Department of Mechanical and Aerospace Engineering

Julian Jose Rimoli, Department Chair
4221 Engineering Gateway
949-824-8451
http://mae.eng.uci.edu/

The Department of Mechanical and Aerospace Engineering offers two undergraduate B.S. programs: one in Mechanical Engineering and the other in Aerospace Engineering. The Department also offers M.S. and Ph.D. programs in Mechanical and Aerospace Engineering.

Mechanical Engineers and Aerospace Engineers design, manufacture, and control machines ranging from robots to aircraft and spacecraft, design engines and power plants that drive these machines, analyze the environmental impact associated with power generation, and strive to promote environmental quality. These disciplines require the creative use of mathematics, physics, and chemistry together with engineering science and technology in areas such as fluid and solid mechanics, thermodynamics and heat transfer, dynamics, controls, and atmospheric science to achieve these goals. Mechanical Engineering and Aerospace Engineering students at UCI learn the problem-solving, design, modeling, and testing skills required to contribute to be leaders in advancing modern technology and to be on the forefront of scientific discoveries.

The Mechanical Engineering undergraduate program includes required courses that provide engineering fundamentals and technical electives that allow students to study particular areas of interest. Elective courses can be organized into specializations in Aerospace Engineering, Energy Systems and Environmental Engineering, Flow Physics and Propulsion Systems, and Design of Mechanical Systems. Independent research opportunities allow students to pursue other avenues for focusing their studies.

Aerospace Engineering deals with all aspects of aircraft and spacecraft design and operation, thus requiring the creative use of many different disciplines. The undergraduate curriculum in Aerospace Engineering includes courses in subsonic and supersonic aerodynamics, propulsion, controls and performance, light-weight structures, spacecraft dynamics, and advanced materials. In the senior capstone course, students work in teams on the preliminary design of a commercial jet transport.

Career opportunities for Mechanical and Aerospace Engineering graduates are in a broad range of industries, including manufacturers of vehicles of all types, as well as aircraft and spacecraft, micro-mechanical systems, rehabilitation engineering, and research laboratories in universities and government.

- Aerospace Engineering, B.S.
- Mechanical and Aerospace Engineering, M.S.
- Mechanical and Aerospace Engineering, Ph.D.
- Mechanical Engineering, B.S.

Faculty

Satya N. Atluri, ScD Massachusetts Institute of Technology, *Professor Emeritus of Mechanical and Aerospace Engineering*

James E. Bobrow, Ph.D. University of California, Los Angeles, *Professor Emeritus of Mechanical and Aerospace Engineering* (robotics, mechatronics, and design optimization)

Ramin Bostanabad, Ph.D. Northwestern University, *Assistant Professor of Mechanical and Aerospace Engineering* (design under uncertainty, probabilistic machine learning, materials informatics, computational microstructure characterization, topology optimization)

Jacob Brouwer, Ph.D. Massachusetts Institute of Technology, *Director of Advanced Power and Energy Program and Director of National Fuel Cell Research Center and Professor and Chancellor's Fellow of Mechanical and Aerospace Engineering; Chemical and Biomolecular Engineering; Civil and Environmental Engineering* (fuel cells, energy systems dynamics, electrochemical systems design and analysis, chemical kinetics, reacting flows)

Natascha Buswell, Ph.D. Purdue University, *Assistant Professor of Teaching of Mechanical and Aerospace Engineering; Education* (graduate engineering education, faculty development, engineering teaching, engineering education research methods)

Penghui Cao, Ph.D. Boston University, *Assistant Professor of Mechanical and Aerospace Engineering; Materials Science and Engineering* (fundamental understanding of the mechanisms by which materials plasticly deform and fail, particularly in extreme environments)

David Copp, Ph.D. University of California, Santa Barbara, *Assistant Professor of Teaching of Mechanical and Aerospace Engineering* (optimal control and estimation, hybrid dynamical systems, energy storage, pedagogy)

Donald Dabdub, Ph.D. California Institute of Technology, *Professor Emeritus of Mechanical and Aerospace Engineering* (mathematical modeling of urban and global air pollution, dynamics of atmospheric aerosols, secondary organic aerosols, impact of energy generation on air quality, chemical reactions at gas-liquid interfaces)

Derek Dunn-Rankin, Ph.D. University of California, Berkeley, *Professor Emeritus of Mechanical and Aerospace Engineering; Civil and Environmental Engineering; Environmental Health Sciences* (combustion, optical particle sizing, particle aerodynamics, laser diagnostics and spectroscopy)

Said E. Elghobashi, Ph.D. University of London, *Distinguished Professor Emeritus of Mechanical and Aerospace Engineering* (direct numerical simulation of turbulent, chemically reacting and dispersed two-phase flows)

Manuel Gamero-Castaño, Ph.D. Yale University, *Professor of Mechanical and Aerospace Engineering* (electric propulsion, with emphasis on colloid thruster technology for precision formation flying missions and Hall thrusters. Electrohydrodynamic atomization of liquids and related problems like electrospray ionization and technological applications of electrosprays, Aerosol diagnostics)

Tryphon Georgiou, Ph.D. University of Florida, *Distinguished Professor of Mechanical and Aerospace Engineering* (dynamical systems and control, mathematical physics, applied mathematics. Current interests focus on stochastic control, geometry of optimal mass transport, inverse problems in physics and signal analysis, and topics related to the control of fluids, networks and thermodynamic systems)

Mircea Gradu, Ph.D., *Adjunct Professor of Mechanical and Aerospace Engineering*

Faryar Jabbari, Ph.D. University of California, Los Angeles, *Associate Dean for Academic Affairs and Professor of Mechanical and Aerospace Engineering* (optimal control theory, distributed parameter systems, parameter identification)

Perry Johnson, Ph.D. John Hopkins University, *Assistant Professor of Mechanical and Aerospace Engineering* (turbulent flows, particle-laden and multiphase flows, turbulent boundary layers, large-eddy simulations, scientific computing)

Solmaz S. Kia, Ph.D. University of California, Irvine, *Associate Professor of Mechanical and Aerospace Engineering; Computer Science* (systems and control, decentralized/distributed algorithm design for multi-agent systems, cooperative robotics)

Lawrence Kulinsky, Ph.D. University of California, Berkeley, *Adjunct Professor of Mechanical and Aerospace Engineering* (micro- and nano-manufacturing, hybrid manufacturing, microfluidics, electrokinetic phenomena, BioMEMs, personalized diagnostics, and drug delivery)

John C. LaRue, Ph.D. University of California, San Diego, *Professor Emeritus of Mechanical and Aerospace Engineering* (fluid mechanics, heat transfer, turbulence)

Jaeho Lee, Ph.D. Stanford University, *Assistant Professor of Mechanical and Aerospace Engineering* (heat transfer, thermal management, thermoelectrics, phononics, nanomaterials)

Robert Liebeck, Ph.D. University of Illinois at Urbana-Champaign, *Adjunct Professor of Mechanical and Aerospace Engineering* (aerodynamics, hydrodynamics, aircraft design)

Feng Liu, Ph.D. Princeton University, *Professor of Mechanical and Aerospace Engineering* (computational fluid dynamics, turbomachinery, propulsion)

Marc J. Madou, Ph.D. Ghent University, *Distinguished Professor Emeritus of Mechanical and Aerospace Engineering* (miniaturization science (MEMS and NEMS) with emphasis on chemical and biological applications)

J. Michael McCarthy, Ph.D. Stanford University, *Director of the Performance Engineering Program and Distinguished Professor of Mechanical and Aerospace Engineering* (design of mechanical systems, computer aided design, kinematic theory of spatial motion)

Vincent G. McDonell, Ph.D. University of California, Irvine, *Adjunct Professor of Mechanical and Aerospace Engineering* (combustion, alternative fuels, gas turbines, sprays, diagnostics, combined heat and power, emissions, autoignition/flashback)

Kenneth D. Mease, Ph.D. University of Southern California, *Professor Emeritus of Mechanical and Aerospace Engineering* (nonlinear dynamics and control; flight guidance and control)

Lawrence Muzio, Ph.D. University of California, Berkeley, *Adjunct Professor of Mechanical and Aerospace Engineering* (thermodynamics, combustion and combustion in practical systems, air pollution formation and control, advanced diagnostics applied to practical combustion systems)

SungWoo Nam, Ph.D. Harvard University, *Associate Professor of Mechanical and Aerospace Engineering; Materials Science and Engineering* (Materials, mechanics and multifunctionality; understanding mechanically coupled properties in low-dimensional materials; building devices based on advanced materials)

Bihter Padak, Ph.D. Stanford University, *Associate Director of UCI Combustion Laboratory and Assistant Professor of Mechanical and Aerospace Engineering; Chemical and Biomolecular Engineering* (combustion, reaction kinetics, emission control technologies, catalysis)

Dimitri Papamoschou, Ph.D. California Institute of Technology, *Professor of Mechanical and Aerospace Engineering* (compressible turbulence, jet and fan aeroacoustics, jet noise reduction, mixing enhancement, microphone phased array methods)

Roger H. Rangel, Ph.D. University of California, Berkeley, *Professor of Mechanical and Aerospace Engineering* (heat transfer, fluid mechanics, two-phase flows, fluid instability and atomization)

David J. Reinkensmeyer, Ph.D. University of California, Berkeley, *Professor of Anatomy and Neurobiology; Biomedical Engineering; Mechanical and Aerospace Engineering; Physical Medicine and Rehabilitation*

Julián Rimoli, Ph.D. California Institute of Technology, *Department Chair and Professor of Mechanical and Aerospace Engineering* (computational solid mechanics, aerospace structures, multiscale modeling)

Nina Robson, Ph.D. University of California, Davis, *Associate Adjunct Professor of Mechanical and Aerospace Engineering* (kinematics, mechanical systems design, robotics, biomechanics)

G. Scott Samuelsen, Ph.D. University of California, Berkeley, *Research Professor and Professor Emeritus of Mechanical and Aerospace Engineering; Civil and Environmental Engineering* (fuel cells, combustion, air quality, smart grid and microgrid technology, practical systems, energy and environmental conflict)

Xian Shi, Ph.D. University of California, Berkeley, *Assistant Professor of Mechanical and Aerospace Engineering* (energy conversion, propulsion, reacting flows, shock and detonation, chemical kinetics, energy storage, carbon materials, materials synthesis, nanoparticle dynamics, carbon capture and storage)

Andrei M. Shkel, Ph.D. University of Wisconsin-Madison, *Professor of Mechanical and Aerospace Engineering; Biomedical Engineering; Electrical Engineering and Computer Science* (design and advanced control of micro-electro-mechanical systems (MEMS); high precision micro-machined gyroscopes; MEMS-enhanced optical systems, tools and prosthetic appliances; electromechanical and machine-information systems integration)

Athanasios Sideris, Ph.D. University of Southern California, *Professor of Mechanical and Aerospace Engineering* (control systems, neural networks)

William A. Sirignano, Ph.D. Princeton University, *Distinguished Professor of Mechanical and Aerospace Engineering* (combustion theory, multiphase flows, turbulent reacting flows, computational methods, rocket and jet propulsion, gas turbine and internal combustion engines)

Haithem Taha, Ph.D. Virginia Polytechnic Institute and State University, *Associate Professor of Mechanical and Aerospace Engineering* (geometric nonlinear control theory; unsteady aerodynamics and aeroelasticity; optimization, calculus of variations and optimal control; flight dynamics and autopilot design; airplane performance and configuration aerodynamics)

Jacqueline Thomas, Ph.D. Massachusetts Institute of Technology, *Assistant Professor of Mechanical and Aerospace Engineering* (design of aircraft systems and operations, aviation environmental impacts, aeroacoustics)

Camilo Velez Cuervo, Ph.D. University of Florida, *Assistant Professor of Mechanical and Aerospace Engineering; Electrical Engineering and Computer Science* (micro/nano robotics, micro/nano device fabrication, microfabrication of magnetic microsystems, magnetic micro/nanostructures, selective magnetization of micro patterns, microsystems (MEMS), biomedical microsystems, semiconductor devices and microfluidics)

Alexandra Voloshina, Ph.D. University of Michigan, *Assistant Professor of Mechanical and Aerospace Engineering* (wearable robotics, gait rehabilitation, human biomechanics, motor impairment, neural control of movement)

Mark Walter, Ph.D. California Institute of Technology, *Professor of Teaching of Mechanical and Aerospace Engineering* (mechanics of multifunctional materials, building energy efficiency)

Yun Wang, Ph.D. Pennsylvania State University, *Professor of Mechanical and Aerospace Engineering* (fuel cells, computational modeling, thermo-fluidics, two-phase flows, electrochemistry, Computational Fluid Dynamics (CFD), turbulent combustion)

Yoon Jin Won, Ph.D. Stanford University, *Associate Professor of Mechanical and Aerospace Engineering; Electrical Engineering and Computer Science; Materials Science and Engineering* (multi-scale structures for thermal and energy applications, in particular fabrication, characterization, and integration of structured materials)

Affiliate Faculty

Mohammad Al Faruque, Ph.D. University of Kaiserslautern, *Chair of Emulex Career Development and Professor of Electrical Engineering and Computer Science; Computer Science; Mechanical and Aerospace Engineering* (cyber-physical systems, internet of things, embedded systems, CPS security)

Aparna Chandramowlishwaran, Ph.D. Georgia Institute of Technology, *Associate Professor of Electrical Engineering and Computer Science; Mechanical and Aerospace Engineering* (high-performance computing, domain-specific compilers, algorithm-architecture co-design, data analysis, and scientific computing)

Magnus Egerstedt, Ph.D. KTH Royal Institute of Technology, *Stacey Nicholas Dean of Engineering and Professor of Electrical Engineering and Computer Science; Mechanical and Aerospace Engineering* (Control theory and robotics, control and coordination of complex networks, multirobot systems, mobile sensor networks and cyber-physical systems)

Joyce H. Keyak, Ph.D. University of California, San Francisco, *Professor of Radiological Sciences; Biomedical Engineering; Mechanical and Aerospace Engineering*

Arash Kheradvar, Ph.D. California Institute of Technology, *Professor of Biomedical Engineering; Electrical Engineering and Computer Science; Mechanical and Aerospace Engineering* (cardiac mechanics, cardiovascular devices, cardiac imaging)

Abraham P. Lee, Ph.D. University of California, Berkeley, *Chancellor's Professor of Biomedical Engineering; Mechanical and Aerospace Engineering* (integrated point-of-care diagnostics, engineered "theranostic" vesicles and particles, active cell sorting microdevices, microphysiological microsystems, and high throughput droplet bioassays)

Timothy Rupert, Ph.D. Massachusetts Institute of Technology, *Director of the Materials Discovery and Synthesis Center (MDSC) and Professor of Materials Science and Engineering; Mechanical and Aerospace Engineering* (mechanical behavior, nanomaterials, alloy design, structure-property-processing relationships, microstructural stability, grain boundaries and interfaces, atomistic modeling, materials characterization)

Lorenzo Valdevit, Ph.D. Princeton University, *Director of Institute for Design and Manufacturing Innovation (IDMI) and Professor of Materials Science and Engineering; Mechanical and Aerospace Engineering* (architected materials, mechanical metamaterials, additive manufacturing, optimal design)

Vasan Venugopalan, Sc.D. Massachusetts Institute of Technology, *Department Chair and Professor of Chemical and Biomolecular Engineering; Biomedical Engineering; Mechanical and Aerospace Engineering; Surgery* (laser-generated thermal, mechanical and radiative transport processes for application in medical diagnostics, imaging, therapeutics, biotechnology)

Iryna Zenyuk, Ph.D. Carnegie Mellon University, *Associate Director of National Fuel Cell Research Center and Associate Professor of Chemical and Biomolecular Engineering; Materials Science and Engineering; Mechanical and Aerospace Engineering* (renewable energy, fuel cells, electrolyzers, batteries, X-ray imaging techniques, multi-scale modeling, transport phenomena)

Courses

ENGRMAE 10. Introduction to Engineering Computations. 4 Units.
Introduction to the solution of engineering problems through the use of the computer. Elementary programming, numerical analysis, and data visualization with a high-level programming language such as MATLAB.

(Design units: 1)

Corequisite: MATH 2A
Prerequisite: MATH 2A or MATH 5A or AP Calculus AB. AP Calculus AB with a minimum score of 3

Overlaps with EECS 10, EECS 12, BME 60B.

Restriction: Aerospace Engineering Majors have first consideration for enrollment. Chemical Engineering Majors have first consideration for enrollment. Materials Science and Engr Majors have first consideration for enrollment. Mechanical Engineering Majors have first consideration for enrollment.

ENGRMAE 30. Statics. 4 Units.
Addition and resolution of forces, distributed forces, equivalent system of forces centroids, first moments, moments and products on inertia, equilibrium of rigid bodies, trusses, beams, cables. Course may be offered online.

(Design units: 0)

Corequisite: MATH 2D
Prerequisite: MATH 2D and PHYSICS 7C

Same as ENGRCEE 30, ENGR 30.

Restriction: School of Engineering students have first consideration for enrollment.

ENGRMAE 52. Computer-Aided Design. 4 Units.
Develops skills for interpretation and presentation of mechanical design drawings and the use of CAD in engineering design. An integrated approach to drafting based on sketching, manual drawing, and three-dimensional CAD techniques is presented. Materials fee.

(Design units: 0.5)

Restriction: Mechanical Engineering Majors have first consideration for enrollment. Materials Science and Engr Majors have first consideration for enrollment.

ENGRMAE 60. Electric Circuits. 4 Units.
Design and analysis of analog circuits based on lumped circuit elements with emphasis on the use of operational amplifiers. Sinusoidal and transient response. Constructional and laboratory testing of analog circuits, and introduction to data acquisition. Materials fee.

(Design units: 2)

Corequisite: MATH 3D
Prerequisite: PHYSICS 7D and PHYSICS 7LD

Overlaps with EECS 70A.

Restriction: Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment.

ENGRMAE 80. Dynamics. 4 Units.
Introduction to the kinematics and dynamics of particles and rigid bodies. The Newton-Euler, Work/Energy, and Impulse/Momentum methods are explored for ascertaining the dynamics of particles and rigid bodies. An engineering design problem using these fundamental principles is also undertaken.

(Design units: 0.5)

Prerequisite: MATH 2D and PHYSICS 7C

Same as ENGRCEE 80, ENGR 80.

Restriction: Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment. Civil Engineering Majors have first consideration for enrollment. Materials Science and Engr Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRMAE 91. Introduction to Thermodynamics. 4 Units.
Thermodynamic principles; open and closed systems representative of engineering problems. First and second law of thermodynamics with applications to engineering systems and design.

(Design units: 0.5)

Prerequisite: PHYSICS 7C and MATH 2D

Overlaps with CBE 40B.

Restriction: Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment. Civil Engineering Majors have first consideration for enrollment. Materials Science and Engr Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRMAE 93. Topics in Design Project . 1-4 Units.
Early-stage design/hands-on experience for students, and allows them to participate alongside seniors in the design project.

(Design units: 1)

Repeatability: Unlimited as topics vary.

Restriction: Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment.

ENGRMAE 106. Mechanical Systems Laboratory. 4 Units.
Experiments in linear systems, including op-amp circuits, vibrations, and control systems. Emphasis on demonstrating that mathematical models can be useful tools for the analysis and design of electro-mechanical systems. Materials fee.

(Design units: 2)

Prerequisite: ENGRMAE 60 or EECS 70A

Restriction: Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment. Civil Engineering Majors have first consideration for enrollment. Materials Science and Engr Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRMAE 107. Fluid Thermal Science Laboratory. 4 Units.
Fluid and thermal engineering laboratory. Experimental analysis of fluid flow, heat transfer, and thermodynamic systems. Probability, statistics, and uncertainly analysis. Report writing is emphasized and a design project is required. Materials fee.

(Design units: 1)

Corequisite: ENGRMAE 120

Restriction: Mechanical Engineering Majors have first consideration for enrollment.

ENGRMAE 108. Aerospace Laboratory. 4 Units.
Analytical and experimental investigation in aerodynamics, fluid dynamics, and heat transfer. Emphasis on study of flow over objects and lift and drag on airfoils. Introduction to basic diagnostic techniques. Report writing is emphasized.

(Design units: 2)

Prerequisite: ENGRMAE 130B

Restriction: Aerospace Engineering Majors have first consideration for enrollment. Mechanical Engineering majors have second consideration for enrollment.

ENGRMAE 110. Combustion and Fuel Cell Systems. 4 Units.
Fundamentals of gaseous, liquid, and coal-fired combustion and fuel cell systems. Fuels, fuel-air mixing, aerodynamics, and combustion and fuel cell thermodynamics. Operating and design aspects of practical systems including engines, power generators, boilers, furnaces, and incinerators.

(Design units: 2)

Prerequisite: ENGRMAE 115

Restriction: Mechanical Engineering Majors have first consideration for enrollment. Chemical Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRMAE 112. Propulsion. 4 Units.
Application of thermodynamics and fluid mechanics to basic flow processes and cycle performance in chemical propulsion systems: gas turbines, ramjets, scramjets, and rockets. Introduction to electric and electromagnetic rocket thrusters, nuclear rockets, and solar sails.

(Design units: 1)

Prerequisite: ENGRMAE 130C

Restriction: Aerospace Engineering Majors have first consideration for enrollment. Mechanical Engineering majors have second consideration for enrollment.

ENGRMAE 113. Electric Propulsion. 4 Units.
Space propulsion requirements and maneuvers, stressing those best suited to electric propulsion. An introduction to plasma physics. Electrothermal, electromagnetic, and electrostatis accelerators, with emphasis in technologies (ion engines, Hall thrusters, and colloidal thrusters) belonging to the latter family.

(Design units: 1)

Prerequisite: ENGRMAE 112

Restriction: Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment.

Concurrent with ENGRMAE 213.

ENGRMAE 114. Fuel Cell Fundamentals and Technology. 4 Units.
Introduction to electrochemistry and electrocatalysis; nature of fuel-cell electrodes and electrolytes; charge transfer reactions at interfaces; charge transport and mass transport processes; fuel processing reactions; determination of fuel cell efficiency, fuel flexibility, emissions, and other characteristics.

(Design units: 0)

Prerequisite: ENGRMAE 115

Restriction: Seniors only. Mechanical Engineering Majors have first consideration for enrollment. Chemical Engineering majors have second consideration for enrollment.

Concurrent with ENGRMAE 214A.

ENGRMAE 115. Applied Engineering Thermodynamics. 4 Units.
Application of thermodynamic principles to compressible and incompressible processes representative of practical engineering problems; power cycles, refrigeration cycles, multicomponent mixtures, air conditioning systems, combustion, and compressible flow. Design of a thermodynamic process.

(Design units: 2)

Prerequisite: ENGRMAE 91 or CBE 40B or ENGRMSE 65A

Restriction: Mechanical Engineering Majors have first consideration for enrollment. Environmental Engineering majors have second consideration for enrollment.

ENGRMAE 117. Solar and Renewable Energy Systems. 4 Units.
Basic principles, design, and operation of solar and other renewable energy systems including solar photo-voltaic, solar thermal, wind, and PEM fuel cell. Includes power generation and storage, and renewable fuels for transportation and stationary power generation.

(Design units: 1)

Prerequisite: (ENGRMAE 91 or CBE 40B)

Restriction: Mechanical Engineering Majors have first consideration for enrollment.

ENGRMAE 118. Sustainable Energy Systems. 4 Units.
Basic principles, design, and operation of sustainable energy systems including wind, solar photo-voltaic and thermal, hydroelectric, geothermal, oceanic, biomass combustion, advanced coal, and next generation nuclear. Includes power generation, storage, and transmission for stationary power generation.

(Design units: 1)

Prerequisite: ENGRMAE 115

Restriction: Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment.

Concurrent with ENGRMAE 218.

ENGRMAE 119. Climate Solutions. 4 Units.
Introduction to climate change science and impacts on the health of people and the planet with a focus on the multi-dimensional aspects of solutions to the climate crisis.

Same as EARTHSS 179, UPPP 111.

Restriction: Upper-division students only.

ENGRMAE 120. Heat and Mass Transfer. 4 Units.
Fundamentals of heat and mass transfer. Conduction, heat and mass transfer by convection in laminar flow, radiation heat transfer, and combined modes of heat and mass transfer. Practical engineering applications.

(Design units: 0)

Prerequisite: ENGRMAE 130B

Overlaps with CBE 120B.

Restriction: Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment. Materials Science and Engr Majors have first consideration for enrollment.

ENGRMAE 130A. Fluid Dynamics I. 4 Units.
Fundamental concepts; fluid statics; kinematics; incompressible and compressible flows; Bernoulli's equation; control-volume analysis; conservation of mass, momentum, and energy; differential analysis; introduction to potential flow and viscous flow.

(Design units: 0)

Corequisite: (ENGRMAE 80 or ENGRCEE 80 or ENGR 80) and ENGRMAE 91 and MATH 2E
Prerequisite: PHYSICS 7C and MATH 2D and MATH 3D and (ENGRMAE 30 or ENGRCEE 30 or ENGR 30) and (ENGRMAE 80 or ENGRCEE 80 or ENGR 80). PHYSICS 7C with a grade of C- or better. MATH 2D with a grade of C- or better. MATH 3D with a grade of C- or better. ENGRMAE 30 with a grade of C- or better. ENGRCEE 30 with a grade of C- or better. ENGR 30 with a grade of C- or better. ENGRMAE 80 with a grade of C- or better. ENGRCEE 80 with a grade of C- or better. ENGR 80 with a grade of C- or better

Restriction: Aerospace Engineering Majors have first consideration for enrollment. Mechanical Engineering Majors have first consideration for enrollment.

ENGRMAE 130B. Fluid Dynamics II. 4 Units.
Analysis of viscous flows: stress-strain rate, fully developed laminar and turbulent flows. Review of thermodynamics, sound speed, stagnation properties. One dimensional isentropic and non-isentropic compressible flows. Normal and oblique shock waves. Two-dimensional supersonic isentropic flow.

(Design units: 1)

Prerequisite: ENGRMAE 130A

Restriction: Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment.

ENGRMAE 130C. Fluid Mechanics III. 4 Units.
Advanced topics in viscous and compressible flows. Viscous boundary layers, basic concepts in turbulent flow, separated flows, thermal transport, two-dimensional supersonic flow, shock polars, supersonic airfoils, conical flows.

Prerequisite: ENGRMAE 130B

Restriction: Aerospace Engineering Majors have first consideration for enrollment. Mechanical Engineering majors have second consideration for enrollment.

ENGRMAE 132. Computational Fluid Dynamics. 4 Units.
Introduction to computational fluid dynamics in simple engineering devices. The numerical simulations will be performed via the widely-used software ANSYS-Fluent. While Fluent is the choice of software, all major CFD packages are based on a similar numerical method.

(Design units: 0)

Prerequisite: ENGRMAE 130B. ENGRMAE 130B with a grade of C- or better

Restriction: Aerospace Engineering Majors only. Mechanical Engineering Majors only.

ENGRMAE 135. Compressible Flow. 4 Units.
Compressibility effects in fluid mechanics. One-dimensional flow with area variation, friction, heat transfer, and shocks. Design of gas supply systems. Two-dimensional flow with oblique shocks and isentropic waves. Supersonic airfoil theory and design, wind tunnel design. Basic diagnostics.

(Design units: 1)

Prerequisite: ENGRMAE 130A

Restriction: Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment.

ENGRMAE 136. Aerodynamics. 4 Units.
Advanced potential flow, vorticity, and circulation. Flow over aircraft wings and airfoils: Kutta-Joukowski theory, lift, moment, and drag. Flow similitude; three dimensional wing theory, compressibility, viscous effects. Source panel methods. Supersonic aerodynamics.

(Design units: 1)

Prerequisite: ENGRMAE 130B

Restriction: Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment.

ENGRMAE 145. Theory of Machines and Mechanisms. 4 Units.
Presents the basic mathematical theory of machines. Focuses on the principles of cam design, gearing and gear train analysis, and the kinematic and dynamic analysis of linkages, together with an introduction to robotics.

(Design units: 2)

Prerequisite: ENGRMAE 52 and (ENGRMAE 80 or ENGRCEE 80 or ENGR 80) and (MATH 3A or I&C SCI 6N)

Restriction: Mechanical Engineering Majors have first consideration for enrollment. Materials Science and Engineering majors have second consideration for enrollment.

ENGRMAE 146. Astronautics. 4 Units.
Motion in gravitational force fields, orbit transfers, rocketry, interplanetary trajectories, attitude dynamics and stabilization, navigation, reentry, the space environment.

(Design units: 1)

Prerequisite: ENGRMAE 80 or ENGRCEE 80 or ENGR 80

Restriction: Aerospace Engineering Majors have first consideration for enrollment.

ENGRMAE 147. Vibrations. 4 Units.
Analysis of structural vibrations of mechanical systems. Modeling for lumped and distributed parameter systems. Topics include single and multi-degree of freedom systems, free and forced vibrations, Fourier series, convolution integral, mass/stiffness matrices, and normal modes with design project.

(Design units: 1)

Prerequisite: (ENGR 80 or ENGRCEE 80 or ENGRMAE 80) and MATH 2E and MATH 3D

Restriction: Mechanical Engineering Majors have first consideration for enrollment. Materials Science and Engr Majors have first consideration for enrollment.

ENGRMAE 148. Mechanics of Smart Structures. 4 Units.
Introduction to modeling, numerical simulation, design, and control of axial, torsional, and bending actuators. Fundamentals of shape-changing trusses, frames, and panels. Introduction to the behavior and modeling of smart materials such as shape memory alloys/polymers.

Prerequisite: ENGRMAE 150

Concurrent with ENGRMAE 248.

ENGRMAE 150. Mechanics of Structures. 4 Units.
Introduction to mechanics of materials. Topics include stresses and strains, axial and torsional loading, bending, shear, combined loading, stress and strain transformation, failure theories, beam deflection, and buckling.

(Design units: 2)

Prerequisite: (ENGRCEE 30 or ENGR 30 or ENGRMAE 30) and MATH 3A

Same as ENGR 150.
Overlaps with ENGRCEE 150.

Restriction: Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment. Chemical Engineering Majors have first consideration for enrollment. Materials Science and Engr Majors have first consideration for enrollment.

ENGRMAE 150L. Mechanics of Structures Laboratory. 1 Unit.
Experimental techniques for the measurement of mechanical properties of materials and structures. Methods for load, displacement, and strain measurements. Tension, bending, compression tests. Determination of strength. Materials fee.

(Design units: 0)

Corequisite: ENGRMAE 150
Prerequisite: ENGRMAE 30 or ENGR 30 or ENGRCEE 30

Overlaps with ENGRCEE 150L.

Restriction: Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment. Materials Science and Engr Majors have first consideration for enrollment.

ENGRMAE 151A. Mechanical Engineering Design I. 4 Units.
Teaching and implementation of all phases of the engineering design process that begins with identifying needs, setting requirements, concept generation, and preliminary design. Emphasis on detailed engineering analysis and documentation for a small-team, open-ended design project. Materials fee.

(Design units: 3)

Corequisite: ENGRMAE 120
Prerequisite: ENGRMAE 106 and ENGRMAE 145 and ENGRMAE 150

Restriction: Seniors only. Mechanical Engineering Majors only.

ENGRMAE 151B. Mechanical Engineering Design II. 4 Units.
Manufacturing, diagnostics and quality, economics, ethics, and inclusivity. Continuation of the engineering design process with analysis and modeling, physical prototyping, testing, verification, and validation of solutions for the open-ended design project. Teamwork, project presentations, and documentation. Materials fee.

(Design units: 3)

Prerequisite: ENGRMAE 151A

Restriction: Seniors only. Mechanical Engineering Majors have first consideration for enrollment.

ENGRMAE 152. Introduction to Computer-Aided Engineering. 4 Units.
Elements and principles of computer-aided engineering with modern hardware and software are presented with a design focus. Case studies are used to assist in finite-element method techniques. Not offered every year.

(Design units: 2)

Prerequisite: (ENGRMAE 150 or ENGR 150) and ENGRMAE 120

Restriction: Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment. Materials Science and Engr Majors have first consideration for enrollment.

ENGRMAE 153. Advanced BIOMEMS Manufacturing Techniques. 4 Units.
Introduction to BIOMEMS. Advanced biotechnology/biomedicine equipment based on MEMS and NEMS. Fundamentals of MEMS/NEMS sensing techniques and the biological and physics principles involved and the preferred MEMS and NEMS manufacturing techniques.

(Design units: 0)

Restriction: Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment. Biomedical Engineering Majors have first consideration for enrollment.

Concurrent with ENGRMAE 253.

ENGRMAE 155. Composite Materials and Structures. 4 Units.
Micro and macro mechanical properties and failure mechanisms of lamina and laminates. Laminate theory, hygrothermal effects, failure analysis and design. Manufacturing methods, non-destructive evaluation, experimental characterization. Application of numerical modeling for analysis and design.

(Design units: 0)

Prerequisite: ENGR 54 and (ENGRMAE 150 or ENGRCEE 150 or ENGR 150)

Restriction: Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering majors have second consideration for enrollment. Chemical Engineering majors have second consideration for enrollment. Civil Engineering majors have second consideration for enrollment. Materials Science and Engineering majors have second consideration for enrollment.

Concurrent with ENGRMAE 255.

ENGRMAE 156. Mechanical Behavior and Design Principles. 4 Units.
Principles governing structure and mechanical behavior of materials, relationship relating microstructure and mechanical response with application to elasticity, plasticity, yielding, necking, creep, and fracture of materials. Introduction to experimental techniques to characterize the properties of materials. Design parameters.

(Design units: 2)

Prerequisite: ENGR 54

Same as ENGRMSE 155.

Restriction: Mechanical Engineering Majors have first consideration for enrollment. Materials Science and Engr Majors have first consideration for enrollment. Aerospace Engineering majors have second consideration for enrollment.

ENGRMAE 157. Lightweight Structures. 4 Units.
Mass minimization under stiffness, strength, and buckling constraints. Finite Element method and application to trusses. Three-dimensional bending. Thin-wall, composite, and functionally graded beams. Plates and shells, design of laminated and functionally graded plates. Stress analysis of aircraft components.

(Design units: 2)

Prerequisite: ENGR 150 or ENGRCEE 150 or ENGRMAE 150

Restriction: Aerospace Engineering Majors have first consideration for enrollment. Mechanical Engineering majors have second consideration for enrollment. Civil Engineering majors have second consideration for enrollment. Materials Science and Engineering majors have second consideration for enrollment.

ENGRMAE 158. Aircraft Performance. 4 Units.
Flight theory applied to subsonic propeller and jet aircraft. Nature of aerodynamic forces, drag and lift of wing and fuselage, high-lift devices, level-flight performance, climb and glide performance, range, endurance, take-off and landing distances, static and dynamic stability and control.

(Design units: 2)

Prerequisite: ENGRMAE 130A

Restriction: Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment.

ENGRMAE 159. Aircraft Design. 4 Units.
Preliminary design of subsonic general aviation and transport aircraft with emphasis on layout, aerodynamic design, propulsion, and performance. Estimation of total weight and weight distribution, design of wings, fuselage, and tail, selection and location of engines, prediction of overall performance.

(Design units: 4)

Prerequisite: ENGRMAE 112 and ENGRMAE 136 and ENGRMAE 158

Restriction: Aerospace Engineering Majors have first consideration for enrollment. Mechanical Engineering Majors have first consideration for enrollment.

ENGRMAE 163. Aviation Systems and the Environment. 4 Units.
Methods for analyzing aviation systems, flight and engine performance, and operations, and associated modern environmental challenges, including fuel burn, emissions, and noise are introduced. Analysis methods and technological and policy approaches for environmental impact mitigation examined.

Prerequisite: ENGRMAE 80 or ENGRMAE 91 or ENGRMAE 107

Restriction: Mechanical Engineering Majors only. Aerospace Engineering Majors only.

Concurrent with ENGRMAE 263.

ENGRMAE 164. Air Pollution and Control. 4 Units.
Sources, dispersion, and effects of air pollutants. Topics include emission factors, emission inventory, air pollution, meteorology, air chemistry, air quality modeling, impact assessment, source and ambient monitoring, regional control strategies.

(Design units: 2)

Prerequisite: (ENGRMAE 91 or CBE 40B) and ENGRMAE 130A

Restriction: Mechanical Engineering Majors have first consideration for enrollment. Chemical Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRMAE 170. Introduction to Control Systems. 4 Units.
Feedback control systems. Modeling, stability, and systems specifications. Root locus, Nyquist, and Bode methods of analysis and design.

(Design units: 2)

Prerequisite: ENGRMAE 80 or ENGRCEE 80 or ENGR 80

Restriction: Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment. Civil Engineering Majors have first consideration for enrollment. Materials Science and Engr Majors have first consideration for enrollment.

ENGRMAE 171. Digital Control Systems. 4 Units.
Methods for analysis and design of discrete-time control systems. Z-transforms, difference equations, discrete Fourier transforms. Sampling theorem and applications. Z-plane stability, frequency response. Digital controller design. Introduction to digital filters.

(Design units: 2)

Prerequisite: ENGRMAE 170

Restriction: Civil Engineering Majors have first consideration for enrollment. Mechanical Engineering Majors have first consideration for enrollment.

ENGRMAE 172. Design of Computer-Controlled Robots. 4 Units.
Students design a small robotic device and program it to exhibit sentient behaviors. The basic aspects of mechatronic design are covered, including motor and sensor selection, control strategies, and microcomputer programming for the implementation of control paradigms. Materials fee.

(Design units: 3)

Corequisite: ENGRMAE 60
Prerequisite: ENGRMAE 170

Restriction: Mechanical Engineering Majors have first consideration for enrollment.

Concurrent with ENGRMAE 280.

ENGRMAE 175. Dynamics and Control of Aerospace Vehicles. 4 Units.
Equations of motion, linearization, stability derivatives, and longitudinal and lateral modes of motion. Handling qualities, sensors and actuators, and effects of various feedbacks on stability and performance. Stability augmentation. Autopilot design.

(Design units: 3)

Restriction: Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment.

ENGRMAE 181A. Racecar Engineering I. 2 Units.
Project-based learning course focused on the design, fabrication, and testing of vehicles for intercollegiate competition. Focuses on the system and subsystem engineering analysis, design drawings, and parts specification.

Restriction: Upper-division students only. School of Engineering students only.

ENGRMAE 181B. Racecar Engineering II. 2 Units.
Project-based learning course focused on the design, fabrication, and testing of vehicles for intercollegiate competition. Focuses on subsystem prototype fabrication and verification, as well as system integration.

(Design units: 2)

Restriction: Upper-division students only. School of Engineering students only.

ENGRMAE 181C. Racecar Engineering III. 2 Units.
Project-based learning course focused on the design, fabrication, and testing of vehicles for intercollegiate competition. Focuses on system verification, driver training, competition team training, in-field maintenance, and design improvements for the following year.

(Design units: 2)

Restriction: Upper-division students only. School of Engineering students only.

ENGRMAE 182. Introduction to Machine Learning. 4 Units.
Fundamental principles necessary to understand statistical learning methods. Introduction to the R programming language. Mathematical foundation for various machine learning algorithms. Computer implementation.

ENGRMAE 183. Computer-Aided Mechanism Design. 4 Units.
Focuses on design of planar, spherical, and spatial mechanisms using computer algebra and graphics. Topics include exact and approximate analytical design techniques. Students are required to use existing software (or develop new algorithms) to design various mechanisms for new applications.

(Design units: 4)

Prerequisite: MATH 3A or I&C SCI 6N

Restriction: Mechanical Engineering Majors have first consideration for enrollment.

ENGRMAE 184. Fundamentals of Experimental Design. 4 Units.
Review of statistics as applied to experimental research. Fundamentals and principles of statistical experimental design and analysis with emphasis on understanding and use of designed experiments, response surfaces, linear regression modeling, and process optimization.

(Design units: 1)

Restriction: Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment.

Concurrent with ENGRMAE 284.

ENGRMAE 185. Numerical Analysis in Mechanical and Aerospace Engineering. 4 Units.
Solution of mechanical and aerospace engineering equations by means of numerical methods. Errors in numerical analysis. Methods for solving systems of algebraic equations. Interpolation, integration and differentiation. Numerical solutions to differential equations. Introduction to Python and its scientific computing modules.

(Design units: 2)

Corequisite: MATH 2E
Prerequisite: (ENGRMAE 10 or EECS 10 or EECS 12 or BME 60B) and MATH 3D and MATH 2E

Overlaps with MATH 105A.

ENGRMAE 188. Engineering Design in Industry. 4 Units.
Principles of engineering design in the context of an industrial application. Local manufacturing firms define an engineering design project to be completed in 10 weeks. Projects include initial brainstorming to final design, with a formal presentation.

(Design units: 4)

Repeatability: May be taken for credit 3 times.

Restriction: Mechanical Engineering Majors have first consideration for enrollment.

ENGRMAE 189. Senior Project - Special Topics. 1-4 Units.
Group or individual senior project of theoretical or applied nature involving design.

(Design units: 1-4)

Repeatability: May be taken for credit for 12 units as topics vary.

Restriction: Seniors only. Mechanical Engineering Majors only.

ENGRMAE 193. Topics in MAE Design. 1-4 Units.
Provides early-stage design/hands-on experience for upper-division students, and allows them to participate in senior design projects course ENGRMAE 189.

(Design units: 1)

Repeatability: May be taken for credit for 12 units as topics vary.

Restriction: Aerospace Engineering Majors have first consideration for enrollment. Mechanical Engineering Majors have first consideration for enrollment.

ENGRMAE 195. Seminars in Engineering. 1-4 Units.
Seminars by individual faculty in major fields of interest. Materials fee.

(Design units: 1-4)

Repeatability: Unlimited as topics vary.

ENGRMAE 197. Mechanical and Aerospace Engineering Internship. 2-12 Units.
Students majoring in MAE may receive credit for an approved internship, working at a company under the supervision of an industry mentor and a faculty advisor. Enables students to gain valuable experience in a professional setting and enhance their skills.

Grading Option: Pass/no pass only.

Repeatability: May be taken for credit 3 times.

ENGRMAE 198. Group Study. 1-4 Units.
Group study of selected topics in Aerospace and Mechanical Engineering.

(Design units: 1-4)

Repeatability: May be repeated for credit unlimited times.

Restriction: Upper-division students only.

ENGRMAE 199. Individual Study. 1-4 Units.
For undergraduate Engineering majors in supervised but independent reading, research, or design. Students taking individual study for design credit are to submit a written paper to the instructor and to the Undergraduate Student Affairs Office in the School of Engineering.

(Design units: 1-4)

Repeatability: May be taken for credit for 8 units.

ENGRMAE 199P. Individual Study. 1-4 Units.
For undergraduate Engineering majors in supervised but independent reading, research, or design. Students taking individual study for design are to submit a written paper to the instructor and to the Undergraduate Student Affairs Office in the School of Engineering.

(Design units: 1-4)

Grading Option: Pass/no pass only.

Repeatability: May be repeated for credit unlimited times.

ENGRMAE 200A. Engineering Analysis I. 4 Units.
Linear algebra, including vector spaces, matrices, linear systems of equations, least squares, and the eigenvalue problem. Ordinary differential equations, including analytical and numerical solution methods, stability, and phase portraits.

Restriction: Graduate students only.

ENGRMAE 200B. Engineering Analysis II. 4 Units.
Review of ordinary differential equations, including Bessel and Legendre functions. Partial differential equations, including the diffusion equation, Laplace's equation, and the wave equation. Fourier series, Fourier and Laplace transforms and their applications.

Restriction: Graduate students only.

ENGRMAE 202P. Professional Engineering Fundamentals. 4 Units.
The fundamentals of the core topics in mechanical and aerospace engineering are first reviewed and then integrated and applied in the context of engineered systems.

Restriction: Graduate students only. Master of Engineering students only.

ENGRMAE 204P. Personalized Medical Devices. 4 Units.
Introduces students to fundamental aspects of medical devices and discusses therapeutic as well as diagnostic devices. Basic aspects of microfluidics and biology critical to personalized medical systems are studied. Typical FDA approval pathways for medical devices are presented.

Same as EECS 204P.

Restriction: Master of Engineering students only.

Concurrent with BME 204P.

ENGRMAE 205. Perturbation Methods in Engineering. 4 Units.
Asymptotic Expansions of integrals. Regular and singular perturbations. Perturbation methods for ordinary and partial differential equations. Matched asymptotic expansions. Multiple-scale asymptotic expansion schemes. Not offered every year.

Prerequisite: ENGRMAE 200A and ENGRMAE 200B. ENGRMAE 200A with a grade of B- or better. ENGRMAE 200B with a grade of B- or better. Knowledge of linear differential equations.

Restriction: Graduate students only.

ENGRMAE 205P. Model-Based Engineering: Systems and Design. 4 Units.
Engineering design, systems engineering, and product lifecycle management. Model-based approaches and modeling for the digital twin. Software tools and application to the design of a complete product from problem definition to production.

Restriction: Master of Engineering students only.

ENGRMAE 206. Nonlinear Optimization Methods. 4 Units.
Numerical methods for constrained and unconstrained optimization. Necessary and sufficient conditions for optimimality. Conjugate gradient, variable metric algorithms. Gradient projection, penalty functions, and Lagrange methods. Not offered every year.

Prerequisite: ENGRMAE 200A. ENGRMAE 200A with a grade of B- or better

Restriction: Graduate students only.

ENGRMAE 209P. Energy Efficiency in the Built Environment. 4 Units.
Energy and power for the built environment; building energy modeling; heat transfer and losses; heating and cooling cycles; control hardware and software; carbon neutrality, optimization.

Restriction: Master of Engineering students only. Graduate students only.

ENGRMAE 210. Advanced Fundamentals of Combustion. 4 Units.
Premixed, nonpremixed, and heterogenous reactions, with emphasis on kinetics, thermal ignition, turbulent flame propogation, detonations, explosions, flammability limits, diffusion flame, quenching, flame stabilization, and particle and spray combustion. Not offered every year.

Prerequisite: ENGRMAE 224 or ENGRMAE 230B

Restriction: Graduate students only.

ENGRMAE 211P. Energy Storage Systems and Technology. 4 Units.
Basic principles, design, and operation of energy storage systems and technology including lithium ion battery systems for transportation and stationary applications, for flow batteries (e.g., vanadium redox, sodium sulfur), and for reversible fuel cell electrolyzer systems and hydrogen energy storage.

Prerequisite: Required: Undergraduate-level knowledge of applied engineering thermodynamics.

Restriction: Master of Engineering students only. Graduate students only.

ENGRMAE 212. Engineering Electrochemistry: Fundamentals and Applications. 4 Units.
Introduction to engineering electrochemistry fundamentals and applications. Examine thermodynamics and transport principles in typical electrochemical systems. Electrochemical sensors, batteries, fuel cells, and supercapacitors. Manufacturing aspects will also be covered.

Restriction: Graduate students only.

ENGRMAE 212P. Engineering Electrochemistry: Fundamentals and Applications. 4 Units.
Introduction to engineering electrochemistry fundamentals and applications. Examine thermodynamics and transport principles in typical electrochemical systems. Electrochemical sensors, batteries, fuel cells, and supercapacitors. Manufacturing aspects are also covered.

Restriction: Master of Engineering students only. Graduate students only.

ENGRMAE 213. Electric Propulsion. 4 Units.
Space propulsion requirements and maneuvers, stressing those best suited to electric propulsion. An introduction to plasma physics. Electrothermal, electromagnetic and electrostatic accelerators, with emphasis in technologies (ion engines, Hall thrusters and colloidal thrusters) belonging to the latter family.

Restriction: Graduate students only.

Concurrent with ENGRMAE 113.

ENGRMAE 214A. Fuel Cell Fundamentals and Technology. 4 Units.
Introduction to electrochemistry and electrocatalysis; nature of fuel-cell electrodes and electrolytes; charge transfer reactions at interfaces; charge transport and mass transport processes; fuel processing reactions; determination of fuel cell efficiency, fuel flexibility, emissions and other characteristics.

Restriction: Graduate students only.

Concurrent with ENGRMAE 114.

ENGRMAE 214B. Fuel Cell Systems and Degradation. 4 Units.
Fuel cell systems design; impacts of operating conditions; experimental and theoretical analysis methods for fuel cells systems; introduction to degradation mechanisms and mitigation techniques; provides broad insight into fuel-cell science, technology, system design and operation. Offered every other year.

Prerequisite: ENGRMAE 214A. ENGRMAE 214A with a grade of B- or better

Restriction: Graduate students only.

ENGRMAE 214C. PEM Fuel Cells . 4 Units.
In-depth introduction to the fundamental principles of PEM fuel cells, including thermodynamics, kinetics, transport, cold start, manufacturing, and experiment.

Prerequisite: ENGRMAE 214A. ENGRMAE 214A with a grade of B- or better

Restriction: Graduate students only.

ENGRMAE 214P. Fuel Cell Fundamentals and Technology. 4 Units.
Introduction to electrochemistry and electrocatalysis; nature of fuel-cell electrodes and electrolytes; charge transfer reactions at interfaces; charge transport and mass transport processes; fuel processing reactions; determination of fuel cell efficiency, fuel flexibility, emissions, and other characteristics.

Restriction: Master of Engineering students only. Graduate students only.

ENGRMAE 215. Advanced Combustion Technology. 4 Units.
Recap of combustion thermodynamics, equilibrium, chemistry concepts in the context of practical systems. Overview of renewable and non-renewable fuels and their implications for practical devices. Concepts associated with computation and experimental methods. Emphasis on pollutant formation and emissions.

Prerequisite: ENGRMAE 200A and (ENGRMAE 230A or ENGRMAE 270A)

Restriction: Graduate students only.

ENGRMAE 216. Statistical Thermodynamics. 4 Units.
Statistics of independent particles, development of quantum mechanical description of atoms and molecules, application of quantum mechanics, evaluation of thermodynamics properties for solids, liquids, and gases, statistical mechanics of dependent particles (ensembles).

Restriction: Graduate students only.

ENGRMAE 217. Generalized Thermodynamics. 4 Units.
Generalized thermodynamics develops the laws of continuum thermodynamics from a set of plausible and intuitive postulates. The postulates are motivated qualitatively by a statistical description of matter and are justified by a posterior success for the resulting theory.

Restriction: Graduate students only.

ENGRMAE 217P. Generalized Thermodynamics. 4 Units.
Generalized thermodynamics develops the laws of continuum thermodynamics from a set of plausible and intuitive postulates. The postulates are motivated qualitatively by a statistical description of matter and are justified by a posterior success for the resulting theory.

Restriction: Master of Engineering students only. Graduate students only.

ENGRMAE 218. Sustainable Energy Systems. 4 Units.
Basic principles, design and operation of sustainable energy systems including wind, solar photo-voltaic and thermal, hydroelectric, geothermal, oceanic, biomass combustion, advanced coal and next generation nuclear. Includes power generation, storage, and transmission for stationary power generation.

Restriction: Graduate students only.

Concurrent with ENGRMAE 118.

ENGRMAE 218P. Sustainable Energy Systems. 4 Units.
Basic principles, design, and operation of sustainable energy systems including wind, solar photo-voltaic and thermal, hydroelectric, geothermal, oceanic, biomass combustion, advanced coal, and next generation nuclear. Includes power generation, storage, and transmission for stationary power generation.

Restriction: Master of Engineering students only. Graduate students only.

ENGRMAE 219P. Solar and Renewable Energy Systems. 4 Units.
Basic principles, design, and operation of solar and other renewable energy systems including solar photo-voltaic, solar thermal, wind, and PEM fuel cell. Includes power generation and storage, and renewable fuels for transportation and stationary power generation.

Prerequisite: Required: Knowledge of applied engineering thermodynamics.

Restriction: Master of Engineering students only. Graduate students only.

ENGRMAE 220. Conduction Heat Transfer. 4 Units.
Steady state and transient conduction heat transfer in one- and multi-dimensional geometries. Analytical methods, exact and approximate. Numerical techniques are also included.

Restriction: Graduate students only.

ENGRMAE 221. Convective Heat and Mass Transfer. 4 Units.
Fundamental convective heat transfer for various cases, including flow conditions, flow phases, and boundary conditions. Analysis of heat convection by exact, approximate solutions, and similarity solutions. Boundary layer theory and equations.

Prerequisite: ENGRMAE 230B. ENGRMAE 230B with a grade of B- or better

Restriction: Graduate students only.

ENGRMAE 223A. Numerical Methods in Heat, Mass, and Momentum Transport (Laminar Flows) I. 4 Units.
Introduction to the discretization of various types of partial differential equations (parabolic, elliptic, hyperbolic). Finite-volume discretization for one- and two-dimensional flows. Use of a two-dimensional elliptic procedure to predict sample laminar flows.

Prerequisite or corequisite: ENGRMAE 230A. ENGRMAE 230A with a grade of B- or better

Restriction: Graduate students only.

ENGRMAE 224. Advanced Transport Phenomena. 4 Units.
Fundamentals of transport phenomena. Covers the subjects of conservation equations, dimensionless numbers, fundamentals of diffusion, perturbation methods, ion transport, two-phase transport, and interfacial phenomena.

Restriction: Graduate students only.

ENGRMAE 227. Thermal Resistance Analysis in Microdevices and Nanomaterials. 4 Units.
Heat transfer and thermal resistance analysis relevant for microdevices and nanomaterials. Overview of recent progress in nanotechnology and materials science. Thermal modeling strategies for novel electronic devices and energy conversion systems.

Restriction: Graduate students only.

ENGRMAE 228. Nanoscale Phase Change Transport Physics. 4 Units.
Discusses a wide range of phase change processes (i.e., evaporation, boiling, condensation, and freezing) through the use of novel thermal metamaterials with the aim of enhancing phase change performances.

Prerequisite: Undergraduate-level heat transfer is recommended.

Restriction: Graduate students only.

ENGRMAE 230A. Inviscid Incompressible Fluid Mechanics I. 4 Units.
Equations of motion. Vector notation. Flow kinematics. Potential flow and complex potential. Vorticity and circulation. Bernoulli's theorem. Crocco's theorem. Conformal, Joukowski, and Schwarz-Christoffel transformations.

Restriction: Graduate students only.

ENGRMAE 230B. Viscous Incompressible Fluid Mechanics II. 4 Units.
Review of mass, momentum, energy equations. Stress tensor, constitutive relations. Laminar flows. Stokes and Oseen flows. Self-similarity. Boundary layer theory: thin-layer approximation, Falkner-Skan, Blasius solutions, integral methods. Jet, wake, cavity flows. Introduction to turbulence: instability, Reynolds averaging, mixing length.

Restriction: Graduate students only.

ENGRMAE 230C. Compressible Fluid Dynamics. 4 Units.
One-dimensional unsteady flow; Riemann invariants, acoustics, shock tube. Two-dimensional flow: shock polars, linear theory, similarity rules, method of characteristics. Three dimensional flow: slender-body theory. Effects of viscosity and conductivity: laminar boundary layer, Crocco-Busemann relations.

Prerequisite: ENGRMAE 230A or ENGRMAE 230B. ENGRMAE 230A with a grade of B- or better. ENGRMAE 230B with a grade of B- or better

Restriction: Graduate students only.

ENGRMAE 230D. Theoretical Foundations of Fluid Mechanics. 4 Units.
Well-posed problems and boundary, initial, and interface conditions; strong and weak solutions. Similarity, perturbation theory and limit behavior, bifurcations. Dispersive and nondispersive wave propagation, acoustics, ship waves, internal gravity waves, water waves. Vortices: mutual interactions and stability. Jets, wakes, cavities.

Prerequisite: ENGRMAE 230A and ENGRMAE 230B. ENGRMAE 230A with a grade of B- or better. ENGRMAE 230B with a grade of B- or better

Restriction: Graduate students only.

ENGRMAE 230P. Introduction to Machine Learning. 4 Units.
Introduces fundamental concepts in programming and machine learning. The goal is to provide an accessible introduction to the field of machine learning and related techniques for students with a wide variety of engineering degrees.

Same as BME 230P, ENGRCEE 230P, EECS 230P, ENGR 230P.

Restriction: Master of Engineering students only.

ENGRMAE 231. Fundamentals of Turbulence. 4 Units.
Phenomenon of turbulence. Reynolds equations. Dynamics of turbulence. Free turbulent shear flows. Wall-bounded turbulent shear flows. Turbulent transport of scalar quantities. Spectral dynamics. Mathematical models of turbulence.

Prerequisite: ENGRMAE 230A and ENGRMAE 230B. ENGRMAE 230A with a grade of B- or better. ENGRMAE 230B with a grade of B- or better

Restriction: Graduate students only.

ENGRMAE 231P. Robotics and Controls. 4 Units.
Covers basic aspects of robotic and mechatronic design, including motor and sensor selection, control strategies, finite state machines, and implementation of advanced feedback control laws.

Same as ENGR 231P.

Restriction: Master of Engineering students only.

ENGRMAE 233. Turbulent Free Shear Flows. 4 Units.
Practical and theoretical aspects of turbulent free shear flows. Instability, global scaling laws, mixing, and noise generation in incompressible and compressible shear layers, jets, and wakes. Kelvin-Helmholtz instability, near- and far-field growth rates, effect of compressibility, aeroacoustics of jets.

Prerequisite: ENGRMAE 200B and ENGRMAE 230A and ENGRMAE 230B. ENGRMAE 200B with a grade of B- or better. ENGRMAE 230A with a grade of B- or better. ENGRMAE 230B with a grade of B- or better

Restriction: Graduate students only.

ENGRMAE 235P. Engineering Design and Simulation: Tools and Process. 4 Units.
Practical techniques and use of industry tools that improve the engineering design process by simulating the performance of design options prior to the costly steps of prototyping and manufacturing are covered. Applicable to a wide variety of engineering disciplines.

Same as ENGR 235P.

Restriction: Graduate students only. Master of Engineering students only.

ENGRMAE 236. Nonequilibrium Gas Dynamics. 4 Units.
Molecular description of fluid flow. Boltzmann equation. Chapman-Enskog expansion for flows with translational nonequilibrium. Shock structure. Inviscid flows with chemical and vibrational nonequilibrium. Not offered every year.

Prerequisite: ENGRMAE 230C. ENGRMAE 230C with a grade of B- or better

Restriction: Graduate students only.

ENGRMAE 239. Dynamics of Unsteady Flows. 4 Units.
Unsteady potential flow modeling (Kelvin's circulation theorem, unsteady Bernoulli's equation). Theodorsen's frequency response, Wagner's step response, and the Kussner sharp-edged gust. State Space approximations for Unsteady Loads. Vortex Lattice. Flutter.

Prerequisite: ENGRMAE 230A is recommended.

Restriction: Graduate students only.

ENGRMAE 240. Inertial Navigation. 4 Units.
Provides a basic understanding of 1) theory, operation, and performance characteristics of a strapdown inertial navigation system (INS), (2) distinction between strap down and gimbaled INS, (3) Kalman filtering theory and its application to strap down INS aiding.

Restriction: Graduate students only.

ENGRMAE 241. Dynamics. 4 Units.
Kinematics and dynamics of three-dimensional motions. Lagrange's equations, Newton-Euler equations. Applications include robot systems and spinning satellites.

Restriction: Graduate students only.

ENGRMAE 242. Robotics. 4 Units.
Spatial rigid-body transformations. Forward and inverse kinematics. Jacobian of serial and parallel chains. Screw coordinates and transformations. Rate and static analyses using screw theory. Singularity analysis. Trajectory generation. Not offered every year.

Restriction: Graduate students only.

ENGRMAE 245. Spatial Mechanism Design. 4 Units.
Fundamental kinematic theory required for planar, spherical, and spatial mechanism design. The focus is on algebraic methods for the exact solution of constraint equations. Not offered every year.

Restriction: Graduate students only.

ENGRMAE 247. Micro-System Design. 4 Units.
Covers the fundamentals of the many disciplines needed for design of Micro-Electro-Mechanical Systems (MEMS): microfabrication technology, structural mechanics on micro-scale, electrostatics, circuit interface, control, computer-aided design, and system integration.

Same as EECS 278.

Restriction: Graduate students only.

ENGRMAE 247P. Micro-System Design. 4 Units.
Covers the fundamentals of the many disciplines needed for design of Micro-Electro-Mechanical Systems (MEMS): microfabrication technology, structural mechanics on micro-scale, electrostatics, circuit interface, control, computer-aided design, and system integration.

Restriction: Master of Engineering students only. Graduate students only.

ENGRMAE 249. Micro-Sensors and Actuators. 4 Units.
Introduction to the technology of Micro-Electro-Mechanical Systems (MEMS). Fundamental principles and applications of important microsensors, actuation principles on microscale. Introduction to the elements of signal processing; processing of materials for micro sensor/actuator fabrication; smart sensors and microsensor/microactuator array devices.

Same as EECS 279.

Restriction: Graduate students only.

ENGRMAE 249P. Micro-Sensors and Actuators. 4 Units.
Introduction to the technology of Micro-Electro-Mechanical Systems (MEMS). Fundamental principles and applications of important microsensors, actuation principles on microscale. Introduction to the elements of signal processing; processing of materials for micro sensor/actuator fabrication; smart sensors and microsensor/microactuator array devices.

Restriction: Master of Engineering students only. Graduate students only.

ENGRMAE 250. Biorobotics. 4 Units.
Sensors, actuators, and neural circuits for biological movement control from an engineering perspective. Current approaches to robotic and mechatronic devices that support and enhance human movement in health and following neurologic injuries like stroke and spinal cord injury.

Restriction: Graduate students only.

ENGRMAE 251. Micro/Nano Robotics. 4 Units.
Covers the emerging field of robotics at small scale (micro/nano robotics). Understanding different physical phenomena at small scales, the differences between nano and micro robotics, common fabrication, and different mechanisms of locomotion and environmental interaction.

Restriction: School of Engineering students have first consideration for enrollment. Graduate students only.

Concurrent with MAE 173.

ENGRMAE 252. Fundamentals of Microfabrication. 4 Units.
Introduces Engineering and Science students to the science of miniaturization. Different options to make very small machines (micro and nano size) are reviewed, materials choices are discussed, scaling laws are analyzed, and many practical applications are listed.

Restriction: Graduate students only.

ENGRMAE 252P. Fundamentals of Microfabrication. 4 Units.
Introduces engineering and science students to the science of miniaturization. Different options to make very small machines (micro and nano size) are reviewed, materials choices are discussed, scaling laws are analyzed, and many practical applications are listed.

Same as ENGR 252P.

Restriction: Graduate students only. Master of Engineering students only.

ENGRMAE 253. Advanced BIOMEMS Manufacturing Techniques. 4 Units.
Introduction to BIOMEMS. Advanced biotechnology/biomedicine equipment based on MEMS and NEMS. Fundamentals of MEMS/NEMS sensing techniques and the biological and physics principles involved and the preferred MEMS and NEMS manufacturing techniques.

Restriction: Graduate students only.

Concurrent with ENGRMAE 153.

ENGRMAE 254. Mechanics of Solids and Structures. 4 Units.
Finite deformation kinematics; stress and strain measures; invariance in solid mechanics; objective rates; constitutive theory of elastic and inelastic solids; rate formulations; computational approaches; theories of plates and shells; applications to aerospace vehicles.

Restriction: Graduate students only.

ENGRMAE 254P. Mechanics of Solids and Structures. 4 Units.
Finite deformation kinematics; stress and strain measures; invariance in solid mechanics; objective rates; constitutive theory of elastic and inelastic solids; rate formulations; computational approaches; theories of plates and shells; applications to aerospace vehicles.

Restriction: Master of Engineering students only. Graduate students only.

ENGRMAE 255. Composite Materials and Structures. 4 Units.
Motivation for composite materials. Different classifications according to the nature of the matrix (PMC, MMC, CMC) and the reinforcement topology (fibers, whiskers, particulates). Mechanical properties. Failure mechanisms. Designing with composite materials. Advantages and limitations of homogenization techniques for numerical modeling.

Restriction: Graduate students only.

Concurrent with ENGRMAE 155.

ENGRMAE 257. Materials Failure and Fracture. 4 Units.
Introduces materials failure and fracture behaviors under mechanical, thermal, and environmental conditions. It aims to provide a solid foundation and basic understanding of classic fatigue and fracture problems, and their underlying physical mechanisms.

Prerequisite: Recommended: A foundational knowledge of mechanical behavior and mechanics of materials, or completion of ENGRMAE 156.

Restriction: Graduate students only.

Concurrent with MAE 154.

ENGRMAE 257P. Fabrication and Characterization of Nanomaterials . 4 Units.
Introduction to nanoscale materials and experimental and computational techniques. Topics materials synthesis techniques, thin film deposition, nanoparticle and nanowire growth, characterization with electrons and X-rays, forces and surface interactions at the nanoscale, structure-property scaling laws, and atomistic/multiscale computer modeling.

Restriction: Master of Engineering students only. Graduate students only.

ENGRMAE 258. Mechanical Behavior of Solids - Continuum Theories. 4 Units.
Presents a continuum, macroscopic view of deformation and failure of solids. Covers elasticity, plasticity, visco-elasticity, visco-plasticity, fracture and fatigue. Topics include discussions of physical behavior, mathematical formalism and measurement techniques.

Prerequisite: ENGRMAE 254. ENGRMAE 254 with a grade of B- or better

Restriction: Graduate students only.

ENGRMAE 259. Mechanical Behavior of Solids - Atomistic Theories. 4 Units.
Presents atomistic mechanisms that control mechanical behavior of materials. Covers plasticity, dislocation theory, strengthening mechanisms, high-temperature diffusion and gain boundary sliding, shear localization, void formation, ductile rupture, brittle fracture and fatigue.

Restriction: Graduate students only.

ENGRMAE 259P. Mechanical Behavior of Solids - Atomistic Theories. 4 Units.
Presents atomistic mechanisms that control mechanical behavior of materials. Covers plasticity, dislocation theory, strengthening mechanisms, high-temperature diffusion and gain boundary sliding, shear localization, void formation, ductile rupture, brittle fracture, and fatigue.

Restriction: Master of Engineering students only. Graduate students only.

ENGRMAE 260. Current Issues Related to Air Quality, Climate, and Energy. 4 Units.
Current issues related to the atmosphere, climate, and air quality in the context of energy conversion and sustainability. Topics include transportation systems; building design; impacts on humans and ecosystems; modeling and meteorology; economics; and application to public policies.

Prerequisite: ENGRMAE 261 or CHEM 245 or EARTHSS 240. ENGRMAE 261 with a grade of B- or better. CHEM 245 with a grade of B- or better. EARTHSS 240 with a grade of B- or better

Same as CHEM 241.

Restriction: Graduate students only.

ENGRMAE 263. Aviation Systems and the Environment. 4 Units.
Methods for analyzing aviation systems, flight and engine performance, operations, and associated modern environmental challenges, including fuel burn, emissions, and noise are introduced. Analysis methods and technological and policy approaches for environmental impact mitigation examined.

Restriction: Graduate students only.

Concurrent with ENGRMAE 163.

ENGRMAE 270A. Linear Systems I. 4 Units.
Input-output and state-space representations of continuous-time linear systems. State transition matrices, Controllability and observability. Irreducible realizations. State feedback and observer design.

Restriction: Graduate students only.

ENGRMAE 270B. Linear Systems II. 4 Units.
Advanced topics in linear systems: bases, linear operator representations, and Jordan forms. Review of dynamical systems, and stability. Time-varying systems, discrete-time representations, and multi-input/multi-output systems. Introduction to continuous and discrete time linear regulator (LQR) problems. Not offered every year.

Prerequisite: ENGRMAE 270A. ENGRMAE 270A with a grade of B- or better

Restriction: Graduate students only.

ENGRMAE 271. Network Control. 4 Units.
Provides foundations on graph-theoretic, probabilistic and analytic techniques that have proven instrumental for studying networked dynamical systems. Applications are presented in diverse areas of science and engineering that include the coordination of vehicles and distribution of energy and resources.

Restriction: Graduate students only.

ENGRMAE 273. Stochastic Control. 4 Units.
Introduction to the tools stochastic differential equations and stochastic control. Focus on optimal control of dynamical systems in the presence of stochastic noise. Basic concepts are also central in various branches of theoretical physics and mathematical finance; examples are discussed.

Restriction: Graduate students only.

ENGRMAE 274. Optimal Control. 4 Units.
Principles and methods of optimal control. Topics include objectives and issues in controlling nonlinear systems; linear variational and adjoint equations; optimality conditions via variational calculus, maximum principle, and dynamic programming; solution methods; applications to control robots and aerospace vehicles.

Prerequisite: ENGRMAE 200A and ENGRMAE 270A. ENGRMAE 200A with a grade of B- or better. ENGRMAE 270A with a grade of B- or better

Restriction: Graduate students only.

ENGRMAE 275. Nonlinear Feedback Systems. 4 Units.
Advanced tools for feedback control system analysis and synthesis. Norms, operators, Lp spaces, contraction mapping theorem, Lyapunov techniques along with their extensions. Circle criterion positivity and passivity. Applications to nonlinear control methods, such as sliding mode or adaptive techniques.

Prerequisite: ENGRMAE 270B. ENGRMAE 270B with a grade of B- or better

Restriction: Graduate students only.

ENGRMAE 276. Geometric Nonlinear Control. 4 Units.
Using the mathematics of differential geometry, a number of the concepts and results of linear systems theory have been extended to nonlinear systems. Describes these extensions and illustrate their use in nonlinear system analysis and design. Not offered every year.

Prerequisite: ENGRMAE 200A and ENGRMAE 270A. ENGRMAE 200A with a grade of B- or better. ENGRMAE 270A with a grade of B- or better

Restriction: Graduate students only.

ENGRMAE 277. Learning Control Systems. 4 Units.
Supervised learning for classification and regression: perceptrons, support vector machines, feed-forward neural networks, Gaussian processes. Generalization and model selection: cross-validation, regularization, and Bayesian methods. Unsupervised learning: clustering and dimensionality reduction. Learning control systems. Introduction to reinforcement learning.

Restriction: Graduate students only.

ENGRMAE 278. Parameter and State Estimation. 4 Units.
Bayesian and frequentist approaches to parameter and state estimation. Properties of estimators. Linear Gaussian systems and the Kalman Filter. Nonlinear state estimation, extended and unscented Kalman Filters. Introduction to Monte Carlo methods and particle filtering. Application to tracking and navigation.

Prerequisite: ENGRMAE 200A and ENGRMAE 270A. ENGRMAE 200A with a grade of B- or better. ENGRMAE 270A with a grade of B- or better

Restriction: Graduate students only.

ENGRMAE 279. Special Topics in Mechanical Systems. 4 Units.
Selected topics of current interest in mechanical systems. Topics include robotics, kinematics, control, dynamics, and geometric modeling.

Prerequisite: ENGRMAE 270A and ENGRMAE 241. ENGRMAE 270A with a grade of B- or better. ENGRMAE 241 with a grade of B- or better

Repeatability: Unlimited as topics vary.

Restriction: Graduate students only.

ENGRMAE 280. Design of Computer-Controlled Robots. 4 Units.
The basic aspects of mechatronic design are covered, including motor and sensor selection, control strategies, finite state machines, inertial measurement units, and implementation of advanced feedback control laws. Students work in groups to create their own mechatronic device. Materials fee.

Restriction: Graduate students only.

Concurrent with ENGRMAE 172.

ENGRMAE 284. Fundamentals of Experimental Design. 4 Units.
Fundamentals and principles of statistical experimental design and analysis. Emphasis addresses understanding and use of designed experiments, response surfaces, linear regression modeling, process optimization, and development of links between empirical and theoretical models.

Restriction: Graduate students only.

Concurrent with ENGRMAE 184.

ENGRMAE 285. Engineering Design Under Uncertainty. 4 Units.
Introduces students to statistical and ML methods used in engineering design under uncertainty. Students learn how to probabilistically formulate a design problem, translate the formulations into a computer, and systematically find the solution.

Restriction: Graduate students only.

ENGRMAE 286. Design for Human Movement. 4 Units.
Introduces techniques for analysis and modeling of human locomotion, with a focus on lower-limb rehabilitating and robotic assistive devices. Discusses background and current research, with assignments covering independent reading, computer simulations, and a final project.

Restriction: Master of Engineering students only. Graduate students only.

ENGRMAE 291. Research Communication in Engineering. 4 Units.
Guides students along research communication milestones by completion of a conference/journal publication, research proposal, MS thesis, or other significant publication. Peer review, response to reviewers, and a presentation are used to build skill and confidence.

Restriction: School of Engineering students have first consideration for enrollment. Graduate students only.

ENGRMAE 294. Master of Science Thesis Project. 4 Units.
Tutorial in which masters-level students taking the comprehensive examination option undertake a masters-level research project.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

ENGRMAE 295. Special Topics in Mechanical and Aerospace Engineering. 1-4 Units.
Special topics by individual faculty in major fields of interest.

Repeatability: Unlimited as topics vary.

ENGRMAE 295P. Special Topics in Mechanical and Aerospace Engineering. 4 Units.
Studies in selected areas of Mechanical and Aerospace Engineering. Topics addressed vary each quarter.

Repeatability: Unlimited as topics vary.

Restriction: Graduate students only. Master of Engineering students only.

ENGRMAE 296. Master of Science Thesis Research. 1-16 Units.
Individual research or investigation conducted in the pursuit of preparing and completing the thesis required for the M.S. in Engineering.

Repeatability: May be repeated for credit unlimited times.

ENGRMAE 297. Doctor of Philosophy Dissertation Research. 1-16 Units.
Individual research or investigation conducted in the pursuit of preparing and completing the dissertation required for the Ph.D. in Engineering.

Repeatability: May be repeated for credit unlimited times.

ENGRMAE 298. Seminars in Mechanical and Aerospace Engineering. 1 Unit.
Presentation of advanced topics and reports of current research efforts in mechanical engineering. Required of all graduate students in mechanical engineering.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

ENGRMAE 299. Individual Research. 1-16 Units.
Individual research or investigation under the direction of an individual faculty member.

Repeatability: May be repeated for credit unlimited times.

Restriction: Consent of instructor to enroll