Mechanical Engineering Course Descriptions

ME 200a. Fluid Mechanics (3-0-3) *Prerequisites: Undergraduate fluid mechanics, AMCS 201 and AMCS 202 or equivalent (may be taken concurrently).* Fundamentals of fluid mechanics. Microscopic and macroscopic properties of liquids and gases; the continuum hypothesis; review of thermodynamics; general equations of motion; kinematics; stresses; constitutive relations; vorticity, circulation; Bernoulli's equation; potential flow; thin-airfoil theory; surface gravity waves; buoyancy-driven flows; rotating flows; viscous creeping flow; viscous boundary layers; introduction to stability and turbulence; quasi one-dimensional compressible flow; shock waves; unsteady compressible flow; acoustics.

ME 200b. Fluid Mechanics (3-0-3) Continuation of ME 200a.

ME 211a. Mechanics of Structures and Solids (3-0-3)
Prerequisite: Undergraduate strength of materials and stress analysis, AMCS 201 and AMCS 202 or equivalent (may be taken concurrently). Static and dynamic stress analysis. Two-and three-dimensional theory of stressed elastic solids. Analysis of structural elements with applications in a variety of fields. Variational theorems and approximate solutions, introduction to finite elements. A variety of special topics will be discussed in the second term such as, but not limited to, elastic stability, wave propagation, and introductory fracture mechanics.

ME 211b. Mechanics of Structures and Solids (3-0-3) Continuation of ME 211a.

ME 212a. Continuum Mechanics (3-0-3) Elements of Cartesian tensors. Configurations and motions of a body. Kinematics—study of deformations, rotations and stretches, polar decomposition. Lagrangian and Eulerian strain velocity and spin tensor fields. Irrotational motions, rigid motions. Kinetics—balance laws. Linear and angular momentum, force, traction stress. Cauchy's theorem, properties of Cauchy's stress. Equations of motion, equilibrium equations. Power theorem, nominal (Piola-Kirchoff) stress. Thermodynamics of bodies. Internal energy, heat flux, heat supply. Laws of thermodynamics, notions of entropy, absolute temperature. Entropy inequality (Clausius-Duhem). Examples of special classes of constitutive laws for materials without memory. Objective rates, corotational, convected rates. Principles of materials frame indifference. Examples: the isotropic Navier-Stokes fluid, the isotropic thermoelastic solid. Basics of finite differences, finite elements, and boundary integral methods, and their applications to continuum mechanics problems illustrating a variety of classes of constitutive laws.

ME 212b. Continuum Mechanics (3-0-3) Continuation of ME 212a.

ME 214. Experimental Methods (2-2-4) *Prerequisites: AMCS 201 and AMCS 202 or equivalent (may be taken concurrently), ME 200a and b or ME 211a and b or equivalent (may be taken concurrently).* Lectures on experiment design and implementation. Measurement methods, transducer fundamentals, instrumentation, optical systems, signal processing, noise theory, analog and digital electronic fundamentals, with data acquisition and processing systems.

ME 221a. Control Theory (2-2-4)
Prerequisites: Undergraduate Calculus of One and Several Variables, Linear Algebra, Differential Equations, Probability and Statistics or equivalents; AMCS 201 and AMCS 202 or

equivalent may be taken concurrently. An introduction to analysis and design of feedback control systems, including classical control theory in the time and frequency domain. Modeling of physical, biological, and information systems using linear and nonlinear differential equations. linear vs. nonlinear models, and local vs. global behavior, Input/output response, modeling and model reduction, Stability and performance of interconnected systems, including use of block diagrams, Bode plots, the Nyquist criterion, and Lyapunov functions. Robustness and uncertainty management in feedback systems through stochastic and deterministic Basic principles of feedback and its use as a tool for altering the dynamics of systems and managing uncertainty methods. Introductory random processes, Kalman filtering, and norms of signals and systems.

ME 221b. Control Theory (2-2-4) Continuation of ME 221a.

ME 222a. Mechatronics and Intelligent Systems (2-2-4) *Prerequisite: ME 23a and b.* Principles, modeling, interfacing and signal conditioning of motion sensors and actuators; acquire and analyze data and interact with operators. Basic electronic devices, embedded microprocessor systems and control, power transfer components and mechanism design. hardware-inthe-loop simulation and rapid prototyping of real-time closed-loop computer control of electromechanical systems; modeling, analysis and identification of discrete-time or samples-data dynamic systems; commonly used digital controller design methods; introduction to nonlinear effects and their compensation in mechatronic systems; robotic manipulation and sensing; obstacle avoidance and motion planning algorithms; mobile robots, use of vision in navigation systems. The lectures will be divided between a review of the appropriate analytical techniques and a survey of the current research literature. Course work will focus on an independent research project chosen by the student.

ME 222b. Mechatronics and Intelligent Systems (2-2-4) Continuation of ME 222a.

ME 224. System Identification and Estimation (3-0-3) *Prerequisite: ME 221a and b (ME 221 b can be taken concurrently*). Deterministic state estimation, recursive observers, estimation for uncertain process dynamics; SISO and MIMO least-squares parameter estimation, linear system subspace identification. Random variables and random processes: linear systems forced by random processes, power-spectral density. Bayesian filtering including Kalman filter. Jump-Markov estimation and fault diagnosis.
Nonlinear estimation, particle filters, unscented Kalman filter. Introduction to estimation for hybrid systems.

ME 226. Fuzzy Sets in Engineering (3-0-3) *Prerequisites: AMCS 201 and AMCS 202, working knowledge of the C computer programming language.* The relatively new mathematics of fuzzy sets has recently been used to represent and manipulate vague and imprecise information in engineering. This course will present the basics of fuzzy sets and fuzzy mathematics and explore applications in the areas of data representation; function representation; filters and triggers; engineering design and optimization, including (fuzzy) set-based concurrent engineering.

ME 231. Introductory Concepts for Dynamical Systems (3-0-3) *Prerequisites: Undergraduate Calculus of One and Several Variables, Linear Algebra, Differential Equations, Probability and Statistics or equivalents.* Nonlinear system dynamics. Initial-and boundary-value problems, ordinary and partial differential equations. Hybrid system models; modeling/simulation environments such as Dymola, Modelica, Ptolemy, Simulink and StateFlow. Networked system models. System analysis: elementary discretization methods, initial value, ordinary differential equation theory; linearization; convolution, state-space and frequency domain representations; stability, input/output operator norms, least squares and inverse problems; model reduction.

ME 232a. Advanced Dynamics (3-0-3) *Prerequisite: AMCS 201 and AMCS 202 or equivalents (may be taken concurrently).* Basics in topics in dynamics in Euclidean space, including equilibria, stability, Lyapunov functions, periodic solutions, Poincaré-Bendixon theory, Poincaré maps. Attractors and structural stability. The Euler-Lagrange equations, mechanical systems, small oscillations, dissipation, energy as a Lyapunov function, conservation laws. Introduction to imple bifurcations and eigenvalue crossing conditions. Discussion of bifurcations in applications, invariant manifolds, the method of averaging, Melnikov's method, and the Smale horseshoe.

ME 232b. Advanced Dynamics (3-0-3) Continuation of ME 232a.

ME 234a. Introduction to Kinematics and Robotics (3-0-3) *Prerequisites: AMCS 201 and AMCS 202 or equivalent (may be taken concurrently).*Introduction to the study of planar, rotational, and spatial motions with applications to robotics, computers, computer graphics, and mechanics. Topics in kinematic analysis will include screw theory, rotational representations, matrix groups, and Lie algebras. Applications include robot kinematics, mobility in mechanisms, and kinematics of open and closed chain mechanisms. Additional topics in robotics include path planning for robot manipulators, dynamics and control, and assembly. Course work will include laboratory demonstrations using simple robot manipulators.

ME 234b. Introduction to Kinematics and Robotics (3-0-3) Continuation of ME 234a.

ME 241. Thermodynamics (3-0-3) *Prerequisites: Undergraduate thermodynamics, AMCS 201 and AMCS 202 (may be taken concurrently) or equivalent.* Fundamentals of classical and statistical thermodynamics. Basic postulates, thermodynamic potentials, chemical and phase equilibrium, phase transitions, and thermodynamic properties of solids, liquids, and gases.

ME 242. Heat and Mass Transfer (3-0-3) *Prerequisites: Undergraduate thermodynamics, AMCS 201 and AMCS 202 (may be taken concurrently).* Transport properties, conservation equations, conduction heat transfer, convective heat and mass transport in laminar and turbulent flows, phase change processes, thermal radiation.

ME 244. Combustion (3-0-3) *Prerequisite: ME 241 or equivalent.* Basic principles including chemical equilibrium, Arrhenius law, and Rankine-Hugoniot relations will be first discussed. Multi-component conservation equations with chemical reaction will be introduced. Various characteristics of premixed and diffusion flames will be studied which covers flame structure, flame stability, flame stabilization, flammability limit, quenching distance, and thermal explosion. Combustion phenomena in gas turbines, gasoline engines, diesel engines and power plants will be discussed. A matched asymptotic expansion technique will be introduced and applied in analyzing flame structures.

ME 246. Laser Diagnostics for Thermal Engineering (3-0-3) *Prerequisite: ME 241 or equivalent.* Non-intrusive measurement techniques using lasers in thermo-fluid fields to probe temperature, species concentration and velocity. Principles of lasers. Geometrical and physical optics. Quantum mechanical nature of diatomic molecules, including rotational vibrational, and electronic transition frequencies. Mie and Rayleigh scattering. Raman scattering. Laser-induced fluorescence (LIF) technique for minor species. Coherent anti-Stokes-Raman spectroscopy (CARS) for temperature and major species. Laser induced incandescence (LII) for soot volume fraction. Velocity measurement techniques including laser Doppler velocimetry (LDV) and particle image velocimetry (PIV).

ME 250. Energy (3-0-3) Review of first and second laws of thermodynamics. Principles of energy conversion: vapor power cycles, combustion, combined cycle, and fuel cells. Modeling and forecasting. Heating, transportation, and electricity demand. Fossil-fuel supplies: oil, natural gas, coal, oil sands, and oil shale. Alternative energy sources: hydroelectric, nuclear fission and fusion, wind, biomass, geothermal, biofuels, waves, ocean thermal, solar photovoltaic, and solar thermal. Transportation systems: internal combustion engines, gas turbines, and electric vehicles. Energy systems: pipelines, rail and water transport, shipping, carbon capture and sequestration, transmission lines and electricity distribution networks. Energy policy: efficiency regulations, biofuels vs food, water impacts, air pollution, and climate.

ME 252. Sustainable Energy Engineering (3-0-3) *Prerequisites: Undergraduate Thermodynamics, AMCS 201 and AMCS 202 (may be taken concurrently), ME 250.*
An in-depth examination of engineering systems to convert, store, transport, and use energy, with emphasis on technologies that reduce or eliminate dependence on fossil fuels and/or emission of greenhouse gases. Topics include thermodynamics of energy conversion, energy resources, stationary power generation (vapor power cycles, combined cycles, solar thermal systems, nuclear fission and fusion, solar photovoltaics, fuel cells, wind, geothermal), carbon sequestration, alternative fuels (hydrogen, biofuels), and transportation systems (internal combustion engines, gas turbines, fuel cell and electric vehicles). The course will emphasize using quantitative methods to assess and compare different technologies.

ME 254. Theory and Methods in Product Design (2-2-4) *Prerequisite: graduate standing in mechanical engineering or consent of instructor.* The engineering design process and conceptual design of products. This course provides an experience in preliminary project planning of complex and realistic mechanical engineering systems. Design concepts and techniques are introduced, and the student's design ability is developed in a design or feasibility study chosen to emphasize innovation and ingenuity and provide wide coverage of engineering topics. Design optimization and social, economic and political implications are included. Emphasis on hands-on creative components, teamwork and effective communication. Special emphasis on management of innovation processes for sustainable products, from product definition to sustainable manufacturing and financial models. The patent process. Both individual and group oral presentations are made, and participation in conferences is required.

ME 256. Computer-Aided Engineering Design (1-2-3) *Prerequisites: AMCS 201 and AMCS 202, working knowledge of the C computer programming language.* Methods and algorithms for design of engineering systems using computer techniques. Topics include the design process; interactive computer graphics; curves and surfaces (including cubic and B-splines); solid modeling (including constructive solid geometry and boundary models); kinematic and dynamic mechanism simulation; single and multivariable optimization; optimal design, and symbolic manipulation. Assessment of CAD as an aid to the design process.

ME 290. Mechanical Engineering Seminar (1 credit) All candidates for the M.S. degree in mechanical engineering are required to attend one graduate seminar in any division each week of the Fall and Spring Semesters and 3 graduate seminars each week of the Winter Enrichment Program. Graded pass/fail.

ME 299. Individual Study or Research (variable credit) *Prerequisites: M.S. status and consent of instructor.* Course may be repeated for credit. Maximum number of units is 3 per semester (6 in the Summer). Must be taken on a pass/fail basis. Individual investigation on topics of relevance to mechanical engineering.

ME 300. Advanced Fluid Mechanics (3-0-3) *Prerequisites: ME 200a and b or equivalent; AMCS 201 and AMCS 202 (may be taken concurrently).* A more rigorous mathematical introduction to fluid mechanics. Derivation of Navier-Stokes; physical properties of real gases; the equations of motion of viscous and inviscid dynamics; the dynamical significance of vorticity; vortex dynamics; Kelvin circulation theorem and consequences; Biot-Savart Law, exact solutions in vortex dynamics; motion at high Reynolds numbers; hydrodynamic stability; boundary layers; flow past bodies; compressible flow; subsonic, transonic, and supersonic flow; Lax theory of shock waves.

ME 302. Multi-Phase Flows (3-0-3) *Prerequisites: ME 241, AMCS 201 and AMCS 202, ME 200a and b, ME 211a and b or equivalents.* Selected topics in engineering two-phase flows with emphasis on practical problems in modern hydro-systems. Fundamental fluid mechanics and heat, mass, and energy transport in multiphase flows. Liquid/vapor/gas (LVG) flows, nucleation, bubble dynamics, cavitating and boiling flows, models of LVG flows; instabilities, dynamics, and wave propagation; fluid/structure interactions. Discussion of two-phase flow problems in conventional, nuclear, and geothermal power plants, marine hydrofoils, and other hydraulic systems.

ME 304. Experimental Methods in Fluid Mechanics (2-2-4) *Prerequisites: ME 200a and b or equivalent; AMCS 201 and AMCS 202 (may be taken concurrently).* Basic sampling theory. Spectral decomposition, aliasing, Nyquist criterion and dynamic range. Basic optics, lasers, diffraction limit. Particle tracking and streak photography. Point measurements of velocity, pitot static tube, hot wires, laser-doppler velocimetry. Measurements of velocity fields in planes and volumes, using particle image velocimetry. Micro-PIV. Measurement of scalar fields. Holographic PIV. High-speed video technology. This course has a significant laboratory component.

ME 305a. Computational Fluid Dynamics (3-0-3) *Prerequisites: ME 200a and b or equivalent; AMCS 201 and AMCS 202 or equivalent.* Introduction to floating point arithmetic. Introduction to numerical methods for Euler and Navier-Stokes equations with emphasis on error analysis, consistency, accuracy and stability. Modified equation analysis (dispersion vs. dissipation) and Von Neumann stability analysis. Finite difference methods, finite volume and spectral element methods. Explicit vs. implicit time stepping methods. Solution of systems of linear algebraic systems. Higher-order vs. higher resolution methods. Computation of turbulent flows. Compressible flows with high-resolution shock-capturing methods (e.g. PPM, MUSCL, WENO). Theory of Riemann problems and weak solutions for hyperbolic equations.

ME 305b. Computational Fluid Dynamics (3-0-3) Continuation of ME 305a.

ME 306. Hydrodynamic Stability (3-0-3) *Prerequisite: ME 200a and b or equivalent; AMCS 201 and AMCS 202 (may be taken concurrently).* Laminar-stability theory as a guide to laminar-turbulent transition. Rayleigh equation, instability criteria, and response to small inviscid disturbances. Discussion of Kelvin-Helmholtz, Rayleigh-Taylor, Richtmyer-Meshkov, and other instabilities, for example, in geophysical flows. The Orr-Sommerfeld equation, the dual role of viscosity, and boundary-layer stability. Modern concepts such as pseudomomentum conservation laws and nonlinear stability theorems for 2-D and geophysical flows.

ME 307. Turbulence (3-0-3) *Prerequisites: ME 200a and b; AMCS 201 and AMCS 202.* Introduction to turbulence. Fundamental equations of turbulent flow. Statistical description of turbulence. Experimental methods for turbulence. Reynolds equations. Kolmogorov's theory. Scales of turbulence. Homogeneous turbulence. Free-shear flows. Bounded flows. Boundary layers. Simulating turbulent flows. Reynolds Average Navier-Stokes approach. Introduction to Large Eddy Simulation.

ME 308. Introduction to Plasma Physics and Magneto-hydrodynamics (3-0-3) *Prerequisites: ME 200a and b; AMCS 201 and AMCS 202.* Motion of charged particles; Statistical behavior of plasmas. Vlasov and Fokker-Planck equations and derivation of fluid models for plasmasclosure problem and models. Dispersive waves in plasmas. Ideal and non-ideal magneto-hydrodynamics. Exact solutions. Alfvén and shock waves in MHD. MHD instabilities.

ME 310. Mechanics and Materials Aspects of Fracture (3-0-3) *Prerequisites: ME 211a and b (concurrently) or equivalent and instructor's permission.* Analytical and experimental techniques in the study of fracture in metallic and nonmetallic solids. Mechanics of brittle and ductile fracture; connections between the continuum descriptions of fracture and micromechanisms. Discussion of elastic-plastic fracture analysis and fracture criteria. Special topics include fracture by cleavage, void growth, rate sensitivity, crack deflection and toughening mechanisms, as well as fracture of nontraditional materials. Fatigue crack growth and life prediction techniques will also be discussed. In addition, "dynamic" stress wave dominated, failure initiation growth and arrest phenomena will be covered. This will include traditional dynamic fracture considerations as well as discussions of failure by adiabatic shear localization.

ME 319a. Computational Solid Mechanics (3-0-3) *Prerequisites: AMCS 201 and AMCS 202 or equivalent; ME 211a and b or equivalent; ME 212a and b or taken concurrently.* Variational principles in linear elasticity. Finite element analysis. Error estimation. Convergence. Singularities. Adaptive strategies. Constrained problems. Mixed methods. Stability and convergence. Variational problems in nonlinear elasticity. Consistent linearization. The Newton-Rahpson method. Bifurcation analysis. Adaptive strategies in nonlinear elasticity. Constrained finite deformation problems. Contact and friction. Time integration. Algorithm analysis. Accuracy, stability, and convergence. Operator splitting and product formulas. Coupled problems. Impact and friction. Space-time methods. Inelastic solids. Constitutive updates. Stability and convergence. Consistent linearization. Applications to finite deformation viscoplasticity, viscoelasticity, and Lagrangian modeling of solids.

ME 319b. Computational Solid Mechanics (3-0-3) Continuation of ME 319a.

ME 312. Dynamic Behavior of Material (3-0-3) *Prerequisites: AMCS 201 and AMCS 202 or equivalent; ME 211a and b.* Fundamentals of theory of wave propagation; plane waves, wave guides, dispersion relations; dynamic plasticity, adiabatic shear banding; dynamic fracture; shock waves, equation of state.

ME 313a. Theory of Structures (3-0-3) Geometry of spatial curves; finite 3-D rotations; finite deformations of curved rods; dynamics of rods; strings and cables; theory of plastic rods; statistical mechanics of chains; applications including frames and cable structures, polymers, open-cell foams, DNA mechanics, cell mechanics; small strain and von Karman theory of plates; applications to thin films, layered structures, functionally graded thin films, delamination, plastic collapse; surface geometry; finite deformations of shells; dynamics of plates and shells; membranes; theory of plastic plates and shells; fracture of plates and shells; elastic and plastic stability; wrinkling and relaxation; applications including solar sails, space structures, closedcell foams, biological membranes; numerical methods for structural analysis; discrete geometry; finite elements for rods, plates and shells; time-integration methods; thermal analysis.

ME 313b. Theory of Structures (3-0-3) Continuation of ME 313a.

ME 314. Plasticity (3-0-3) *Prerequisite: ME 211a and b or instructor's permission.*
Theory of dislocations in crystalline media. Characteristics of dislocations and their influence on the mechanical behavior in various crystal structures. Application of dislocation theory to single and polycrystal plasticity. Theory of the inelastic behavior of materials with negligible time effects. Experimental background for metals and fundamental postulates for plastic stress-strain relations.
Variational principles for incremental elasticplastic problems, uniqueness. Upper and lower bound theorems of limit analysis and shakedown. Slip line theory and applications. Additional topics may include soils, creep and rate-sensitive effects in metals, the thermodynamics of plastic deformation, and experimental methods in plasticity.

ME 315. Computational Mechanics Using Particle Methods (3-0-3) *Prerequisites: ME 319 or equivalent.* Particle simulations of continuum and discrete systems. Advances in molecular, mesoscopic, and macroscale simulations using particles, identification of common computing paradigms and challenges across disciplines, discretizations and representations using particles, fast summation algorithms, time integrators, constraints, and multiresolution. Exercises will draw on problems simulated using particles from diverse areas such as fluid and solid mechanics, computer graphics, and nanotechnology.

ME 316. Micromechanics (3-0-3) *Prerequisites: AMCS 201 and AMCS 202 or equivalent, ME 211a and b and ME 212a and b or instructor's permission.* The course gives a broad overview of micromechanics, emphasizing the microstructure of materials, its connection to Mechanical Engineering. Courses molecular structure, and its consequences on macroscopic properties. Topics include phase transformations in crystalline solids, including martensitic, ferroelectric, and diffusional phase transformations, twinning and domain patterns, active materials; effective properties of composites and polycrystals, linear and nonlinear homogenization; defects, including dislocations, surface steps, and domain walls; thin films, asymptotic methods, morphological instabilities, self-organization; selected applications to microactuation, thin-film processing, composite materials, mechanical properties, and materials design.

ME 317a. Mechanics of Composite Materials and Structures (3-03) *Prerequisite: ME 211a and b or instructor's permission; AMCS 201 and AMCS 202.* Introduction and fabrication technologies. Elastic response of composite materials (especially fiber and particulate reinforced materials) from the fabrication to the in-service structure. Up scaling strategies from the microstructure to the single ply: kinematic and static bounds, asymptotic expansion and periodical homogenization. Up scaling strategies from the single ply to the structural scale: elastic deformation of multidirectional laminates (lamination theory, ABD matrix). Mechanics of degradation in composite materials: fiber-matrix debonding, plasticity, microcracking and induced delamination. Tools for description of non-linear effects: damage mechanics for laminates, applications of fracture mechanics. Aging and fatigue. Basic criteria-based theories will also be reviewed, including first ply failure, splitting and delamination. Basic experimental illustration will include: hand lay up of a simple laminate, characterization using full field measurement of its material properties

.

ME 317b. Mechanics of Composite Materials and Structures (3-03) Continuation of ME 317a.

ME 318. Dynamic Fracture and Frictional Faulting (3-0-3) *Prerequisite: ME 211a and b or ME 212a and b or instructor's permission.* Introduction to elastodynamics and waves in solids. Dynamic fracture theory, energy concepts, cohesive zone models. Friction laws, nucleation of frictional instabilities, dynamic rupture of frictional interfaces. Radiation from moving cracks. Thermal effects during dynamic fracture and faulting. Crack branching and faulting along nonplanar interfaces. Related dynamic phenomena, such as adiabatic shear localization. Applications to engineering phenomena and physics and mechanics of earthquakes.

ME 320. Geometry of Nonlinear Systems (3-0-3) *Prerequisite: AMCS 202.* Basic differential geometry, oriented toward applications in control and dynamical systems. Topics include smooth manifolds and mappings, tangent and normal bundles. Vector fields and flows. Distributions and Frobenius's theorem. Matrix Control and Dynamical Systems. Lie groups and Lie algebras. Exterior differential forms, Stokes' theorem.

ME 324. Advanced Control Systems (3-0-3) *Prerequisites: AMCS 201 and AMCS 202 or equivalent; ME 221a and b or equivalent*. Introduction to modern control systems with emphasis on the role of control in overall system analysis and design. Input-output directions in multivariable systems: eigenvalues and singular value decomposition. System norms and introduction to MIMO robustness. Controller design for multivariable plants: linear quadratic regulator, linear quadratic Gaussian optimal control, H-infinity and H-2 control, sampled-data, model predictive control. Convex design methods: Youla parameterization, linear matrix inequalities; adaptive control, neural networks, fuzzy logic systems; introduction to neuro-fuzzy systems and soft computing. Multivariable control design examples drawn from throughout engineering and science in the field of aerospace, automotive, chemical-and energy-efficient buildings.

ME 326. Robust Control (3-0-3) *Prerequisites: AMCS 201 and AMCS 202 or equivalents; ME 221a and b or equivalent.* Linear systems, realization theory, time and frequency response, norms and performance, stochastic noise models, robust stability and performance, linear fractional transformations, structured uncertainty, optimal control, model reduction, m analysis and synthesis, real parametric uncertainty, Kharitonov's theorem, uncertainty modeling.

ME 332. Geometric Mechanics (3-0-3) *Prerequisites: ME 232.* The geometry and dynamics of Lagrangian and Hamiltonian systems, including symplectic and Poisson manifolds, variational principles, Lie groups, momentum maps, rigid-body dynamics, Euler-Poincaré equations, stability, and an introduction to reduction theory. More advanced topics (taught in a course the following year) will include reduction theory, fluid dynamics, the energy momentum method, geometric phases, bifurcation theory for mechanical systems, and nonholonomic systems.

ME 340. Advanced Combustion Theory (3-0-3) *Prerequisites: ME 244 or equivalent classes.* Review of fundamental concept of and phenomenology of combustion. Singularities in nonlinear problems. Matched asymptotic expansion technique. Large activation energy, Dankӧhler number and rate ratio asymptotics. Ignition/extinction. Laminar burning velocity. Diffusion flame. Aerodynamic effect. Preferential diffusion, differential diffusion, and heat loss effects. Hydrodynamic and acoustic instabilities. Reduced mechanisms.

ME 342. Combustion Kinetics (3-0-3) *Prerequisites: ME 244 or equivalent.* Non-equilibrium processes in chemically reacting gases. Example applications to combustion, atmospheric chemistry, plasmas, chemical and materials processing, rocket nozzles, and gaseous lasers. Bimolecular reaction theory (collision theory); transition state theory; unimolecular and association reactions; complex reactions; straight chain reactions; explosions and branched chain
reactions; photochemistry, photophysics; energy transfer in fuel tracers; vibrational relaxation; experimental techniques.

ME 344. Gasdynamics (3-0-3) *Prerequisites: ME 241.* Concepts and techniques for description of high-temperature and chemically reacting gases from a molecular point of view. Introductory kinetic theory; chemical thermodynamics; statistical mechanics as applied to properties of gases and gas mixtures; transport and thermodynamic properties; law of mass action; equilibrium chemical composition; Maxwellian and Boltzmann distributions of velocity and molecular energy; examples and applications from areas of current interest such as combustion and materials processing.

ME 346. Turbulent Combustion (3-0-3) *Prerequisites: ME 244, ME 307 or equivalents.* Governing equations of reactive fluid flow. Review of fundamental concepts in turbulence. Non-premixed turbulent combustion. Conserved scalar modeling approach and turbulent non-premixed combustion models. Premixed turbulent combustion fundamentals and combustion regimes. Canonical models for premixed turbulent combustion. Partially premixed combustion. Scaling laws for lifted turbulent jet flames.

ME 397. Ph.D. Dissertation *Prerequisites: Ph.D. status and consent of instructor.*
Course may be repeated for credit. Maximum number of units is 12 per semester. Must be taken on a pass/fail basis. Individual investigation on topics of relevance to mechanical engineering.

ME 400. Contemporary Topics in Fluid Mechanics (3-0-3) *Prerequisites: ME 200a and b and consent of the instructor.* Lecture and/or seminar course on advanced topics in fluid mechanics. Topics are determined by the instructor and may vary from year to year. The course may be repeated for credit.

ME 410. Contemporary Topics in Solid Mechanics (3-0-3) *Prerequisites: ME 211a and b, ME 212a and b and consent of the instructor.* Lecture and/or seminar course on advanced topics in solid mechanics. Topics are determined by the instructor and may vary from year to year. The course may be repeated for credit.

ME 420. Contemporary Topics in Control Theory and Practice (3-03) *Prerequisites: ME 221a and b and consent of the instructor.* Lecture and/or seminar course on advanced topics in control theory and practice. Topics are determined by the instructor and may vary from year to year. The course may be repeated for credit.

ME 430. Contemporary Topics in Dynamic (3-0-3) *Prerequisites: ME 232a and b and consent of the instructor.* Lecture and/or seminar course on advanced topics in dynamics. Topics are determined by the instructor and may vary from year to year. The course may be repeated for credit. Maximum number of units is 3 per semester.

ME 440. Contemporary Topics in Thermal Science and Engineering (3-0-3) *Prerequisites: ME 241 and ME 242 or ME 244 and consent of the instructor*. Lecture and/or seminar course on advanced topics in thermal science and engineering. Topics are determined by the instructor and may vary from year to year. The course may be repeated for credit.

ME 450. Contemporary Topics in Design Theory and Practice (3-03) *Prerequisites: ME 254 and consent of the instructor.* Lecture and/or seminar course on advanced topics in design theory and practice. Topics are determined by the instructor and may vary from year to year. The course may be repeated for credit.