Mechanical Engineering and Mechanics

OUR MISSION

The mission of the Department of Mechanical Engineering & Mechanics is to:

1. Provide quality education and training to undergraduate and graduate students,

2. Develop new knowledge, and engineering methodology through research, and

3. Serve industry and society at large.

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 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 to improving and advancing the community and society at large.

OUR FACULTY

A complete listing of the faculty can be found on our website (https://engineering.lehigh.edu/meche/faculty/).

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.

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 (https://engineering.lehigh.edu/academics/accreditation/#meche).

PROGRAM OBJECTIVES

In harmony with the mission stated previously, 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 demonstrate leadership qualities.

By "successfully practice mechanical engineering" we mean:

- Advancement in careers in Mechanical, other Engineering, or careers such as health care, consulting, entrepreneurship, finance, management etc. assuming the utilization of basic engineering and science/mathematics principles and/or methodology taught in an ME program.
- Assuming increased levels of responsibility is a clear indicator of success.
- Effective communication with peers and working/leading diverse multi-disciplinary teams.
- Recognizing the global, societal and ethical contexts of their work.

In order to achieve these objectives the ME program ensures that its graduates are capable of the Student Outcomes (1-7) proposed by the accreditation organization ABET and adopted verbatim by the Lehigh University ME program. These outcomes are:

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
3. An ability to communicate effectively with a range of audiences.
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

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 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 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, writing 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

First Year			
First Semester	**Credits**	**Second Semester**	**Credits**
WRT 001	3	WRT 002	3
MATH 021 (Calculus I)	4	MATH 022 (Calculus II)	4
ENGR 005 (Introduction to Engineering Practice)	2	ECO 1 or HSS elective[2]	4
Select one of the following:	5-6	Select one of the following	5-6
ENGR 010 & CHM 030[1]		ENGR 010 & CHM 030[1]	
PHY 011 & PHY 012 (Introductory Physics I and Lab)[1]		PHY 011 & PHY 012 (Introductory Physics I and Lab)[1]	
	14-15		**16-17**

Second Year			
First Semester	**Credits**	**Second Semester**	**Credits**
ME 010 (Graphics for Engineering Design)	3	ME 104 (Thermodynamics I)	3
MECH 003 (Fundamentals of Engineering Mechanics)	3	MECH 012 (Strength of Materials)	3
ME 017 (Numerical Methods in ME)	2	MATH 205 (Linear Methods)	3
MAT 033 (Engineering Materials and Processes)	3	PHY 021 & PHY 022 (Introductory Physics II and Lab)	5
MATH 023 (Calculus III)	4	HSS Elective	3-4
	15		**17-18**

Third Year			
First Semester	**Credits**	**Second Semester**	**Credits**
ME 021 (Mechanical Engineering Laboratory I)	1	ME 121 (Mechanical Engineering Lab II)	1
ME 231 (Fluid Mechanics)	3	ME 240 (Manufacturing)	3
MECH 102 (Dynamics)	3	ME 252 (Mechanical Elements)	3
HSS Electives	6-8	ME 211	3
Select one of the following:	3	ECE 083 (Introduction to Electrical Engineering)	3
ME 215 (Engineering Reliability)		ECE 162 (Electrical Laboratory)	1
MATH 231 (Probability & Statistics)		Select one of the following:	3
MATH 208 (Complex Variables)		ME 242 (Mechanical Engineering Systems)	
MATH 230 (Numerical Methods)		ME 245 (Engineering Vibrations)	
	16-18		**17**

Fourth Year			
First Semester	**Credits**	**Second Semester**	**Credits**
ME 111 (Professional Development (fall only])	1	Engineering Required/ Technical-Elective courses	12-14
Engineering Required/ Technical-Elective courses	6-8	HSS & Free Electives[3]	4
ME 212	2		
HSS and Free Electives[3]	4-6		
	13-17		**16-18**

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
WRT 001 Academic and Analytical Writing 3 credits
WRT 002 Research and Argument 3 credits

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

ME 321	Introduction to Heat Transfer (For 3 credits; available Fall or Spring)	3
ME 207	Mechanical Engineering Laboratory III (For 2 credits; available Fall or Spring)	2
Engineering Elective A: Select one of the following for 3 credits		3
MECH 302	Advanced Dynamics (Spring Semester)	
MECH 305	Advanced Mechanics of Materials (Fall Semester)	
ME 304	Thermodynamics II (Fall Semester)	
ME 322	Gas Dynamics (Spring Semester)	
ME 331	Advanced Fluid Mechanics (Fall Semester)	
ME 343	Control Systems (Fall Semester)	
Engineering Elective B: Select one of the following for 3 credits:		3
Any ME or MECH three-hundred-level course, excluding ME 300 and ME 310		
Engineering Electives C: Select three courses for 9 credits		9
Any ME or MECH three-hundred-level course or an engineering/science/mathematics course, as approved by the depatment. ME 300 and ME 310 can count once each towards Engineering Electives C.		
Total Credits		**20**

4

Total Credits Required: 129

For the flow chart of the program please follow the link: Flow Chart **(**http://catalog.lehigh.edu/coursesprogramsandcurricula/engineeringandappliedscience/mechanicalengineeringandmechanics/BSME_Flowchart_August2023.pdf**)**

**Co-op students must take* ME 021 *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 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

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			
First Semester	**Credits**	**Second Semester**	**Credits**
WRT 001	3	WRT 002	3
MATH 021 (Calculus I)	4	MATH 022 (Calculus II)	4
ENGR 005 (Introduction to Engineering Practice)	2	ECO 1 or HSS elective[2]	3-4
Select one of the following:	5-6	Select one of the following	5-6
ENGR 010 & CHM 030[1]	6	ENGR 010 & CHM 030[1]	6
PHY 011 & PHY 012 (Introductory Physics I and Lab)[1]	5	PHY 011 & PHY 012 (Introductory Physics I and Lab)[1]	5
	14-15		**15-17**
Second Year			
First Semester	**Credits**	**Second Semester**	**Credits**
ME 010 (Graphics for Engineering Design)	3	ME 104 (Thermodynamics I)	3
MECH 003 (Fundamentals of Engineering Mechanics)	3	MECH 012 (Strength of Materials)	3
ME 017 (Numerical Methods in ME)	2	PHY 021 & PHY 022 (Introductory Physics II and Lab)	5
MAT 033 (Engineering Materials and Processes)	3	MATH 205 (Linear Methods)	3
MATH 023 (Calculus III)	4	Elective	3-4
Elective	2-3		
	17-18		**17-18**
Third Year			
First Semester	**Credits**	**Second Semester**	**Credits**
ME 021 (Mechanical Engineering Laboratory I)	1	ME 121 (Mechanical Engineering Lab II)	1
ME 231 (Fluid Mechanics)	3	ME 240 (Manufacturing)	3
MECH 102 (Dynamics)	3	MATH 208 (Complex Variables)	3
MATH 230 (Numerical Methods)	3	ECE 083 (Introduction to Electrical Engineering)	3
Electives	6-8	ECE 162 (Electrical Laboratory)	1
		Electives	3-4
		Select one of the following:	3
		ME 242 (Mechanical Engineering Systems)	
		ME 245 (Engineering Vibrations)	
	13-15		**17-18**
Fourth Year			
First Semester	**Credits**	**Second Semester**	**Credits**
ME 111 (Professional Development [fall only])	1	Engineering Required/ Technical-Elective courses	9-11
Engineering Required/ Technical-Elective courses	9-11	HSS and Free Electives[3]	4
HSS and Free Electives[3]	4	undefined	
	14-16		**13-15**

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).
Required HSS courses 10 credits: ECO 001 Principles of Economics 4 credits
WRT 001 Academic and Analytical Writing 3 credits
WRT 002 Research and Argument 3 credits

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

ME 321	Introduction to Heat Transfer (For 3 credits; available Fall or Spring)	3
ME 207	Mechanical Engineering Laboratory III (For 2 credits; available Fall or Spring)	2
Engineering Elective A: Select two of the following for 6 credits		6
MECH 302	Advanced Dynamics (Spring Semester)	

MECH 305	Advanced Mechanics of Materials (Fall Semester)	
ME 304	Thermodynamics II (Fall Semester)	
ME 322	Gas Dynamics (Spring Semester)	
ME 331	Advanced Fluid Mechanics (Fall Semester)	
ME 343	Control Systems (Fall Semester)	
Engineering Elective B: Select 4 courses for 12 credits		12
From any ME or MECH three-hundred-level course, excluding ME 300 and ME 310		
Total Credits		**23**

4

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	3
MECH 312	Finite Element Analysis	3
MATH 309	Probability with Applications and Simulations	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 Macro/ Nanoscale Materials	3
PHY 031	Introduction to Modern Physics	3
PHY 363	Physics of Solids	3
Fluid Mechanics		
ME 331	Advanced Fluid Mechanics	3
ME 322	Gas Dynamics	3
MECH 326	Aerodynamics	3
MATH 322	Methods of Applied Analysis I	3

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	3
MECH 326	Aerodynamics	3
MECH 328	Fundamentals of Aircraft Design	3
Elective Courses		
Select two of the following:		6
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	
ME 354	Automatic Control of Aerospace Vehicles	
ME 355	Spacecraft Systems Engineering	
ME 356	Astrodynamics	
MECH 302	Advanced Dynamics	
MECH 305	Advanced Mechanics of Materials	
MECH 312	Finite Element Analysis	
Total Credits		**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	3
Elective Energy Courses		
Select at least three of the following:		9
ME 360	Nuclear Reactor Engineering	
ME 362	Nuclear Fusion and Radiation Protection	
ME 364	Renewable Energy	
ME 366	Power Generation Technologies	
Additional Electives		
Select one of the following:		3
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	
Other Energy related 300 level courses with the approval of the ME Dept. Chair.		
Total Credits		**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 003	Fundamentals of Engineering Mechanics	3
MECH 012	Strength of Materials	3
Electives		
Select three of the following:		9
ME 010	Graphics for Engineering Design	
ME 215	Engineering Reliability	
ME 240	Manufacturing	
ME 252	Mechanical Elements	
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**

GRADUATE PROGRAMS

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

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

Consistent with the above mission statement, the education components of the graduate programs strive to:

- Educate graduate students to a level of mechanical engineering higher than that of the high-quality undergraduate program. This level is mainly defined by the content and scope of the core courses offered.
- Enable students to engage in advanced study and research with scholars on various topics relating to mechanical engineering.
- Familiarize students with issues relating to support, funding and presentation of research results and products.

In addition to the foregoing objectives, the presence of graduate programs and students has additional, beneficial effects on the goals of the Department and the University, such as:

- Interaction of undergraduate students with a diverse body of highly motivated learners.
- Increase in the efficiency of basic and applied research.
- Continuous incentive for improvement in the methods and material taught to graduate and undergraduate students.

Subject to approval, courses from other interdisciplinary curricula in engineering, mathematics, sciences and more may be included in the degree program.

MASTERS DEGREE PROGRAM

The Department of Mechanical Engineering & Mechanics offers a Master of Science degree that requires 30 credit hours of graduate work. Audit courses may not be used towards the degree. Master's degrees must satisfy the University course distribution requirements, as outlined in the P.C. Rossin College of Engineering & Applied Science (RCEAS) Graduate Student Handbook (https://engineering.lehigh.edu/academics/graduate/student-handbook/). The minimum program for all Masters degrees includes:

- Not less than 24 credits of 300- and 400-level coursework and at least 18 hours at the 400-level. Thesis credits count as part of the 400-level requirement.
- Not less than 18 credit hours in Mechanical Engineering & Mechanics.
- Not less than 15 credit hours of 400-level coursework in Mechanical Engineering & Mechanics.
- No course below the 300-level in Mechanical Engineering & Mechanics can be used towards the degree; however, two courses (6 credits) outside of the department may be taken at the 200-level.

Master of Science in Mechanical Engineering

Required Core Course in Engineering Mathematics:		3
ME 452	Mathematical Methods In Engineering I	
Required Core Course in MEM (choose two courses):		6
ME 402	Advanced Manufacturing Science	
ME 413	Numerical Methods in Mechanical Engineering	
ME 423	Heat and Mass Transfer	
ME 430	Advanced Fluid Mechanics	
ME 433	Linear Systems and Control	
ME 453	Mathematical Methods in Engineering II	
MECH 408	Introduction to Elasticity	
MECH 425	Analytical Methods in Dynamics and Vibrations	
MEM Electives: Three courses (9 credits) selected from ME and MECH courses at the 300 and 400 level, excluding ME 460 and ME 490. Only one ME or MECH course in this group may be at the 300 level.		9
Free Electives: Four courses (12 credits) at the 300 and 400 selected level from ME and MECH courses or from another department. Up to two courses from another department may be taken at the 200 level.		12

In total, at least 18 credits must be take at the 400 level.

Doctor of Philosophy in Mechanical Engineering

The Ph.D. program in Mechanical 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). The first stage of Ph.D. candidacy is attained by achieving a minimum GPA of 3.35 in five core courses (see core course requirements in the table below). Ph.D. 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. Beyond the five core courses, students must complete a minimum of three technical electives, to be selected in consultation with the student's advisor and doctoral committee. Ph.D. students who previously completed graduate courses at another institution may petition through a Department process for evaluation of eligibility for waiver of course requirements. The second stage of candidacy involves completion of a General Examination, which is based on an assessment of a research topic, formulation of a research proposal, and completion of an associated oral examination. Formal admission to candidacy for the Ph.D. is granted upon submittal of a proposal for the dissertation research and recommendation of the doctoral committee followed by approval of the P.C. Rossin College of Engineering & Applied Science. To complete the Ph.D. degree, the student must present and defend a dissertation before the doctoral committee.

Required Core Courses in Engineering Mathematics (two courses):		6
ME 452	Mathematical Methods In Engineering I	
ME 413	Numerical Methods in Mechanical Engineering	
or ME 453	Mathematical Methods in Engineering II	
Required Core Courses in MEM (choose three courses):		9
ME 402	Advanced Manufacturing Science	
ME 423	Heat and Mass Transfer	
ME 430	Advanced Fluid Mechanics	
ME 433	Linear Systems and Control	
MECH 408	Introduction to Elasticity	
MECH 425	Analytical Methods in Dynamics and Vibrations	

Technical Electives: Three courses (9 credits) selected from ME and MECH courses at the 400 level, or at 400 level from another department.		9
Additional Requirements:		3
ME 440	General Examination	

Course requirements for the PhD Degree

A student pursuing a PhD after completing an MS/MSc degree from another institution may petition for a waiver of some coursework requirements. Petitions for waiver of coursework requirements may include up to one course equivalent to a core course in engineering mathematics and one course equivalent to a core course in MEM. In addition, the student may petition for a waiver of up to three courses taken elsewhere for technical electives. All courses being used to waive coursework requirements must be approved by the instructor of the corresponding Lehigh course. The student must submit a petition with the following: (a) a syllabus in English or a sufficiently detailed print-out of the course catalog from the MS institution; (b) a letter of support or a signed petition from the PhD advisor; and (c) any additional documentation beyond the syllabus as requested by the instructor.

General Examination for the PhD Degree

Students must achieve the minimum GPA of 3.35 in the first five core courses to be eligible to take the General Examination. Students taking the General Examination must register for three credits of ME 440. Detailed procedures related to administration of the General Exam can be found in the MEM Graduate Student (https://engineering.lehigh.edu/sites/engineering.lehigh.edu/files/MEM%20Grad%20Program%20Guidelines%20NEW2024%20v01.pdf)Guidelines. (https://engineering.lehigh.edu/sites/engineering.lehigh.edu/files/MEM%20Grad%20Program%20Guidelines%20NEW2024%20v01.pdf)

Proposal for the PhD Degree

To formally become a PhD candidate at the University level, the student must prepare a proposal for the dissertation research. This proposal includes a course plan for all courses during the PhD program. The proposal is presented to, and approved by, the PhD Committee. The student then submits the proposal signed by the Committee members for approval by the college.

Additional Requirements for the PhD Degree

Two or more manuscripts must be submitted for peer-reviewed journal publication prior to the dissertation defense. At least one of these manuscripts must have undergone a first external review process. A student may petition, with detailed justification, to account for unusual preparation efforts, for example, the submittal of a single manuscript to an extraordinarily competitive journal, an unreasonably long review time for a submitted manuscript, or alternate products consistent with the indicators of scholarship in the student's area of research.

The minimum number of department seminars must have been attended by the student during the course of the PhD program.

Complete information on all requirements and procedures for the PhD in Mechanical Engineering can be found in the MEM Graduate Student Handbook.

RESEARCH FACILITIES

The Department has a wide range of faculty-led research labs with facilities for experimental research. These resources include laser diagnostics for experiments in fluid mechanics, two wind tunnels, and three large-scale water channels. Laboratories for multidisciplinary studies of phenomena in solid mechanics include comprehensive mechanical testing equipment and world-class microscopy facilities. Extensively equipped interdepartmental robotics, controls, and manufacturing laboratories are also available.

Computational resources for high-end modeling and simulation include Department-maintained computer labs and computational workstations in faculty research groups. The University supports high-performance computing (HPC) through two compute clusters that provide over 17 million core-hours for research on campus. The Department and University also provide access to a wide range of software (https://software.lehigh.edu/) packages for academic and research use. Access to journals and databases is provided through Library & Technology Services (https://lts.lehigh.edu/).

RECENT RESEARCH ACTIVITIES

Information about recent MEM faculty and student research accomplishments can be found on our departmental news (https://engineering.lehigh.edu/meche/news/) and research (https://engineering.lehigh.edu/meche/research/) web pages.

Mechanical Engineering Courses

ME 010 Graphics for Engineering Design 0,3 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 0,1 Credits
Experimental methods in mechanical engineering and mechanics. Analysis of experimental error and error propagation. Introduction to elementary instrumentation. Introduction to digital data acquisition.
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 wil 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 0,3 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 0,1 Credits
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.

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 205 Application of Differential Equations in Mechanical Engineering 3 Credits
Solution and application of differential equations in engineering, including linear methods underpinning solution methodologies. Applications of differential equations include: Newton's law of cooling; linear and nonlinear dynamical systems; mechanical vibrations; beam theory; column buckling; heat/diffusion, wave, and Laplace's equations. This course counts as a fifth mathematics course or an Engineering C elective for MEM students.
Prerequisites: MATH 022

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 211 (BIOC 211, BIOE 211, ENGR 211, MAT 211) Capstone Design Project I 3 Credits
Students work on teams, integrating knowledge and skills acquired in their prior course work, to design practical solutions to real-world problems, typically in collaboration with industry, entrepreneurs, faculty, or campus departments. Teams perform in-depth engineering design while considering engineering standards and the project business case. Constraints, including technical, financial, environmental, societal, supply chain, regulatory, and others are considered throughout. Teams produce written reports, oral presentations, and prototypes appropriate for the project.
Prerequisites: ME 104 and ME 231 and ME 240 and MECH 102
Can be taken Concurrently: ME 231, ME 240, MECH 102

ME 212 (BIOC 212, BIOE 212, ENGR 212, MAT 212) Capstone Design Project II 2 Credits
Students continue developing their solutions from ME 211 through prototype fabrication and testing, iteration, and failure mode analysis. New information about the project, as well as new knowledge, standards, and constraints, may be identified, considered and integrated into the solution. Teams are expected to produce a final project-specific prototype, an implementation plan appropriate to the project, as well as related business case financial models. Additional deliverables include written reports and presentations.
Prerequisites: ME 211

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
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.
Prerequisites: (MATH 205 or ME 205) and ME 104

ME 240 Manufacturing 0,3 Credits
Analytical and technological base for several manufacturing processes and common engineering materials. Processes include metal cutting, metal deformation, injection molding, thermoforming, and composites. Process planning, computer-aided manufacturing, manufacturing system engineering, and quality measurements. Design project. Weekly laboratory.
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 0,3 Credits
Physical modeling of vibrating systems. Free and forced single and multiple degree of freedom systems. Computer simulations. Engineering applications.
Prerequisites: MECH 102 and ME 017 and (MATH 205 or ME 205)

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
An introductory course in the core engineering principles used in the aerospace industry: aerodynamics, controls, propulsion, and structures. The course is designed for any engineering student who may intend to work in the aerospace industry and develops a basic understanding of the technologies used in the design and operation of today's aircraft, rockets, and spacecraft.
Prerequisites: ME 104

ME 299 Special Topics In Mechanical Engineering 1-4 Credits
Repeat Status: Course may be repeated.

ME 300 Apprentice Teaching 1-3 Credits
Repeat Status: Course may be repeated.

ME 304 Thermodynamics II 3 Credits
Availability and Second Law Analysis. Design of gas and vapor power cycles, and refrigeration systems. Generalized property relations for gases and gas-vapor. Combustion and chemical equilibrium. Design of engineering systems and processes incorporating thermodynamic concepts and analysis.
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 (TE 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
Mechanical metallurgy and mechanics of metal forming processes. Yield criteria. Workability. Friction and lubrication. Engineering analysis of forging, extrusion, wire and tube drawing, rolling, sheet forming and other processes. Recent developments in metal forming.

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 316 (BIOE 316) Introduction to Force Spectroscopy 3 Credits
Fundamentals of major force spectroscopy methods, including atomic force microscopy, optical tweezers, and magnetic tweezers. Principles of force measurement, force calibration, and signal and noise. Applications to the mechanical properties of biomaterials, such as polymer elasticity, protein folding, nanoindentation, and structural transitions in macromolecules. Closed to students who have taken BIOE 416.
Prerequisites: MECH 003

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
Flow equations for compressible fluids; thermodynamic properties of gases. Normal shock waves. Steady one-dimensional flows with heat addition and friction. Oblique shock waves. Expansion waves. Nozzle flows. Shock tubes; performance calculations and design. Supersonic wind tunnels; diffuser design. Real gas effects.
Prerequisites: ME 231 and ME 104

ME 323 Reciprocating and Centrifugal Engines 0,3 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 325 Ethical Issues for Mechanical Engineers 3 Credits
Introduction to Engineering Ethics familiarizes students with the methods used for developing ethical approaches in engineering practice. Through reading, writing and discussion this course takes a ‘case-study’ approach. Cases are historical and contemporary and may include: Challenger, Chernobyl, Bhopal, Ford Pinto, Essure as well as more general areas as: Genetic Technology, Energy, AI, Medical Technology and the newly emerging study of Design Ethics. Each student will research and prepare a major presentation. Senior standing and/or instructor permission required.
Prerequisites: ME 111

ME 331 Advanced Fluid Mechanics 3 Credits
Kinematics of fluid flow. Conservation equations for inviscid and viscous flows; integral forms of equations. Two-dimensional potential flow theory of incompressible fluids with applications. Boundary layers. Introduction to free shear layer and boundary layer stability and structure of turbulence. Transition from laminar to turbulent boundary layers. Separation of flow. Steady and unsteady stall. Secondary flows. Hydrodynamic lubrication. Measurement techniques.
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
Can be taken Concurrently: MECH 326

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
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 projects using commercial computer-aided-engineering software for the design and evaluation of typical machine systems.
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. Lumped and distributed-parameter models. Use of computer tools for modeling, design and simulation. Design projects.
Prerequisites: ME 242

ME 343 Control Systems 3 Credits
A comprehensive course in classical and modern linear control systems. Includes root locus, frequency response, state space, and digital control techniques with extensive use of computational methods. A design project provides experience with practical design 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 354 Automatic Control of Aerospace Vehicles 3 Credits
The forces and moments acting on rigid aircraft are developed from basic aerodynamics and used to determine the equations of motion and the resulting dynamic models. Analysis from these dynamic models supports the design of flight control, guidance, and autopilot systems. Modern control methods for missiles and spacecraft are also included. Undergraduate course assumes rigid airplane structures, while the graduate course develops the effects of flexible structures.
Prerequisites: MECH 326 and ME 343

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 356 Astrodynamics 3 Credits
Kepler's Laws are discussed and proven from basic mechanics, then used to determine the equations of motion for a satellite. Subsequent topics include various kinds of orbits in use today, orbit determination, orbital maneuvers, and rendezvous. Interplanetary trajectories, satellite attitude dynamics, rocket vehicles, and orbital perturbations are also discussed.
Prerequisites: MECH 102

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
Structure of the nucleus. Quantum theory. Nuclear energy release: Fission vs. Fusion. Plasma for fusion. Power balances in fusion plasmas. Magnetic and inertial confinement fusion concepts. Magnetic equilibrium configurations and limitations. The Tokamak. Emerging and alternative concepts. Fusion reactor economics. Radiation sources and Radioactive decay. Interactions of radiation with matter, detectors and protection from radiation. Energy deposition and dose calculations. Applications in dosimetry, imaging and spectroscopy. Must have senior standing in engineering or physical science.

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. Credit not given for both ME 364 and ME 464.
Prerequisites: ME 104 and ME 231

ME 366 Power Generation Technologies 3 Credits
The energy matrix is changing due to economic, environmental, and political pressure, requiring a transition to become more efficient, carbon-neutral, resilient, and competitive. This course looks at the design and performance of conventional (coal and natural gas) power generation systems, including thermal cycles, power plant efficiency, technologies for environmental compliance, carbon capture and sequestration, plant flexibilization and energy storage, and advanced plant data analytics. 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.
Prerequisites: CHE 210 or ME 104 or CHM 342 or MAT 205

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 (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 413 Numerical Methods in Mechanical Engineering 3 Credits
Zeros of functions, difference tables, interpolation, integration, differentiation. Divided differences, numerical solution of ordinary differential equations of the boundary and initial value type. Eigen problems. Curve fitting, matrix manipulation and solution of linear algebraic equations. Partial differential equations of the hyperbolic, elliptic and parabolic type. Application to problems in mechanical engineering.

ME 420 Advanced Thermodynamics 3 Credits
Critical review of thermodynamics systems. Criteria for equilibrium. Applications to electromagnetic systems. Statistical thermodynamics. Irreversible thermodynamics. Thermoelectric phenomena.

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 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
Method of characteristics. Unsteady continuous flow. Unsteady flows with discontinuities. Shock tubes. Detonation waves. Two-dimensional and axisymmetric supersonic flows. Momentum and energy equation of compressible viscous fluids.

ME 433 (CHE 433, ECE 433) Linear Systems and Control 3 Credits
This course covers the following topics in linear systems and control theory: review of fundamental concepts in linear algebra, state-space representation of linear systems, linearization, time-variance and linearity properties of systems, impulse response, transfer functions and their state-space representations, solution to LTI and LTV state equations, Jordan form, Lyapunov stability, input-output stability, controllability, stabilizability, observability, detectability, Canonical forms, minimal realizations, introduction to optimal control theory, Linear Quadratic Regulator (LQR), Algebraic Riccati Equation (ARE), frequency domain properties of LQR controllers.

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 440 General Examination 3 Credits
A critical assessment and definition of major unresolved issues for an assigned research topic during the first half of the semester, followed by formulation of a research proposal in accord with the format of a federal funding agency during the second half of the semester. In addition to the written proposal, the student gives a presentation to the Doctoral Committee, followed by extensive discussion. Grade assigned by the committee; minimum grade of B+ required. Instructor (doctoral student adviser) approval required.

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 (BIOE 452, CHE 452, ENGR 452) Mathematical Methods In Engineering I 3 Credits
Analytical techniques relevant to the engineering sciences are described. Vector spaces; eigenvalues; eigenvectors. Linear ordinary differential equations; 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
Theory of complex functions; Cauchy-Riemann relations. Integration in the complex plane, Cauchy's integral formula. Laurent series; singular points; contour integrals; Fourier and Laplace transforms. Evaluation of real integrals; Cauchy principal values. Laplace's equation; conformal mappings; Poisson formulae. Singular integral equations. Classification of partial differential equations. Hyperbolic systems of partial differential equations; uniqueness, shock formation. Nonlinear parabolic equations; Burger's equation.

ME 454 Automatic Control of Aerospace Vehicles 3 Credits
The forces and moments acting on aircraft are developed from basic aerodynamics and used to determine the equations of motion and the resulting dynamic models. Analysis from these dynamic models supports the design of flight control, guidance, and autopilot systems. Modern control methods for missiles and spacecraft are also included. Effects of flexible structures are developed. Cannot receive credit if previously completed ME 354.
Prerequisites: MECH 326 and MECH 343

ME 456 Astrodynamics 3 Credits
Kepler's Laws are proven from basic mechanics, then used to determine the equations of motion for a satellite. Subsequent topics include various kinds of orbits in use today, orbit determination, orbital maneuvers, and rendezvous. Interplanetary trajectories, satellite attitude dynamics, rocket vehicles, and orbital perturbations are also discussed. ME 456 is the graduate level version of ME 356; requires additional assignments and/or projects appropriate for graduate level study. Credit will not be given for both ME 356 and ME 456.

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 adviser 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 Renewable Energy 3 Credits
Fundamentals and design aspects of Renewable Energy (RE) technologies; bio-fuels, hydropower, solar photovoltaic, solar thermal, wind, geothermal energies. Details and difficulties in implementing RE. ME 464 is graduate level version of ME 364 and will require additional assignments and/or projects appropriate for graduate level study. Closed to students who have taken ME 364.

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 475 Directed Studies 1-3 Credits
Special problems related to a topic in mechanical engineering and mechanics.

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 0,3 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 0,3 Credits
Stress due to normal, bending, and shear loads in beams; stress transformations via Mohr's circle; principal stress analysis; plastic yield criteria; design of thin-walled pressure vessels; deflection of beams and static indeterminacy; finite element analysis of simple structures; stresses in thick-walled cylinders; stress concentration effects.
Prerequisites: MECH 003 and (MATH 023 or MATH 033)
Can be taken Concurrently: MATH 023, MATH 033

MECH 050 Supplemental Topis 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: ME 231

MECH 328 Fundamentals of Aircraft Design 3 Credits
Review of dynamic pressure, lift, drag. International Standard Atmosphere. Basics of wing sections. Parasitic and induced drag, best glide ratio and minimum sink of gliders. Basics of planforms, propulsion (piston/propeller and jet). Performance estimates (max speed, climb, endurance, range, stall), stability and trim, aerodynamic moments. Phugoid. Wing spar analysis. Electric aircraft.
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
Behavior of structural members under a variety of loading conditions in the elastic and inelastic range. Introduction to the theory of elasticity and plasticity. Basics of linear elastic fracture mechanics and fatigue. Analysis of structural member behavior in axial, bending, shear, and torsion. Stability analysis of beam-columns. Beams on elastic foundations. Energy concepts and their use in structural analysis.

MECH 406 Fundamentals of Solid Mechanics 3 Credits
An introductory graduate course in the mechanics of solids. Topics to be addressed include: curvi-linear tensor analysis, analysis of strain and nonlinear kinematics, stress, work conjugate stress-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 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 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 424 Unsteady Flows 3 Credits
This course examines the forces and flows that arise when rigid or flexible objects produce unsteadiness in a surrounding flow. The concepts of added mass and circulatory forces, hydrodynamic impulse, and vortex force are introduced. For unsteady lifting surfaces, classic theories such as Theodorsen, and von Kármán and Sears are examined. Unsteady flows produced by bluff bodies, such as vortex shedding from a cylinder, are discussed as well as unsteady flows from oscillating bodies, such as flying and swimming animals.

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 nonlinear 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
Time-independent and dependent inelastic material behavior. Time-independent plasticity. Yield criteria in multi-dimensions, J2 incremental plasticity in multi-dimensions with associated flow rule. Numerical integration of plasticity equations by radial return and other methods. Deformation theory of plasticity. Time dependent behavior including linear viscoelasticity and nonlinear creep behavior. Nonlinear material behavior at elevated temperatures.

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.