available.

Total Credits 30

Doctor of Philosophy in Mechanical Engineering

The PhD program in Mechanical Engineering and Mechanics requires innovative research in collaboration with one or more faculty members, along with the completion of 72 credit hours beyond the bachelor's degree (if graduate study is carried out entirely at Lehigh University), or 48 beyond the master's degree (obtained at another university). The first stage of PhD candidacy in Mechanical Engineering and Mechanics is attained by achieving a minimum GPA of 3.35 in five core courses (see core course requirements for Master of Science in Mechanical Engineering). PhD students must also take ME 453, which can either be taken as part of the five core course requirement or taken as an additional course. The second stage of candidacy involves completion of a General Examination, which is based on assessment and presentation of a research topic. Formal University candidacy for the PhD is granted upon recommendation of the doctoral committee and approval by the engineering college. Course work for the PhD is determined in consultation with the student's advisor and doctoral committee. To complete the PhD degree, the student must present and defend a dissertation before the doctoral committee.

Doctor of Philosophy in Computational and Engineering Mechanics

The PhD program in Computational and Engineering Mechanics requires innovative research in collaboration with one or more faculty members, along with the completion of 72 credit hours beyond the bachelor's degree (if graduate study is carried out entirely at Lehigh University), or 48 beyond the master's degree (obtained at another university). Students wishing to pursue a PhD in Computational and Engineering Mechanics must take the following courses as part of their total credit requirement:
RECENT RESEARCH ACTIVITIES

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 heat transfer;
- 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.

Design

- Geometric modeling; tolerance analysis and synthesis; assembly modeling; geometric dimensioning and tolerancing; 3D 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; composites processing; thermoforming; resin transfer molding; spin coating; electronic packaging.

Systems Dynamics and Controls

- Modeling, simulation and control of dynamic systems including: control of unstable processes, programmed logic control experience, compensator design and construction, issues in digital implementation, state-of-the-industrial art experimental equipment, energy methods and bond graph modeling, methods of model identification from experimental data; application to various mechanisms, vehicles, chemical processes, aircraft systems, chemical processes, hydraulic systems, thermodynamic systems, microelectromechanical actuators; application to mechatronics for the integration of mechanical systems, computer control and programming for the design of smart consumer products and intelligent manufacturing machinery.
Stochastic Processes
Modeling of random behavior in mechanical systems; static and time-dependent stochastic fracture mechanics, with particular applications to assessments of reliability and service life prediction.

Engineering Mathematics

Mechanical Engineering Courses
ME 010 Graphics for Engineering Design 3 Credits
Graphical description of mechanical engineering design for visualization and communication by freehand sketching, production drawings, and 3D solid geometric representations. Introduction to creation, storage, and manipulation of such graphical descriptions through an integrated design project using state-of-the-art, commercially available computer-aided engineering software. Lectures and laboratory. (ES 1), (ED 2).

ME 017 Numerical Methods in Mechanical Engineering 2 Credits
Numerical methods applied to mechanical engineering problems. Techniques for interpolation, curve fitting, plotting of numerical data, etc. Numerical techniques for solving algebraic and differential equations. Computational platforms to be used include MATLAB.
Prerequisites: ENGR 010

ME 021 Mechanical Engineering Laboratory I 1 Credit
Prerequisites: MECH 012
Can be taken Concurrently: MECH 012

ME 050 Supplemental Topics in Mechanical Engineering 1-2 Credits
Completion of material for Mechanical Engineering courses transferred from other institutions. Student will be scheduled for that part of Mechanical Engineering that is required for completion of missing material. Subject matter and credit hours to be determined by department chair for each student.

ME 104 Thermodynamics I 3 Credits
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.
Prerequisites: (MATH 033 or MATH 023) and (PHY 011)
Can be taken Concurrently: MATH 033, MATH 023, PHY 011

ME 111 Professional Development 1 Credit
Examination of ethical and professional choices facing mechanical engineers. Written and oral communications. Must have senior standing in Mechanical Engineering and Mechanics.

ME 121 Mechanical Engineering Laboratory II 1 Credit
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 021 and ME 104 and ME 231
Can be taken Concurrently: ME 231

ME 141 General Aviation Technology and Operations 2 Credits
A Federal Aviation Administration (FAA) certified course for students interested in understanding the engineering and operational aspects of the general aviation industry, including aerodynamics, aircraft systems and performance, weather, navigation, flight procedures, regulations, maneuvers, and the physiology of flight. Successful completion of the course will fulfill the FAA requirement for the ground school component of a private pilot certification.
Prerequisites: PHY 011

ME 142 Instrument Ground Training 2 Credits
A Federal Aviation Administration (FAA) certified course for students interested in pursuing an instrument rating from the FAA. Successful completion of the course will fulfill the FAA requirement for the ground school component of an instrument rating.
Prerequisites: ME 141

ME 207 Mechanical Engineering Laboratory III 2 Credits
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.
Prerequisites: ME 121

ME 215 Engineering Reliability 3 Credits
Applications of reliability methods to engineering problems. Modeling and analysis of engineered components and systems subjected to environmental and loading conditions. Modeling content encompasses mechanistically based probability and experientially based statistical approaches. Concepts needed for design with uncertainty are developed. Principles are illustrated through case studies and projects. Engineering applications software will be extensively utilized for the projects.
Prerequisites: (MATH 023 or MATH 033) and MECH 012
Can be taken Concurrently: MECH 012

ME 231 Fluid Mechanics 3 Credits
Prerequisites: MATH 205

ME 240 Manufacturing 3 Credits
Prerequisites: ME 010 and MECH 012

ME 242 Mechanical Engineering Systems 3 Credits
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 and MATH 205

ME 245 Engineering Vibrations 3 Credits
Prerequisites: MECH 102 and MATH 205 and ME 017

ME 252 Mechanical Elements 3 Credits
Methods for the analysis and design of machine elements such as springs, gears, clutches, brakes, and bearings. Motion analysis of cams and selected mechanisms. Projects requiring the design of simple mechanisms of mechanical sub-assemblies.
Prerequisites: MECH 012 and ME 010 and MECH 102
ME 255 Introduction to Aerospace Engineering 3 Credits
Properties of the atmosphere, aircraft design and performance basics including estimation of lift and drag of aerodynamic bodies. Concepts of stall and service ceiling of aircraft along with propulsive forces, stability and control.
Prerequisites: (PHY 011 and ME 104 and ME 231)
Can be taken Concurrently: ME 231
ME 299 Special Topics In Mechanical Engineering 1-4 Credits
Repeat Status: Course may be repeated.
ME 300 Apprentice Teaching 3 Credits

ME 304 Thermodynamics II 3 Credits
Prerequisites: ME 104

ME 309 (MAT 309) Composite Materials 3 Credits
Principles and technology of composite materials. Processing, properties, and structural applications of composites, with emphasis on fiber-reinforced polymers.
Prerequisites: (MECH 003 and MAT 033)

ME 310 Directed Study 1-3 Credits
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. Consent of department required.
Repeat Status: Course may be repeated.

ME 312 Analysis and Synthesis Of Mechanisms 3 Credits
Types of motion. Degrees of freedom of motion. Position, velocity and acceleration analysis of linkage mechanisms. Systematic approach to the design of linkage mechanisms. Motion generation, path synthesis and function synthesis. Structural synthesis of planar and spatial mechanisms. Static force analysis of mechanisms using virtual work.
Prerequisites: MATH 205 and MECH 102

ME 314 (MAT 314) Metal Forming Processes 3 Credits

ME 315 (BIOE 315) Bioengineering Statistics 3 Credits
Probability and statistics applied to bioengineering problems focusing on modeling and data analysis. Types of data, types of distributions, parametric and nonparametric analyses, goodness-of-fit, regression, power analysis, and multivariate analysis, life models, simulation, cluster analysis, and Bayesian statistics. Projects and case studies.
Prerequisites: MATH 231

ME 321 Introduction to Heat Transfer 3 Credits
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 and ME 231

ME 322 Gas Dynamics 3 Credits
Prerequisites: ME 231 and ME 104

ME 323 Reciprocating and Centrifugal Engines 3 Credits
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.
Prerequisites: ME 104

ME 331 Advanced Fluid Mechanics 3 Credits
Prerequisites: ME 231

ME 333 Propulsion Systems 3 Credits
Review of jet and rocket engine technologies. Jet and rocket engine thermodynamic and aerodynamic principles. Performance of turbojet, turbofan, and turboprop jet engines. Rocket engines include liquid, cryogenic, solid, and electric propulsion.
Prerequisites: ME 104 and (MECH 326 or ME 322)

ME 340 Advanced Mechanical Design 3 Credits
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.

ME 341 Mechanical Systems 3 Credits
Prerequisites: ME 252

ME 342 Dynamics of Engineering Systems 3 Credits
Dynamic analysis of mechanical, electromechanical, fluid and hybrid engineering systems with emphasis on the modeling process. Lumpd and distributed-parameter models. Use of computer tools for modeling, design and simulation. Design projects.
Prerequisites: ME 242

ME 343 Control Systems 3 Credits
Linear analyses of mechanical, hydraulic and electrical feedback control systems by root locus and frequency response techniques. A design project provides experience with practical issues and tradeoffs.
Prerequisites: ME 242 or ECE 125 or ME 245

ME 348 Computer-Aided Design 3 Credits
Impact of computer-aided engineering tools on mechanical design and analysis. Part geometry modeling and assembly modeling using solid representations. Analysis for mass properties, interference, kinematics, displacements, stresses and system dynamics by using state-of-the-art commercially available computer-aided-engineering software. Integrated design projects.
Prerequisites: ME 010 and MECH 012 and MECH 102 and MATH 205

ME 350 Special Topics 1-5 Credits
A study of some field of mechanical engineering not covered elsewhere. Consent of department chair required.
Repeat Status: Course may be repeated.
ME 355 Spacecraft Systems Engineering 3 Credits  
Systems engineering approach to design, integration, testing, and operations of spacecraft for various missions. Technologies currently used in modern spacecraft bus and payload systems, astrodynamics, launch systems, life-cycle costs, and operational issues. Team works to design a spacecraft that meets a specific set of mission requirements.  
Prerequisites: ME 255

ME 360 Nuclear Reactor Engineering 3 Credits  
A consideration of the engineering problems related to nuclear reactor design and operation. Topics include fundamental properties of atomic and nuclear radiation, reactor fuels and materials, reactor design and operation, thermal aspects, safety and shielding, instrumentation and control. Course includes several design projects stressing the major topics in the course. Must have senior standing in engineering or physical science.

ME 362 Nuclear Fusion and Radiation Protection 3 Credits  

ME 364 Renewable Energy 3 Credits  
Fundamentals and design aspects of Renewable Energy (RE) technologies; biofuels, hydropower, solar photovoltaic, solar thermal, wind, geothermal energies. Details and difficulties in implementing RE. Senior standing in Engineering.  
Prerequisites: ME 104 and ME 231

ME 366 Engineering Principles of Clean Coal Technology 3 Credits  
Effect of coal properties on plant performance. Design and performance of coal-based electric power generation systems. Technologies to control emissions. Carbon capture and sequestration methods for coal-fired power plants and analysis of CCS options. Must have junior standing in engineering or physical science.

ME 368 Fundamentals of Energy Efficiency Practicum 3 Credits  
Studies of the plant operation and energy usage. Students work with the Lehigh Industrial Assessment Center to do technical and economic feasibility studies of optimizing energy consumption. Industrial experience. Fundamentals of best practices to save energy, reduce waste, and increase productivity. Consent of instructor required.  
Prerequisites: ME 104 and ME 231

ME 373 Mechatronics 3 Credits  
Synergistic integration of mechanical engineering with electronics and intelligent computer control in designing and manufacturing machines, products and processes; semiconductor electronics, analog signal processing, with op amps, digital circuits, Boolean algebra, logic network designs, Karnaugh map, flip-flops and applications, data acquisition, A/D and D/A, interfacing to personal computers, sensors and actuators, microcontroller programming and interfacing.

ME 374 Mechatronics Laboratory 3 Credits  
Experiments and applications utilizing combinations of mechanical, electrical, and microprocessor components. Theory and application of electronic and electromechanical equipment, operation and control of mechatronic systems. Projects integrating mechanical, electronic and microcontrollers.

ME 376 (CHE 376) Energy: Issues & Technology 3 Credits  
Energy usage and supply, fossil fuel technologies, renewable energy alternatives and environmental impacts. The scope will be broad to give some perspective of the problems, but in-depth technical analysis of many aspects will also be developed. Must have college-level introductory courses in chemistry, physics and mathematics. Consent of instructor required.

ME 385 Polymer Product Manufacturing 3 Credits  
Polymer processes such as injection molding through a combination of theory development, practical analysis, and utilization of commercial software. Polymer chemistry and structure, material rheological behavior, processing kinetics, molecular orientation development, process simulation software development, manufacturing defects, manufacturing window establishment, manufacturing process design, manufacturing process optimization. Must have senior level standing in engineering or science. Credit not given for both ME 385 and ME 485.

ME 387 (CHE 387, ECE 387) Digital Control 3 Credits  
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 (two lectures and one laboratory per week).  
Prerequisites: CHE 386 or ECE 212 or ME 343

ME 388 Honors Project for Eckardt Scholar 1-4 Credits  
Opportunity for Eckardt Scholars to pursue an extended project for senior honors. Transcript will identify department in which project was completed.  
Repeat Status: Course may be repeated.

ME 389 (CHE 389, ECE 389) Control Systems Laboratory 2 Credits  
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 design of feedback controllers and comparison of theoretical computer simulation predictions with actual experimental data. Lab teams will be interdisciplinary.  
Prerequisites: CHE 386 or ECE 212 or ME 343

ME 401 (MSE 401) Integrated Product Development 3 Credits  
An integrated and interdisciplinary approach to engineering design, concurrent engineering, design for manufacturing, industrial design and the business of new product development. Topics include design methods, philosophy and practice, the role of modeling and simulation, decision making, risk, cost, material and manufacturing process selection, platform and modular design, mass customization, quality, planning and scheduling, business issues, teamwork, group dynamics, creativity and innovation. The course uses case studies and team projects. ME 402.

ME 402 (MAT 402) Advanced Manufacturing Science 3 Credits  
The course focuses on the fundamental science-base underlying manufacturing processes, and applying that science base to develop knowledge and tools suitable for industrial utilization. Selected manufacturing processes representing the general classes of material removal, material deformation, material phase change, material flow, and material joining are addressed. Students create computer-based process simulation tools independently as well as utilize leading commercial process simulation packages. Laboratory experiences are included throughout the course.

ME 411 Boundary-Layer Theory 3 Credits  
The course is intended as a first graduate course in viscous flow. An introduction to boundary-layer theory, thermodynamics and heat transfer at the undergraduate level are assumed to have been completed. Topics include the fundamental equation of continuum fluid mechanics, the concept of asymptotic methods and low and high Reynolds number flows, laminar boundary layers, generalized similarity methods, two-and three-dimensional flows, steady and unsteady flows and an introduction to hydrodynamic stability. The material is covered in the context of providing a logical basis as an introduction to a further course in turbulent flows.

ME 413 Numerical Methods in Mechanical Engineering 3 Credits  
ME 415 Flow-Induced Vibrations 3 Credits

ME 420 Advanced Thermodynamics 3 Credits

ME 421 Topics in Thermodynamics 3 Credits
Emphasis on theoretical and experimental treatment of combustion processes including dissociation, flame temperature calculations, diffusion flames, stability and propagation; related problems in compressible flow involving one-dimensional, oblique shock waves and detonation waves. Methods of measurement and instrumentation.

ME 423 Heat and Mass Transfer 3 Credits
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.

ME 424 Unsteady and Turbulent Flow 3 Credits
Stability of laminar flow; transition to turbulence. Navier-Stokes equations with turbulence. Bounded turbulent shear flows; free shear flows; statistical description of turbulence.

ME 426 Radiative and Conductive Heat Transfer 3 Credits
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 conductive and radiative heat transfer.

ME 428 Boundary Layers and Convective Heat Transfer 3 Credits
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.

ME 430 Advanced Fluid Mechanics 3 Credits
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.

ME 431 Advanced Gas Dynamics 3 Credits

ME 433 (CHE 433, ECE 433) State Space Control 3 Credits
This course will cover the following topics in control theory: State-space representation of linear systems, linearization, causality, time-variation and linearity properties of systems, review of some of the fundamental concepts in linear algebra, impulse response and transfer functions, solutions to LTV systems, solutions to LTI systems and Jordan form, Lyapunov stability, input-output stability, an introduction to optimal control theory, controllable and reachable subspaces, controllable systems, controllable decompositions, stabilizability, observability, output feedback, minimal realizations, Linear Quadratic Regulator (LQR), the Algebraic Riccati Equation (ARE), frequency domain properties of LQR controller. Several examples will be given from mechanical, electrical and chemical engineering applications.

ME 434 (CHE 434, ECE 434) Multivariable Process Control 3 Credits
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.

Prerequisites: CHE 433 or ME 433 or ECE 433

ME 436 (CHE 436, ECE 436) Systems Identification 3 Credits
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, quasilinearization and invariant-imbedding techniques for nonlinear system parameter identification included.

ME 437 (CHE 437, ECE 437) Stochastic Control 3 Credits

Prerequisites: CHE 433 or ME 433 or ECE 433

ME 444 Experimental Stress Analysis in Design 3 Credits
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.

ME 446 Mechanical Reliability 3 Credits

ME 450 Special Topics 3 Credits
An intensive study of some field of mechanical engineering not covered in more general courses.

Repeat Status: Course may be repeated.

ME 452 Mathematical Methods In Engineering I 3 Credits
Analytical techniques relevant to the engineering sciences are described. Vector spaces; eigenvectors; eigenvalues; diagonalizable and non-diagonalizable systems. Inhomogeneous linear systems; variation of parameters. Non-linear systems; stability; phase plane. Series solutions of linear ordinary differential equations; special functions. Laplace and Fourier transforms; application to partial differential equations and integral equations. Sturm-Liouville theory. Finite Fourier transforms; planar, cylindrical, and spherical geometries.
ME 453 Mathematical Methods in Engineering II 3 Credits

ME 458 Modeling of Dynamic Systems 3 Credits
Modeling of complex linear and nonlinear energetic dynamic engineering systems. Emphasis on subdivision into multiport 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.

ME 460 Engineering Project 1-6 Credits
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. Consent of department required.
Repeat Status: Course may be repeated.

ME 461 Integrated Product Development (IPD) Projects-1 2 Credits
Technical and economic feasibility study of new products. Selection and content of the project is determined by the faculty project advisor in consultation with the student, progress and final reports, oral and posters presentations. Consent of the program director and faculty project advisor required.
Prerequisites: TE 401 or ME 401

ME 462 IPD: Manufacturing 3 Credits
Industry sponsored Integrated Product Development Project (IPD) projects. The student works with an industry sponsor to create detailed design specifications, fabricate and test a prototype new product and plan for production. Selection and content of the project is determined by the faculty project advisor in consultation with the industry sponsor. Deliverables include progress and final reports, oral presentations, posters and a prototype. Consent of the department chair and faculty project advisor required.

ME 464 Computer-Aided Geometric Modeling 3 Credits
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.

ME 466 Fundamentals of Acoustics 3 Credits

ME 468 Advanced Energy Efficiency Practicum 3 Credits
Critical assessments of energy management systems. Establishment of framework for industrial facilities to manage energy systems. Fundamentals of best practices for energy efficiencies associated with industrial energy savings. Progress and final reports required. Engineering graduate students only. Consent of instructor required.

ME 485 Polymer Product Manufacturing 3 Credits
An exploration of the science underlying polymer processes such as injection molding through a combination of theory development, practical analysis, and utilization of commercial software. Polymer chemistry and structure, material rheological behavior, processing kinetics, molecular orientation development, process simulation software development, manufacturing defects, manufacturing window establishment, manufacturing process design, manufacturing process optimization. This course is a version of ME 385 for graduate students, with research projects and advanced assignments. Closed to students who have taken ME 385. Must have graduate level standing in engineering or science.

ME 490 Thesis 1-6 Credits
Repeat Status: Course may be repeated.

ME 499 Dissertation 1-15 Credits
Repeat Status: Course may be repeated.

Mechanics Courses

MECH 002 Elementary Engineering Mechanics 3 Credits
Static equilibrium of particles and rigid bodies. Elementary analysis of simple truss and frame structures, internal forces, stress, and strain. Credit will not be given for both MECH 002 and MECH 003.
Prerequisites: (MATH 022 or MATH 052 or MATH 032) and (PHY 010 or PHY 011)
Can be taken Concurrently: MATH 022, MATH 052, MATH 032

MECH 003 Fundamentals of Engineering Mechanics 3 Credits
Static equilibrium of particles and rigid bodies. Analysis of simple truss and frame structures, internal forces, stress, strain, and Hooke’s Law, torsion of circular shafts; pure bending of beams. Is intended as a prerequisite for MECH 012. Credit not given for both MECH 002 and MECH 003.
Prerequisites: (MATH 022 or MATH 032) and PHY 011
Can be taken Concurrently: MATH 022, MATH 032

MECH 012 Strength of Materials 3 Credits
Prerequisites: MECH 003 and (MATH 023 or MATH 033)
Can be taken Concurrently: MATH 023, MATH 033

MECH 050 Supplemental Topics in Mechanics 1-2 Credits
Completion of material for MECH courses transferred from other institutions. Student will be scheduled for that part of MECH course that is required for completion of missing material. Subject matter and credit hours to be determined by department chair for each student.

MECH 102 Dynamics 3 Credits
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 002 or MECH 003) and (MATH 023 or MATH 033)
Can be taken Concurrently: MATH 023, MATH 033

MECH 103 Principles of Mechanics 4 Credits
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 023 or MATH 033) and (PHY 010 or PHY 011)

MECH 300 Apprentice Teaching 3 Credits

MECH 302 Advanced Dynamics 3 Credits
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: MATH 205 and (MECH 102 or MECH 103)

MECH 305 Advanced Mechanics of Materials 3 Credits
Strength, stiffness, and stability of mechanical components and structures. Fundamental principles of stress analysis: three-dimensional stress and strain transformations, two-dimensional elasticity, contact stresses, stress concentrations, energy and variational methods. Stresses and deformations for rotating shafts, thermal stresses in thick-walled cylinders, curved beams, torsion of prismatic bars, and bending of plates. Projects relate analysis to engineering design.
Prerequisites: MECH 012 and MATH 205

MECH 307 Mechanics of Continua 3 Credits
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 flows.
Prerequisites: MECH 305
MECH 312 Finite Element Analysis 3 Credits
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 element codes. Applications to design.
Prerequisites: MECH 012

MECH 313 Fracture Mechanics 3 Credits
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 012 and MATH 205

MECH 326 Aerodynamics 3 Credits
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: MECH 231

MECH 328 Fundamentals of Aircraft Design 3 Credits
Review of aerodynamics; Weight and balance; stability, loads; Basics of propellers; Power and performance; International Standard Atmosphere; Introduction to aerospace composites; Introduction to FAA regulations.
Prerequisites: MECH 012

MECH 350 Special Topics 3 Credits
A study of some field of engineering mechanics not covered elsewhere. Consent of department required.

MECH 404 Mechanics & Behavior of Structural Members 3 Credits

MECH 406 Fundamentals of Solid Mechanics 3 Credits
An introductory graduate course in the mechanics of solids. Topics to be addressed include: curvilinear tensor analysis, analysis of strain and nonlinearity, constitutive relations, stress and strain measures, conservation laws and energy theorems, variational calculus, isotropic and anisotropic linear elasticity, boundary value problems, beam and plate theories.

MECH 408 Introduction To Elasticity 3 Credits
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.

MECH 410 Theory of Elasticity II 3 Credits
Advanced topics in the theory of elasticity. The subject matter may vary from year to year and may include, 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 microstructure theory of elasticity.

MECH 411 Continuum Mechanics 3 Credits
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.

MECH 413 Fracture Mechanics 3 Credits
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.

MECH 415 Stability of Elastic Structures 3 Credits

MECH 418 Finite Element Methods 3 Credits
Finite element approximations to the solution of differential equations of engineering interest. Linear and nonlinear examples 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. Must have knowledge of a high-level programming language.

MECH 419 (CHE 419) Asymptotic Methods in the Engineering Sciences 3 Credits

MECH 424 Unsteady Fluid Flows 3 Credits
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.

MECH 425 Analytical Methods in Dynamics and Vibrations 3 Credits
This course will mainly cover the following topics: coordinate systems, conservations laws, inertial frames, systems of particles, DAE sets, variable-mass systems, transport equation, review of some of the basic concepts from variational calculus, D’Alembert’s principle, Hamilton’s principle, Lagrange multipliers, generalized momenta, 3D rigid-body motion, Inertia matrices, Euler angles, inertial and elastic coupling, discrete eigenvalue problem, linearization of non-linear systems, chaotic systems, Hamilton’s principle for continuous systems, Torsion, Sturm-Liouville equations, Rayleigh’s quotient, finite-element eigen-problems, interpolating functions, combined-effect vibrations, and some other related topics.

MECH 432 Inelastic Behavior Of Materials 3 Credits

MECH 445 Nondeterministic Models in Engineering Sciences 3 Credits
Application of probability and stochastic processes to engineering problems for a variety of applications. Modeling and analysis of common nondeterministic 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. Must have advanced calculus and some exposure to probability and statistics.
MECH 450 Special Problems 3 Credits
An intensive study of some field of applied mechanics not covered in more general courses.
Repeat Status: Course may be repeated.

MECH 454 Mechanics and Design of Composites 3 Credits

MECH 490 Thesis 1-6 Credits

MECH 499 Dissertation 1-15 Credits