ME - Mechanical Engineering

Courses numbered 500 to 799 = *undergraduate/graduate*. (Individual courses may be limited to undergraduate students only.) Courses numbered 800 to 999 = *graduate*.

ME 502. Thermodynamics II (3).
Continuation of ME 398, emphasizing cycle analysis, thermodynamic property relationships and psychrometrics, with an introduction to combustion processes and chemical thermodynamics. For undergraduate students only. Prerequisite(s): ME 398.

ME 521. Fluid Mechanics (3).
The definition of a fluid and the concept of a continuum. Stress and strain in a Newtonian fluid. Description and classification of fluid motions. Hydrostatic pressure and forces on submerged surfaces. Reynolds Transport Theorem and integral analysis of conservation laws. Introduction to differential analysis of fluid motion. Dimensional analysis and similitude. Study of flow in closed conduits: pressure drop in fully developed viscous flow. The boundary layer concept and lift and drag forces on immersed bodies. For undergraduate students only. Prerequisite(s): ME 335, ME 398, MATH 555; all with a minimum grade of C (2.000). Corequisite(s): ME 521L.

ME 522. Heat Transfer (3).
Introduction to the three modes of heat transfer in the context of the laws of thermodynamics; the heat equation and its application to steady conduction in one- and two-dimensions as well as to unsteady one-dimensional conduction; the thermal boundary layer, Reynolds Analogy, and the problem of convection; free and forced convection in internal and external flows; boiling and condensation; thermal radiation. Emphasizes problem solving using analytical methods approximate solutions, analogies, empirical correlations, and numerical methods. For undergraduate students only. Prerequisite(s): ME 325, ME 521 and PHYS 314; each with a minimum grade of C (2.000).

ME 533. Mechanical Engineering Laboratory (3).
Introduces the basics of engineering measurements. Discusses related theory, followed by applications in such areas as strain, sound, temperature and pressure measurements. Format includes lectures, recitation (presenting the concept of the experiment to be performed and the required data analysis), and laboratories. Analyzes the data obtained from measuring systems set up and operated in the laboratory to demonstrate and reinforce fundamental concepts of engineering mechanics. For undergraduate credit only. Prerequisite(s): ECE 282, AE 333, ME 325, ENGL 102, COMM 111, PHYS 315. Pre- or corequisite(s): ME 522. Corequisite(s): ME 533L.

ME 541. Mechanical Engineering Design II (3).
Continues on the basis of applications of engineering design principles, engineering analytical skills and failure theories, to the creative design of mechanical assemblies and equipment. Using the basics of machine design (e.g., design process, engineering mechanics and materials, failure prevention under static and variable loading), students learn to examine the safety of the structure, leading to decision making and selection of mechanical components and standard parts (e.g., shafts, bearings, fasteners, gears, springs, sprockets, breaks and clutches), according to the available standards, codes, handbooks and catalogs. Problem definition, conceptual design, feasibility studies, design calculations to obtain creative solutions for current real engineering problems, introduction to human factors, economics and reliability theory are part of the experience through group and/or individual design projects. For undergraduate students only. Prerequisite(s): ME 339 and ME 439; both with a GPA of 2.000 or above. Pre- or corequisite(s): ME 475.

ME 581. Introduction to Corrosion (3).
Presents information about basic corrosion processes, underlying principles of corrosion formations, and general protection methods. Studies basic corrosion and corrosion mechanisms, importance of corrosion, coating systems, and how the materials are protected from the corrosion formations. Concerns fundamental theory of the thermodynamics and kinetics of the corrosion process of metals and alloys as well as polymer materials both in atmosphere and water solutions. Focuses on electrochemical aspects and the influences of the properties of the metals and their oxides on the corrosion behavior, which is exemplified by different corrosion types. Existing corrosion protection strategies, including surface treatments and coatings are described and choice of material is discussed from a corrosion point of view. Prerequisite(s): ME 250 and ME 398; or instructor’s consent.

ME 602. Engineering for the Environment (3).
Basic principles of conservation of mass and chemistry as relevant to environmental processes, both natural and engineered, are reviewed. The course also covers air and water pollution, along with the major pollutants, their health effects, their sources, their transport and attainment/remediation technologies. Additional topics include solid and hazardous waste, major greenhouse gases and climate change, environmental justice, and Life Cycle Assessment. Students work in teams on a term project to perform in-depth research on an environmental problem currently in need of a solution. This course satisfies the ME departmental criteria for an ME elective, or a thermal/fluids/energy/environment elective, or an open technical elective course required for graduation. *Course includes diversity content*. Prerequisite(s): ME 398 (or CHEM 211) and MATH 243 (with a grade not lower than one that generates 2.000 or more credit points per credit hour), or instructor’s consent.

ME 625. Applications in Thermal Engineering (3).
Application of energy concepts to thermal fluid applications. Open-ended problems in incompressible and compressible fluid flows, boundary layer modeling and analogies, LMTD, heat exchangers, pumps and turbines, modeling and prototype, and gas radiation. Theoretical analysis and report preparation. For undergraduate students only. Prerequisite(s): ME 521 and ME 522; both with a GPA of 2.000 or above. Pre- or corequisite(s): ME 533.

ME 633. Mechanical Engineering Systems Laboratory (3).
Selected experiments illustrate the methodology of experimentation as applied to mechanical and thermal systems. Experiments include the measurement of performance of typical systems and evaluation of physical properties and parameters of systems. Group design and construction of an experiment is an important part of the course. Team and individual efforts are stressed as are written and oral communication skills. For undergraduate students only. Prerequisite(s): ME 522, ME 533. Corequisite(s): ME 633L.

ME 637. Computer-Aided Engineering (3).
Integrates computer-aided design, finite element analysis, kinematics analysis, heat transfer analysis and other considerations for design of mechanical components and systems. Provides a blend of theory and practice. Prerequisite(s): ME 339 and ME 439, or equivalent. Corequisite(s): ME 637L.

ME 644. Design of HVAC Systems (3).
Analysis and design of heating, ventilating and air-conditioning systems based on psychometrics, thermodynamics and heat transfer fundamentals with focus on advanced duct design for composite building, cooling load calculations and thermal-issues based psychometric. Focuses on design procedures for space air-conditioning, and heating and cooling loads in buildings. Prerequisite(s): ME 521, 522; or instructor's consent.

ME 650. Selected Topics in Mechanical Engineering (1-3).
An umbrella course created to explore a variety of subtopics differentiated by letter (e.g., 650A, 650B). Not all subtopics are offered each semester – see the course schedule for availability. Students enroll in the lettered courses with specific topics in the titles rather than in this root course. Prerequisite(s): departmental consent.

ME 651. Biomaterials (3).
Introduction to biomaterials and biotechnology for both undergraduate and graduate students focusing on biomaterials (e.g., metals and alloys, composites, polymers and ceramics), biodevices, basic fabrication and characterization techniques, and their general properties and applications. Prerequisite(s): ME 250, ME 251; or instructor's consent.

ME 659. Mechanical Control Systems (3).
Modeling and simulation of dynamic systems. Theory and analysis of the dynamic behavior of control systems, based on the laws of physics and linear mathematics. Concerns classical methods of feedback control systems and design. Prerequisite(s): (1) ECE 282 and MATH 555, or (2) ECE 383.

ME 660. Polymer Materials and Engineering (3).
Introduces the basic science and engineering of polymer materials. Provides the scientific foundation for an understanding of the relationships among material structures and properties of different types of polymer materials (thermoplastics, thermosets, synthetic fibers and rubbers, etc.) for various applications from consumer electronics to aviation industry. An understanding of these materials, processing techniques, their properties, and how they are applied in the industry. Prerequisite(s): ME 250 or CHEM 211.

ME 662. Senior Capstone Design (3).
Culminating course allows students nearing graduation to combine the knowledge and skills acquired in their program and apply them to a major project or assignment. Exercise in the practice of mechanical engineering for undergraduate students in their graduating semester; students engage in a comprehensive design project requiring the integration of knowledge gained in prerequisite engineering, science and design courses along with economic comparisons of engineering alternatives considering the time value of money, taxes and depreciation. Team effort and both oral and written presentations are a part of the experience. This course has a lab component. For undergraduate students only. Prerequisite(s): PHIL 385, ME 475, ME 522 and ME 541 with a GPA of 2.000 or better. Pre- or corequisite(s): ME 633 and ME 659.

ME 665. Selection of Materials for Design and Manufacturing (3).
Focuses on the selection of engineering materials to meet product and manufacturing requirements. Solution to various product and manufacturing problems by appropriate selection of materials is illustrated through the use of numerous examples and case studies. Prerequisite(s): ME 439.

ME 667. Mechanical Properties of Materials (3).
Major focus on deformation mechanisms and on crystal defects that significantly affect mechanical properties. Also covers plasticity theory, yield criteria for multi-axial states of stress, fracture mechanics and fracture toughness. Includes some review of basic mechanics of materials and elasticity as needed. Prerequisite(s): ME 439.

ME 670. Introduction to Nanotechnology (3).
Introduction to the underlying principles and applications of the field of nanotechnology and nanoscience. Covers basic principles of nanotechnology, nanomaterials and associated technologies and provides a background of the understanding, motivation, implementation, impact, future, and implications of nanotechnology. Focuses on processing techniques of nanoparticles, nanofibers/wires, nanotubes, nanofilms and nanocomposites using physical, chemical and physicochemical techniques, as well as their characterizations and potential commercial applications. An understanding of nanomaterials, fabrication and characterization techniques, and how they are applied in nanodevice fabrication. Material covered includes nanofabrication technology (how one achieves the nanometer length scale, from "bottom up" to "top down" technologies), the interdisciplinary nature of nanotechnology and nanoscience (including areas of chemistry, material science, physics and molecular biology), examples of nanoscience phenomena (the crossover from bulk to quantum mechanical properties), and applications (from integrated circuits, quantum computing, MEMS and bioengineering). Prerequisite(s): ME 250 and ME 398; or instructor’s consent.

ME 672. Manufacturing of Composites (3).
Provides the basis for understanding and use of composite materials in various engineering applications such as space and aerospace structures. Different classes of composite materials, the characteristics of their constituents, an introduction to micromechanics of composites, commonly used composite manufacturing techniques in detail, along with their capabilities and limitations, characterization methods, degradation, joining, tooling, machining, and recycling of composites is discussed. Contains laboratory modules designed to provide hands-on experience to emphasize the practical aspects of the topics covered. Prerequisite(s): ME 250, ME 251, AE 333; or instructor's consent. Corequisite(s): ME 672L.

ME 673. Recovery of Engineering Materials (3).
Introduces basic standards in recycling and reusing processes of different materials and the importance of recycling for the economy, health and environment. Focuses on basic separation techniques of various recyclable materials, recycled products, reprocessing, as well as characterizations and potential commercial applications in different industries. Undergraduate and graduate students are expected to gain an understanding of recycling processes, recycled materials and applications. Prerequisite(s): ME 250 and ME 398 or instructor’s consent.

ME 680. Laser Materials Processing and Design (3).
Studies laser science such as the methods, processes or products that make use of the spectrum of laser light. Covers laser processing to produce features and modify properties in metals, organic polymers, inorganic insulators, superconductors, semiconductors and biological materials on the meso/micro/nano scales. Research into laser nano/micro materials processing in electronic, opto-electronic, MEMS, medical-therapeutic and other applications. Finite volume-based software Flow 3D is part of the lab experience. Prerequisite(s): ME 398 or instructor's consent. Corequisite(s): ME 680L.

ME 680L. Laser Materials Processing and Design Lab (0).
Studies laser science such as the methods, processes or products that make use of the spectrum of laser light. Covers laser processing to produce features and modify properties in metals, organic polymers, inorganic insulators, superconductors, semiconductors and biological materials on the meso/micro/nano scales. Research into laser nano/micro materials processing in electronic, opto-electronic, MEMS, medical-therapeutic and other applications. Finite volume-based software Flow 3D is part of the lab experience. Corequisite: ME 680.

ME 702. Energy and Sustainability (3).
Cross-listed as PHYS 702. Introduces sustainability in a world of increasing population with more energy intensive lifestyles and diminishing resources; anthropogenic global climate change and the engineer's responsibilities; estimating our carbon footprint; surveys alternative energy sources with special emphasis on wind and solar energy; life cycle analysis (LCA) of engineered products; the electric grid; emissions from various transportation modes, and alternatives. Consists of traditional lectures, seminars by invited experts, and

case studies. Meets the ME undergraduate curricular requirement for thermal/fluids elective and/or a general ME elective. *Course includes diversity content*. Pre- or corequisite(s): ME 522 or PHYS 551; or instructor's consent.

ME 709. Injury Biomechanics (3).
Offers insight into the trauma problem and methods used to quantify and reduce it. Research methods used in injury biomechanics and their limitations are discussed including tests with human volunteers, cadavers, animals, mechanical crash test dummies and computer models. Provides a basic understanding of injury mechanisms and tolerances for the different body parts, including head, spine, thorax and extremities. Presents both automotive and aircraft impact safety regulations on occupant protection and related biomechanical limits. Students are exposed to and gain experience in using mathematical/numerical/computer models for injury biomechanics. Prerequisite(s): instructor's consent.

ME 710. Six Sigma for Mechanical Engineers (3).
Introduces the basic principles behind six sigma engineering as applicable to mechanical engineering. Provides the scientific foundation for an understanding of the six sigma tools and principles and applications towards design and development of mechanical components, ensuring regulatory compliance through qualification and validation by identifying manufacturing issues, developing advanced manufacturing cost-effective solutions, and overseeing successful implementation into production, eliminating waste to reduce overhead motive, cost, etc. Uses a set of management methods, mainly empirical and statistical methods, and creates a special infrastructure of people within the organization who are experts in these methods. Students gain an understanding of how six sigma improves the quality of the output of a process by removing the causes of defects and minimizing variability in the various facets of mechanical engineering related to industry. Pre- or corequisite(s): ME 339 and MATH 555, both with a GPA of 2.000 or above; or graduate status.

ME 719. Basic Combustion Theory (3).
Introduces the fundamental principles of combustion processes. Examines the chemistry and physics of combustion phenomena, that is, detonation and flames, explosion and ignition processes. Prerequisite(s): CHEM 211, ME 522.

ME 725. Mechanical Vibrations and Acoustics (3).
Studies free and forced vibrations of damped and undamped single and multiple degrees of freedom discrete mechanical systems, vibration isolation, rotating imbalance, psychophysiological acoustics, noise emission assessment, types of sound waves and their sources, sound reflection/absorption/transmission/diffraction, sound propagation in porous materials and multilayered walls, sound propagation in ducts, silencer design, and mechanisms for acoustic radiation from a vibrating surface. Prerequisite(s): ME 325, ME 335, MATH 555; or instructor’s consent.

ME 728. Advanced Electronic Materials (3).
Focuses on electronic materials which are fundamental and critical to performances and applications of electronic devices. Structure-property and property-relationships of different types of electronic materials are discussed. Cutting edge technologies in development of advanced electronic materials and devices are introduced. High level knowledge of electronic material structures, properties and applications of electronic materials, and basic principles for material design for electronics. Prerequisite(s): ME 250 or PHYS 313; or instructor's consent.

ME 729. Computer-Aided Analysis of Mechanical Systems (3).
Modeling and analysis of planar motion for multibody mechanical systems including automatic generation of governing equations for kinematic and dynamic analysis, as well as computational methods and numerical solutions of governing equations. Computer applications. Open-ended student projects on engineering applications such as mechanisms design and vehicle dynamics. Technical elective course for mechanical engineering students. Prerequisite(s): ME 339, MATH 555 or instructor's consent.

ME 730. Modeling of Engineering Systems (3).
Provides rigorous understanding of physics and engineering mathematics in order to model practical scientific and engineering problems in fluid mechanics, heat transfer, solid mechanic, and vibrations. Focuses on analytical approaches and introduces computational methods for modeling engineering systems using computer codes. Prerequisite(s): MATH 555 and ME 325, or departmental consent.

ME 731. Advanced Heat Exchanger Design (3).
Topics cover advanced design of fluidized bed, heat pipe, and high-temperature heat exchangers. Design experience through individual projects. Prerequisite(s): ME 521, ME 522.

ME 737. Robotics and Control (3).
Systems engineering approach to robotic science and technology. Fundamentals of manipulators, sensors, actuator, end-effectors and product design for automation. Includes kinematics, trajectory planning, control, programming of manipulator and simulation, along with introduction to artificial intelligence and computer vision. Prerequisite(s): ECE 282, ME 335, ME 339, MATH 555 or graduate status.

ME 739. Advanced Machine Design (3).
A broad coverage of principles of mechanical analysis and design of machine elements. Emphasizes dynamic system modeling, prediction of natural frequencies and forced response, effect of support flexibility, failure theories used in design and fatigue life prediction. Typical mechanical systems studied are gears, bearings, shafts, rotating machinery and many types of spring-mass systems. Uses fundamentals learned in mechanics, strength of materials and thermal sciences to understand mechanical system modeling, analysis and design. Prerequisite(s): ME 541 or instructor's consent.

ME 740. Indoor Air Pollution and Simulation (3).
This course focuses on air pollution in building indoors and modeling topics with an emphasis on how air quality models can be used to help inform decision makers. In addition to introducing the fundamentals of air pollution and addressing general modeling considerations, topics covered in this course include the health and environmental effects of key air pollutants, how air quality modeling was used in major studies leading to better air quality. Specific modeling topics include box and plume modeling, indoor air quality and monitoring, numerical and statistical modeling. Prerequisite(s): ME 398 and ME 521 with a GPA of 2.000 or better in both courses, or graduate status.

ME 745. Design of Thermal Systems (3).
Covers component design for a typical Rankine power cycle. Design of boilers, condensers, various types of turbine, pipe flow network, and power plant system integration are covered. Prerequisite(s): ME 521, ME 522.

ME 747. Microcomputer-Based Mechanical Systems (3).
Microcomputer-based real-time control of mechanical systems. Familiarizes students with design and methodology of software for real-time control. Includes an introduction to the C programming language which is most relevant to interfacing and implementation of control theory in computer-based systems. Laboratory sessions involve interfacing microcomputers to mechanical systems and software

development for control methods such as PID. This course has a lab component. Prerequisite(s): ME 659 or instructor's consent.

ME 749. Applications of Finite Element Methods in Mechanical Engineering (3).
Introduces the finite element method (FEM) as a powerful and general tool for solving differential equations arising from modeling practical engineering problems. Finite element solutions to one- and two-dimensional mechanical engineering problems in mechanical systems, heat transfer, fluid mechanics and vibrations. Includes Galerkin's and variational finite element models. Introduces commercial finite element computer tools such as ANSYS. Prerequisite(s): ME 325 and ME 439. Pre- or corequisite(s): ME 522 or graduate status. Corequisite(s): ME 749L.

ME 750. Selected Topics in Mechanical Engineering (1-3).
An umbrella course created to explore a variety of subtopics differentiated by letter (e.g., 750A, 750B). Not all subtopics are offered each semester – see the course schedule for availability. Students enroll in the lettered courses with specific topics in the titles rather than in this root course. Prerequisite(s): departmental consent.

ME 750AE. Computational Modeling for Fluid Flow and Heat Transfer (3).
Reviews the basic laws of fluid flow and heat transfer including the Navier-Stokes equations. Applications include a CFD software emphasizing the finite volume method and introducing turbulence modeling. Additional topics include grid generation and benchmarking exercises as well as open-ended projects. Prerequisite(s): ME 325 (or AE 227) and ME 522 (or AE 424) with a minimum grade of C in each, or instructor's consent.

ME 750AF. Autonomous Vehicles (3).
Overview of the concepts required to create autonomous vehicles. Introduces topics such as sensing, localization, perception, deep learning for motion planning, decision making, object recognition, and intelligent control. Pre- or corequisite(s): ME 659 or equivalent.

ME 750AJ. Transport in Porous Media (3).
Studies the fundamentals of heat and mass transport in porous media including single- and multiphase flows and conduction/convection/radiation, and phase change heat transfer in energy, thermal management, water desalination and filtration systems. Prerequisite(s): graduate standing or departmental consent.

ME 752. Failure Analysis Methods and Tools (3).
Introduces the fundamental concepts of the failure analysis of engineering components at various environmental and testing conditions, and provides general knowledge on the procedures and mechanisms involved in failure analysis. Topics include procedural approaches in failure analysis; metallographic and fractographic studies, analysis of broken components by macroscopic, microscopic and nanoscopic observations, reviews common experimental methods used in failure analysis, and specific descriptions of failures for metallic, ceramics, polymeric and composite materials at micro- and nanoscales. Students learn advanced materials characterization techniques including scanning electron microscopy (SEM), energy dispersive spectroscopy (EDS) and compositional dot mapping, x-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR) optical microscopy, and fracture surface sample preparation. Undergraduate and graduate students are expected to gain an understanding of these subjects, and how they are applied in industrial applications. Prerequisite(s): ME 250, and ME 439; or instructor's consent.

ME 753. Advanced Materials for Energy Systems (3).
Introduces the advanced materials and fundamental principles behind the energy systems and devices. Focuses on advanced materials (e.g., metals and alloys, composites, polymers, ceramics and semiconductors) at micro- and nanosize, novel energy conversion systems and devices, fabrication and characterization techniques and their general properties and applications. Efficiencies of most energy systems are limited by materials engineering and reliability of these systems. Covers the application of scientific and engineering principles for materials used in energy systems. Equips students with knowledge and skills that enable them to solve a wide range of energy materials technology and engineering problems to minimize operational risks and maximize process reliability, and ensure a more sustainable future. Students gain an understanding of these advanced materials and devices, importance of them, and how they are applied in energy related technologies and future developments. Prerequisite(s): ME 250, ME 398 and ME 522; or instructor's consent.

ME 758. Nonlinear Controls of Electro-Mechanical Systems (3).
Standard first nonlinear controls course. Covers stability, feedback linearization (robotic, mechanical, electro-mechanical system applications), differentially-flat systems (with rotor-craft position tracking applications), back-stepping control-design methods (electro-mechanical, robotic and rotor-craft applications), MIMO systems, normal form, zero dynamics, and adaptive control of robotic systems. ECE 792, Linear Systems, while not a prerequisite, is helpful. Prerequisite(s): ME 659 or ECE 684; or equivalent.

ME 760. Fracture Mechanics (3).
Covers fracture mechanics in metals, ceramics, polymers and composites. Suitable for graduate and undergraduate study in metallurgy and materials, mechanical engineering, civil engineering and aerospace engineering where a combined materials-fracture mechanics approach is stressed. Prerequisite(s): ME 439 or instructor's consent.

ME 762. Polymeric Composite Materials (3).
Designed to provide students with an understanding and knowledge about polymeric composite materials. The characteristics of various reinforcements and polymeric matrices are presented and their processing techniques, capabilities and limitations are highlighted. In addition, various methods for manufacturing of polymeric composites along with their capabilities are discussed. Characterization techniques, test methods, assembly and joining of polymeric composites are presented. Prerequisite(s): AE 333 or equivalent; or graduate standing; or instructor's consent.

ME 775. Introduction to Microelectromechanical Systems (3).
Introduces the design and manufacture of microelectromechanical systems, including principles of MEMS sensing and actuation, microfabrication and packaging. Covers electrical, thermal and mechanical behavior of microsystems, the design of electromechanical and thermal sensors and actuators, MEMS microfabrication, and MEMS packaging techniques. Studies a variety of microscale sensors and actuators (e.g., electrical switches, pressure sensors, inertial sensors and optical MEMS). Devotes the last third of the semester largely to design. Prerequisite(s): ME 439, ME 533, and MATH 555 with a minimum of C or better; or graduate standing.

ME 777. Mechanical Engineering Seminar (0).
A mechanical engineering graduate seminar to develop critical thinking/foundation for students' future professional careers with cutting-edge research activities in the area of mechanical engineering. Provides the necessary scientific and mechanical engineering knowledge for future successful professionals. Students are required to register and pass this course at least one semester during their entire graduate study. Course meets biweekly per semester. Repeatable.

ME 779. Phase Transformations in Materials (3).
An in-depth analysis of the thermodynamics and kinetics of phase transformation in materials. Topics include: phase equilibria and transformations, thermodynamics applied to processing of materials

(metal and alloys, polymers, composites, ceramics, etc.), and kinetics in materials systems including diffusion, nucleation, growth, gas-solid and liquid-solid reactions. This course also highlights a number of commercially-significant applications where phase transformations are important. Prerequisite(s): ME 250 and ME 398; or graduate student status.

ME 781A. Cooperative Education (1).
Introduces the student to professional practice by working in industry in an academically-related job and provides a planned professional experience designed to complement and enhance the student's academic program. Individualized programs must be formulated in consultation with, and approved by, appropriate faculty sponsors and cooperative education coordinators. Intended for students who will be working full time on their co-op assignment and need not be enrolled in any other course. Graded Cr/NCr unless student has received permission before enrolling for course to be used as an elective. Repeatable for credit. Prerequisite(s): approval by the appropriate faculty sponsor.

ME 781P. Cooperative Education (1).
Introduces the student to professional practice by working in industry in an academically-related job and provides a planned professional experience designed to complement and enhance the student's academic program. Individualized programs must be formulated in consultation with, and approved by, appropriate faculty sponsors and cooperative education coordinators. Students must enroll concurrently in a minimum of 6 hours of coursework including this course in addition to a minimum of 20 hours per week at their co-op assignment. Graded Cr/NCr unless student has received permission before enrolling for course to be used as an elective. Repeatable for credit. Prerequisite(s): approval by the appropriate faculty sponsor.

ME 782. Engineering Applications of Computational Fluid Dynamics and Heat Transfer (3).
Lectures review the basic laws of fluid flow and heat transfer including the Navier-Stokes equations. Laboratory activities include use of a CFD software emphasizing the finite volume method and introducing turbulence modelling. Additional topics include grid generation and benchmarking exercises as well as open-ended projects. Prerequisite(s): ME 325 (or MATH 551) and ME 522 (or AE 424) with a minimum grade of C in each, or the instructor’s consent, or graduate standing.

ME 801. Boundary Layer Theory (3).
Development of the Navier-Stokes equation, laminar boundary layers, transition to turbulence, turbulent boundary layers, and an introduction to homogeneous turbulence. Prerequisite(s): ME 521 or departmental consent.

ME 802. Turbulence (3).
An overview of the theory, practical significance and computation of turbulent fluid flow. Prerequisite(s): ME 521, 801.

ME 803. Solar Energy Materials (3).
Focuses on working mechanism, design, fabrication and manufacturing of solar energy technologies, including solar thermal energy systems, photovoltaic systems and photocatalytic processes. Topics include non-concentrating solar collectors; concentrating solar collectors; first, second and third generation of photovoltaics; photo-electrochemical cells and photocatalytic processes for clean fuel generation and water treatment. In addition, planning, installation and operation, cost and payback analysis of solar energy systems are also included. Prerequisite(s): graduate student status or instructor’s consent.

ME 829. Advanced Computer-Aided Analysis of Mechanical Systems (3).
Computational methods in modeling and analysis of spatial multibody mechanical systems. Includes Euler parameters, automatic generation of governing equations of kinematics and dynamics, numerical techniques and computational methods; computer-oriented projects on ground vehicles with suspension and steering mechanisms, crashworthiness and biodynamics. Prerequisite(s): ME 729 or instructor's consent.

ME 835. Modeling and Optimization of Building Energy (3).
Focuses on building energy modeling and optimization topics with an emphasis on how building energy models can be used to help inform decision makers. In addition to introducing the fundamentals of building physics and addressing general modeling considerations, topics covered in this course include the application of thermodynamics, heat transfer and fluid mechanics. This course builds essential knowledge of building energy and sustainability and provides the necessary background to use building energy simulation software tools. The goal of this course is using building performance modeling as an investigative tool to improve building energy efficiency. Prerequisite(s): graduate student status.

ME 844. Advanced Biomaterials (3).
Explores the cutting-edge technologies for synthesis of advanced biomaterials related to biotechnology. Focuses on biomaterials (e.g., metals and alloys, composites, polymers and ceramics), biodevices, basic fabrication and characterization techniques and their general properties and applications. The interaction between the human body environment and synthetic materials, including materials for medical implants and for dental restoration and appliances is explored. Tissue engineering, biosensing, imaging and drug delivery interact directly with biomaterials. Consideration of new technologies that depend on overcoming present material limits, and improving material/biological environment interactions. Throughout the lectures, students are expected to gain an understanding of these materials, importance of them, and how they are applied in medical technology. Prerequisite(s): ME 250, and ME 651; or instructor's consent.

ME 845. Renewable Energy (3).
A study of renewable energy, covering current energy portfolio, energy projections, energy sources, energy storage and energy devices. Review of major types of renewable energy including wind, solar, biomass, geothermal and hydropower/marine; alternative fuel and ammonia; energy storage technologies and batteries; and hydrogen energy and fuel cells. Prerequisite(s): graduate student status.

ME 848. Recycling of Advanced Engineering Materials (3).
Introduces the fundamentals of recycling processes, recycling, reprocessing and reusing advanced materials, importance of recycling for the economy, health and environment, and future trends in the field. Focuses on fundamental aspects of advanced materials recycling processes with regard to efficiency of the recycling methods, comparison of the alternative processes, energy usage and efficiency, cost analysis, environmental friendliness (reduction of air, water and soil pollutions), return on investment of recycling factories, characterization, quality and marketability of the recyclates. Graduate students are expected to gain knowledge of fundamental aspects of recycling processes, understanding the separation science and technology, and new techniques developed in the field. Prerequisite(s): ME 250 and ME 522; or instructor’s consent.

ME 850. Selected Topics in ME (1-3).
An umbrella course created to explore a variety of subtopics differentiated by letter (e.g., 850A, 850B). Not all subtopics are offered each semester – see the course schedule for availability. Students enroll in the lettered courses with specific topics in the titles rather than in this root course. Prerequisite(s): departmental consent.

ME 850AG. Nonlinear Dynamics and Chaos (3).
Provides an introduction to nonlinear systems including one-dimensional flows, two dimensional flows and chaos with heavy emphasis on mathematical theory. Covers a wide range of disciplines,

from biology to engineering. Studies several classes of devices including applications to mechanical vibrations, lasers, biological rhythms, insect outbreaks and even a technique for using chaos to send secret messages. Devotes a portion of the semester to the design and analysis of physical and/or biological systems. Prerequisite(s): graduate standing.

ME 850AJ. CFD for Microfluidics Modeling and Simulation (3).
Covers conservation laws for fluid dynamics and heat transfer; derivation of related PDE's; finite difference vs finite volume methods; time-stepping schemes; stability and consistency; convergence and grid-independence; bench-marking exercises; low Re flows; additional special applications. Prerequisite(s): ME 522 with grade of 2.000 or above.

ME 850AX. Electrochemical Systems (3).
An introduction to and discussion about electrochemistry, electrochemical techniques and electrochemical systems. As a necessary foundation, the electrochemistry section centers on the thermodynamics of electrochemical cells, the rise of electrical potentials, standard reduction potentials, reference electrodes, kinetics of electrode reactions, mass transfer by diffusion, and double-layer structure and adsorption. The section on electrochemical techniques focuses on potential sweep methods, currented-current techniques covering the fundamental electrochemistry, forced convection method, and impedance. Mathematic methods and digital simulations of electrochemical processes is also introduced. The section on electrochemical systems covers some prevailing electrochemical applications including rechargeable batteries (such as lead-acid batteries and lithium-ion batteries), redox-flow cells (all-vanadium flow cells), electrolysis (water splitting and alkali-chlorine processes), electro-extracting/electro-thinning (aluminum production), electroplating/electrodeposition, and electrodialysis, and fuel cells.

ME 854. Two-Phase Flow Heat Transfer (3).
Thermodynamic and mechanical aspects of interfacial phenomena, boiling; condensation near immersed surface, pool boiling, internal flow convective boiling and condensation. Prerequisite(s): ME 522, MATH 555, or departmental consent.

ME 859. Introduction to Molecular Simulations (3).
Introduces the molecular simulation methods (classical molecular dynamics simulations and Monte-Carlo simulation) aimed at understanding fundamentals of the nanoscale mechanical, thermal, materials, energy, and bio systems and their engineering for desired functionalities. Prerequisite(s): MATH 555 and ME 335, or instructor's consent.

ME 861. Advanced Nonlinear Controls of Electro-Mechanical Systems (3).
Lyapunov theorems for obtaining boundedness of closed-loop signals, bounding asymptotic output tracking/regulation errors, design methodologies associated therein; concepts of global versus semi-global results, invariant sets, existence of Lyapunov functions. Feedback linearization, methods of dynamic extension, differentially-flat systems, back-stepping control-design method, relative degree for SISO and relative degree for MIMO systems, normal form, zero dynamics of nonlinear systems, differentiable manifolds, Lie brackets, Frobenius theorem, nonsingular distributions, diffeomorphisms, local versus global concepts. Adaptive control and associated Barbalat-like theories. Two/multiple-time-scale methods for appropriate-tracking and regulation. If time-permits: variable-structure control design including the design of chatter-free versions of the control laws, nonlinear observers, design of optimal trajectories and feedback optimal control laws for nonlinear systems, and using neural networks therein. Prerequisite(s): ME 659 or ECE 684; or equivalent.

ME 862. Synthesis and Applications of Nanomaterials (3).
Introduces various types of nanomaterials, nanostructures, their synthesis methods, properties, characterization techniques, and explores their engineering applications. The structural defects, purification techniques, and functionalization of nanomaterials and nanostructures is discussed. Self-assembly of nanomaterials in various patterns and processing of structural nanocomposites is lectured and several lab activities are performed. In addition, fabrication of nanodevices, nanosensors, energy storage systems, and various forms of nanocomposites are explored and their performance is discussed. Prerequisite(s): graduate standing or instructor's consent.

ME 865. Corrosion Science Engineering (3).
Designed for graduate students aimed at investigating the complex causes of corrosion problems and failures. Emphasizes the electrochemical reactions occurring and the tools and knowledge necessary for predicting corrosion, measuring corrosion rates, and combining this with prevention and materials selection. Studies oxidation and degradation processes, and protection methods. Provides an overview of the surface treatment, surface modification, and coatings synthesis and deposition technologies. Conventional and most advanced techniques and processes of coatings and thin films deposition to prevent corrosion. Surface interface phenomena occurring during the coatings of thin films deposition (such agglomeration, adsorption, diffusion, nucleation, microstructure development, etc.) are covered. Coating techniques, monitoring, performance evaluation, characterization and applications of advanced coatings in industry are investigated for advanced corrosion protection. Prerequisite(s): ME 250, ME 398, ME 581; or instructor’s consent.

ME 870. Advanced Laser Applications in Manufacturing (3).
Examines laser technology which is defined as the methods, processes or products that make use of the spectrum of laser light, and any system whose function is to study, measure, transform or transmit the light. Covers laser processing to produce features and modify properties in metals, organic polymers, inorganic insulators, superconductors, semiconductors and biological materials on the meso, micro and nano scales. Students analyze and discuss selected technical papers on using laser nano/micro materials processing in electronic, opto-electronic, MEMS, medical-therapeutic applications, heat treatment, scanning, engraving, photolithography, peening, cladding, engraving and bonding. Investigates cutting-edge technologies in design and applications of new laser systems. Finite volume-based software Flow 3D is part of the lab experience. Prerequisite(s): ME 522 or instructor's consent. Corequisite(s): ME 870L.

ME 870L. Advanced Laser Applications in Manufacturing Lab (0).
Examines laser technology which is defined as the methods, processes or products that make use of the spectrum of laser light, and any system whose function is to study, measure, transform or transmit the light. Covers laser processing to produce features and modify properties in metals, organic polymers, inorganic insulators, superconductors, semiconductors and biological materials on the meso, micro and nano scales. Students analyze and discuss selected technical papers on using laser nano/micro materials processing in electronic, opto-electronic, MEMS, medical-therapeutic applications, heat treatment, scanning, engraving, photolithography, peening, cladding, engraving and bonding. Investigates cutting-edge technologies in design and applications of new laser systems. Finite volume-based software Flow 3D is part of the lab experience. Corequisite(s): ME 870.

ME 872. Graduate Capstone Design (3).
Allows graduate students to combine the knowledge and skills they have acquired in their graduate program and apply them to a major project or assignment for an experiential, induced, active and applied

learning experience. Exercise in the practice of mechanical engineering for graduate students; students engage in a comprehensive design project requiring the integration of knowledge gained in engineering, science and design courses. Both oral and written presentations are a part of the experience. Prerequisite(s): graduate status.

ME 875. Advanced Robotics and Mechanism Synthesis (3).
Designed to expose graduate students to the design and analysis theory of different mechanisms/robots that are needed in several sectors such as manufacturing, rehabilitation and military applications. Introduces the algebraic tools used to describe motion and the basics of kinematic synthesis theory. This is applied to the design of planar mechanisms and spatial mechanisms. Addresses advanced topics in kinematics including quaternion methods, introduction to screw-based kinematics and its applications to mechanism analysis and synthesis, and open research problems in robotics. Prerequisite(s): ME 737 or instructor's consent.

ME 876. Thesis (1-6).
Student-driven research experience to address a specific research question. Potential topics should be formulated by the student and discussed with their advisor. Repeatable for credit. Prerequisite(s): MS thesis advisor's consent.

ME 878. Master's Directed Project (1-4).
A project conducted under the supervision of an academic advisor for the directed project option. Requires a written report and an oral presentation on the project. Prerequisite(s): consent of academic advisor.

ME 890. Independent Study in Mechanical Engineering (1-3).
Arranged individual, independent study in specialized content areas. Prerequisite(s): instructor's consent.

ME 960. Advanced Selected Topics (1-3).
An umbrella course created to explore a variety of subtopics differentiated by letter (e.g., 960A, 960B). Not all subtopics are offered each semester – see the course schedule for availability. Students enroll in the lettered courses with specific topics in the titles rather than in this root course. Prerequisite(s): instructor's consent.

ME 976. PhD Dissertation (1-16).
Student-driven research experience to address a specific research question. Potential topics should be formulated by the student and discussed with their advisor. Repeatable for credit. Prerequisite(s): admission to doctoral aspirant status.

ME 990. Advanced Independent Study (1-16).
Arranged individual, independent study in specialized content areas. Repeatable toward the PhD degree. Prerequisite(s): advanced standing and instructor's consent.