Mechanical Engineering (M E)

M E 302 Introduction to Engineering Design and Graphics 3 Hours
Introduction to mechanical engineering education and practice through lectures and laboratory experiences. Graphics and modeling fundamentals for engineering design: freehand sketching, computer modeling of solid geometry, and generation of engineering drawings. Introduction to reverse engineering, computer-aided design, rapid prototyping, and manufacturing. Application of the design process and problem solving through individual and team projects.

M E 103 Studies in Engineering Design Graphics 1 Hour
Computer laboratory work in engineering design graphics for students with transfer credit for Mechanical Engineering 210 who need additional work.

M E 205 Introduction to Computers and Programming 2 Hours
Introduction to computer hardware and software systems; programming using a high-level language; mathematical software programming; and introduction to machine language. Includes significant hands-on programming opportunities.

M E 109M, 209M, 309M Topics in Mechanical Engineering 1-3 Hours

M E 210 Engineering Design Graphics 2 Hours
Graphics and modeling fundamentals for engineering design: freehand sketching, computer modeling of solid geometry, and generation of engineering drawings. Introduction to reverse engineering, computer-aided design, rapid prototyping, and manufacturing. Application of the design process to problem solving. Individual and team design projects.

M E 210H Engineering Design Graphics: Honors 2 Hours
Graphics and modeling fundamentals for engineering design: freehand sketching, computer modeling of solid geometry, and generation of engineering drawings. Introduction to reverse engineering, computer-aided design, rapid prototyping, and manufacturing. Application of the design process to problem solving. Individual and team design projects.

M E 310T Applied Thermodynamics 3 Hours
First and second laws of thermodynamics; thermodynamics processes, cycles, and heat transfer.

M E 311 Materials Engineering 3 Hours
An exploration of fundamental aspects of the structure, properties, and behavior of engineering materials.

M E 111L Materials Engineering Laboratory 1 Hour
Hands-on experiments in materials science and engineering topics and microstructure-property relationships discussed in Mechanical Engineering 311.

M E 314D Dynamics 3 Hours
Analysis of motions, forces, momenta, and energies in mechanical systems.

M E 316T Thermodynamics 3 Hours
Properties, heat and work, first and second laws, thermodynamic processes, introduction to ideal power cycles.

M E 218 Engineering Computational Methods 2 Hours
Applied numerical analysis, programming of computational algorithms using mathematical software, and applications of computational methods to the solution of mechanical engineering problems.

M E 318M Programming and Engineering Computational Methods 3 Hours
An investigation of applied numerical analysis, programming of computational algorithms using mathematical software, and applications of computational methods to the solution of mechanical engineering problems.

M E 119S, 219S, 319S, 419S, 519S, 619S, 719S, 819S, 919S Topics in Mechanical Engineering 1-9 Hours
Used to record credit the student earns while enrolled at another institution in a program administered by the University's Study Abroad Office. Credit is recorded as assigned by the study abroad adviser in the Department of Mechanical Engineering. University credit is awarded for work in an exchange program; it may be counted as coursework taken in residence. Transfer credit is awarded for work in an affiliated studies program.

M E 320 Applied Thermodynamics 3 Hours
First and second laws of thermodynamics; thermodynamic processes, cycles, and heat transfer.

M E 120C Humanitarian Engineering Seminar 1 Hour

M E 324 Dynamics 3 Hours
Analysis of motions, forces, momenta, and energies in mechanical systems.

M E 025LX Cooperative Engineering 0 Hours
This course covers the work period of mechanical engineering students in the Cooperative Engineering Program.

M E 025LY Cooperative Engineering 0 Hours
This course covers the work period of mechanical engineering students in the Cooperative Engineering Program.

M E 025LZ Cooperative Engineering 0 Hours
This course covers the work period of mechanical engineering students in the Cooperative Engineering Program.

M E 326 Thermodynamics 3 Hours
Properties, heat and work, first and second laws, thermodynamic processes, introduction to ideal power cycles.

M E 326H Thermodynamics: Honors 3 Hours
Properties, heat and work, first and second laws, thermodynamic processes, introduction to ideal power cycles.

M E 129S, 229S, 329S, 429S, 529S, 629S, 729S, 829S, 929S Topics in Mechanical Engineering 1-9 Hours
Used to record credit the student earns while enrolled at another institution in a program administered by the University's Study Abroad Office. Credit is recorded as assigned by the study abroad adviser in the Department of Mechanical Engineering. University credit is awarded for work in an exchange program; it may be counted as coursework taken in residence. Transfer credit is awarded for work in an affiliated studies program.

M E 330 Fluid Mechanics 3 Hours
Fluid properties, statics, conservation laws, inviscid and viscous incompressible flow, flow in confined streams and around objects.

M E 130L Experimental Fluid Mechanics 1 Hour
Experimental design concepts, uncertainty analysis, and systems analysis as applied to thermodynamics, fluid mechanics, and heat transfer systems.

M E 333H Engineering Communication: Honors 3 Hours
Professional communication skills for engineers, with emphasis on research, writing, editing, and oral presentation on topics of social and technical significance in engineering. Students collaborate to publish an online journal.

M E 333T Engineering Communication 3 Hours
Professional communication skills for engineers, with emphasis on research, writing, and oral presentation on topics of social and technical significance in engineering.

M E 334 Materials Engineering 3 Hours
Fundamental aspects of the structure, properties, and behavior of engineering materials.

M E 134L Materials Engineering Laboratory 1 Hour
Hands-on experiments in materials science and engineering topics and microstructure-property relationships discussed in Mechanical Engineering 334.

M E 335 Engineering Statistics 3 Hours
Fundamentals of probability, distribution theory, data analysis and statistics, interval estimation, hypothesis testing, and statistical quality control.

M E 336 Materials Processing 3 Hours
Effects of processing on materials properties; materials selection.

M E 136L Materials Processing Laboratory 1 Hour
Hands-on study of selected materials processing procedures and processing-microstructure-property relationships discussed in Mechanical Engineering 336.

M E 136N, 236N Concepts in Nuclear and Radiation Engineering 1-2 Hours

M E 336P Concepts in Nuclear and Radiation Engineering 3 Hours
Explore different aspects and applications of nuclear and radiation engineering/physics. Examine the history of nuclear development, basic concepts of radiation and radioactivity, radioactive waste management, global warming and the impact of nuclear power plants, industrial applications, health physics, nuclear medicine, job opportunities at power plants, non-proliferation, and nuclear security.

M E 337C Introduction to Nuclear Power Systems 3 Hours
Explore radioactivity, nuclear interactions: fission and fusion, fission reactors, nuclear power systems, nuclear power safety.

M E 337F Nuclear Environmental Protection 3 Hours
Explore ionizing radiation and its interactions with matter and living tissues; radioactive decay kinetics; external and internal dose measurement; transportation through the environment; managing radioactive waste streams; and safeguards.

M E 337G Nuclear Safety and Security 3 Hours
Explore policy and technical aspects related to nuclear safety and security. Evaluate the proliferation of risk from facilities within the nuclear fuel cycle. Examine the criticality conditions for a nuclear assembly and derive parent/daughter decay equations.

M E 338 Machine Elements 3 Hours
Analysis for the design and manufacture of basic mechanical elements, and their role in the design of machines; application of finite element modeling.

M E 339 Heat Transfer 3 Hours
Steady and transient heat conduction; forced and natural convection; radiation; introduction to heat exchangers and applications.

M E 139L Experimental Heat Transfer 1 Hour
Experimental design concepts, uncertainty analysis, and systems analysis as applied to thermodynamics, fluid mechanics, and heat transfer systems.

M E 340 Mechatronics 3 Hours
Theory and application of electrical circuits, electronics, and electromechanical devices; concepts in electrical power transmission; instrumentation; feedback; integration of electronics and instrumentation with mechanical engineering systems (mechatronics).

M E 140L Mechatronics Laboratory 1 Hour
Hands-on laboratory using hand-held and bench-top electronic test and prototyping equipment for circuits and mechatronics applications; computer-aided instrumentation and data acquisition; laboratory study in design, prototyping, and testing with electrical and electronics components and electromechanical devices.

M E 343 Thermal-Fluid Systems 3 Hours
Analysis and design of integrated systems involving simultaneous application of thermodynamics, heat transfer, and fluid mechanics. Applications to power generation, vehicle engineering, materials processing, environmental control, and manufacturing.

M E 344 Dynamic Systems and Controls 3 Hours
Lumped physical system models; electrical, fluid, mechanical, and thermal system analysis; linear system transient, steady-state behavior; introduction to feedback control.

M E 144L, 244L Dynamic Systems and Controls Laboratory 1-2 Hours
Modeling of engineering systems, digital simulation, and assessment of results with experimental study; methods for analysis of first- and second-order systems, system identification, frequency response and feedback control principles; hands-on experimentation with mechanical, fluid, electrical, and magnetic systems; data acquisition and analysis using oscilloscopes and microcomputer-based analog-to-digital and digital-to-analog conversion; theoretical and practical principles governing the design and use of various sensors and transducers.

M E 347 Topics in Processing of Materials 3 Hours
Analysis of forces in processing operations; effects of friction and their control; metalworking efficiencies.

M E 347.1 Powder Processing 3 Hours
Powder particle characterization and size/shape/distribution, powder synthesis, compaction, sintering theory, sintering maps, full-density processing, powder-processed part microstructure and properties.

M E 347.2 Deformation Processing 3 Hours
Analysis of forces in processing operations; effects of friction and their control; slab method; upper-bound force theory; slip-line field theory; metalworking efficiencies.

M E 348E Advanced Mechatronics I 3 Hours
Integrated use of mechanical, electrical, and computer systems for information processing and control of machines and devices. System modeling, electromechanics, sensors and actuators, basic electronics design, signal processing and conditioning, noise and its abatement, grounding and shielding, filters, and system interfacing techniques.

M E 348F Advanced Mechatronics II 3 Hours
Interfacing microcomputers with sensors and actuators; hybrid (analog/digital) design; digital logic and analog circuitry; data acquisition and control; microcomputer architecture, assembly language programming; signal conditioning, filters, analog-to-digital and digital-to-analog conversion.

M E 349 Corrosion Engineering 3 Hours
Corrosion principles; electrochemical, environmental, and metallurgical effects; types of corrosion; corrosion testing and prevention; modern theories: principles and applications.

M E 350 Machine Tool Operations for Engineers 3 Hours
Hands-on manual and computer-numerical-controlled machine tool operation. Part design and tool selection for production.

M E 350D Design and Control of Robots for Rehabilitation 3 Hours
Explore the roles of sensors, actuators, and neural circuits for biological movement control from an engineering perspective. Examine 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 are discussed. Study the latest literature in neuromuscular controls, neuromotor recovery, and design and control of rehabilitation robots.

M E 350R Robot Mechanism Design 3 Hours
Studies the analysis and synthesis of motions of mechanisms in order to design robotic systems. Examines motion properties of mechanisms including degrees of freedom, velocity, and acceleration. Explores ideas and motion analysis for robotic systems for a wide range of applications including spatial, industrial and medical robotics.

M E 352K Engineering Computer Graphics 3 Hours
Introduction to interactive computer graphics as a tool in computer-aided design. Use of graphics software packages.

M E 353 Engineering Finance 3 Hours
Evaluating the financial impact of engineering decisions. Comparing alternatives with cash flow analysis considering rate of return, inflation, and taxes, with emphasis on analyzing risk. Managing complex projects with activity scheduling and resource allocation considering cash flows. Methods include probabilistic analysis and simulation.

M E 354 Introduction to Biomechanical Engineering 3 Hours
The application of mechanical engineering principles to problems in the life sciences; transport phenomena of physiological solids and fluids; biosignal analysis and instrumentation; biomaterials design and compatibility; principles of medical imaging, diagnostics, and therapeutics; rehabilitation engineering.

M E 354M Biomechanics of Human Movement 3 Hours
Modeling and simulation of human movement; neuromuscular control; computer applications; introduction to experimental techniques.

M E 355K Engineering Vibrations 3 Hours
Time-domain and frequency-domain analysis of vibrating systems; matrix methods, instrumentation, and vibration control; numerical methods.

M E 259, 359 Materials Selection 2-3 Hours
Description of commercial metals, polymers, ceramics, concrete, and wood for use in mechanical engineering applications. Applications include strength, toughness, stiffness, fatigue, creep, corrosion, casting, forming, machining, and welding.

M E 360 Vehicle System Dynamics and Controls 3 Hours
Fundamentals of ground vehicle dynamics, tire-road mechanics, vehicle control systems, vehicle stability, and simulation of vehicle systems.

M E 360C Cyber Vehicle Systems 3 Hours
Study of the engineering principles of autonomous mobile robots. Subjects include understanding the dynamics of vehicle systems, and the principles and practical implementation of sensing, actuation, and control. Emphasis on providing practical laboratory study of these subjects using mobile robot platforms, and the use of the commercial software package LabVIEW for programming of real-time data acquisition and control targets. Simulation studies may also be conducted in LabVIEW and/or the Matlab environment, so some proficiency in use of both of these software packages is expected.

M E 360D Propulsion Systems and Controls 3 Hours
Study principles, modeling, analysis, system integration, control, and diagnosis of diverse ground vehicle propulsion and driveline systems.

M E 360E Advanced Vehicle Powertrain Systems and Control 3 Hours
Explore the basic concept of vehicle powertrain systems and controller design, and discuss state of the art vehicle powertrain development. Examine modeling skills to capture the system dynamics and modern control strategies to achieve the desired system performance.

M E 260K, 360K Metallurgy of Engineering Alloys 2-3 Hours
Microstructure and property relationships of metals and alloys; steel alloys; aluminum alloys; titanium alloys; magnesium alloys; solidification and casting; thermomechanical processing; heat treating and solid-state phase transformations.

M E 360L Turbomachinery and Compressible Flow 3 Hours
Positive displacement and dynamic rotating machinery; pumps, compressors, and turbines; performance characteristics and scaling laws. One-dimensional compressible flow with area change, friction, or heat addition. Normal and oblique shock waves; Prandtl-Meyer expansion.

M E 360N Intermediate Heat Transfer 3 Hours
Multidimensional and transient diffusion; laminar and turbulent convection; radiation exchange; special topics.

M E 360S Advanced Packaging and Thermal Management 3 Hours

M E 361E Nuclear Reactor Operations and Engineering 3 Hours
Explore fission and chain reactions; neutron diffusion and moderation; reactor equations; Fermi Age theory; and multigroup and multiregional analysis.

M E 361F Radiation and Radiation Protection Laboratory 3 Hours
Introduction to the application of radiation and radiation protection instrumentation. Lecture and laboratory topics include personnel monitoring, radiation detection systems, gamma-ray spectroscopy, determination of environmental radiation, counting statistics, gamma and neutron shielding, and air sampling.

M E 261M, 361M Materials Thermodynamics 2-3 Hours
First and second laws; heat of combustion; heat engine cycles; chemical equilibria and/or phase equilibria; point defects in crystals.

M E 362K Readings in Engineering 3 Hours
A study of the interrelated problems of society, technology, and energy.

M E 362S Development of a Solar-Powered Vehicle 3 Hours
Analysis, design, and construction of a solar-powered car for national competitions involving other universities. Study of electrical, mechanical, and aerodynamic systems.

M E 363L Energy Systems Laboratory 3 Hours
Experimental analysis of thermal energy systems, including heat transfer equipment, engines, the University chilling station and the University power plant. Use of a variety of industrial instrumentation for assessment of system and component performance and of experimental uncertainty. Written and oral technical communication of experimental results.

M E 363M Energy Technology and Policy 3 Hours
An overview of energy technologies, fuels, environmental impacts and public policies. Subjects are interdisciplinary and include an introduction to quantitative concepts in energy, including the differences among fuels and energy technologies, energy policy levers, and the societal aspects of energy, such as culture, economics, war, and international affairs. Includes brief snippets of energy history, use of real-world examples, and looks forward into the future. Interactive and lecture-oriented around current events related to energy.

M E 364D Intermediate Dynamics 3 Hours
Focuses on efficient formulation and solution of equations of motion for complex 3D multi-body mechanical systems. Emphasizes the formulation of the dynamical equations of motion using Kane's method and will use symbolic and numerical simulation techniques (MATLAB(R) and MotionGenesis) to solve these equations. Preparation for advanced research and professional work analyzing the dynamics of complex multi-body mechanical systems.

M E 364L Automatic Control System Design 3 Hours
Feedback principles; control components; industrial compensators; Routh, Nyquist, Bode, and root locus methods; controller design; continuous and discrete time control.

M E 365D Data Science for Engineers 3 Hours
Learn data analysis and programming skills. Explore essential data science techniques, including regression, decision trees, classification, and neural networks.

M E 365E Engineering Entrepreneurship 3 Hours
Focus on developing a basic understanding for the assessment of emerging technologies including the analysis of the status and future development issues, establish a comprehension of what 'market' means in terms of potential technology applications, and of how that market is identified and characterized. Create new knowledge about the potential match of an emerging technology with a defined market as a member of a multidisciplinary team, establish a basic understanding of IP rights, assessment and strategy related to emerging technology, and assess the course and participate in discussions about how it can be evolved for future offerings. Exploration the innovation and technology commercialization process especially as it relates to individual expertise and career goals.

M E 365K Finite Element Method 3 Hours
Introduction and application of the finite element method in engineering analysis and design problems; demonstration of techniques using commercial codes.

M E 365L Industrial Design for Production 3 Hours
Current techniques for making transitions from theoretical concepts to cost effective designs suitable for manufacturing.

M E 466E Mechanical Engineering Capstone Design 4 Hours
Examine creative design, analysis, selection, development, and fabrication of engineering components and systems.

M E 366J Mechanical Engineering Design Methodology 3 Hours
An examination of structured methodologies for designing mechanical systems; reverse engineering/redesign projects and conceptual design projects.

M E 366L Operations Research Models 3 Hours
Formulation and solution-interpretation for operations research models requiring, for example, optimization, simulation, or analysis of Markov chains or queues. Applications include manufacturing design and control, routing and scheduling, plant location, inventory analysis, and management of queueing systems.

M E 366Q Deterministic Methods for Operations Research 3 Hours
Theory and algorithms for deterministic operations research methods. Algorithms for solving linear, integer, and nonlinear optimization models.

M E 366R Stochastic Methods for Operations Research 3 Hours
Theory and algorithms for stochastic operations research methods. Algorithms related to stochastic processes: Markov chain analysis; queueing theory; stochastic inventory theory and decision analysis.

M E 366T Biomems and Bionems 3 Hours
Micro/Nano technology has been used to create many new materials and devices with a vast range of applications in materials science, electronics and photonics, and biomedical applications. BioMEMS and BioNEMS is the application of micro/nano technology in the fields of biomedical and health sciences by offering advantages of small size (from submicron to a few mm), low cost, high throughput, and importantly requiring much less sample/reagent.

M E 367S Simulation Modeling 3 Hours
Basic concepts of discrete-event simulation. Statistical input and output analysis. Application of simulation software. Modeling of systems under uncertainty.

M E 368C Additive Manufacturing 3 Hours
Additive manufacturing (AM) is the use of layer-based processes for producing parts directly from computer (CAD) models, without part-specific tooling. Students learn about a variety of additive manufacturing (AM) AM technologies, their potential to support rapid prototyping and manufacturing, and some of of the important research challenges associated with AM.

M E 368J Computer-Aided Design 3 Hours
Application of computers to design problems and simulation of mechanical systems; creation of interactive special applications programs.

M E 369L Introduction to Computational Fluid Dynamics 3 Hours
Applied numerical analysis, including solution of linear algebraic equations and ordinary and partial differential equations; modeling of physical processes, including fluid flow and heat and mass transfer; use of general purpose computer codes, including commercial computational fluid dynamics software packages.

M E 369M Computational Methods in Thermal/Fluid Systems 3 Hours
Use of basic tools of computational mathematics to set up numerical simulations for a variety of problems in thermo fluids. Explicit versus implicit time-stepping schemes, the issues of numerical stability and numerical errors, the issue of computational costs, difficulties with boundary and initial conditions, basic decision paths in the choice of numerical methods depending on the target system, and design of diagnostic steps.

M E 369P Application Programming for Engineers 3 Hours
Designed for students who have some experience in programming and are interested in the sharing and development of open source software applications. Provides an introduction to the Python Programming language, an open source, flexible, and intuitive debug programming language, with an emphasis on system modeling, simulation, data analysis, and software/data management. Students will create mini projects in Python that demonstrate software design and organization, debugging, open source practices, and data visualization.

M E 371D Medical Device Design and Manufacturing 3 Hours
Explores how to solve medical device design problems using systematic design thinking and practices. Interpret clinical needs and define an open engineering medical device design problem, including formulating engineering requirements/specifications to address a marketable need, generate concepts in a way that promotes both creativity and usefulness, make well-informed, well-justified design decisions in the early and later stages of design, design and analyze experiments, follow statistical best practices in Design of Experiments(DoE), embody solutions with "Design for X" considerations, and communicate intermediate and final designs clearly and effectively in written and oral formats.

M E 371K Legal Aspects of Engineering Practice 3 Hours
Legal considerations in the practice of engineering; specifications and contracts for equipment and engineering services.

M E 372C Theory and Design for Mechanical Sensing and Measurements 3 Hours
Explore basic concepts of mechanical measurements: sensing, signal processing, experimental methods, uncertainty analysis, detection, and estimation.

M E 372J Robotics and Automation 3 Hours
Component technologies for precision machines based on dynamic modeling and motion programming: cams, linkages, planar robot manipulators and open architecture vehicles. Homework includes 15 simulations.

M E 372M Mechanism Design 3 Hours
Design of planar mechanisms for applications that require rigid body guidance, function generation, and path generation. Graphical and analytical techniques. Computer-aided design projects.

M E 372N Design of Smart Mechanisms 3 Hours
Design of reprogrammable multiple-degree-of-freedom architectures. The course addresses various mechanical configurations and stresses the integrated design approach to sensing/actuation/control architecture and control software.

M E 374C Combustion Engine Processes 3 Hours
Principles of internal combustion engines, fuels, carburetion, combustion, exhaust emissions, knock, fuel injection, and factors affecting performance.

M E 374D Automotive Engineering Laboratory 3 Hours
Engines and emissions. Students use commercial engine-modeling software to explore effects of valve timing and intake tuning and conduct experiments with vehicle emissions, ignition timing, engine mechanisms, engine controls, and emissions control.

M E 374E Race Car Engineering and Project Management 3 Hours
Explores designing a Formula SAE race car, a hot rod (UT's 1937 Chevy project), and a Formula SAE Electric race car. Divided into four major sections: Project Management, including tools for project organization and management, Powertrain, including engine basics, calibration, intake and exhaust design, cooling and oiling systems, fuel economy and emissions, transmission/differential, vehicle performance modeling, Brake systems, longitudinal weight transfer, longitudinal force requirements of the tires for both braking and acceleration, tires and tire models, and Vehicle dynamics (suspension systems, anti-roll bars, lateral weight transfer, tires and tire models).

M E 374F Fire Science 3 Hours
Analysis of the dynamics and consequences of fire in structures. Topics include combustion thermochemistry, premixed and diffusion flames, fluid mechanics of fire, human tenability in burning structures, and computer modeling of fires.

M E 374L Design of Thermal Systems 3 Hours
Methodology and approach to design of thermal energy systems; component and system modeling; optimization, including economic considerations.

M E 374R Design of Air Conditioning Systems 3 Hours
Load calculations, design of thermal distribution systems, component selection and control.

M E 374S Solar Energy Systems Design 3 Hours
Insolation characteristics and measurement, component design, solar energy system modeling, introduction to photovoltaic systems, cost analysis, and case studies.

M E 374T Renewable Energy Technology 3 Hours
Cultivates an enhanced level of theoretical and conceptual understanding of thermodynamics, fluid mechanics and heat transfer, and of how these disciplines apply to the design and analysis of complex thermal-fluid systems. Enhances skills in designing, programming and debugging software tools for systems analysis, working in teams, and communicating engineering results in a professional manner.

M E 376N High Throughput Nanopatterning 3 Hours
Introduction to the basic tools and materials involved in the patterning processes needed to create nano-scale structures and functional materials and discusses the relevance of these processes to applications in the electronics, display, and energy industries. Includes take-home portable nano-labs which allow hands-on experience in nano-scale fabrication processes and relevant nanometrology techniques. Explores industry and research roadmaps that provide relevant metrics and timelines for fabrication, materials, nano-enabled components and devices. Exposure to relevant computational modeling and simulation tools allows exploration of novel nano-enabled components and devices.

M E 177K, 277K, 377K, 477K Projects in Mechanical Engineering 1-4 Hours
Independent project carried out under the supervision of a faculty member in mechanical engineering. Student prepares a project proposal and a final report, each of which is evaluated by the faculty committee on individual projects.

M E 378C Electroceramics 3 Hours
Bonding; crystal structures; defects; phase diagrams; glass ceramics; electrical, dielectric, magnetic, and optical ceramics.

M E 378D Failure Analysis 3 Hours
Introduction to methodology of analyzing failures of engineering parts and devices. Explores a broad range of analysis, but the focus is on understanding fractography and relating this back to material and mechanics relevant to failure to determine the likely root cause(s). Lectures are primarily based on case studies and are supplemented by two hands-on class projects, one performed individually and the other larger project performed as a team project.

M E 378E Nanotechnology for Sustainable Energy 3 Hours
Demonstrates the role of nanoscale materials in solving one of the most critical socio-economic issues of our time, affordable and sustainable energy. An overview of emerging nanotechnology, and how people can critically impact many energy technologies (from energy harvesting, conversion, to storage). Explores various types of energy devices, including solar cell, solar fuel, piezoelectrics, thermoelectrics, battery, supercapacitor, and fuel cell as well as basic device principles, current technology status and new opportunities of nanotechnology for energy device applications. Content is at the intersection of nanoscale science and engineering, and energy science and technology.

M E 378F Enhancing Sustainability Through Tribology 3 Hours
Explore the principles of macro-scale tribology and discuss the potential impact of tribology in enhancing sustainable development. Discuss physical properties of lubricants; lubricants and their composition; contact mechanics; hydrodynamic lubrication; hydrostatic lubrication; elastohydrodynamic lubrication; boundary lubrication; solid lubrication and surface treatments; wear of materials; nanotribolgy; and green tribology.

M E 378K Mechanical Behavior of Materials 3 Hours
Elastic deformation; viscoelasticity; yielding, plastic flow, plastic instability, strengthening mechanisms; fracture, fatigue, creep; significance of mechanical properties tests.

M E 378P Properties and Applications of Polymers 3 Hours
Introduction to polymers as structural materials: polymerization, polymer structure, physical and mechanical properties, processing and fabrication.

M E 378Q Polymer Nanocomposites 3 Hours
Fundamentals, properties, and applications of polymer nanocomposites.

M E 378S Structural Ceramics 3 Hours
Powder processing, powder characterization, forming techniques, densification, and development of microstructure; emphasis on understanding materials, selection, and microstructure-mechanical property relationships.

M E 679H Undergraduate Honors Thesis 6 Hours
Research performed during two consecutive semesters under the supervision of an engineering faculty member; topics are selected jointly by the student and the faculty member with approval by the director of the Engineering Honors Program. The student makes an oral presentation and writes a thesis.

M E 179M, 279M, 379M Topics in Mechanical Engineering 1-3 Hours

M E 179M.1, 279M.1, 379M.1 Design of Machines and Systems 1-3 Hours
Introduction to techniques for analyzing and designing machine components (linkages, cams, springs, gears, etc.) within the context of reverse engineering and redesigning existing products. Covers the application of structure methods for engineering design and prototyping.

M E 179M.7, 279M.7, 379M.7 Technology Needs of Refugee Communities 1-3 Hours
Examine the refugee crisis with an emphasis on refugee flows into Greece.

M E 379N Engineering Acoustics 3 Hours
Principles of acoustics, with applications drawn from audio engineering, biomedical ultrasound, industrial acoustics, noise control, room acoustics, and underwater sound.

M E 379Q Musical Acoustics 3 Hours
Designed to help students develop the intuition and vocabulary for understanding the basic physical principles relevant to musical instruments and sound (e.g., mechanics, vibrations, acoustics, harmonics, acoustic-electronic conversions, speakers, hearing, perception, room acoustics) in order to be able to read basic articles on the subject of musical acoustics. Material is kept relevant to musical principles (e.g., performance techniques, scales/harmony) throughout.

M E 180E, 280E, 380E Special Topics in Mechanical Engineering 1-3 Hours

M E 180M, 280M, 380M, 680M, 980M Research 1,2,3,6,9 Hours

M E 380Q Topics in Mathematical Methods in Engineering 3 Hours
Applications of mathematical analysis and numerical concepts to typical engineering problems.

M E 380Q.1 Engineering Analysis: Analytical Methods 3 Hours
Analytical solutions for linear ordinary differential equations; numerical integration of ordinary differential equations; Fourier series and integrals; the Laplace transform; the solution of partial differential equations; vector analysis and linear transformations.

M E 380Q.2 Engineering Analysis: Advanced Analytical Methods 3 Hours
Classification and solution of partial differential equations; includes linear superposition, separation of variables, Fourier and Laplace transform methods, Green's functions, similarity solution, and spectral methods; introduction to solution of nonlinear partial differential equations, including both exact and approximate techniques, with a strong emphasis on physical systems.

M E 380Q.3 Perturbation Methods 3 Hours
Introduction to perturbation theory; regular expansions and sources of nonuniformities; method of strained coordinates and multiple scales; method of matched asymptotic and composite expansions. Places strong emphasis on the relationship between the physical and the mathematical basis and on the crucial role of nondimensionalization in problem solving.

M E 380Q.4 Numerical Methods for Differential Equations 3 Hours
Numerical solution of ordinary differential equations, both initial and boundary value equations; includes quasilinearization, shooting methods, and method of adjoints; classification and solution of partial differential equations by the finite difference method; stability and convergence criteria for various schemes; special attention to nonlinear equations with a strong emphasis on the Navier-Stokes equations.

M E 380R Robot Mechanism Design 3 Hours
Examines analysis and synthesis of motions of mechanisms in order to design robotic systems. Motion properties of mechanisms including degrees of freedom, velocity, and acceleration will be studied. Discusses design ideas and motion analysis for robotic systems for a wide range of applications including spatial, industrial and medical robotics. Simulates and analyzes motions of multi-link mechanisms in the MATLAB programming environment. Design and build robots with interesting mechanisms and mechatronics elements as part of group projects. Studies machining, assembly, mechatronics and programming through the projects.

M E 381M Statistical Methods for Process Control Manufacturing 3 Hours
Covers fundamental methods for statistical monitoring of processes, including Shewhart control charts, control charts for individual measurements, CUSUM charts and attribute control charts. Explores the design of experiments, including the statistical evaluation of main and interaction effects, as well as intelligent experimentation through reduced factorial experimental design. Outlines DOE-based search techniques for surface response based design optimization. Offers advanced research in model based and active process control in highly flexible and sophisticated manufacturing systems, such as semiconductor manufacturing lithography of flexible automotive assembly lines.

M E 381P Topics in Dynamics of Fluids 3 Hours
Detailed study of fluid dynamics, boundary layer phenomena, and incompressible flows.

M E 381P.1 Fundamentals of Incompressible Flow 3 Hours
Fundamentals. Kinematic and dynamic equations for compressible viscous flow, incompressible flow criteria, viscous flow patterns, and solution methods.

M E 381P.2 Compressible Flow and Turbomachinery 3 Hours
Two-dimensional flow at subsonic and supersonic Mach numbers, method of characteristics, shock tubes, oblique shocks, wave interactions.

M E 381P.3 Dynamics of Turbulent Flow 3 Hours
Fundamentals of turbulence, including scaling, transport, and kinetic energy of turbulence; wakes, jets; wall-bounded flows; spectrum of turbulence.

M E 381P.4 Multiscale Flow and Transport Phenomena 3 Hours
Fundamentals of flow and transport phenomena in multiscale systems, including momentum, energy, and mass transport phenomena at the microscale; surface tension (capillarity); electrokinetics; micro-scale transport in porous media; multi-phase flow; rheology; and complex fluids.

M E 381P.5 Applications of Incompressible Flow 3 Hours
Dynamics of vorticity, inviscid flow; boundary layer theory and computational techniques, linear stability theory for parallel flow, flow at moderate Reynolds number.

M E 381Q Topics in Thermodynamics 3 Hours

M E 381Q.1 Advanced Thermodynamics 3 Hours
Development of macroscopic thermodynamics from basic physical relationships; introduction to the thermodynamics of mixtures.

M E 381Q.4 Molecular Gas Dynamics 3 Hours
Kinetic theory, chemical thermodynamics, statistical mechanics. Applications: equilibrium gas properties, chemical kinetics, interaction of matter with radiation, rarefied gas dynamics.

M E 381R Topics in Heat Transfer and Rate Processes 3 Hours

M E 381R.1 Advanced Conductive Heat Transfer 3 Hours
Modeling approaches for composite systems; phase change in conduction-dominant heat transfer systems; analysis of complex source terms in conduction systems; conduction physics at material interfaces; coupled thermo-mechanical response in conduction systems; and solution techniques for multidimensional, unsteady conduction phenomena.

M E 381R.2 Advanced Convective Heat and Mass Transfer 3 Hours
Fundamental study of momentum, energy, and mass transport in convective systems in laminar and turbulent regimes, and several flow configurations.

M E 381R.3 Radiation Heat Transfer 3 Hours
Thermal radiation, blackbody properties, surface properties, radiant exchange, absorbing and emitting media, combined modes.

M E 381R.4 Fundamentals of Heat and Mass Transfer 3 Hours
Fundamentals of conduction, convective heat transfer, diffusive and convective mass transfer, thermal radiative exchange.

M E 381R.5 Radiation in Participating Media 3 Hours
Methods for treating thermal radiation in absorbing, transmitting, and scattering media.

M E 381R.6 Multiphase Flow and Heat Transfer 3 Hours
Heat, mass, and momentum transfer in multi-phase flow systems: flows with particles, drops and bubbles, boiling, condensation, and absorption.

M E 381R.7 Nanoscale Energy Transport and Conversion 3 Hours
Nanoscale transport phenomena and energy conversion processes. Parallel theoretical treatment of transport and conversion processes of electrons, phonons, photons, and molecules in various applications including photovoltaic and thermoelectric energy conversions, microelectronics, nanomaterials, and laser materials processing.

M E 381R.8 Microelectronics Packaging and Thermal Management 3 Hours
Explore basics of semiconductor fabrication, microelectronics packaging techniques, thermomechanical issues in packaging, reliability-related aspects in packaging, thermal management conditions, Conduction-based cooling, air and liquid cooling, phase change-based cooling, role of packaging materials. Discuss challenges and solutions at multiple length scales, from transistors (nanometers) to data centers (10's of meters).

M E 382N Topics in Computational Fluid Dynamics 3 Hours
Numerical analysis applied to fluid flow and heat transfer problems.

M E 382N.1 Introduction to Computational Fluid Dynamics 3 Hours
Applied numerical analysis, including solution of linear algebraic equations and ordinary and partial differential equations; modeling of physical processes, including fluid flow and heat and mass transfer; use of general-purpose computer codes, including commercial computational fluid dynamics software.

M E 382N.2 Computational Methods for Thermal Fluid Systems 3 Hours
Introduction to the use of computational tools in the analysis of thermal-fluid systems, with particular emphasis on verification of results and error analysis. Included are interpolation, differentiation, quadrature, solution of linear and non-linear equations, optimization, differential equations and statistics.

M E 382P Topics in Experimental Thermal/Fluid Systems 3 Hours
Use of modern experimental techniques and instrumentation in the thermal/fluid sciences.

M E 382P.1 Advanced Experimental Methods for Thermal/Fluid Systems 3 Hours
Design of experiments; fundamentals of electronic signal processing and optics; advanced experimental techniques, including flow measurements with laser-Doppler velocimetry, particle image velocimetry, and hot-wire anemometry; and thermal measurements with infrared cameras and thermocouples.

M E 382P.2 Optics and Lasers 3 Hours
Fundamentals of geometric and physical optics; interaction of light with matter; spectroscopy; and laser and electro-optics applications.

M E 382Q Topics in Design of Thermal and Fluid Systems 3 Hours

M E 382Q.2 Solar Energy System Design 3 Hours
Solar radiation, solar collectors, storage, and system analysis and design. Application to both thermal and photovoltaic systems.

M E 382Q.3 Advanced Thermo-Fluid Systems 3 Hours
Project-based course addressing the design and analysis of systems in which thermal and fluid processes are central to function and performance. Advanced topics including transient system analysis, multicomponent nonreacting and reacting gas mixtures, phase change phenomena, and design principles based on entropy generation minimization are covered in the context of specific thermal-fluid applications.

M E 382Q.4 Energy Technology and Policy 3 Hours
Multidisciplinary overview of energy technologies, fuels, environmental impacts, and public policies. Quantitative engineering analysis in energy, including the differences among fuels and energy technologies, the electricity sector, liquid fuels, conventional fuels, renewable fuels, impacts on the environment, basics of atmospheric chemistry, and water use for power plant cooling. Energy policy and the societal aspects of energy, such as culture, economics, war, and international affairs, are covered.

M E 382R Topics in Combustion 3 Hours
Fundamentals of combustion science, technology, and engineering.

M E 382R.1 Fundamentals of Combustion 3 Hours
Combustion phenomena are examined from a fundamental perspective. Topics include equilibrium phenomena, chemical kinetics, explosions, detonations, and premixed and diffusion flames.

M E 382R.2 Chemical Kinetics 3 Hours
The theory of combustion chemistry. Issues include physics of molecular interactions, the explosion peninsula, elementary reaction schemes, reduced reaction schemes, and global chemistry.

M E 382R.5 Advanced Combustion 3 Hours
Presentation and analysis of multi-component and reacting conservation equations; examination of the theory of laminar flames (premixed and nonpremixed) using asymptotic methods; detailing of ignition and extinction phenomena; discussion of flame response to transport and flow modifications; and approaches to analyzing turbulent premixed and nonpremixed flames.

M E 382R.6 Combustion Engine Processes 3 Hours
Principles of internal combustion engines, fuels, carburetion, combustion, exhaust emissions, knock, fuel injection, and factors affecting performance.

M E 382T Fire Science 3 Hours
Analysis of dynamics and consequences of fire in structures. Topics include combustion thermochemistry, premixed and diffusion flames, fluid mechanics of fire, human tenability in burning structures, computer modeling of fires.

M E 383D Theory and Design for Mechanical Sensing and Measurements 3 Hours
Explore fundamental aspects of measurement systems: sensing, signal processing, experimental methods, uncertainty analysis, detection, and estimation.

M E 383M Heat Transfer in Industrial Systems 3 Hours
Provides understanding of heat transfer physics and the tools to analyze a wide range of industrially relevant heat transfer problems. Analyzes heat transfer systems associated with a diversity of industrial applications, as well as how to use order of magnitude analysis to simplify complex problems and solution techniques for the three modes of heat transfer.

M E 383Q Topics in Analysis of Mechanical Systems 3 Hours
Detailed studies in the characteristics of mechanical systems.

M E 383Q.1 Vibrations 3 Hours
Formulation of discrete and continuous models for mechanical systems in vibration; modal analysis; analytical solution methods for constant property linear systems; numerical solution methods.

M E 383Q.10 Modeling and Simulations of Multienergy Systems 3 Hours
Methods for modeling and simulation of multienergy systems. Detailed study of applications in electromechanical systems, fluid power, chemical and biological processes, optimal control, and other areas of interest to the class.

M E 383Q.2 Dynamics of Mechanical Systems 3 Hours
Advanced dynamics, including Newton-Euler, Lagrange, and Hamilton's principles; gyroscopic effects in mechanical systems; analysis of stability of systems; continuous bodies; introduction to Hamilton-Jacobi.

M E 383Q.4 Modeling of Physical Systems 3 Hours
Development of models for mechanical, electrical, fluid, thermal, and chemical systems; circuit techniques; bond graphs; energy and variational methods; hardware examples.

M E 383Q.5 Wave Propagation 3 Hours
Fundamentals of wave propagation; transverse waves on strings and membranes; compressional, torsional, and flexural waves in rods and plates; longitudinal, shear, and surface waves in elastic media; tube waves; and water waves.

M E 383Q.6 Fourier and Spectral Analysis in Dynamic Systems 3 Hours
Fourier transformations (series, integrals, fast Fourier transforms) and their relationships. Sampling, aliasing, convolution, correlation, leakage, windowing, power spectra, frequency response functions, and coherence functions in one-dimensional digital signal processing. Cepstrum analysis, Hilbert transforms. Experimental techniques and applications include modal analysis, mechanical signature analysis, and path identification.

M E 383Q.8 Digital Signal Processing 3 Hours
Sampling and quantizing processes; analog/digital and digital/analog conversion; digital Fourier analysis, including fast Fourier transform; z transform; design of finite impulse response and infinite impulse response digital filters.

M E 383Q.9 Applied Intelligence for Engineers 3 Hours
Fundamental concepts of artificial neural systems; architecture, paradigms, topology, and learning algorithms. Introduction to the most popular networks and to their selection for engineering applications.

M E 383S Topics in Lubrication, Wear, and Bearing Technology 3 Hours
Theory of friction and wear; design of bearing systems, including hydrodynamic, rheodynamic, and direct contact devices.

M E 383S.1 Friction and Wear of Materials 3 Hours
Theories of friction, theories of wear (adhesion, delamination), pitting, spalling, fretting, and galvanic corrosion.

M E 384D Intermediate Dynamics 3 Hours
Focus on efficient formulation and solution of equations of motion for complex 3D multi-body mechanical systems. Explore the formulation of the dynamical equations of motion using Kane's Method and use of symbolic and numerical simulation techniques to solve these equations.

M E 384E Topics in Electromechanics 3 Hours

M E 384M Fluid Mechanics in Industrial Processes 3 Hours
Offers practicing engineers and technology managers a comprehensive treatment of various fluid mechanics topics. Explores fluid flow and related phenomena in multiple application spaces. Benefit the design and analyses of various fluid-based systems.

M E 384N Topics in Acoustics 3 Hours

M E 384N.1 Acoustics I 3 Hours
Plane waves in fluids; transient and steady-state reflection and transmission; lumped elements; refraction; strings, membranes, and rooms; horns; ray acoustics; absorption and dispersion.

M E 384N.2 Acoustics II 3 Hours
Spherical and cylindrical waves, radiation and scattering, multipole expansions, Green's functions, waveguides, sound beams, Fourier acoustics, Kirchhoff theory of diffraction, and arrays.

M E 384N.3 Electromechanical Transducers 3 Hours
Modeling, analysis, and design of transducers for reception and transmission of acoustic and vibration signals; dynamics of coupled electrical, mechanical, and acoustical systems; and the effects of transducer characteristics on fidelity and efficiency of transduction.

M E 384N.4 Nonlinear Acoustics 3 Hours
Waveform distortion and shock formation, harmonic generation and spectral interactions, effects of absorption and dispersion, parametric arrays, Rankine-Hugoniot relations, weak shock theory, numerical modeling, radiation pressure, and acoustic streaming.

M E 384N.5 Underwater Acoustics 3 Hours
Acoustic properties of the ocean; acoustic propagation, reflection, reverberation, scattering and target strength; ocean noise; introduction to array and signal processing; basics of sonar design.

M E 384N.6 Architectural Acoustics 3 Hours
Human perception of sound, principles of room acoustics, sound-absorptive materials, transmission between rooms, and acoustical design of enclosed spaces.

M E 384N.7 Ultrasonics 3 Hours
Acoustic wave propagation in fluids, elastic solids, and tissue; transducers, arrays, and beamforming; nondestructive evaluation; and acoustical imaging.

M E 384N.8 Wave Phenomena 3 Hours
Fourier acoustics and angular spectra; nearfield acoustical holography; Fraunhofer, Fresnel, and parabolic approximations; sound beams; Green's functions; Born approximation; propagation and scattering in moving, periodic, and random media.

M E 384N.9 Acoustic Metamaterials 3 Hours
Examine wave propagation in heterogeneous media displaying nonclassical effective properties. Introduction to effective medium theories including fundamental limits on effective properties, transmission and scattering matrices, waves in periodic media, localized resonance, and transformation acoustics.

M E 384Q Topics in Design of Control Systems 3 Hours

M E 384Q.1 Introduction to Modern Control 3 Hours
State variable methods, eigenvalues, and response modes; controllability, observability, and stability; calculus of variations; optimal control; Pontryagin maximum principle; control of regulator and tracking servomechanisms; Hamilton-Jacobi, dynamic programming; deterministic observers, Kalman filter; discrete and continuous time.

M E 384Q.10 Real-Time Control System Labs 3 Hours
Conduct design, implementation, hands-on experiments, and analysis of real-time estimation and control algorithms for physical systems.

M E 384Q.11 Estimation and Control of Ground Vehicle Systems 3 Hours
Examine advanced control and estimation systems for ground vehicle propulsion, chassis, and automation systems. Discuss combinations of physical insight into ground vehicle systems with control and estimation methods.

M E 384Q.12 Digital Control 3 Hours
Explore the concepts of sampling and discrete-time signals/systems; analysis of discrete-time systems; design of discrete-time controllers, including input/output approaches, polynomial methods, state space techniques, and linear quadratic optimal control design. Examine understanding of computer controlled systems, construction of discrete-time models, analysis of the open loop and closed-loop behavior, and design of digital control algorithms.

M E 384Q.2 Nonlinear Control Systems 3 Hours
State space formulation; stability criteria; Liapunov functions; describing functions; signal stabilization; Popov and circle criteria for design.

M E 384Q.3 Time-Series Modeling, Analysis, and Control 3 Hours
Methods for analytical modeling, analysis, prediction, and control of linear, stationary time series. Includes examples of advanced research in nonstationary time-series modeling and applications in manufacturing, financial engineering, geosciences, and other areas. Students complete a project on a topic of their choice.

M E 384Q.4 Automatic Control System Design 3 Hours
Examine feedback principles; control components; industrial compensators; Routh, Nyquist, Bode, and root locus methods; controller design; continuous and discrete time control.

M E 384Q.7 Stochastic Systems, Estimation, and Control 3 Hours
Probability and random variables; filtering theory; stochastic calculus; stochastic control; engineering applications; linear and nonlinear systems; spectral techniques.

M E 384Q.8 Propulsion Systems and Controls 3 Hours
Study principles, modeling, analysis, system integration, control, and diagnosis of diverse ground vehicle propulsion and driveline systems.

M E 384Q.9 Advanced Vehicle Powertrain Systems and Control 3 Hours
Explore the basic concept of vehicle powertrain systems and controller design, and discuss state of the art vehicle powertrain development. Examine modeling of system dynamics, and applying modern control strategies to achieve the desired system performance.

M E 384R Topics in Robotics 3 Hours

M E 384R.1 Robotics and Automation 3 Hours
Component technologies for precision machines based on dynamic modeling and motion programming: cams, linkages, planar manipulators.

M E 384R.2 Design of Smart Mechanisms 3 Hours
Design of reprogrammable multiple-degree-of-freedom architectures. The course addresses various mechanical configurations and stresses the integrated design approach to sensing/actuation/control architecture and control software. Includes design project.

M E 384R.3 Advanced Dynamics of Robotic Systems 3 Hours
Treatment in depth of the dynamics of robotic systems. Discussion of modeling, analysis, and control of conventional serial robots, in-parallel manipulators, dual arms, and legged locomotion systems.

M E 384R.4 Geometry of Mechanisms and Robots 3 Hours
Advanced topics in theoretical kinematics geometry: applications of screw system theory to the study of motion and force fields in spatial mechanisms and robotic systems; analytical and numerical schemes associated with kinematics geometry.

M E 384R.5 Planar Mechanism Synthesis 3 Hours
Design of planar mechanisms for applications that require rigid body guidance, function generation, and path generation. Graphical and analytical techniques. Computer-aided design projects.

M E 384R.7 Brain, Body, and Robotics 3 Hours
Examine computational models of brain control of human movement. Explore the roles of sensors, actuators, and neural circuits for biological movement control from an engineering perspective. Study current approaches to robotic and mechatronic devices that support and enhance human movements. Develop and test prototypes for robot modules that interact with the human body while studying the latest literature in neuromuscular controls, neuromotor recovery, and design and control of rehabilitation robots.

M E 384R.8 Algorithms for Sensor-Based Robotics 3 Hours
Use advanced mathematical concepts in linear algebra and optimization to develop applied algorithms for robotic systems utilizing various imaging modalities and sensors. Explore all phases of kinematics/dynamics modeling, preparation, motion planning, and execution. Examine examples of such algorithms in various areas including, but not limited to, robotic surgery, mobile robotics, manipulation, and human-machine interaction systems.

M E 384R.9 Haptics and Teleoperated Systems 3 Hours
Examine theory, analysis, and application of a variety of haptic and teleoperated systems, particularly in robotics and consumer electronics.

M E 385J Topics in Biomedical Engineering 3 Hours

M E 385J.1 Cell and Tissue Anatomy and Physiology for Engineers 3 Hours
An overview of cellular biology, including functional cellular anatomy, DNA replication and the cell cycle, protein synthesis, membrane structure and function, energy metabolism, cellular homeostasis, and cell repair and death; and functional anatomy and physiology of the basic tissues.

M E 385J.10 Biomedical Application of Transport Phenomena 3 Hours
Investigates radioisotopic methods for biological transport, including theory and experiments. Investigates artificial organ systems with clinical laboratory experiments to augment theory presented in lectures.

M E 385J.11 Biomedical Engineering Hospital Interfaces 3 Hours
Students gain firsthand knowledge of the instrumentation, procedures, and organization of a modern hospital. Class sessions are held in the different clinical services and laboratories of the hospital.

M E 385J.12 Biomedical Heat Transfer 3 Hours
Heat transfer in biological tissue; determination of thermodynamic and transport properties of tissue; thermal effects of blood perfusion; cryobiology; numerical modeling methods; clinical applications.

M E 385J.13 Molecular Recognition in Biology and Biotechnology 3 Hours

M E 385J.15 Biosignal Analysis 3 Hours
Theory and classification of biological signals such as EEG, EKG, and EMG. Data acquisition and analysis procedures for biological signals, including computer applications.

M E 385J.16 Laser-Tissue Interaction: Optical 3 Hours
The optical behavior of random media such as tissue in interaction with laser irradiation. Approximate transport equation methods to predict the absorption and scattering parameters of laser light inside tissue. Port-wine stain treatment; cancer treatment by photochemotherapy; and cardiovascular applications.

M E 385J.17 Biomedical Instrumentation II: Real-Time Computer-Based Systems 3 Hours
Design, testing, patient safety, electrical noise, biomedical measurement transducers, therapeutics, instrumentation electronics, and microcomputer interfaces. Several case studies are presented.

M E 385J.18 Biomedical Image Processing 3 Hours
Physical principles and signal processing techniques used in thermographic, ultrasonic, and radiographic imaging, including image reconstruction from projections such as CT scanning, MRI, and millimeter wave determination of temperature profiles.

M E 385J.2 Organ System Anatomy, Physiology, and Pathology for Engineers 3 Hours
The functional anatomy and physiology of the major human organ systems; representative pathologic disorders associated with these organs. An overview of general pathologic processes, with emphasis on the influences of normal and abnormal organ anatomy, physiology, and disease on the definition and solution of biomedical engineering problems.

M E 385J.20 Network Thermodynamics in Biophysics 3 Hours
Modeling and simulation methods for nonlinear biological processes, including coupling across multienergy domains; practical implementation by bond graph techniques.

M E 385J.23 Optical Spectroscopy 3 Hours
Measurement and interpretation of spectra: steady-state and time-resolved absorption, fluorescence, phosphorescence, and Raman spectroscopy in the ultraviolet, visible, and infrared portions of the spectrum.

M E 385J.24 Rehabilitation Engineering 3 Hours
Explores use of robotic devices in physical therapy for neuromuscular injury. Clinicians lecture each week on a specific malady, followed by critical review of the literature of that malady from the perspective of rehabilitation engineering. Shadows therapists and develops a prototype of a device for therapy, assistance or diagnosis of patients, or conducts an experiment to test a hypothesis in the field using a device.

M E 385J.26 Therapeutic Heating 3 Hours
Engineering aspects of electromagnetic fields that have therapeutic applications: diathermy (short wave, microwave, and ultrasound), electrosurgery (thermal damage processes), stimulation of excitable tissue, and electrical safety.

M E 385J.27 The Biotechnology Revolution and Engineering Ethics 3 Hours
The history and status of genetic engineering; potential applications in medicine, agriculture, and industry; ethical and social issues surrounding the engineering of biological organisms; ethics in engineering practice in physical and biological realms.

M E 385J.28 Noninvasive Optical Tomography 3 Hours
Basic principles of optical tomographic imaging of biological materials for diagnostic or therapeutic applications. Optical-based tomographic imaging techniques including photothermal, photoacoustic, and coherent methodologies.

M E 385J.29 Transport Processes in Biological Systems 3 Hours
Introduction to engineering analysis of transport phenomena in living systems, including fluid flow, heat transfer, pharmacokinetics, and membrane fluxes with clinical applications.

M E 385J.3 Bioelectric Phenomena 3 Hours
Examines the physiological bases of bioelectricity and the techniques required to record bioelectric phenomena both intracellularly and extracellularly; the representation of bioelectric activity by equivalent dipoles and the volume conductor fields produced.

M E 385J.30 Introduction to Biomechanics 3 Hours
Modeling and simulation of human movement; neuromuscular control; computer applications; introduction to experimental techniques.

M E 385J.31 Biomedical Instrumentation I 3 Hours
Application of electrical engineering techniques to analysis and instrumentation in biological sciences: pressure, flow, temperature measurement; bioelectrical signals; pacemakers; ultrasonics; electrical safety; electrotherapeutics.

M E 385J.32 Projects in Biomedical Engineering 3 Hours
An in-depth examination of selected topics, such as optical and thermal properties of laser interaction with tissue; measurement of perfusion in the microvascular system; diagnostic imaging; interaction of living systems with electromagnetic fields; robotic surgical tools; ophthalmic instrumentation; noninvasive cardiovascular measurements.

M E 385J.33 Neurophysiology/Prosthesis Design 3 Hours
The structure and function of the human brain. Discussion of selected neurological diseases in conjunction with normal neurophysiology. Study of neuroprosthesis treatments and design philosophy, functional neural stimulation, and functional muscular stimulation.

M E 385J.34 Biopolymers and Drug/Gene Delivery 3 Hours
Introduction to different classes of biopolymers. Biodegradability and biocompatibility. Interaction of cells and tissues with polymers and polymeric implants; immunology of biomaterials. Applications of polymers in medicine and biology. Gene therapy and generic immunization. The use of biopolymers and drug/gene delivery in organ regeneration and tissue engineering.

M E 385J.35 Rehabilitation Robotics and Engineering 3 Hours
Explores the use of robotic devices to support the strength of patients and therapists, quantitatively diagnose impairment, and augment function. Critically review the literature in rehabilitation engineering from both robotics and scientific perspectives. Students also shadow therapists and develop a prototype of a device for therapy, assistance or diagnosis of patients, or conduct an experiment to test a hypothesis in the field using a device.

M E 385J.36 Modeling and Simulation of Human Movement 3 Hours
Examine a synthesis of neuromusculoskeletal properties and interactions with the environment to construct detailed musculoskeletal models and computer simulations that allow for the investigation of various aspects of human movement. Explore a review of rigid-body dynamics, inverse and forward dynamic analyses, muscle physiology and models, musculoskeletal anthropometrics, muscle induced acceleration and segment power analyses, contact models, optimal control, muscle force distribution solutions, and simulation applications.

M E 385J.5 Cardiovascular Dynamics 3 Hours
Anatomy, physiology, pathophysiology, and dynamics of the cardiovascular system, with emphasis on the design and application of electrical and mechanical devices for cardiac intervention.

M E 385J.9 Laser-Tissue Interaction: Thermal 3 Hours
The thermal response of random media in interaction with laser irradiation. Calculation of the rate of heat production caused by direct absorption of the laser light, thermal damage, and ablation.

M E 385M Applied Thermodynamics 3 Hours
Addresses the design and analysis of systems in which thermodynamic processes are central to function and performance. Reviews fundamental thermodynamic concepts, such as enthalpy, entropy, exergy, 1st & 2nd law, psychrometrics and combustion. Discusses practical topics, such as system-level thermodynamic processes for automotive engines, power plants, renewable energy production and HVAC systems. Gives real-world examples to cultivate skills of solving problems with basic knowledge of thermodynamics.

M E 386M Modeling, Simulation, and Control of Physical Systems 3 Hours
Reviews principles used to understand and model physical systems and introduces methods for building mathematical and simulation models of engineering systems. Emphasis on the development of dynamic system models for predicting the behavior or performance of systems, models for efficient data reduction or test development, models for design, and the role of models in control development. Bond graph methods are introduced especially for analysis of systems having combinations of mechanical, electrical, magnetic, electromechanical, fluid, and thermodynamic effects. Covers the role and application of physical models in development and design of feedback controllers and estimation methods.

M E 386P Topics in Materials Science: Fundamentals 3 Hours

M E 386P.1 Introduction to Phase Transformations 3 Hours
Basics of crystal structures and phase diagrams; diffusion; solidification; solid-state phase transformations.

M E 386P.2 Mechanical Behavior of Materials 3 Hours
Elastic deformation; viscoelasticity; yielding, plastic flow, plastic instability; strengthening mechanisms; fracture, fatigue, creep; significance of mechanical properties tests. Microstructural mechanisms and macroscopic behavior of metals, polymers, ceramics, and composites.

M E 386P.3 Introduction to Thermodynamics of Materials 3 Hours
Thermodynamic properties; reactions and chemical equilibrium in gases; solutions, phase equilibria, phase diagrams, reaction equilibria; surfaces and interfaces; point defects in crystals.

M E 386P.4 Introduction to Solid-State Properties of Materials 3 Hours
Introduction to the electronic, magnetic, and optical properties of materials. Solid-state properties of metals, semiconductors, and ceramics; fundamental concepts needed for the description of these properties, using an introductory-level description of the electronic structure of solids.

M E 386P.5 Structure of Materials 3 Hours
Essential crystallography of lattices and structures; symmetry; elements of diffraction and reciprocal lattices; point, line, and surface defects in crystals; crystalline interfaces; noncrystalline materials; polymers; glasses.

M E 386P.6 Kinetic Processes in Materials 3 Hours
Review of irreversible thermodynamics and rate of entropy production to define the equilibrium state of a system; derivation of mathematical expressions to describe relaxation from a constrained state to equilibrium; diffusional processes in materials; calculation of diffusion coefficients from solid-state properties; dislocations and interfaces; kinetics of phase transformations.

M E 386Q Topics in Materials Science: Structure and Properties 3 Hours

M E 386Q.1 Theory of Materials 3 Hours
Periodic behavior and the periodic table; historical approach to the principles of crystal structure; complex alloy phases; some aspects of phase stability.

M E 386Q.10 High-Temperature Materials 3 Hours
Theory and practice in use of materials for high-temperature structural applications; case-study considerations of actual problems and requirements; interactive process-microstructure-property relationships in materials development and applications of superalloys, intermetallics, composites, and ceramics; prospective trends.

M E 386Q.11 Electroceramics 3 Hours
Bonding; crystal structures; defects; phase diagrams; glass ceramics; electrical, dielectric, magnetic, and optical ceramics.

M E 386Q.14 Electrochemical Energy Materials 3 Hours
Electrochemical cells; principles of electrochemical power sources; materials for rechargeable and nonrechargeable batteries, fuel cells, and electrochemical capacitors.

M E 386Q.15 Computational Materials Science and Engineering 3 Hours
Examine theory and a hands-on tutorial for atomistic modeling of materials.

M E 386Q.16 Application Perspectives of Nanotechnology 3 Hours
Subjects include standard top-down and the state-of-the-art bottom-up nanofabrication, manipulation, and assembling techniques, commonly used characterization instruments; applications of nanomaterials in biochemical sensing based on electric, optical, magnetic and mechanical effects; flexible nanoelectronics; nanomanipulation and nanorobotics, applications of nanomaterials in Nanoelectromechanical System (NEMS) devices, bioMEMS, and microfluidics. Emphasis on oral and written scientific communication skills.

M E 386Q.17 Failure Analysis 3 Hours
Introduction to methodology of analyzing failures of engineering parts and devices. Explores a broad range of analysis, but the focus is on understanding fractography and relating this back to material and mechanics relevant to failure to determine the likely root cause(s). Lectures are primarily based on case studies and are supplemented by two hands-on class projects, one performed individually and the other larger project performed as a team project.

M E 386Q.18 Advanced Numerical Methods: Theory and Practice 3 Hours
Apply the theory behind numerical simulation, optimization of electrochemical engineering, and other engineering models described by nonlinear differential, differential-algebraic, and partial differential equations. Explore a self-contained, fundamental and practical approach to the theory, algorithm development, and implementation relevant to engineering systems, in particular for electrochemical systems, and batteries.

M E 386Q.19 Nanotechnology for Sustainable Energy 3 Hours
Explore an overview of emerging nanotechnology and how nanoscience can critically impact many energy technologies (from energy harvesting, conversion, to storage). Examine various types of energy devices covered, including solar cell, solar fuel, piezoelectrics, thermoelectrics, battery, supercapacitor, and fuel cell. Discuss basic device principles, current technology status, and new opportunities of nanotechnology for energy-related applications.

M E 386Q.2 Phase Diagrams 3 Hours
Phase equilibria in materials systems; systematic treatment of unary, binary, and ternary phase diagrams.

M E 386Q.20 Polymer Nanocomposites 3 Hours
Explore an overview of key technologies and processes in polymer nanocomposites. Examine a different property (structural, mechanical, thermal, flammability, ablation, and electrical) and relevant commercial and industrial applications. Discuss examples for a wide variety of usage for spacecraft and defense vehicles, medical and dental implants, flame-retardant and conductive polymers for additive manufacturing, and fire-resistant woven and nonwoven fabrics.

M E 386Q.23 Structural Ceramics 3 Hours
Explore microstructure-mechanical property relationships in ceramics; principles of fracture mechanics, and static and dynamic fracture; static and cyclic fatigue; high-temperature behavior; strengthening and toughening mechanisms in monolithic ceramics; and particulate and fibrous ceramic composites.

M E 386Q.3 Fracture of Structural Materials 3 Hours
Microscopic and macroscopic aspects of ductile and brittle fracture; fracture mechanisms and fracture prevention.

M E 386Q.4 Physical Metallurgy of Steels 3 Hours
The iron-carbon system; transformations and structures of steels; properties of pearlite, bainite, and martensite; tempering; hardenability and the effect of alloying elements.

M E 386Q.7 Composite Materials 3 Hours
The theory of structural composite materials, their physical and mechanical properties; processing associated with metal-ceramic-polymer composites.

M E 386Q.9 Crystalline and Composite Anisotropy 3 Hours
Mathematical analysis of anisotropic materials, including single crystals, laminate composites, and deformation-hardened metals. Topics include thermal and electrical conductivity, diffusivity, thermal expansion, elasticity, and yielding.

M E 386R Topics in Materials Science: Physical and Electronic Properties 3 Hours

M E 386R.1 Localized versus Itinerant Electrons in Solids 3 Hours
Description of electrons, from free atoms to crystals; band theory contrasted with crystal-field theory; evolution of electronic properties on passing from magnetic insulators to normal metals, from ionic to covalent solids, from single-valent compounds to mixed-valent systems; electron-lattice interactions and phase transitions; many examples.

M E 386R.2 Localized-Electron Phenomena 3 Hours
Analysis of the variation in physical properties versus chemical composition of several groups of isostructural transition-metal compounds.

M E 386R.3 Transport Properties of Transition-Metal Oxides 3 Hours
Electronic and ionic transport in transition-metal oxides as they relate to battery cathodes, solid oxide cells, spin electronics, thermistors, and high-temperature superconductors.

M E 386R.4 Nanophotonics and Machine Learning 3 Hours
Explore recent trend of applying artificial intelligence (AI) techniques, especially machine learning, to specific tasks which has revolutionized many research subjects in different fields. Examine the fundamentals of the most important concepts from both sides, such as deep neural networks that has been used to design and decode nanophotonic devices, and metasurfaces and photonic circuits that can perform optical computing.

M E 386S Topics in Materials Science: Microelectronics and Thin Films 3 Hours

M E 386S.1 Thin Films and Interfaces 3 Hours
Application of thin films and interfaces in microelectronics; basic properties, deposition techniques, microstructures and defects, diffusion characteristics; materials reaction in thin films and at interfaces.

M E 386S.2 Metallization and Packaging 3 Hours
Technology requirements and trends, impact of device scaling, multilayered interconnect structures, Schottky and ohmic contacts, contact reactions, silicide properties and applications, electromigration, thermal/mechanical properties, reliability.

M E 386S.3 Materials for Semiconductor Packaging and Heterogeneous Integration 3 Hours
Explore the process of integrating separately manufactured components into a higher-level assembly. Examine how materials play a critical role in protecting the chips, ensuring reliable operation, efficient thermal management, and for the development of smaller, lighter, and more powerful devices. Focus on materials for package substrates, thermal interface materials, materials for interconnects and for encapsulation, and materials for thermal management and immersion cooling, as well as novel materials that are currently under development.

M E 386T Topics in Materials Science: The Design of Technical Materials 3 Hours
The process of designing a material for a specific engineering function as illustrated for various materials.

M E 386T.1 Ionic Conductors 3 Hours

M E 386T.2 High-Temperature Superconductors 3 Hours

M E 386T.3 Catalytic Electrodes 3 Hours

M E 386T.4 Magnetic Materials 3 Hours

M E 386T.5 Battery Systems Engineering 3 Hours
Explore the development of models and algorithms to analyze, optimize, and improve the performance of batteries. Discuss the mathematical formulation for predicting the performance of batteries using physics-based models. Examine a self-contained, fundamental approach to modeling, analysis, operation, and control of batteries.

M E 387M Applied Dynamics and Feedback Control 3 Hours
Provides advanced tools for describing and controlling the motion of dynamical systems. Studies how to apply Newton's Second Law as well as Lagrange's equations to find equations of motion. Emphasis on rigid body dynamics as well as motion constraints arising in complex systems. Examines fundamental concepts in both the time and frequency domains to develop feedback controllers and thus advance from open loop simulation of dynamic systems to closed loop control. Introduces common control strategies and tools for designing and testing control systems. Uses MATLAB extensively throughout the course, and emphasizes applications to realistic systems, simulations and numerical solutions.

M E 387Q Topics in Materials Science: Thermodynamics and Kinetics 3 Hours

M E 387Q.1 Diffusion in Solids 3 Hours
Atomic mechanisms and phenomenological basis for transport by diffusion.

M E 387Q.2 Kinetics and Phase Transformations 3 Hours
Nucleation and growth, spinodal decomposition, transformations in alloy systems.

M E 387Q.3 Solidification 3 Hours
Liquid to solid transformations in pure materials, alloys and eutectics; applications such as zone refining, composites, and castings.

M E 387Q.4 Corrosion 3 Hours
Electrode kinetics and the theory of polarization, passivity, galvanic coupling, and high temperature oxidation.

M E 387Q.5 Thermodynamics of Materials 3 Hours
First and second laws, fugacity, activity, chemical equilibrium, phase diagrams, and introductory statistical concepts.

M E 387Q.6 Statistical Thermodynamics of Materials 3 Hours
Quantum mechanics applied to partition functions of condensed and gaseous phases; chemical equilibria; phase transitions; and lattice statistics including the Ising model.

M E 387Q.7 Group Theory and Phase Transformations 3 Hours
Symmetry principles and the associated mathematics applied to the description of condensed phases and their transformations.

M E 387R Topics in Materials Science: Experimental Techniques 3 Hours

M E 387R.1 Nondestructive Testing 3 Hours
Acoustic emission, ultrasonic, eddy current, dye penetrant, and magnetic methods.

M E 387R.3 Electron Diffraction and Microscopy 3 Hours
Transmission electron microscopy, kinematic electron diffraction theory, reciprocal lattice, defect analyses, scanning electron microscopy.

M E 387R.4 Advanced Electron Microscopy Theory and Techniques 3 Hours
Scanning transmission electron microscopy, microanalysis techniques, dynamical diffraction theory, convergent beam diffraction.

M E 387R.5 Materials Characterization Techniques 3 Hours
Classification and selection of characterization techniques: principles and applications of diffraction, spectroscopic, quantitative chemical analysis, thermal analysis, and transport and magnetic measurement techniques.

M E 387R.6 High-Resolution Transmission Electron Microscopy Techniques 3 Hours
Theory and practice of high-resolution phase contrast electron microscopy. Computer simulation of images and diffraction patterns.

M E 387R.7 Scanning Electron Microscopy 3 Hours
Theory and practice of scanning electron microscopy; image formation, elemental analysis, sample preparation, and electron-sample interactions.

M E 387R.8 Practical Electron Microscopy 3 Hours
Principles, operation, and techniques of transmission electron microscopy; acquiring and interpreting imaging, diffraction, and spectroscopy information; and hands-on experience with a transmission electron microscope.

M E 387R.9 Advanced Methods for Surface Analysis 3 Hours
Examine the principles and operation of X-ray photoelectron spectroscopy (XPS) and atomic force microscopy (AFM). Explore state-of-the-art methods for acquiring, processing and interpreting the analytical results. Perform hands-on experiments on XPS and AFM followed by data evaluation and interpretation.

M E 387S Topics in Materials Processing 3 Hours

M E 387S.2 Processing of Materials 3 Hours
Principles, advantages, and problems of solid, liquid, and vapor materials processes; considerations of structural alloys, ceramics, engineering polymers, and composites.

M E 387S.3 Powder Processing 3 Hours
Synthesis of powders, powder characterization, powder stabilization, consolidation of powders, sintering, densification, and grain growth.

M E 388C Nuclear Power Engineering 3 Hours
Fundamental principles of the design and analysis of nuclear systems; introduction to the physics of nuclear reactions, chain reactions, and nuclear energy generation; heat generation and conduction within nuclear systems; heat transfer and fluid flow in nuclear systems; the thermodynamics of nuclear power; the nuclear fuel cycle; and issues related to the materials aspect of reactor engineering.

M E 388D Nuclear Reactor Theory I 3 Hours
Principle concepts in the physics of nuclear systems, including radiation, radioactive decay, and the buildup and depletion of isotopes in nuclear systems; neutron-nucleus interactions and nuclear cross sections; transport or radiation using one-group and two-group diffusion theory; and concepts of criticality and time dependent reactors.

M E 388E Nuclear Reactor Theory II 3 Hours
Neutron-nucleus interactions and nuclear cross section calculations; transport of radiation using neutron transport theory and multigroup diffusion theory; heterogeneous reactor calculations; the kinetics of nuclear systems; perturbation theory; and the nuclear fuel cycle.

M E 388F Computational Methods in Radiation Transport 3 Hours
Transport equation, Monte Carlo method, energy and time discretization, discrete ordinates, integral methods, and even-parity methods.

M E 388G Nuclear Radiation Shielding 3 Hours
Radiation fields/sources; techniques in neutron and photon attenuation; transport description of radiation penetration.

M E 388H Nuclear Safety and Security 3 Hours
Examine probabilistic risk assessment models and nuclear arms nonproliferation, including failure classifications; failure mode, effects, and criticality analysis (FMECA); fault and event trees; and reliability block diagrams. Discuss specific areas from the Code of Federal Regulations.

M E 388J Neutron Interactions and Their Applications in Nuclear Science and Engineering 3 Hours
The fundamental principles of neutron interactions with matter and how these interactions are used in a variety of science and engineering research areas. Includes the history of neutron research, fundamental principles, dosimetry, depth profile, radiography, activation analysis, detection, homeland security, and scattering, with a significant emphasis placed on experimental design of these neutron techniques.

M E 388M Mathematical Methods for Nuclear and Radiation Engineering 3 Hours
Fundamental mathematics used in graduate studies in nuclear and radiation engineering. Topics include statistics, experimental data, propagation of error, detection limits, and differential and partial differential equations.

M E 388N Design of Nuclear Systems 3 Hours
Integration of fluid mechanics, heat transfer, thermomechanics, and thermodynamics with reactor theory for core design.

M E 388P Applied Nuclear Physics 3 Hours
Properties of the nucleus and its structure; binding energy and nuclear stability, and the liquid drop model of the nucleus; the shell model of the nucleus; deuteron bound-state wave function and energy, n-p scattering cross section, transition probability per unit time, and barrier transmission probability; nuclear conservation laws; the energetics and general cross section behavior in nuclear reactions; interactions of charged particles, neutrons, and gamma rays with matter; and alpha, beta, and gamma decay.

M E 388S Modern Trends in Nuclear and Radiation Engineering 3 Hours
Facilitates presentations on research topics in nuclear and radiation engineering outside any research with techniques in proposal writing; or specialized laboratory courses.

M E 389C Nuclear Environmental Protection 3 Hours
Ionizing radiation and its interactions with matter and living tissues; radioactive decay kinetics; external and internal dose measurement; transportation through the environment; managing radioactive waste streams; and safeguards.

M E 389F The Nuclear Fuel Cycle 3 Hours
A survey of the nuclear fuel cycle, including resource acquisition, fuel enrichment and fabrication, spent fuel reprocessing and repository disposal. Nuclear fuel management and reactor physics are addressed in the context of fuel burn-up calculations. Uses cross-disciplinary tools such as cost-benefit and environmental impact analyses. Includes fuel cycles currently in use, advanced fuel cycle concepts currently being presented in the technical literature, and a group project designed to research, analyze, and document the technical, economic, and/or environmental ramifications of one of these advanced fuel cycles.

M E 389M Materials Processing 3 Hours
Explores the principles, advantages, and problems of solid, liquid, and vapor materials processes. Studies the considerations of structural alloys, ceramics, engineering polymers, and composites.

M E 389Q Topics in Nuclear and Radiation Engineering: Design of Systems 3 Hours
Synthesis of engineering concepts, materials specifications, and economics in the design of nuclear systems.

M E 390 Vehicle System Dynamics and Controls 3 Hours
Fundamentals of ground vehicle dynamics, tire-road mechanics, vehicle control systems, vehicle stability, and simulation of vehicle systems.

M E 390C Cyber Vehicle Systems 3 Hours
Study of the engineering principles of autonomous mobile robots. Subjects include understanding the dynamics of vehicle systems, and the principles and practical implementation of sensing, actuation, and control. Emphasis will be given to providing practical laboratory study of these subjects using mobile robot platforms, and the use of the commercial software package LabVIEW for programming of real-time data acquisition and control targets. Simulation studies may also be conducted in LabVIEW and/or the Matlab environment; some proficiency in use of both of these software packages is expected.

M E 390E Nuclear Security System Design 3 Hours
Explore the science and engineering associated with the design, evaluation, and implementation of systems to secure nuclear and radiological materials. Examine methods for planning and evaluating nuclear security activities at the state and facility level. Study the characterization of the adversary, categorization of targets and the consequences associated with failure to protect those targets, detection and delay technologies, on-site and off-site response as well as different response strategies, evaluation of insider threats, mathematical methods for evaluating risk due to the threat and the security system design, and methods for risk minimization and system optimization will also be studied.

M E 390F Nuclear Analysis Techniques 3 Hours
Thermal and fast neutron activation, scintillation and solid-state detectors, beta and gamma spectrometry, coincidence techniques.

M E 390G Nuclear Engineering Laboratory 3 Hours
Experiments using the TRIGA reactor and a subcritical assembly; measurement of reactor characteristics and operational parameters.

M E 390M The Enterprise of Technology 3 Hours
Uses early stage technologies to create new and original commercialization plans which include the best first market, establishing technology features in that market, and estimated benefits and costs to deliver a future product to a customer. Includes in-person market research, a written semester journal, and engagement with multiple projects. Reviews later stages of technology entrepreneurship; includes forming a new company, building a business plan, building a team, getting funding, and scale up to manufacturing. Emphasis on gaining proficient knowledge on intellectual property protection and strategy, and the steps and processes necessary to the successful design and manufacture of a product or service.

M E 390N Health Physics Laboratory 3 Hours
The application of radiation and radiation protection instrumentation. Includes personnel monitoring; radiation detection systems; gamma-ray spectroscopy; determination of environmental radiation; counting statistics; and gamma and neutron shielding.

M E 390T Nuclear and Radiochemistry 3 Hours
Theory and application of nuclear and radiochemistry, including alpha, beta, and gamma ray processes; fission products; statistics; solvent extraction; absorption and teaching techniques; various counting methods; and radiation protection.

M E 390V Advanced Nuclear Engineering 3 Hours
Study radioactivity, fission reactors, nuclear power systems, nuclear power safety, and nuclear interactions: fission and fusion.

M E 390W Proposal Writing 3 Hours
Learn to write a full proposal on current research in any science or engineering discipline.

M E 391M Introduction to Manufacturing Systems 3 Hours
With an emphasis on continuous flow manufacturing, provides the knowledge and skill set to analyze and design production systems to decrease manufacturing costs, decrease defects, and shorten delivery time by reducing process cycle times.

M E 391R Artificial Intelligence Programming for Engineers 3 Hours
Provides a working knowledge of LISP and compares it with PROLOG; use of the Texas Instruments Explorer, and artificial intelligence techniques applied to engineering problems.

M E 392C Design Optimization and Automation 3 Hours
Optimization in mechanical design, including monotonicity analysis, gradient-based constrained optimization, tree-searching, and stochastic approaches.

M E 392G Topics in Computer Graphics and Computer-Aided Design 3 Hours
Studies in computer graphics and its application to design.

M E 392G.1 Introduction to Computer Graphics 3 Hours
Two- and three-dimensional transformations, projections, and the graphics pipeline; fundamental algorithms for wire frame and hidden surface image generation; interactive techniques, geometric modeling, and realistic rendering using a standard graphics library.

M E 392G.2 Computer-Aided Geometric Design 3 Hours
Introduction to techniques for representing geometry for computer-aided engineering design. Two- and three-dimensional curve formulations, techniques from algebraic and vector geometry, implicit versus parametric definitions; and free-form surface formulation and solid modeling.

M E 392G.3 Advanced Computer-Aided Design Applications 3 Hours
Hardware and software for computer-aided design systems. Display devices, multidimensional graphics, optimization, use of artificial intelligence.

M E 392G.4 Advanced Topics in Computer-Aided Design 3 Hours
Detailed execution of an independent computer-aided design project. Projects require significant development and emphasize application of techniques from computer-aided engineering and interactive computer graphics. Lectures deal with the subject matter of the projects.

M E 392M Topics in Advanced Mechanical Design 3 Hours

M E 392M.1 Analytical Techniques in Mechanical Design 3 Hours
Analytical techniques and some computational techniques for the advanced stress and strength analysis of machine components and mechanical structures.

M E 392M.10 Computational Methods for Engineering Design 3 Hours
Examine several categories of computational methods that are useful for engineering design applications. Implement the methods on example engineering design problems.

M E 392M.11 Data-Driven Design and Decision-Making in Complex Systems 3 Hours
Explore state-of-the-art approaches for data-informed decision-making and modeling in complex systems design. Apply various data-driven and theory-driven models to model, estimate, analyze, and predict decision-making behaviors of stakeholders in representative complex engineered systems, such as air transportation networks, power grids, and market systems.

M E 392M.3 Advanced Design of Machine Elements 3 Hours
Review of basic machine elements, properties, and stresses; fluid couplings and torque converters; thermal stresses, relaxation, and beneficial residual stressing; shells and rotors; plasticity.

M E 392M.6 Engineering Design Theory and Mathematical Techniques 3 Hours
Design history and philosophy. Survey of current research areas in design theory, methodology, and manufacturing. Tools for solving engineering system design and synthesis problems. Reverse engineering design project.

M E 392M.7 Product Design, Development, and Prototyping 3 Hours
Methodology and tools for the product development process. Functional designs based on real product needs. Product design project.

M E 392M.8 Medical Device Design and Manufacturing 3 Hours
Explore how to solve medical device design problems using systematic design thinking and practices. Interpret clinical needs, define an open engineering medical device design problem, including formulating engineering requirements/specifications to address a marketable need. Generate concepts in a way that promotes both creativity and usefulness, make well-informed, well-justified design decisions in the early and later stages of design. Design and analyze experiments, follow statistical best practices in Design of Experiments(DoE), embody solutions with "Design for X" considerations, and communicate intermediate and final designs clearly and effectively in written and oral formats.

M E 392M.9 Precision Machine Design 3 Hours
Discuss modeling, design, integration and best practices for use of machine elements such as bearings, springs, gears, cams and mechanisms. Model and analyze these elements based upon extensive application of physics, mathematics, and core mechanical engineering principles (solid mechanics, fluid mechanics, manufacturing, estimation, computer simulation, etc.).

M E 392Q Topics in Manufacturing 3 Hours
Topics that cut across departmental concentrations (mechanical systems and design, metallurgy and materials engineering, operations research and industrial engineering), including design for manufacturing, manufacturing machines and manufacturing processing, and production systems.

M E 392Q.1 Introduction to Manufacturing Systems 3 Hours
Analysis and design of production systems to decrease manufacturing costs, decrease defects, and shorten delivery time by reducing process cycle times. Emphasis is on continuous flow manufacturing.

M E 392Q.10 Statistical Methods in Manufacturing 3 Hours
Statistical monitoring of manufacturing processes; methods and applications of various control charts; formal design of experiments (DOE), including the statistical evaluation of main and interaction effects, as well as intelligent experimentation through reduced factorial experimental design; Taguchi's design philosophy as applied to response surface methods and gradient-based search techniques; and advanced issues in quality control and design of manufacturing systems.

M E 392Q.11 High Throughput Nanopatterning 3 Hours
Introduction to the basic tools and materials involved in the patterning processes needed to create nano-scale structures and functional materials and discusses the relevance of these processes to applications in the electronics, display, and energy industries. Examine industry and research roadmaps that provide relevant metrics and timelines for fabrication, materials, nano-enabled components and devices. Explore novel nano-enabled components and devices using relevant computational modeling and simulation tools.

M E 392Q.12 Additive Manufacturing 3 Hours
Explore, compare, and contrast the major categories of additive manufacturing processes and examine their impact on the design of engineered parts.

M E 392Q.13 Analytics and Control in Semiconductor Manufacturing 3 Hours
Learn key data analytics and process control methods for turning metrology and sensing data into useful information and decisions in semiconductor manufacturing. Explore applications of statistical models for statistical process control, as well as applications of dynamic models for virtual metrology and run-to-run control in semiconductor manufacturing systems.

M E 392Q.14 Bioinspired Micro and Nanostructures 3 Hours
Explore the unique properties, operating principles, and applications of micro/nanostructures that are found in nature. Examine naturally occurring organisms that have unique microscopic features, giving rise to novel behavior not observed in traditional bulk materials. Discuss the design and manufacturing of these bioinspired micro/nanostructures for engineered materials, highlighting applications in renewable energy, aerospace, and next-generation electronics and display.

M E 392Q.15 Optical Engineering 3 Hours
Explore optics, with a focus on engineering applications. Review geometrical optics: ray-tracing, reflection, refraction, lens design, imaging optical systems, as well as subjects in wave optics: basic electrodynamics, scalar wave theory, interference, Fresnel and Fraunhofer diffraction, image formation, Fourier optics, and 4F systems. Examine optical systems and metrology instruments, such as the human eye, microscopes/telescopes, and interferometers. Discuss the role of optics in advanced nano/microscale manufacturing, as well as applications in more efficient solar energy systems, engineered materials, and nanotechnology.

M E 392Q.2 Computer Fundamentals for Manufacturing Systems 3 Hours
Computer graphics, computer-aided design, direct numerical control, relationship between computer-aided design and manufacturing.

M E 392Q.4 Automation and Integration of Manufacturing Systems 3 Hours
Integration of automated manufacturing components into a cohesive manufacturing system. Selection of automation strategy, communication and interaction between system components, economics and reliability of the resulting systems.

M E 392Q.5 Manufacturing Processing: Unit Processes 3 Hours
Important unit processing operations in manufacturing: cutting, drilling, and grinding metals, ceramics, composites, and polymers. Deformation processes: forming and rolling. Laser machining.

M E 392Q.6 Mechatronics I 3 Hours
Integrated use of mechanical, electrical, and computer systems for information processing and control of machines and devices. System modeling, electromechanics, sensors and actuators, basic electronics design, signal processing and conditioning, noise and its abatement, grounding and shielding, filters, and system interfacing techniques.

M E 392Q.7 Microcomputer Programming and Interfacing 3 Hours
Microcomputer architecture and programming; microcomputer system analysis; interfacing and digital control.

M E 392Q.9 Mechatronics II 3 Hours
Interfacing microcomputers with sensors and actuators; hybrid (analog/digital) design; digital logic and analog circuitry; data acquisition and control; microcomputer architecture, assembly language programming; signal conditioning, filters, analog-to-digital and digital-to-analog conversion.

M E 393M Engineering Design Innovation 3 Hours
Focuses on design methodology that includes a survey of current research in areas in design theory and methodology. Studies the tools used for solving engineering system designs and synthesis problems for application in a reverse engineering and redesign project.

M E 394M Topics in Mechanical Engineering 3 Hours
Topics in Engineering.

M E 395 The Enterprise of Technology 3 Hours
Studies the basis for assessing emerging technologies. Describes the process of technology commercialization, including identifying marketable technologies, defining products, and matching products to markets. Also studies intellectual property protection and strategy, and the steps and processes necessary to the successful design and manufacture of a product or service.

M E 395M Engineering Design and Innovation with Product Design 3 Hours
Focuses on design methodology that includes a survey of current research in areas in design theory and methodology. Designed to help students acquire tools for solving engineering system designs and synthesis problems which they can apply in a reverse engineering and redesign project.

M E 396D Decision and Control of Human-Centered Robots 3 Hours
Geared toward students who would like to use Python for their engineering careers with a focus on sharing and development of open source software applications. Emphasis on the important areas of system modeling, simulation, data analysis, and software/data management. Students create mini-projects in Python where they apply basic knowledge on software design and organization, debugging, open source practices, and data visualization. It is expected that students have some experience in programming and would like to advance to the next level.

M E 396M Materials Science and Engineering 3 Hours
An exploration of the fundamental aspects of the relationships between processing, structure, properties and performance of engineering materials. Exploration of metals, ceramics, polymers, and composites.

M E 396P Application Programming for Engineers 3 Hours
Designed for students who have some experience in programming and are interested in the sharing and development of open source software applications. Provides an introduction to the Python programming language, an open source, flexible, and intuitive debug programming language, with an emphasis on system modeling, simulation, data analysis, and software/data management. Students create mini projects in Python that demonstrate software design and organization, debugging, open source practices, and data visualization.

M E 397 Topics in Current Engineering Studies 3 Hours

M E 397.8 Energy and the Environment 3 Hours

M E 197K, 297K, 397K Topics in Graduate Seminar 1-3 Hours

M E 197K.1, 297K.1, 397K.1 Acoustics Seminar 1-3 Hours

M E 197K.2, 297K.2, 397K.2 Advanced Thermal/Fluid Seminar 1-3 Hours

M E 197K.3, 297K.3, 397K.3 Materials Engineering 1-3 Hours

M E 197K.4, 297K.4, 397K.4 Mechanical Systems and Design 1-3 Hours

M E 197K.5, 297K.5, 397K.5 Nuclear Engineering 1-3 Hours

M E 197K.6, 297K.6, 397K.6 Introductory Thermal/Fluid Seminar 1-3 Hours

M E 397M Graduate Research Internship 3 Hours
Research associated with enrollment in the Graduate Research Internship Program (GRIP).

M E 197P, 297P, 397P Projects in Mechanical Engineering 1-3 Hours
Independent project carried out under the supervision of a mechanical engineering faculty member.

M E 097S Introduction to Graduate Studies 0 Hours
Introduction to graduate studies is a first year seminar course for new graduate students that cover topics such as finding a research advisor, how to apply for fellowships, how to select a research topic, how to conduct a literature review, research methods, and research ethics.

M E 698 Thesis 6 Hours

M E 198C, 398C, 698C Engineering Teaching Practicum 1,3,6 Hours

M E 398M Introduction to Automatic Control 3 Hours
Gain a basic intuition for and understanding of linear feedback systems and develop the mathematical tools to understand the basics of design and analysis of single-input single-output feedback control systems. Builds on the system modeling skills developed in previous courses in order to better understand how to control a system's behavior.

M E 198P, 398P, 698P Topics in Engineering Teaching Practicum 1,3,6 Hours
Mentored teaching experience completed by arrangement with the instructor of record for an undergraduate engineering course. May be completed in the same semester as a Teaching Assistant or Assistant Instructor assignment with additional responsibilities.

M E 198Q, 398Q Topics in Teaching Portfolio Preparation 1,3 Hours
Project course for students completing the Graduate Certificate in Engineering Education Program to prepare a portfolio highlighting their teaching qualifications and experiences. Not recommended for students with limited teaching experience or students who are within a few years of applying for full-time employment.

M E 398R Master's Report 3 Hours
Preparation of a report to fulfill the requirement for the master's degree under the report option.

M E 398S Assessment and Curriculum Design in Engineering 3 Hours
Develop curriculum design skills in preparation for engineering faculty positions, including writing learning outcomes, assessing student learning and aligning expectations to activities and outcomes. Assessment is framed as an integrated part of course design, considers the strengths and weaknesses of a variety of quantitative and qualitative assessment strategies. Practice engineering course design and learn important considerations in coordinating department or college resources in preparation for an ABET engineering accreditation review.

M E 398T Supervised Teaching in Mechanical Engineering 3 Hours
Application of learning and motivation theories to learning in engineering contexts. Practice teaching in nontraditional formats. Preparation of a teaching philosophy. Teaching under close supervision, group meetings or individual consultations, and reports as required.

M E 399W, 699W, 999W Dissertation 3,6,9 Hours