MATH 290 Directed Studies 1 to 6 Tutorial, 3 to 18 hours. Prerequisite(s): consent of instructor. Research and special studies in mathematics. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

MATH 291 Individual Study in Coordinated Areas 1 to 6 Individual Study, 3 to 18 hours. Prerequisite(s): graduate standing in Mathematics or consent of instructor. Designed to advise and assist candidates with exam preparation Graded Satisfactory (S) or No Credit (NC). Course is repeatable prior to successful completion of the qualifying examination for M.A. and M.S. students to a maximum of 6 units and for Ph.D. students to a maximum of 12 units.

MATH 297 Directed Research 1 to 6 Research, 3 to 18, hours.Prerequisite(s): consent of department. Directed research in mathematics. Graded Satisfactory (S) or No Credit (NC). Course is repeatable more than once per quarter if studying with two or more faculty members.

MATH 299 Research For Thesis Or Dissertation 1 to 12 Thesis, 3-36 hours. Prerequisite(s): consent of department. Original research in an area selected for the advanced degree. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

Professional Courses

MATH 302 Apprentice Teaching 2 to 4 Lecture, 0 to 1 hour; seminar, 2 to 4 hours; consultation, 1 to 2, Prerequisite(s): graduate standing. Supervised training for teaching in lower- and upper-division Mathematics courses. Modern trends in mathematical pedagogy at the college level. Covers instructional methods and classroom/section activities most suitable for teaching Mathematics. Designed for new graduate students in the Mathematics Department. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

MATH 401 Professional Development in Mathematics 2 Lecture, 1 hour; consultation, 1 hour. Prerequisite(s): graduate standing in Mathematics. Includes professional and research ethics, scientific writing and publications, oral presentation skills, career options in academia, and nonacademic careers. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

MECHANICAL ENGINEERING

Subject abbreviation: ME
The Marlan and Rosemary Bourns College of Engineering

Guillermo Aguilar, Ph.D. Chair
Department Office, A342 Bourns Hall
(951) 827-5830; me.ucr.edu

Professors

Reza Abbaschian, Ph.D.
Distinguished Professor
Guillermo Aguilar, Ph.D.
Chris Lynch, Ph.D., Dean, Bourns College of Engineering
Suveen Mathaudhu, Ph.D.
Cengiz Ozkan, Ph.D.
Marko Princevac, Ph.D.
Thomas Stahovich, Ph.D.
Kambiz Vafai, Ph.D. *Distinguished Professor*
Akula Venkatram, Ph.D.
Guanshui Xu, Ph.D.

Associate Professors

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Lorenzo Mangolini, Ph.D.
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Assistant Professors

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Chen Li, Ph.D.
Monica Martinez, Ph.D.
Bhargav Rallabandi, Ph.D.
Richard Wilson, Ph.D.
Luat Vuong, Ph.D.

**

Adjunct Professors

Chris Dames, Ph.D.
Santiago Camacho-Lopez, Ph.D.
Elisa Franco, Ph.D.
Javier Garay, Ph.D.

Cooperating Faculty

Bahman Anvari, Ph.D. (Bioengineering)
Matthew Barth, Ph.D. (Electrical and Computer Engineering)
Shane Cybart, Ph.D.
Kostas Karydis, Ph.D. (Electrical and Computer Engineering)
Mihri Ozkan, Ph.D. (Electrical and Computer Engineering)
Wei Ren, Ph.D. (Electrical and Computer Engineering)

Major

The design and production of machines requires a broad-based education. The Mechanical Engineering degree program has been structured to provide the necessary background in chemistry, physics, and advanced math to achieve success in the advanced engineering subjects. In addition, students are taught the basics of Mechanical Engineering while learning about the latest developments and experimental techniques.

The Mechanical Engineering Program Educational Objectives are to prepare graduates to make a positive impact on society by being successful in:

- careers as mechanical engineers and as engineering leaders
- graduate studies and research
- professional careers besides mechanical engineering
- advocating for the engineering profession and inspiring others to develop a passion for engineering profession.

The Mechanical Engineering B.S. degree program at UCR is accredited by the Engineering Accreditation Commission of ABET, abet.org. For more details see me.ucr.edu.

All undergraduates in the College of Engineering must see an advisor at least annually. Visit student.engr.ucr.edu for details.

Change of Major Criteria

All students who request a change of major to Mechanical Engineering must meet the following requirements:

- Be in good academic standing
- Have no less than a C- in any Math, Science and Engineering coursework
- Have a minimum 2.0 GPA in all Math, Science and Engineering required coursework
- Be able to complete major within maximum allowable units
- Complete all the courses listed below, based on the total number of units earned, prior to submitting the major change request
- UCR transfer students interested in changing to a BCOE major must have been admissible to the major at point of entry, or must satisfy transfer admission and change of major requirements before earning 120 units
- If changing in the 90-119 units category student must have the ability to complete major within 5 years of entry as a Freshmen or 3 years after entry as a Transfer student
- Students who have earned 120 or more units are not eligible for a change of major in BCOE. NOTE: AP/IB units are excluded from maximum unit calculation

Completed 0 to less than 45 units
Completion of ENGL 001A with C or better and completion of the following with at least 2.500 GPA:

- MATH 009A or MATH 09HA
- MATH 009B or MATH 09HB
- PHYS 040A

Completed 45 to less than 90 units
Completion of ENGL 001A with C or better and completion of the following with at least 2.500 GPA:

- ME 002
- ME 018A
- MATH 009A or MATH 09HA
- MATH 009B or MATH 09HB
- MATH 009C or MATH 09HC
- PHYS 040A

Completed 90 to less than 120 units

Completion of ENGL 001A and ENGL 001B with C or better and completion of the following with at least 2.500 GPA:

- ME 002
- ME 010
- ME 018A
- ME 018B
- MATH 009A or MATH 09HA
- MATH 009B or MATH 09HB
- MATH 009C or MATH 09HC
- PHYS 040A
- PHYS 040B

University Requirements

See Undergraduate Studies section.

College Requirements

See The Marlan and Rosemary Bourns College of Engineering, Colleges and Programs section.

The Mechanical Engineering major uses the following major requirements to satisfy the college's Natural Sciences and Mathematics breadth requirement.

1. BIOL 005A, BIOL 05LA
2. MATH 008B or MATH 009A
3. PHYS 040A, PHYS 040B, PHYS 040C

Major Requirements

1. **Lower-division requirements** (75 units)
   a) BIOL 005A, BIOL 05LA
   b) CHEM 001A, CHEM 001B, CHEM 01LA, CHEM 01LB
   c) EE 001A, EE 01LA
   d) MATH 008B or MATH 009A, MATH 009B, MATH 009C, MATH 010A, MATH 010B, MATH 046
   e) ME 002, ME 009, ME 010, ME 018A, ME 018B
   f) PHYS 040A, PHYS 040B, PHYS 040C
2. **Upper-division requirements** (77 units)
   a) ME 100A, ME 103, ME 110, ME 113, ME 114, ME 116A, ME 118, ME 120, ME 135, ME 170A, ME 170B, ME 174, ME 175A, ME 175B, ME 175C
   b) STAT 100A
   c) Choose one Focus Area:
      (1) Materials and Structures
         Sixteen (16) units of technical electives chosen from ME100B, ME116B, ME121, ME122, ME134/MSE134, ME153, ME156, ME157/MSE143, ME158/MSE148, ME180, ME197
      (2) Energy and Environment
         Sixteen (16) units of technical electives chosen from ME 100B, ME 116B, ME 117, ME 136, ME 137, ME 138, ME 197
      (3) Design and Manufacturing
         Sixteen (16) units of technical electives chosen from ME 121, ME 122, ME 130, ME 131, ME 133, ME 140, ME 144/EE 144, ME 145, ME 153, ME 156, ME 175D, ME 176, ME 180, ME 197
      (4) General Mechanical Engineering
         Sixteen (16) units of technical electives chosen from the following list, in consultation with an advisor: ME 100B, ME 116B, ME 117, ME 121, ME 122, ME 130, ME 131, ME 133, ME 134/MSE 134, ME 136, ME 137, ME 138, ME 140, ME 144/EE 144, ME 145, ME 153, ME 156, ME157/MSE143, ME158/MSE148, ME180, ME 175D, ME 176, ME 180, ME 197

Visit the Student Affairs Office in the College of Engineering or **student.engr.ucr.edu** for a sample program.

Graduate Program

The Department of Mechanical Engineering offers graduate educational programs leading to M.S. and Ph.D. degrees in Mechanical Engineering. Broad areas of research include

1) mechanics and materials, 2) fluids and thermal sciences and 3) information computation and design. Specific research focus areas include the following:

- Air quality, small and large-scale pollutant dispersion in urban flows, turbulent combustion and wildland fire behavior, engine emissions and nanoparticle science, thermal and electrical properties of nanowires and nanotubes, direct energy conversion, porous media and multiphase transport, bioheat transfer, biomedical optics, and medical laser applications
- Wafer fab processing, thin film mechanics and nanotechnology, bio-inspired materials, mechanical behavior of thin films and other small-featured structures, mechanics of interfaces and surfaces, mechanical properties of carbon nanotubes and ferroelectric/piezoelectric materials, sensing and imaging, mechanics of geophysical materials, advanced material synthesis, composites, MEME, BioMEMS, biomedical devices, and processing of nanocrystalline materials
- Artificial intelligence, computer-aided design or manufacturing, process planning, sensor networks, and distributed computing and control

Visit **me.ucr.edu/programs/gradindex.html**, for detailed information on the research programs of individual faculty members.

Combined B.S. + M.S. Five-Year Program

The college offers a combined B.S. + M.S. program in Mechanical Engineering designed to lead to a Bachelor of Science degree as well as a Master of Science degree in five years. Applicants for this program must have a high school GPA above 3.6, a combined SAT Reasoning score above 1950 (or ACT plus Writing equivalent), complete the Entry Level Writing Requirement before matriculation, and have sufficient mathematics preparation to enroll in calculus in their first quarter as freshmen. Eight units of technical electives will count in both programs, reducing the total number of units required for the MS degree.

Interested students who are entering their junior year should check with their academic advisor for information on eligibility and other details.

Admission

In addition to the following requirements, all applicants must meet the general requirements of the Riverside Division of the Academic Senate and the UCR Graduate Council as set forth in this catalog under the Graduate Studies section.

Language Requirement

All international students whose first language is not English must demonstrate proficiency in spoken English by securing at least a "conditional pass" score on the TAST or SPEAK test before they can be appointed as a TA. However, to be considered for subsequent TA appointments, they must secure a "clear pass" on the TAST or SPEAK. The fee associated with this test is paid by the department for the first attempt only. The TAST or SPEAK requirement is, however, waived for international students who are appointed as GSRs or are self-supported throughout their studies at UCR.

Master's Degree

The Department of Mechanical Engineering offers the M.S. degree in Mechanical Engineering.

Admission

Applicants should have an undergraduate degree in engineering, physical sciences, or mathematics; a satisfactory GPA for the last two years of their undergraduate studies; and high scores on the GRE General Test. All official transcripts, official GRE reports and three letters of recommendation must be submitted for evaluation. Foreign students and permanent residents whose first language is not English must also submit an acceptable TOEFL test score prior to admittance; the minimum TOEFL exam score is 550 (paper-based), 213 (computer-based), or 80 (Internet-based).

The M.S. degree in Mechanical Engineering can be earned by either completing a thesis (Plan I), which reports a creative investigation of a defined problem, or passing a comprehensive examination (Plan II). A minimum of three quarters of residency is required. Students should enroll in 12 units each quarter unless the graduate advisor grants an exception.

Course work used to satisfy the student's undergraduate degree requirements may not be applied toward the 36-unit M.S. requirement.

Plan I (Thesis)

Requires completion of a minimum of 36 units of upper-division and graduate-level approved course work and submission of an acceptable thesis. At least 24 of these units must be in graduate courses (200-series courses), a minimum of twenty of these units being Mechanical Engineering graduate courses (ME 200 or higher, excluding ME 250, ME 290, ME 297, ME 2981, and ME 299). The student must take at least 3 units of seminar (ME 250) and at least 7 but no more than 11 units of directed or thesis research credits (ME 297 or ME 299). No more than 8 units of course work may be satisfied with directed studies (ME 290) or individual internship (ME 2981). Students must defend the thesis.

An acceptable M.S. thesis must be submitted. The M.S. thesis may be based on:

1. A research or advanced design project, either analytical, computational or experimental;
2. An extensive report consisting of theoreti-

cal, computational or experimental contribution to mechanical engineering.

The student's M.S. Thesis Committee is responsible for approving the thesis. The thesis committee is composed of three members (including the research advisor).

Plan II (Comprehensive Examination)
Requires completion of a minimum of 36 units of upper-division and graduate-level approved course work and successfully passing a comprehensive examination. At least 24 of these units must be in graduate courses (200 series courses), a minimum of twenty of these units being Mechanical Engineering graduate courses (ME 200 or higher, excluding ME 250, ME 290, ME 297, ME 2981, and ME 299). The student must take I unit of seminar (ME 250) and no more than 7 units of directed studies (ME 290) or individual internship (ME 298I). Guidelines for preparation to the comprehensive examination are detailed in the Graduate Student Handbook.

Normative Time to Degree
Two years

Refer to the department's graduate program guidelines for further details.

Doctoral Degree

The Department of Mechanical Engineering offers the Ph.D. degree in Mechanical Engineering.

Admission
An M.S. or equivalent degree in engineering or physical sciences or mathematics is normally required for admission to the Ph.D. program, although applicants with exceptional undergraduate or research record may be admitted directly into the Ph.D. program without an M.S. degree. Applicants for the Ph.D. degree must also meet the same requirements as for the master's programs. Students in the M.S. program of Mechanical Engineering who desire to pursue the Ph.D. degree must formally apply for admission to the Ph.D. program.

The procedure for satisfying the requirements for the Ph.D. degree in Mechanical Engineering at UCR consists of four principal parts:

1. Successful completion of an approved program of course work below
2. Passing a written and oral preliminary examination
3. Successful oral defense of a written dissertation proposal
4. Defense and approval of the dissertation

Course Work
A course work plan has to be formulated by the student in coordination with their research advisor or the program graduate advisor. It is understood that changes to this may occur as the student's research progresses. These changes should be documented after consultation with the research advisor or the program graduate advisor.

Core Course Work
Before the oral defense of the dissertation proposal at least 32 units of course work must be completed. This is excluding seminar and research credits. Of these a minimum of twenty-four graduate units must be in Mechanical Engineering courses (ME 200 or higher, excluding ME 250, ME 290, ME 297, ME 298-I, and ME 299). Typically students also enroll in ME 250 and ME 297 units their first year. The student may be advised to take additional courses prior to advancement to candidacy.

Seminar Requirement
The student must also complete 6 units of ME 250 (seminar) prior to graduation. One unit of ME 250 is offered each quarter. These units do not have to be completed before the dissertation proposal defense.

Research Units
At least 36 units of directed or thesis research credits (ME 297 or ME 299) must be taken prior to graduation.

Courses taken as part of the Ph.D. requirement in Mechanical Engineering at UCR can be used to satisfy the course requirements for an M.S. in Mechanical Engineering at UCR and vice versa.

Normative Time to Degree
Five years

Refer to the department's graduate program guidelines for further details

Written and Oral Preliminary Examination
The examination aims to screen candidates for pursuing doctoral studies. It is administered by the graduate program committee and is composed of two sessions:

Session 1: Written Examination

Session 2: Oral Examination

Normally, both sessions are completed within a four-week period. The written examination is designed to test understanding of graduate-level mechanical engineering concepts and methods. It covers three subject areas to be selected by the student among the following: materials structure & properties, control systems, engineering analysis, fluid mechanics, heat transfer, thermodynamics, solid mechanics. Students are strongly encouraged to complete the relevant graduate-level course work for the selected subject areas. For details, consult the departmental guidelines. The oral examination assesses the student's ability to conduct independent research. Consult departmental guidelines for details. The preliminary examination is normally offered once every year at the beginning of the summer session.

Dissertation and Final Oral Examination
After successfully completing the preliminary examination, the student, with advice from the advisor, recommends a qualifying committee and prepares a dissertation proposal. The dissertation proposal consists of a written document and an oral presentation or defense. Typically, the student submits a dissertation proposal to the qualifying committee within one year after successfully completing the preliminary examination and completion of the required 24 units of graduate core courses. The qualifying committee chair normally schedules an oral defense within one month of the written proposal submission. The presentation is given only to the qualifying committee members. The student is advanced to candidacy after successfully completing this examination and all coursework.

After completing the dissertation research, a written draft copy of the completed dissertation must be submitted to the dissertation committee for review, evaluation, and determination of whether the draft thesis is ready for oral defense. Once a draft has been approved for defense, an oral defense of the dissertation is scheduled and is open to the entire academic community. This defense consists of a presentation, followed by a question-and-answer period conducted by the dissertation committee and the audience. After successfully defending the dissertation, the candidate must submit final copies of the dissertation that comply with the format requirements set forth by the Graduate Division. Copies are given to the department and the dissertation advisor, in addition to those required by the Graduate Division.

Consult departmental guidelines for appointments to qualifying and dissertation committees.

Refer to the department's graduate program guidelines for further details.

Lower-Division Courses

ME 002 Introduction to Mechanical Engineering 4 Lecture, 3 hours, discussion, 1 hour. Prerequisite(s): MATH 005 or equivalent. An introduction to the field of mechanical engineering. Topics include the mechanical engineering profession; machine components; forces in structures and fluids; materials and stresses; thermal and energy systems; machine motion; and machine design.

ME 003 How Things Work: the Principles Behind Technology 4 Lecture, 3 hours, discussion, 1 hour. Prerequisite(s): none. Introduces the basic physical principles of engineering systems from everyday life such as automobiles, computers, and household appliances. Topics include conservation laws and the physics and chemistry of engineering systems. Does not confer credit towards a degree in the Bourns College of Engineering.

ME 004 Energy and the Environment 4 Lecture, 3 hours, discussion, 1 hour. Prerequisite(s): none. Covers energy conservation, energy sources, market dynamics, and climate change. Addresses cultural, political, and social trends and their impact on the ecosystem. Discusses renewable and nonrenewable energy sources. Technical background not required. Does not confer credit towards a degree in the Bourns College of Engineering.

ME 005 The Science of Mythbusting 4 Lecture, 3 hours, discussion, 1 hour. Prerequisite(s): none. Introduces to the scientific method for non-science majors. Explores the application of scientific concepts to test the validity of myths and events from news stories, movies, and other popular media. Provides critical reasoning skills necessary to interpret advertiser's product claims, critique information on the World Wide Web, and understand new technologies.

ME 009 Engineering Graphics and Design 4 Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): none. Covers graphical concepts and projective geometry relating to spatial visualization and communication in design. Includes technical sketching, computer-aided design with solid modeling, geometric dimensioning and tolerancing, and an introduction to the engineering design process.

ME 010 Statics 4 Lecture, 3 hours, discussion, 1 hour. Prerequisite(s): MATH 009C, PHYS 040A or PHYS 040HA. Covers equilibrium of coplanar force systems; analysis of frames and trusses; noncoplanar force systems; friction; and distributed loads.

ME 018A Introduction to Engineering Computation 2 Lecture, 1 hours; laboratory, 3 hours. Prerequisite(s): MATH 009A or equivalent. An introduction to the use of MATLAB in engineering computation. Covers scripts and functions, programming, input/output, two- and three-dimensional graphics, and elementary numerical analysis.

ME 018B Introduction to Computational Modeling in Mechanical Engineering 4 Lecture, 3 hours, discussion, 1 hour. Prerequisite(s): MATH 009B with a grade of " C-" or better; ME 002 with a grade of "C-" or better; ME 018A. Introduces students to concepts of computational modeling in mechanical engineering. Topics include formulation of models to solve problems involving vector analysis, linear algebra, differential and integral calculus. Explores analytical and numerical solutions to problems in mechanical engineering.

Upper-Division Courses

ME 100A Thermodynamics 4 Lecture, 3 hours, discussion, 1 hour. Prerequisite(s): MATH 010A, ME 018B with a grade of C- or better, PHYS 040B or PHYS 040HB. Introduces basic concepts and applications of thermodynamics relevant to mechanical engineering. Topics include work and energy, the first law of thermodynamics, properties of pure substances, system and control volume analysis, the Carnot cycle, heat and refrigeration cycles, the second law of thermodynamics, entropy, and reversible and irreversible processes. Credit is awarded for only one of CHE 100 or ME 100A.

ME 100B Thermodynamics 4 Lecture, 3 hours, discussion, 1 hour. Prerequisite(s): ME 100A. Topics include the second law of thermodynamics, entropy function, entropy production, analysis of cycles, vapor power systems, gas power systems, refrigeration and heat pump systems, equations of state, thermodynamic property relations, ideal gas mixtures and psychrometrics, multicomponent systems, combustion, and reacting mixtures.

ME 103 Dynamics 4 Lecture, 3 hours, discussion, 1 hour. Prerequisite(s): MATH 046, ME 010 with a grade of "C-" or better, ME 018B with a grade of C- or better. Topics include vector representation of kinematics and kinetics of particles; Newton's laws of motion; force-mass-acceleration, work-energy, and impulse-momentum methods; kinetics of systems of particles; and kinematics and kinetics of rigid bodies.

ME 110 Mechanics of Materials 4 Lecture, 3 hours, discussion, 1 hour. Prerequisite(s): CS 009M or ME 018A; MATH 046, ME 010 with a grade of "C-" or better. Topics include mechanics of deformable bodies subjected to axial, torsional, shear, and bending loads; combined stresses; and their applications to the design of structures.

ME 113 Fluid Mechanics 4 Lecture, 3 hours, discussion, 1 hour. Prerequisite(s): MATH 046, PHYS 040B or PHYS 040HB, ME 010 with a grade of C- or better, ME 018B with a grade of C- or better. Introduces principles of fluid mechanics relevant to mechanical engineering. Topics include shear stresses and viscosity, fluid statics, pressure, forces on submerged surfaces, Bernoulli and mechanical energy equations, control volume approach, mass conservation, momentum and energy equations, the differential approach, turbulent flow in pipes, and lift and drag. Credit is awarded for only one of CHE 114 or ME 113.

ME 114 Introduction to Materials Science and Engineering 4 Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): CHEM 001B, PHYS 040C or PHYS 040HC; upper-division standing. Covers materials classification, atomic structure and interatomic bonding, crystal structure of metals, imperfections in solids, diffusion, mechanical properties of engineering materials, strengthening mechanisms, basic concepts of fracture and fatigue, phase diagrams, ceramics, polymers, and composites.

ME 116A Heat Transfer 4 Lecture, 3 hours, discussion, 1 hour. Prerequisite(s): MATH 046, ME 113 (ME 113 may be taken concurrently). Introduces the analysis of steady and transient heat conduction, fin and heat generating systems, two-dimensional conduction, internal and external forced convection, natural convection, radiation heat transfer, heat exchangers, and mass transfer. Credit is awarded for only one of CHE 116 or ME 116A.

ME 116B Heat Transfer 4 Lecture, 3 hours, discussion, 1 hour. Prerequisite(s): ME 116A. Covers analytical and numerical methods in heat transfer and fluid mechanics. Topics include heat conduction and convection, gaseous radiation, boiling and condensation, general aspects of phase change, mass transfer principles, multimode heat transfer and the simulation of thermal fields, and the heat transfer process.

ME 117 Combustion and Energy Systems 4 Lecture, 3 hours, discussion, 1 hour. Prerequisite(s): ME 100A, ME 113, ME 116A. Discusses premixed and diffusion flames; fuel-air thermochemistry; combustion-driven engine design and operation; engine cycle analysis; fluid mechanics in engine components; pollutant formation; and gas turbines.

ME 118 Mechanical Engineering Modeling and Analysis 4 Lecture, 3 hours, discussion, 1 hour. Prerequisite(s): MATH 046, ME 018B with a grade of C- or better. Introduces data analysis and modeling used in engineering through the software package MATLAB. Numerical methods include descriptive and inferential statistics, sampling and bootstrapping, fitting linear and nonlinear models to observed data, interpolation, numerical differentiation and integration, and solution of systems of ordinary differential equations. Final project involves the development and evaluation of a model for an engineering system. Credit is awarded for only one of ENGR 118 or ME 118.

ME 120 Linear Systems and Controls 4 Lecture, 3 hours, discussion, 1 hour. Prerequisite(s): EE 001A, EE 01LA, ME 018B. Introduces the modeling and analysis of dynamic systems, emphasizing the common features of mechanical, hydraulic, pneumatic, thermal, electrical, and electromechanical systems. Controls are introduced through state equations, equilibrium, linearization, stability, and time and frequency domain analysis.

ME 121 Feedback Control 4 Lecture, 3 hours, discussion, 1 hour. Prerequisite(s): ME 118, ME 120. Introduces students to the analysis and design of feedback control systems using classical control methods. Topics include control system terminology, block diagrams, analysis and design of control systems in the time and frequency domains, closed-loop stability, root locus, Bode plots, and an introduction to analysis in state-space.

ME 122 Vibrations 4 Lecture, 3 hours, discussion, 1 hour. Prerequisite(s): ME 103. Covers free and forced vibration of discrete systems with and without damping resonance; matrix methods for multiple degree-of-freedom systems; normal modes, coupling, and normal coordinates; and use of energy methods.

ME 130 Kinematic and Dynamic Analysis of Mechanisms 4 Lecture, 3 hours, discussion, 1 hour. Prerequisite(s): ME 009, ME 103. Explores the kinematic analysis of planar mechanisms including linkages, cams, and gear trains. Introduces concepts of multibody dynamics.

ME 131 Design of Mechanisms 4 Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): ME 130. Involves design of planar, spherical, and spatial mechanisms using both exact and approximate graphical and analytical techniques. Requires a computer-aided design project.

ME 133 Introduction to Mechatronics 4 Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): ME 120. Introduces hardware, software, sensors, actuators, physical systems models, and control theory in the context of control system implementation. Covers data acquisition (Labview), sensors, actuators, electric circuits and components, semiconductor electronics, logic circuits, signal processing using analog operational amplifiers, programmable logic controllers, and microcontroller programming and interfacing. Uses MATLAB and Simulink.

ME 134 Microstructural Transformations in Materials 4 Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): ME 114 or consent of instructor. An introductory study of the fundamentals (thermodynamics and kinetics) controlling microstructural transformations in materials and their application to both liquid-solid and solid-solid transformations. Focuses on the important transformations that ultimately control the microstructures and properties of crystalline solids. Cross-listed with MSE 134.

ME 135 Transport Phenomena 4 Lecture, 3 hours, discussion, 1 hour. Prerequisite(s): ME 100A, ME 113, ME 116A. Introduces new concepts of thermodynamics, fluid mechanics, and heat transfer: sychrometry, combustion, one-dimensional compressible flow, and turbomachinery. Integrates the most important concepts of transport of momentum, heat, and mass.

ME 136 Environmental Impacts of Energy

Production and Conversion 4 Lecture, 3 hours, discussion, 1 hour. Prerequisite(s): ME 100A, ME 113, ME 116A. Covers thermodynamics, heat transfer, and fluid mechanics as applied to the examination of the environmental impacts of energy production and conversion. Topics include pollution associated with fossil fuel combustion, environmental impacts of energy use, turbulent transport of pollutants, and principles used in the design of pollution control equipment.

ME 137 Environmental Fluid Mechanics 4 Lecture, 3 hours; discussion 1 hour. Prerequisite(s): ME 100A, ME 113. Covers the application of fluid mechanics to flows in the atmosphere and oceans. Topics include hydrostatic balance, Coriolis effects, geostrophic balance, boundary layers, turbulence, tracer and heat transport.

ME 138 Transport Phenomena in Living Systems 4 Lecture, 3 hours; discussion 1 hour. Prerequisite(s): BIEN 105 or ME 113, MATH 046, PHYS 040B or PHYS 040HB. An introduction to the application of the basic conservation laws of mechanics (mass, linear momentum, and energy) to the modeling of complex biological systems. Emphasizes how these concepts can explain and predict life processes.

ME 140 Ship Theory 4 Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): ME 103, ME 113. Covers ship hull form, static and dynamic stability, ship response to waves, grounding and flooding, numerical integration of complex three-dimensional curved shapes and mathematical modeling of curved surfaces. Explores engineering approximations necessary for applications of fundamental principles to complex engineering systems such as ships.

ME 144 Introduction to Robotics 4 Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): EE 132. Covers basic robot components from encoders to microprocessors. Kinematic and dynamic analysis of manipulators. Adrdresses open- and closed-loop control strategies, task planning, contact and noncontact sensors, robotic image understanding, and robotic programming languages. Experiments and projects include robot arm programming, robot vision, and mobile robots. Cross-listed with EE 144.

ME 145 Robotic Planning and Kinematics 4 Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): ME 120 or equivalent; or consent on instructor. Motion planning and kinematics topics with an emphasis in geometric reasoning, programming, and matrix computations. Motion planning includes configuration spaces, sensor-based planning, decomposition and sampling methods, and advanced planning algorithms. Kinematics includes reference frames, rotations and displacements, and kinematic motion models. Cross-listed with EE 145.

ME 153 Finite Element Methods 4 Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): ME 118. Covers weak form formulation, the Galerkin method and its computational implementation, mesh generation, data visualization, as well as programming finite element codes for practical engineering applications.

ME 156 Mechanical Behavior of Materials 4 Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): senior standing; ME 110; ME 114. Introduces the theory and experimental techniques for testing the mechanical behavior of materials and structures. Covers the fundamental mechanisms of deformation and failure of metals, ceramics, polymers, composite materials, and electronic materials as well as structural design and materials selection.

ME 170A Experimental Techniques 4 Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): EE 001A, EE 01LA, ME 018B. Covers the principles and practice of measurement and control, and the design and implementation of experiments. Topics include dimensional analysis, error analysis, signal-to-noise problems, filtering, data acquisition and data reduction, and statistical analysis. Includes experiments on the use of electronic devices and sensors, and practice in technical report writing.

ME 170B Experimental Techniques 4 Laboratory, 6 hours; discussion, 2 hours. Prerequisite(s): ME 103, ME 110, ME 113, ME 116A, ME 170A. Analysis and verification of engineering theory using laboratory measurements in advanced, project-oriented experiments involving fluid flow, heat transfer, structural dynamics, thermodynamic systems, and electromechanical systems.

ME 174 Machine Design 4 Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): ME 009, ME 103 (can be taken concurrently), ME 110, ME 114. An introduction to the fundamentals of strength-based design. Topics include deflection and stiffness, static failure, and fatigue failure.

ME 175A Professional Topics in Engineering 2 Lecture, 2 hours. Prerequisite(s): senior standing in Mechanical Engineering major; ME 009. Topics include technical communication, team work, project management, engineering economics, professional ethics, and computer-aided design. Satisfactory (S) or No Credit (NC) grading is not available.

ME 175B Mechanical Engineering Design 3 Lecture, 2 hours; laboratory, 2 hours. Prerequisite(s): senior standing in Mechanical Engineering. ME 113, ME 116A, ME 170A, ME 174, ME 175A (may be taken concurrently). Outlines the defining of a design problem and the conception and detail of the design solution. Explores design theory, design for safety, reliability, manufacture, and assembly. Graded In Progress (IP) until ME 175B and ME 175C are completed, at which time a final, letter grade is assigned.

ME 175C Mechanical Engineering Design 3 Lecture, 1 hours; discussion, 1 hour; laboratory, 3 hours. Prerequisite(s): senior standing in Mechanical Engineering; ME 175B. Students create, test, and evaluate a prototype based on the project design generated in ME 175B. Lecture topics include prototyping techniques, design verification, and special topics in design. Satisfactory (S) or No Credit (NC) grading is not available.

ME 175D Technological Entrepreneurship 4 Lecture, 2 hours; workshop, 2 hours. Prerequisite(s): senior standing in Mechanicail Engineering. Introduces concepts of business and management required to convert a technology into a viable business. Topics include technological assessment, market analysis, strategy, decision making, legal and intellectual property issues in business, financial analysis, business ethics and communication. Satisfactory (S) or No Credit (NC) grading is not available

ME 176 Sustainable Product Design 4 Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): ME 103, ME 110, ME 113, ME 116A. Introduces the principles of sustainable product design. Topics include life cycle design; design for reliability, maintainability, and recycling/reuse/remanufacture; materials selection; and manufacturing processes. Includes project in which students analyze the environmental impact of a product and redesign it to reduce the impact. Credit is awarded for only one of ME 176 or ME 210.

ME 180 Optics and Lasers in Engineering 4 Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): senior standing; ME 010, ME 110, ME 170A. Focuses on principles of optics and lasers, wave equations, interferometry, diffraction, laser-material interactions. Applications in analytical characterization including confocal microscopy, Raman spectroscopy, mechanical deformation analysis, scanning probe microscopy, ultraviolet-visible spectrophotometry, photoluminescence, optical detectors, and lasers in materials processing.

ME 190 Special Studies 1 to 5 Individual Study, 3 to 15 hours. Prerequisite(s): consent of instructor, department chair, and Mechanical Engineering Undergraduate Program Committee chair. Individual study to meet special curricular needs. Requires a final written report. Course is repeatable to a maximum of 9 units.

ME 197 Research For Undergraduates 1 to 4 Research, 3 to 12 hours. Prerequisite(s): consent of instructor and Mechanical Engineering Undergraduate Program Committee chair. Directed research in a particular subject relevant to mechanical engineering. Requires a final written technical report. Course is repeatable to a maximum of 8 units

ME 198 R'course: Variable Topics 1 Activity, 3 hours. Prerequisite(s): permission needed from department; sophomore standing or better. An opportunity for UCR undergraduate students to develop leadership skills, innovate the undergraduate curriculum, and promote democratic, experiential education. Original course topics are variable and unique from other departmental course offerings, designed to highlight the student facilitators' expertise while working closely with a faculty mentor. Graded Satisfactory (S) or No Credit (NC).Course is repeatable as topics change to a maximum of 8 units.

Graduate Courses

ME 200 Methods of Engineering Analysis 4 Lecture, 4 hours. Prerequisite(s): graduate standing in engineering or consent of instructor. Topics include linear algebra theory, vector spaces, eigenvalue problems, complex analytic functions, contour integration, integral transforms, and basic methods for solving ordinary and partial differential equations in mechanical engineering applications.

ME 201 Computational Methods in Engineering 4 Lecture, 4 hours. Prerequisite(s): graduate standing or consent of instructor. Explores numerical methods with computer applications. Topics include solution of nonlinear algebraic equations, solution of systems of linear equations, interpolation, integration, statistical description of data, model fitting, Fast Fourier Transform and applications, and numerical solution of ordinary and partial differential equations.

ME 202 Spectral Computational Methods 4 Lecture, 3 hours; consultation, 1 hour. Prerequisite(s): ME 200 or equivalent; ME 240A is recommended. Introduces data analysis, including discrete Fourier transforms, sampling theorem, and power spectra. Reviews Sturm-Liouville eigenfunction expansions, Gibbs phenomenon, convergence theorems, and Chebyschev transforms. Additional topics include Galerkin, tau, collocation, and pseudospectral methods, aliasing, time-advancement, and numerical stability. Explores applications to incompressible Navier-Stokes equations, compressible flows, reacting flows, and complex geometries. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor. Course is repeatable.

ME 203 Design and Analysis of Engineering Experiments 4 Lecture, 3 hours; discussion, 1 hour. Prerequisite(s):graduate standing or consent of instructor. ME 203 online section; enrollment in the Online Master-in-Science in Engineering program . Introduces research methods in engineering. Topics include design of experiments, basic statistical tools, data analysis in the time-domain and frequency domain, machine learning and pattern recognition approaches, and computational tools. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor.

ME 210 Sustainable Product Design 4 Lecture, 3 hours; consultation, 1 hour. Prerequisite(s): graduate standing or consent of instructor. ME 210 online section; enrollment in the Online Master-in-Science in Engineering program. Introduces the principles of sustainable product design. Topics include life cycle design; design for reliability, maintainability, and recycling/reuse/remanufacture; materials selection; and manufacturing processes. Includes project in which students analyze the environmental impact of a product and redesign it to reduce the impact. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor. Credit is awarded for only one of ME 176 or ME 210.

ME 220 Optimal Control and Estimation 4 Lecture, 4 hour; term paper, 1 hour. Prerequisite(s): ME 120, ME 121 or equivalent; or consent of instructor. Introduces optimal control and estimation with specific focus on discrete time linear systems. Topics include analysis of discrete Riccati equations; asymptotic properties of optimal controllers; optimal tracking; an introduction to Receding Horizon control; derivation of the Kalman filter; Extended Kalman Filter; and Unscented Kalman filter. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor. Cross-listed with EE 233.

ME 222 Advanced Robotics 4 Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): EE 236/ME 236; ME 120 or equivalent. Topics include robot navigation; description of robot sensors and their characteristics; sensor data processing; feature extraction; and matching. Also covers representations of space for mapping; map-based localization; simultaneous localization and mapping; image-based motion estimation; and motion planning. Cross-listed with EE 245.

ME 223 Secure and Reliable Control Systems 4 Lecture, 4 hours. Prerequisite(s): graduate standing or consent of instructor. ME 223 online section; enrollment in the Online Master-in-Science in Engineering program. An introductory study of fault-tolerant and secure control systems. Topics include models of dynamical systems; linear system theory; detectability of attacks and failures; model-based fault detection; analytical redundancy; unknown-input observers; statistical methods for fault detection; graphical models and structured system theory; and fault-tolerant control. Letter Grade or S/NC; no petition required.

ME 230 Computer-Aided Engineering Design 4 Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): graduate standing or consent of instructor. ME 230 online section; enrollment in the Online Master-in-Science in Engineering program. Introduces fundamentals of interactive computer graphics, three-dimensional representations of curves and surfaces, Bezier parameterizations, and optimization methods. Demonstrates applications of computer graphics and computational geometry to mechanical system simulations, computer-aided design, and engineering design.

ME 231 Pen-Based Computing 4 Lecture, 3 hours, discussion, 1 hour. Prerequisite(s): graduate standing or consent of instructor; computer programming experience Introduces computational techniques for pen-based user interfaces. Covers fundamental issues such as ink segmentation, sketch parsing, and shape recognition. Explores the topic of sketch understanding, including reasoning about context and correcting errors. Also addresses issues related to building practical pen-based systems. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor. Cross-listed with CS 233.

ME 232 Computational Design Tools 4 Lecture, 3 hours, discussion, 1 hour. Prerequisite(s): graduate standing or consent of instructor. An introduction to the theoretical foundations and practical application of computational techniques for engineering design. Topics include geometric modeling, numerical optimization, and artificial intelligence techniques. Includes programming projects in which both symbolic and numerical computational techniques are used to solve engineering problems. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor.

ME 233 Artificial Intelligence For Design 4 Lecture, 3 hours, discussion, 1 hour. Prerequisite(s): graduate standing or consent of instructor. Explores the application of artificial intelligence to engineering design. Topics include the use of search, knowledge-based systems, machine learning, and qualitative physical reasoning for design automation. Addresses the theory behind these techniques and issues related to their practical application. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor. Course is repeatable as content changes.

ME 235 Linear System Theory 4 Lecture, 3 hours, discussion, 1 hour. Prerequisite(s): EE 132. Provides a review of linear algebra. Topics include the mathematical description of linear systems; the solution of state-space equations; controllability and observability; canonical and minimal realization; and state feedback, pole placement, observer design, and compensator design. Cross-listed with EE.235.

ME 236 State and Parameter Estimation Theory 4 Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): EE 215 with a grade of C or better; graduate standing. Covers Fisher information, Cramer-Rao lower bound, efficiency, and sufficient statistics. Addresses minimum variance unbiased, best linear unbiased, maximum likelihood, least squares, maximum a posteriori, and mean-squared estimation. Also covers Weiner and Kalman filtering as well as applications in navigation, signal processing, machine learning, and dynamical systems. Cross-listed with EE 236.

ME 237 Nonlinear Systems and Control 4 Lecture, 3 hours, discussion, 1 hour. Prerequisite(s): EE 235/ME 235. Explores nonlinear systems and control. Topics include nonlinear differential equations, second order nonlinear systems, equilibrium and phase portrait, limit cycle, harmonic analysis and describing function, Lyapunov stability theory, absolute stability, Popov and circle criterion, input-output stability, small gain theorem, averaging methods, and feedback linearization. Cross-listed with EE 237.

ME 238 Linear Multivariable Control 4 Lecture, 3 hours, discussion, 1 hour. Prerequisite(s): EE 235/ME 235. Investigates multivariable feedback systems, stability, performance, uncertainty, and robustness. Topics include analysis and synthesis via matrix factorization; Q-parameterization and all stabilizing controllers; frequency domain methods; and H(insert infinity) design and structured singular value analysis. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor. Cross-listed with EE238.

ME 239 Optimal Control 4 Lecture, 3 hours, discussion, 1 hour. Prerequisite(s): EE 215, EE 235/ME 235. Presents the theory of stochastic optimal control systems and methods for their design and analysis. Covers principles of optimization; Lagrange's equation; linear-quadratic-Gaussian control; certainty-equivalence; the minimum principle; the Hamilton-Jacobi-Bellman equation; and the algebraic Ricatti equation. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor. Cross-listed with EE 239.

ME 240A Fundamentals of Fluid Mechanics 4 Lecture, 4 hours. Prerequisite(s): graduate standing or consent of instructor. ME

240A online section; enrollment in the Online Master-in-Science in Engineering program. Introduction to fluid mechanics. Explores equations of motion, stress tensor, the Navier-Stokes equations, boundary conditions, exact solutions, vorticity, and boundary layers.

ME 240B Fundamentals of Fluid Mechanics 4 Lecture, 4 hours. Prerequisite(s): ME 240A or consent of instructor. Covers inviscid flow, the Euler and Bernouli equations, potential flow, and wing theory and introduces stability theory and turbulence.

ME 241A Fundamentals of Heat and Mass Transfer 4 Lecture, 4 hours. Prerequisite(s): ME 240A or consent of instructor.Introduces in-depth derivations of equations and principles governing heat and mass transfer with an emphasis on formulation of problems. Topics include equations involved in conduction, convection, radiation, energy, and species conservation and the analytical and numerical solution of transport problems. Mechanical Engineering graduate students receive a letter grade; other students receive a letter grade or Satisfactory (S) or No Credit (NC) grade.

ME 241B Transport Through Porous Media 4 Lecture, 4 hours. Prerequisite(s): graduate standing. Covers current theories on flow, heat, and mass transfer and the mechanisms of multiphase transport in porous media. Mechanical Engineering graduate students receive a letter grade; other students receive a letter grade or Satisfactory (S) or No Credit (NC) grade.

ME 241C Electronic Cooling and Thermal Issues in Microelectronics 4 Lecture, 4 hours. Prerequisite(s): graduate standing. Discusses thermal issues associated with the life cycle of electronic products. Covers passive, active, and hybrid thermal management techniques, computational modeling approaches, and advanced thermal management concepts such as single phase, phase change and heat pipes. Mechanical Engineering graduate students receive a letter grade; other students receive a letter grade or Satisfactory (S) or No Credit (NC) grade.

ME 242 Turbulence in Fluids 4 Lecture, 4 hours. Prerequisite(s): ME 240A or consent of instructor. An introduction to the application of fundamental conservation laws of mechanics (mass, momentum, and energy) to the modeling of complex turbulent natural and human-made flows. Covers tensor notation, statistical and spectral analysis, and basic turbulent closure techniques, including understanding of turbulence with intuitive insight into the problems that cannot be rigorously solved. May be taken Satisfactory (S) or No Credit (NC) by students advanced to candidacy for the Ph.D.

ME 243A Advanced Mechanical Engineering Thermodynamics I 4 Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): graduate standing; or consent of instructor. Reviews fundamental concepts in classical thermodynamics such as conservation of energy, entropy, thermodynamic cycles, and functions. Covers Maxwell relations, chemical potentials and stability criteria for thermodynamic systems. Applications include chemical equilibrium and reactions as well as phase transitions, and diagrams. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor.

ME 243B Advanced Mechanical Engineering Thermodynamics Ii 4 Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): graduate standing; or consent of instructor. Introduces the statistical foundations of thermodynamics. Presents the fundamental postulate of thermodynamics and uses microstatistics to derive entropy, pressure, temperature, chemical potential, and free energies. Covers kinetic theory of gasses. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor.

ME 244 Nanoscale Heat Transfer and Energy Conversion 4 Lecture, 4 hours. Prerequisite(s): 2 of the following: MSE 207, ME 100A, ME 116A, EE 201, EE 202, MSE 217; or equivalents; graduate standing. Explores fundamental processes of energy transport and conversion at short length and time scales. Introduces classical and quantum-mechanical size effects on electrons, phonons, and photons. Topics include modes of energy storage, coupling between energy carriers, and electrical and thermal transport using the Boltzmann transport equation and/or kinetic theory. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor. Cross-listed with MSE 208B.

ME 245 Radiative Heat Transfer 4 Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): ME 116A or ME 116B or equivalent or consent of instructor. Offers in-depth study of topics related to radiative heat transfer. Builds upon curriculum of radiation presented at the undergraduate level. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor.

ME 246 Computational Fluid Dynamics With Applications 4 Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): ME 240A or consent of instructor. Introduces finite difference, finite volume, and finite element; spectral methods, governing equations for nonreacting and reacting flows; and stability and convergence for steady and unsteady problems. Students use commercial computational fluid dynamics (CFD) software for the course project.

ME 248 Internal Combustion Engines 4 Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): ME 100A; graduate standing. Covers engine types and their operation. Also addresses engine design and operating parameters, thermochemistry of fuel-air mixture, engine cycles, spark ignition and compressed ignition engines, and emissions. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor.

ME 250 Seminar in Mechanical Engineering 1 or 2 Seminar, 1 or 2 units. Prerequisite(s): graduate standing. Seminar in selected topics in mechanical engineering presented by graduate students, staff, faculty, and invited speakers. Students who present a seminar receive a letter grade; other students receive a Satisfactory (S) or No Credit (NC) grade. Course is repeatable.

ME 255 Transport Processes in the Atmospheric Boundary Layer 4 Lecture, 4 hours. Prerequisite(s): ME 100A or CHE 100, ME 113 or CHE 114, and ME 116A or CHE 116; or consent of instructor. Examines heat, mass, and momentum transport processes in the atmospheric boundary layer using current understanding of micrometeorology. Topics includes surface energy balance, Monin-Obukhov Similarity theory, and dispersion of pollutants in the atmospheric boundary layer. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor.

ME 260 Continuum Mechanics 4 Lecture, 4 hours. Prerequisite(s): graduate standing; or consent of instructor. Covers vector and tensor notation and analysis. Introduces the concept of deformation, strain, and stress tensors. Elaborates fundamental balance and conservation laws of mass, momentum, and energy. Describes constitutive equations for elastic, viscoelastic, and plastic solids; and ideal, compressible, and viscous fluids. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor.

ME 261 Theory of Elasticity 4 Lecture, 4 hours. Prerequisite(s): ME 110 or consent of instructor. Introduction to tensors, strain, equations of motion, and constitutive equations. Topics include typical boundary value problems of classical elasticity, problems of plane strain and plane stress, and variational principles.

ME 266 Mechanics and Physics of Materials 4 Lecture, 4 hours. Prerequisite(s): graduate standing; or consent of instructor. Course introduces students to topics related to Structure-Composition-Processing-Performance relationship of metallic materials. It will cover fundamentals of materials science, materials selection, processing and manufacturing. Materials design or selection-based approach and team activities will be utilized to enhance learning and presentation skills. Cross-listed with MSE 248B.

ME 267 Finite Element Methods in Solid Mechanics 4 Lecture, 4 hours. Prerequisite(s): ME 261 or consent of instructor. Covers the formulation and implementation of finite element methods, including the Galerkin and energy methods. Topics include the static and dynamic analysis of mechanical and multiphysical systems and techniques of automatic mesh generation.

ME 270 Introduction to Microelectromechanical Systems 4 Lecture, 4 hours. Prerequisite(s): ME 110, ME 114, or equivalents, for MSE 238 online section; enrollment in the Online Master-in-Science in Engineering program. An introduction to the design and fabrication of microelectromechanical systems (MEMS). Topics include micromachining processes; material properties; transduction; applications in mechanical, thermal, optical, radiation, and biological sensors and actuators; microfluidic devices; Bio-MEMS and applications; packaging and reliability concepts; and metrology techniques for MEMS. Cross-listed with MSE 238.

ME 271 Therapeutic Biomedical Microdevices 4 Lecture, 4 hours. Prerequisite(s): ME 270/MSE 238 or equivalent or consent of instructor. An introduction to the application of micro device technology towards biomedical therapeutics. Topics include emerging micro device fabrication techniques, bio compatibility requirements, and applications in areas such as cardiovascular intervention, minimally-invasive drug delivery, neuroprosthetic interfaces, and cellular engineering. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor.

ME 272 Nanoscale Science and Engineering 4 Lecture, 4 hours. Prerequisite(s): graduate standing or consent of instructor. For the MSE 248A/ME 272 online sections: enrollment in the Online Master-in-Science in Engineering program; graduate standing. An overview of the machinery and science of the nanometer scale. Topics include patterning of materials via scanning probe lithography; electron beam lithography; nanoimprinting; self-assembly; mechanical, electrical, magnetic, and chemical properties of nanoparticles, nanotubes, nanowires, and biomolecules (DNA, protein); self-assembled monolayers; and nanocomposites and synthetic macromolecules. Cross-listed with MSE 248A.

ME 273 Principles and Designs of Micro Transducers 4 Lecture, 3 hours; term paper, 1 hour; extra reading, 1 hour; written work, 1 hour. Prerequisite(s): ME 270/ MSE 238 or equivalent; or consent of instructor. Emphasizes physical principles and designs of microscopic sensors and actuators. Topics include macroscopic and microscopic physical phenomena and properties; signal processing; mechanical transducers; thermal transducers; electrical transducers; magnetic transducers; optical transducers; chemical and biological transducers; and applications in areas such as lab-on-a-chip, medical diagnosis and power MEMS.

ME 274 Plasma-Aided Manufacturing and Materials Processing 4 Lecture, 4 hours. Prerequisite(s): graduate standing or consent of instructor. For ME 274/MSE 208A online section: enrollment in the Online Master-in-Science in Engineering program; graduate standing. Covers the fundamentals of gaseous plasmas and the physics of both equilibrium and non-equilibrium discharges. Explores the basic techniques for plasma diagnostics. Discusses the use of plasmas as a materials processing medium for a variety of manufacturing processes. Includes topics such as the processing of nanostructured materials using plasmas. Cross-listed with MSE 208A.

ME 278 Imperfections in Solids 4 Lecture, 4 hours. Prerequisite(s): graduate standing; or consent of instructor. Covers fundamentals of crystal structures and crystal defects. Includes the generation of point defects, nucleation and propagation of dislocations, perfect and partial dislocations, twins, stacking faults, transformations, mechanics of semiconductor and metallic thin films, and multilayered structures. Cross-listed with MSE 218.

ME 279 Advanced Solidification Processing 4 Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): MSE 134; graduate standing; or consent of instructor. An overview of the fundamentals of solidification processing. Includes integrated interplay of heat flow, mass transport, and solid/liquid (s/l) interfacial kinetics during discontinuous change of state from liquid to solid of single phase and polyphase materials. Cross-listed with MSE 248C. Credit is awarded for one of the following MSE 248C, ME 279, or MSE 148.

ME 290 Directed Studies 1 to 6 Individual Study, 3 to 18 hours. Prerequisite(s): graduate standing; consent of instructor and graduate advisor. Individual study, directed by a faculty member, of selected topics in mechanical engineering. Graded Satisfactory (S) or No Credit (NC). Course is repeatable to a maximum of 9 units.

ME 297 Directed Research 1 to 4 Research, 3 to 18 hours. Prerequisite(s): graduate standing; consent of instructor. Research conducted under the supervision of a faculty member on selected problems in mechanical engineering. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

ME 298I Individual Internship 1 to 12 Internship, 2 to 24 hours; written work, 1 to 12 hours. Prerequisite(s): graduate standing; consent of graduate advisor. An individual apprenticeship in Mechanical Engineering with an approved professional individual or organization. Includes academic work under the direction of a faculty member. Graded Satisfactory (S) or No Credit (NC). Course is repeatable to a maximum of 12 units.

ME 299 Research For the Thesis Or Dissertation 1 to 12 Research, 3 to 36 hours. Prerequisite(s): graduate standing; consent of instructor. Research in mechanical engineering for the M.S. thesis or Ph.D. dissertation. Graded satisfactory (S) or No Credit (NC). Course is repeatable.

Professional Course

ME 302 Apprentice Teaching 1 to 4 Seminar, 1 to 4 hours. Prerequisite(s): appointment as a teaching assistant or an associate in Mechanical Engineering. Topics include effective teaching methods, such as those involved in leading discussion sections and preparing and grading examinations, and student-instructor relations in lower- and upper-division Mechanical Engineering courses. Required each quarter of teaching assistants and associates in Mechanical Engineering. Graded Satisfactory (S) or No Credit (NC). Course is repeatable to a maximum of 12 units.

MECHANISMS OF GENE EXPRESSION AND REGULATION STUDIES DESIGNATED EMPHASIS

Subject abbreviation: GERS
School of Medicine

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Emma Wilson (Biomedical Sciences)
Meera Nair (Biomedical Sciences)
Declan McCole (Biomedical Sciences)
David Lo (Biomedical Sciences)
Christian Lytle (Biomedical Sciences)
Nicholas DiPatrizio (Biomedical Sciences)
Seema Tiwari-Woodruff (Biomedical Sciences)
Sika Zheng (Biomedical Sciences)
Karine LeRoch (Cell Biology and Neuroscience)
Frances Sladek (Cell Biology and Neuroscience)
Ted Karginov (Cell Biology and Neuroscience)
Yinsheng Wang (Chemistry)
Thomas Girke (Institute for Integrative Genome Biology)
Xinping Cui (Statistics)
Katherine Borkovich (Microbiology)
James Borneman (Microbiology)
Jason Stajich (Microbiology)
Shou-Wei Ding (Microbiology)

Designated Emphasis Requirements

The Designate Emphasis is an interdisciplinary graduate program of study to enhance student training in the field through a focused course-work across at least two departments. The program is optional and the courses used for the DE may not be counted toward MS or PhD requirements.

1. Three (3) courses (12 units) with a focus in basic principles of genetics gene regulation (epigenetics, non coding RNA) and bioinformatics will be selected from:

   MCBL 221 - Microbial Genetics

   CMDB 201 - Molecular Biology

   CMBD 203 - Advanced Genetics

   GEN 203 - Advanced Genetic Analysis of Model Organisms

   GEN 241 - Advances in Genomics

   GEN 242 - Data Analysis in Genome Biology