ENME - ENGINEERING, MECHANICAL

ENME400 Machine Design (3 Credits)
Design of mechanical elements and planar machines. Failure theories. Design of pressure vessels, joints, rotating elements, and transmission elements. Kinematic structures, graphical, analytical, and numerical analysis and synthesis of linkages, gear trains, and flywheels are covered.
Prerequisite: Must have completed or be concurrently enrolled in ENME361.
Restriction: Permission of ENGR-Mechanical Engineering department.

ENME401 Entrepreneurial Design Realization (3 Credits)
The vision for this course, and an aspect that makes it unique, is to expose students to the opportunities and challenges of bringing a product design to reality (entrepreneurship). The emphasis is on environmentally and socially sustainable projects. The end-product of this course will be full-scale implementations or complete design "packages" that can be taken to potential stakeholders.
Restriction: Must have senior standing and permission of instructor. Cross-listed with: ENES401.
Credit Only Granted for: ENME401, ENME489B or ENES401.
Formerly: ENME489B.

ENME406 Roller Coaster Engineering (3 Credits)
Engineering of roller coasters including: specifications, concept creation, structural design, car design, and safety. Course covers biomechanics and rider kinematics as well as manufacturing aspects.
Prerequisite: ENES220, ENES221, and ENME272. And ENME202; or MATH206.
Corequisite: ENME400.
Restriction: Permission of ENGR-Mechanical Engineering department.

ENME407 Sustainability, Climate Change and Renewable Energy Systems (3 Credits)
Countries around the world are developing innovative and sustainable solutions that not only help to protect the environment from the threats of global climate change, but that also can improve human health and quality of life. In this course students will explore solutions to climate change, as well as geothermal and hydroelectric energy systems and their applications.
Prerequisite: PHYS260; or permission of ENGR-Mechanical Engineering department.
Restriction: Students must have completed a minimum of 60 credits by the time they will enroll in this course.

ENME408 Selected Topics in Engineering Design (3 Credits)
Creativity and innovation in design. Generalized performance analysis, reliability and optimization as applied to the design of components and engineering systems. Use of computers in design of multivariable systems.
Restriction: Must be in Engineering: Mechanical program; and senior standing. Or permission of ENGR-Mechanical Engineering department.
Repeatable to: 6 credits if content differs.

ENME410 Design Optimization (3 Credits)
Introduction to the formal process of design optimization, including analytical and computational methods. Step by step design optimization techniques. Design optimization concepts, necessary and sufficient optimality conditions and solution techniques. Solution evaluation and tradeoff exploration.
Prerequisite: ENME271; or MATH206.
Restriction: Permission of ENGR-Mechanical Engineering department; and junior or senior standing.

ENME413 Bio-Inspired Robotics (3 Credits)
Fundamentals and applications of biologically inspired robots, traditional robots, and design and fabrication of biologically inspired robots.
Prerequisite: Must have completed or be concurrently enrolled in ENME351.
Restriction: Permission of ENGR-Mechanical Engineering department.
Credit Only Granted for: ENME413 or ENME489L.
Formerly: ENME489L.

ENME416 Additive Manufacturing (3 Credits)
Develop a comprehensive understanding of fundamental additive manufacturing, 3D printing approaches, including: extrusion-based deposition, stereolithography, powder bed-based melting, and inkjet-based deposition. Cultivate a design for-additive manufacturing skillset for CAD and CAM methodologies to produce successful 3D prints. Fabricate 3D mechanical objects using a variety of 3D printing technologies on campus. Execute a design project that demonstrates how additive manufacturing technologies can overcome critical limitations of traditional manufacturing processes.
Prerequisite: ENME331. And ENME272; or ENME414.
Restriction: Permission of ENGR-Mechanical Engineering department.

ENME417 Numerical Methods in Engineering (3 Credits)
Covers the fundamental aspects of how to apply analytical mathematical concepts to discrete data. The course is aimed at graduate students and senior undergraduate students in any area of engineering, and treats the material in a general manner that is not specific to any application or field of specialization.
Recommended: Senior standing.
Restriction: Permission of ENGR-Mechanical Engineering department. Jointly offered with: ENME745.
Credit Only Granted for: ENME745, ENME808B, ENME417 or ENME489J.
Formerly: ENME489J.

ENME420 De-Carbonization of Building Systems through Energy Audit, Renewable Energy, and Electrification (3 Credits)
Provides students with fundamentals and applications of de-carbonization of building systems for energy sustainability through energy audit and efficiency measures, renewable energy, and electrification. Topics covered include societal and economic motivations for de-carbonization of buildings; building energy auditing and energy consumption analysis; lighting systems and controls; heating/cooling and ventilation systems; integrated building automation systems; fundamentals of renewable energy for building applications; fundamentals of building electrification and energy storage devices; emerging technologies for building energy sustainability.
Prerequisite: ENES232 .
Corequisite: ENME332.
Restriction: Permission of the department.
Credit Only Granted for: ENME420 or ENME489I.
Formerly: ENME489I.

ENME421 Engineering Design Ideation (3 Credits)
Engineering Design Methods is a technical elective for engineering students who wish to improve their ability to produce design ideas (i.e., the ideation process) for further development into conceptual ideas. Ideation is the creative, idea generation activity that happens at the beginning of the conceptual design process. Ideation methods are often built around creativity improving strategies and are often designed for individual use prior to presenting the results in a team setting.
Prerequisite: Must have completed or be concurrently enrolled in ENME371.
Restriction: Junior standing or higher.
Additional Information: Ideally, this course should be taken prior to capstone design.

ENME422 Indoor Environment and Mechanical Systems (3 Credits)
Fundamentals of indoor air quality and its measurements. Exploration of air cleaning technologies for gaseous, particulate and infectious agent contaminants. Simulations of air flow and contaminants with multi-zone models to allow testing of both contaminant dispersion in buildings and effectiveness of air cleaning technologies.
Prerequisite: ENES232 and ENME332. Jointly offered with: ENME753.
Credit Only Granted for: ENME422 or ENME753.

ENME423 Modern Climate Control and Building Energy Design/Analysis (3 Credits)
Fundamentals and design calculations of heat and moisture transfer in buildings; evaluation of cooling, heating and power requirements of buildings; building energy consumption simulations, use of alternative energy and energy conservation measures in buildings; fundamentals of fans/pumps and air/water distribution in buildings; introduction to refrigeration and energy systems for data centers and other mission-critical facilities.
Prerequisite: ENES232.
Corequisite: ENME332.
Restriction: Permission of ENGR-Mechanical Engineering department.

ENME424 Urban Microclimate and Energy (3 Credits)
Urban microclimate from the perspective of transient heat and mass transfer using building energy simulations for building clusters as well as LEED building certification criteria. The focus is on understanding building energy consumption and environmental impacts from the individual building scale to a neighborhood scale.
Prerequisite: Must have completed or be concurrently enrolled in ENME332.
Recommended: ENME423.
Restriction: Permission of ENGR-Mechanical Engineering department.
Credit Only Granted for: ENME424 or ENME808I.

ENME425 Energy Conversion Systems for Sustianability (3 Credits)
Focus on energy sustainability with view on changing global energy availability and use. Addresses the objective of greatly reducing our dependence on the finite amounts of fossil energy sources available for our quest to achieve environmentally benign sustainable energy for green environment. The emphasis will be on sustainability issues, discussion on supply, demand and storage, energy transmission, global warming and carbon management, biomass-resources, uses and production of biofuels, national energy policy discussion, carbon emission, energy security and economics to ensure future energy needs can be met without compromising the ability of future generation to meet their own needs with due considerations to increase in global temperatures.
Prerequisite: ENES232.
Restriction: Permission of the Mechanical Engineering Department.
Credit Only Granted for: ENME489X or ENME425.
Formerly: ENME489X.

ENME426 Production Management (3 Credits)
The basic concepts and models needed to understand and design manufacturing systems, including the history of manufacturing, performance measures, queuing systems, variability, production planning and scheduling, lean manufacturing, and pull production control.
Credit Only Granted for: BMGT385 or ENME426.

ENME427 CSI Mechanical: Finding Reasons for Compromised Structural Integity (3 Credits)
Understanding the causes of product failures including the political, societal, economic, environmental, and ethical impact of these failures, and the strategies to avoid, postpone, or mitigate them. Students will be encouraged to combine concepts from engineering, natural sciences, social sciences, and the humanities to address these complex issues. Basics of failure analysis, forensics, and reliability engineering and the scientific fundamentals underlying the most common types of failure. Issues of legal liability. Methods for monitoring the existing condition of a structure.
Prerequisite: ENES220 and ENME382.
Restriction: Permission of ENGR-Mechanical Engineering department.

ENME430 Fundamentals of Nuclear Reactor Engineering (3 Credits)
Fundamental aspects of nuclear physics and nuclear engineering, including nuclear interactions; various types of radiation and their effects on materials and humans; and basic reactor physics topics, including simplified theory of reactor critically.
Prerequisite: MATH246.
Restriction: Permission of ENGR-Mechanical Engineering department.

ENME431 Nuclear Reactor Systems and Safety (3 Credits)
Engineering, material and thermal aspects of light water reactors, fast reactors, high temperature gas reactors, heavy water moderated reactors, breeder reactors, advanced reactors including GEN IV designs. Evolution of light water reactor safety and regulation in the US that has culminated in the current body of regulations.
Prerequisite: MATH246.
Recommended: ENME430.
Restriction: Permission of ENGR-Mechanical Engineering department.

ENME432 Reactor and Radiation Measurements Laboratory (3 Credits)
Basics concepts of nuclear radiation and radiation detectors including types of radiation, radioactive decay, and interactions of radiation with matter.
Prerequisite: ENME430 and MATH246.
Restriction: Permission of ENGR-Mechanical Engineering department.

ENME433 Nuclear Reactor Design (3 Credits)
Principles of nuclear reactor engineering including nuclear reactor system design, materials, thermal-hydraulics, shielding, mechanical design, and safety analysis.
Restriction: Permission of ENGR-Mechanical Engineering department.
Credit Only Granted for: ENME433 or ENME489T.
Formerly: ENME489T.

ENME435 Remote Sensing Instrumentation (3 Credits)
Explores the fundamentals of remote sensing techniques including light detection and ranging (lidar), radar, and computer vision in the context of emerging technologies such as autonomous navigation, terrain modeling, and embedded smart devices.
Prerequisite: ENME351.
Restriction: Permission of ENGR-Mechanical Engineering department.
Credit Only Granted for: ENME435 or ENME489Y.
Formerly: ENME489Y.

ENME436 Renewable Energy (3 Credits)
Fundamentals, design/analysis tools, and state of the art renewable energy technologies. Energy resources and global perspectives of current and future energy demand/consumption trends, followed by prime renewable energy technologies, including wind, solar, hydro, geothermal, and ocean thermal energy conversion. Economics of renewable energy, energy conservation opportunities, CO2 capture and storage, and thermal energy storage.
Prerequisite: ENME331.
Restriction: Must be in a major within the ENGR-Mechanical Engineering department.
Credit Only Granted for: ENME489K or ENME436.
Formerly: ENME489K.

ENME440 Applied Machine Learning for Engineering and Design (3 Credits)
Learn how to apply techniques from Artificial Intelligence and Machine Learning to solve engineering problems and design new products or systems. Design and build a personal or research project that demonstrates how computational learning algorithms can solve difficult tasks in areas you are interested in. Master how to interpret and transfer state-of-the-art techniques from computer science to practical engineering situations and make smart implementation decisions.
Prerequisite: ENME392; or permission of instructor.
Restriction: Permission of ENGR-Mechanical Engineering department. Jointly offered with: ENME743.
Credit Only Granted for: ENME440 or ENME743.

ENME441 Mechatronics and the Internet of Things (3 Credits)
Mechatronics and the Internet of Things combines sensors, actuators, computation, and communication to realize integrated objects capable of robust Internet-based interfacing. Students will gain experience with circuit development, mechatronic systems, MicroPython coding, and Internet communication protocols using the ESP32 microcontroller platform. The project-focused course combines lectures and hands-on labs to drive learning at the convergence of mechanics, electronics, and software domains for IoT smart object development.
Prerequisite: ENME351.
Restriction: Permission of ENGR-Mechanical Engineering department.
Credit Only Granted for: ENME489B or ENME441.
Formerly: ENME489B.

ENME442 Information Security (3 Credits)
The materials presented are divided into three major components: overview, detailed concepts and implementation techniques. The topics to be covered are: general security concerns and concepts from both a technical and management point of view, principles of security, architectures, access control and multi-level security, trojan horses, covert channels, trap doors, hardware security mechanism, security models, security kernels, formal specifications and verification, networks and distribution systems and risk analysis.
Restriction: Must have Senior standing in engineering; and permission of ENGR-Mechanical Engineering department. Jointly offered with ENRE684 .
Credit Only Granted for: ENRE648J, ENME442, ENRE684, or ENPM808E.

ENME444 Assistive Robotics (3 Credits)
Fundamentals of assistive robots used in a wide varietyof ways to help humans with disabilities. Three application areas will be covered: (1) Rehabilitation robotics to recover motor function from neurologic injuries such as stroke, (2) Prosthetics to enable mobility function in amputees, and (3) Social robotics for cognitive impairment and developmental disorders such as autism. Theory behind different control systems employed by assistive robotics, as well as the mechanical design, sensors & actuators, and user interfaces behind representative robots in the respective areas. Guidelines for designing assistive robots. Ethical and regulatory considerations in the design of assistive robots.
Prerequisite: ENME351; and must have completed or be concurrently enrolled in ENME462.
Restriction: Permission of ENGR-Mechanical Engineering department.

ENME445 Design for Reliability (3 Credits)
Failure prevention, accident prevention, design requirements analysis, designing right the first time, high system reliability, software reliability, manufacturing defect prevention, life cycle costs reduction, design reviews, managing the design for reliability, design trustworthiness, product durability, and writing good specifications are covered.
Restriction: Junior standing or higher.

ENME446 Medical Robotics (3 Credits)
The fundamentals of robot design, control and different areas of research regarding development are explored. Student will engage in a course project where they will learn to develop, build, and control a medical robot. Surgical robotics development and modeling of robotic systems, safety in medical robotics, haptics, ergonomics and surgery. Fundamentals of robot design and control. Kinematics. This proposal was approved through the Testudo Curriculum Management system.
Prerequisite: Must have completed or be concurrently enrolled in ENME361.
Restriction: Permission of ENGR-Mechanical Engineering department.
Credit Only Granted for: ENME489C, ENME808M or ENME446.
Formerly: ENME489C.

ENME454 Vehicle Dynamics (3 Credits)
The fundamentals of passenger vehicle and light truck design and vehicle dynamics are covered. The engineering principles associated with acceleration, braking, handling, ride quality, aerodynamics, and tire mechanics are discussed, as well as suspension and steering design.
Corequisite: ENME361.
Restriction: Permission of ENGR-Mechanical Engineering department.

ENME461 Control Systems Laboratory (3 Credits)
Students will design, implement, and test controllers for a variety of systems. This will enhance their understanding of feedback control familiarize them with the characteristics and limitations of real control devices. Students will also complete a small project. This will entail writing a proposal, purchasing parts for their controller, building the system, testing it, and writing a final report describing what they have done.
Prerequisite: ENME351 and ENME361.
Restriction: Permission of ENGR-Mechanical Engineering department.
Credit Only Granted for: ENEE461 or ENME461.

ENME462 Vibrations, Controls, and Optimization II (3 Credits)
Continuation of ENME361. Fundamentals of vibration, controls, and optimization. Analysis and design in time, Laplace and frequency domains. Mathematical descriptions of system response, system stability, control and optimization. Optimal design of mechanical systems.
Prerequisite: ENME361.
Restriction: Permission of the Mechanical Engineering Department.

ENME464 Cost Analysis for Engineers (3 Credits)
An introduction to the financial and cost analysis aspects of product engineering. Introduces key elements of traditional engineering economics including interest, present worth, depreciation, taxes, inflation, financial statement analysis, and return on investment. Provides an introduction to cost modeling as it applies to product manufacturing and support. Cost modeling topics will include: manufacturing cost analysis, life-cycle cost modeling (reliability and warranty), and cost of ownership.
Prerequisite: ENME392; or students who have taken courses with comparable content may contact the department.
Restriction: Permission of ENGR-Mechanical Engineering department.

ENME465 Probability-Based Design (3 Credits)
Review of probabilistic distributions, introduction to pseudo-random number generation, and algorithms to produce probability distributions using Monte Carlo simulation via Matlab and other approaches to best design probabilistic engineering problems.
Prerequisite: MATH206 and ENME392.
Restriction: Permission of ENGR-Mechanical Engineering department.

ENME466 Lean Six Sigma (3 Credits)
This course intends to provide in-depth understanding of Lean Six Sigma and its Define - Mearsure - Analyze - Improve - Control (DMAIC) Breakthrough Improvement Strategy. The emphasis is placed on the DMAIC process which is reinforced via application of semester long corporate projects and case study analysis.
Corequisite: ENME392; or students who have taken courses with comparable content may contact the department.
Restriction: Permission of ENGR-Mechanical Engineering department.

ENME467 Engineering for Social Change (3 Credits)
Critical analysis of issues at the intersection of engineering, philanthropy and social change. How engineering design, products and processes have created social change in the past and will do so in the future through both intended and unintended consequences. Topics covered include energy, sustainability and climate change, autonomy, the digital future, low cost engineering, manufacturing, philanthropy, ethics and the impact of electronics on society, among others. Faculty and external experts will engage with students on these topics. Students will broadly engage with organizations involved in using technology for positive social impact.
Restriction: Must not be in Engineering: Mechanical program; and junior standing or higher; and must be in a major in ENGR-A. James Clark School of Engineering. Cross-listed with: ENES467.
Credit Only Granted for: ENES467 or ENME467.

ENME470 Finite Element Analysis (3 Credits)
Basic concepts of the theory of the finite element method. Applications in solid mechanics and heat transfer.
Restriction: Senior standing; and permission of ENGR-Mechanical Engineering department.

ENME472 Integrated Product and Process Development (3 Credits)
Integration of product development with the development process. Design strategies. Product architecture. Design for manufacturing. Selection of materials. Design for assembly.
Prerequisite: ENME331, ENME361, ENME351, and ENME371; and must have completed or be concurrently enrolled in ENME332.
Restriction: Permission of the Department of Mechanical Engineering.

ENME473 Mechanical Design of Electronic Systems (3 Credits)
Design considerations in the packaging of electronic systems. Production of circuit boards and design of electronic assemblies. Vibration, shock, fatigue and thermal considerations.

ENME476 Mircoelectromechanical Systems (MEMS) I (3 Credits)
Fundamentals of microelectromechanical systems (MEMS). Introduction to transducers and markets. MEMS fabrication processes and materials, including bulk micromachining, wet etching, dry etching, surface micromachining, sacrificial layers, film deposition, bonding, and non-traditional micromachining. Introduction to the relevant solid state physics, including crystal lattices, band structure, semiconductors, and doping. The laboratory covers safety, photolithography, profilometry, wet etching.
Restriction: Senior standing.
Credit Only Granted for: ENME476 or ENME489F.
Formerly: ENME489F.

ENME477 Microelectromechanical Systems (MEMS) II (3 Credits)
Fabrication of devices designed in MEMS I, including everything from mask printing through training on state-of-the-art fabrication equipment through device testing. In-depth understanding of MEMS devices and technologies, such as mechanical and electromagnetic transducers, microfluidics, and chemical sensors.
Prerequisite: ENME476.

ENME480 Introduction to Robotics (3 Credits)
An introductory course in robotics that will educate students in the elementary concepts of robotics. The course will encompass both theory and experiments.
Prerequisite: MATH246 or ENES221; and (CMSC131, ENME202, ENAE202 or ENEE150).
Restriction: Must be in the Robotics and Autonomous Systems minor; or Permission of ENGR-Mechanical Engineering department.

ENME483 Physics of Turbulent Flow (3 Credits)
Specific problems of turbulent flow including automobile and truck aerodynamics and canonical flows including pipes, jets and boundary layers that are measured and simulated to gain basic understanding of turbulence. A goal of the course is to impart the necessary background for students to be able to critically assess and most effectively employ the turbulent flow prediction codes (e.g. Fluent) that are a mainstay of how turbulence is analyzed in modern industries.
Prerequisite: ENME331.
Restriction: Permission of ENGR-Mechanical Engineering department. Jointly offered with ENME656. Credit only gran ted for: ENME483 or ENME656.

ENME484 Analysis of Turbulent Flow (3 Credits)
Relentless growth in the speed and size of supercomputers has encouraged the ever expanding use of numerical simulation in the practice of fluids engineering. For the flow past ground vehicles, in the urban grid, re-entering rockets, helicopters landing on ships at sea and countless other examples, the flow is turbulent, and simulation is becoming or will one day become the methodology of choice in analyzing and designing such technologies. The goal of this course is to give an introduction to the analysis of turbulent flow via simulation and the modeling that is used in its development. Among the questions to be considered: What can one hope to learn from flow simulation? What are the strengths of the approach and what obstacles inhibit its application? What kind of physical considerations are required in setting up simulations? How does one analyze the results of a simulation?
Prerequisite: ENME331.
Restriction: Permission of ENGR-Mechanical Engineering department. Jointly offered with: ENME657.
Credit Only Granted for: ENME484 or ENME657.

ENME486 Computational Modeling, Simulation, and Interactive Visualization (3 Credits)
Creation of interactive graphic displays from the numerical simulation of mechanical engineering models. Brief description of each model provided, along with varied parameters to explore models' characteristics. Conclusions drawn from use of each interactive graphic. Mathematica language introduced and interwoven with the numerical simulation of the models, which will include: robotics and mechanisms, static response of beams, control systems, measurement systems, fluid flow, vibrations, geometric modeling, finite element analysis, and nonlinear phenomena.
Restriction: Senior standing; and permission of ENGR-Mechanical Engineering department.

ENME488 Special Problems (3 Credits)
Advanced problems in mechanical engineering with special emphasis on mathematical and experimental methods.
Restriction: Permission of ENGR-Mechanical Engineering department.
Repeatable to: 6 credits if content differs.

ENME489 Special Topics in Mechanical Engineering (3 Credits)
Selected topics of current importance in mechanical engineering.
Restriction: Permission of ENGR-Mechanical Engineering department.
Repeatable to: 6 credits.

ENME600 Engineering Design Methods (3 Credits)
An introductory graduate level course in critical thinking about formal methods for design in Mechanical Engineering. Course participants gain background on these methods and the creative potential each offers to designers. Participants will formulate, present, and discuss their own opinions on the value and appropriate use of design materials for mechanical engineering.

ENME605 Advanced Systems Control (3 Credits)
Modern control theory for both continuous and discrete systems. State space representation is reviewed and the concepts of controllability and observability are discussed. Design methods of deterministic observers are presented and optimal control theory is formulated. Control techniques for modifying system characteristics are discussed.
Prerequisite: ENME462; or permission of instructor.

ENME607 Engineering Decision Making and Risk Management (3 Credits)
Individual decision-making, group decisionmaking, and organizations of decision-makers in the context of engineering design, project management, and other functions. Techniques for making better decisions, for understanding how decisions are related to each other, and for managing risk.Cross-listed with ENRE671.
Credit Only Granted for: ENME808X, ENRE671 or ENME607.
Formerly: ENME 808X.

ENME610 Engineering Optimization (3 Credits)
Overview of applied single- and multi- objective optimization and decision making concepts and techniques with applications in engineering design and/or manufacturing problems. Topics include formulation examples, concepts, optimality conditions, unconstrained/constrained methods, and post-optimality sensitivity analysis. Students are expected to work on a semester-long real-world multi-objective engineering project.

ENME611 Fiber Optics (3 Credits)
Introduces students to fiber optics, provides a background including fiber optic components and terminology, and equip students with ability to understand and evaluate various kinds of fiber optic sensors for a wide range of applications along with a detailed understanding of relevant signal processing and analysis techniques.
Credit Only Granted for: ENME611,ENME808 or ENME489R.
Formerly: ENME808R.

ENME625 Multidisciplinary Optimization (3 Credits)
Overview of single- and multi-level design optimization concepts and techniques with emphasis on multidisciplinary engineering design problems. Topics include single and multilevel optimality conditions, hierarchic and nonhierarchic modes and multilevel post optimality sensitivity analysis. Students are expected to work on a semester-long project.

ENME631 Advanced Conduction and Radiation Heat Transfer (3 Credits)
Theory of conduction and radiation. Diffused and directional, poly- and mono-chromatic sources. Quantitative optics. Radiation in enclosures. Participating media. Integrodifferential equations. Multidimensional, transient and steady-state conduction. Phase change. Coordinate system transformations.
Prerequisite: ENME332; or students who have taken courses with comparable content may contact the department; or permission of instructor.

ENME632 Advanced Convection Heat Transfer (3 Credits)
Statement of conservation of mass, momentum and energy. Laminar and turbulent heat transfer in ducts, separated flows, and natural convection. Heat and mass transfer in laminar boundary layers. Nucleate boiling, film boiling, Leidenfrost transition and critical heat flux. Interfacial phase change processes; evaporation, condensation, industrial applications such as cooling towers, condensers. Heat exchangers design.
Credit Only Granted for: ENNU615 or ENME632.

ENME633 Molecular Thermodynamics (3 Credits)
An examination of the interactions between molecules, which govern thermodynamics relevant to engineering, will be conducted. We will investigate both classical and statistical approaches to thermodynamics for understanding topics such as phase change, wetting of surfaces, chemical reactions, adsorption, and electrochemical processes. Statistical approaches and molecular simulation tools will be studied to understand how molecular analysis can be translated to macroscopic phenomena.

ENME635 Energy Systems Analysis for Sustainability and Decarbonization (3 Credits)
Methods for the analysis of conventional and novel energy systems are taught throughout the course. Additional topics are, using the US National Energy Flow Chart to understand sources of carbon emissions, discussion of energy efficiency improvement methods, discussion of decarbonization and carbon capture and sequestration approaches and their impact on efficiency and emissions.
Prerequisite: Undergraduate thermodynamics course or permission of the instructor.
Credit Only Granted for: ENPM635 or ENME635.

ENME640 Fundamentals of Fluid Mechanics (3 Credits)
Equations governing the conservation of mass, momentum, vorticity and energy in fluid flows. Low Reynolds number flows. Boundary layers. The equations are illustrated by analyzing a number of simple flows. Emphasis is placed on physical understanding to facilitate the study of advanced topics in fluid mechanics.
Prerequisite: Must have completed partial differential equations at the level of MATH 462; or permission of ENGR-Mechanical Engineering department.
Formerly: ENME651.

ENME641 Viscous Flow (3 Credits)
Fluid flows where viscous effects play a significant role. Examples of steady and unsteady flows with exact solutions to the Navier-Stokes equations. Boundary layer theory. Stability of laminar flows and their transition to turbulence.
Prerequisite: ENME640; or students who have taken courses with comparable content may contact the department; or permission of instructor.
Formerly: ENME652.

ENME642 Hydrodynamics I (3 Credits)
Exposition of classical and current methods used in analysis of inviscid, incompressible flows.
Prerequisite: ENME640; or students who have taken courses with comparable content may contact the department; or permission of instructor.
Formerly: ENME653.

ENME644 Fundamentals of Acoustics (3 Credits)
This course will cover the fundamental principles of acoustics allowing the students to go on to more advanced course in acoustics, sauch as Underwater Sound Propagation, Active Noise Control, or Radiation and Scattering from Elastic Structures.

ENME645 Fluid-Structure Interactions (3 Credits)
Fundamentals of fluid-structure interactions, fluid-elastic instabilities (buckling, flutter, galloping) and their engineering applications. Possible domains of applications are civil engineering, aerospace engineering, ocean engineering, biomechanics, and soft robotics. Examples include tall bridges, aircraft wing, parachutes, solid rocket motor, turbomachinery, offshore platform, subsea pipelines, paper printing, MEMS mircochannels, blood flow in arteries, and heart valves. The fish swimming mechanics with be studied to inspire novel efficient propulsion mechanisms for soft robotics applications.
Prerequisite: ENME331 and ENME361.
Restriction: Must be a student in the Clark School of Engineering.
Credit Only Granted for: ENME498U, ENME645 or ENME809C.
Formerly: ENME809C.

ENME646 Computational Fluid Dynamics (3 Credits)
Fundamentals of numerical analysis of engineers. Inversion of large, sparse matrices. Numerical solution of the incompressible Navier-Stokes equations in Cartesian and curvilinear grids. Application to turbulent flows and micro-fluidics.
Prerequisite: Must have completed graduate-level fluid mechanics; or permission of instructor.

ENME647 Multiphase Flow and Heat Transfer (3 Credits)
Boiling and condensation in stationary systems, phase change heat transfer phenomenology, analysis and correlations. Fundamentals of two-phase flow natural circulation in thermal hydraulic multi-loop systems with applications to nuclear reactors safety. Multiphase flow fundamentals. Critical flow rates. Convective boiling and condensation. Multiphase flow and heat transfer applications in power and process industries.

ENME656 Physics of Turbulent Flow (3 Credits)
Definition of turbulence and its physical manifestations. Statistical methods and the transport equations for turbulence quantities. Laboratory measurement and computer simulation methods. Isotropic turbulence. Physics of turbulent shear flows.
Prerequisite: ENME640; or students who have taken courses with comparable content may contact the department; or permission of instructor.

ENME657 Analysis of Turbulent Flow (3 Credits)
Mathematical representation of turbulent transport, production and dissipation. Closure schemes for predicting flows. Recent advances in direct and large eddy numerical simulation techniques.
Prerequisite: ENME640; and (ENME641; or students who have taken courses with comparable content may contact the department). Or permission of instructor.

ENME662 Linear Vibrations (3 Credits)
Development of equations governing small oscillations and spatially continuous systems. Newton's equations, Hamilton's principle, and Lagrange's equations. Free and forced vibrations of mechanical systems. Modal analysis. Finite element discretization and reductions of continuous systems. Numerical methods. Random vibrations.

ENME664 Dynamics (3 Credits)
Kinematics in plane and space; Dynamics of particle, system of particles, and rigid bodies. Holonomic and non-holonomic constraints. Newton's equations, D'Alembert's principle, Hamilton's principle, and equations of Lagrange. Impact and collisions. Stability of equilibria.
Prerequisite: ENES221; or students who have taken courses with comparable content may contact the department; or permission of instructor.

ENME665 Nonlinear Oscillations (3 Credits)
Nonlinear oscillations and dynamics of mechanical and structural systems. Classical methods, geometrical, computational and analytical methods. Birfurcations of equillibrium and periodic solutions; chaos.
Prerequisite: ENME662 and ENME 700; or equivalent.

ENME670 Continuum Mechanics (3 Credits)
Mechanics of deformable bodies, finite deformation and strain measures, kinematics of continua and global and local balance laws. Thermodynamics of continua, first and second laws. Introduction to constitutive theory for elastic solids, viscous fluids and memory dependent materials. Examples of exact solutions for linear and hyper elastic solids and Stokesian fluids.

ENME672 Composite Materials (3 Credits)
Micromechanics of advanced composites with passive and active reinforcements, mathematical models and engineering implications, effective properties and damage mechanics, recent advances in "adaptive" or "smart" composites.

ENME674 Finite Element Methods (3 Credits)
Theory and application of finite element methods for mechanical engineering problems such as stress analysis. Basic development of the method for solving the types of governing partial differential equations that are the foundations for many engineering and physical sciences. The emphasis is on balancing the theoretical/mathematical background with a computable implementation to reach applications. Some code writing and debugging will be involved. This class is suited for graduate students or high-achieving undergraduates in engineering, mathematics, or the physical sciences. A very basic knowledge of matrix-vector calculations and multivariable calculus are required. Some exposure to partial differential equations and experience with Matlab or a compiled language will be helpful but are not required.
Restriction: Must be in one of the following programs (ENGR: MS/PhDMechanical Engineering (Master's); ENGR: MS/PhDMechanical Engineering (Doctoral); ENGR: MS/PhDReliability Engineering (Master's); ENGR: MS/PhDReliability Engineering (Doctoral); or permission of ENGR-Mechanical Engineering department.
Credit Only Granted for: ENME 674, ENAE652, ENPM652 or ENPM808F.

ENME675 A Mathematical Introduction to Robotics (3 Credits)
Designed to provide graduate students with some of the concepts in robotics from a mathematical viewpoint, including introduction to group theory and basics of SO(3) and SE(3) group applied to robotics; rigid body motion; manipulator kinematics; introduction to holonomic & non-holonomic constraints; dynamics of robot manipulators.
Credit Only Granted for: ENME675 or ENME808V.
Formerly: ENME808V.

ENME678 Fracture Mechanics (3 Credits)
An advanced treatment of fracture mechanics covering in detail the analysis concepts for determining the stress intensity factors for various types of cracks. Advanced experimental methods for evaluation of materials or structures for fracture toughness. Analysis of moving cracks and the statistical analysis of fracture strength. Finally, illustrative fracture control plans are treated to show the engineering applications of fracture mechanics.

ENME680 Experimental Mechanics (3 Credits)
Advanced methods of measurement in solid and fluid mechanics. Scientific photography, moire, photoelasticity, strain gages, interferometry, holography, speckle, ndt techniques, shock and vibration, and laser anemometry.

ENME684 Modeling Material Behavior (3 Credits)
Constitutive equations for the response of solids to loads, heat, etc. based on the balance laws, frame invariance, and the application of thermodynamics to solids. Non-linear elasticity with heat conduction and dissipation. Linear and non-linear non-isothermal viscoelasticity with the elastic-viscoelastic correspondence principle. Classical plasticity and current viscoplasticity using internal state variables. Maxwell equal areas rule, phase change, and metastability and stability of equilibrium states. Boundary value problems. Introduction to current research areas.
Prerequisite: ENME670; or permission of instructor.

ENME690 Mechanical Fundamentals of Electronic Systems (3 Credits)
An understanding of the fundamental mechanical principles used in design of electronic devices and their integration into electronic systems will be provided. Focus will be placed on the effect of materials compatibility, thermal stress, mechanical stress, and environmental exposure on product performance, durability and cost. Both electronic devices and package assemblies will be considered. Analysis of package assemblies to understand thermal and mechanical stress effects will be emphasized through student projects.

ENME695 Design for Reliability (3 Credits)
Reliability is the ability of a product or system to perform as intended (i.e., without failure and within specified performance limits) for a specified time, in its life-cycle conditions. Knowledge of reliability concepts and principles, as well as risk assessment, mitigation and management strategies prepares engineers to contribute effectively to product development and life cycle management. This course teaches the fundamental knowledge and skills in reliability as it pertains to the design, manufacture, and use of electrical, mechanical, and electro-mechanical products. Topics cover the suitability of the supply chain members to contribute towards development, manufacturing, distribution and support of reliable products; efficient and cost-effective design and manufacture of reliable products; process capability and process control; derating, uprating, FMMEA, reliability prediction and reliability allocation; how to plan and implement product testing to assess reliability; how to analyze degradation, failure, and return data to estimate fundamental reliability parameters; root cause analysis; and reliability issues associated with warranties, regulatory requirements, and liabilities.Cross-listed with: ENRE695.
Credit Only Granted for: ENME695 or ENRE695.

ENME700 Advanced Mechanical Engineering Analysis I (3 Credits)
An advanced, unified approach to the solution of mechanical engineering problems, emphasis is on the formulation and solution of equilibrium, eigenvalue and propagation problems. Review and extension of undergraduate material in applied mathematics with emphasis on problems in heat transfer, vibrations, fluid flow and stress analysis which may be formulated and solved by classical procedures.

ENME701 Sustainable Energy Conversion and the Environment (3 Credits)
Discussion of the major sources and end-uses of energy in our society with particular emphasis on renewable energy production and utilization. The course introduces a range of innovative technologies and discusses them in the context of the current energy infrastructure. Renewable sources such as wind and solar, and renewable enabling technologies such as energy storage are discussed in detail. Particular attention is paid to the environmental impact of the various forms of energy. This course is designed to provide, when taken together with ENME635, a comprehensive overview of sustainable energy production and utilization including carbon capture and sequestration.
Prerequisite: Undergraduate thermodynamics course or permission of instructor.

ENME704 Active Vibration Control (3 Credits)
This course aims at introducing the basic principles of the finite element method and applying it to plain beams and beams treated with piezoelectric actuators & sensors. The basic concepts of structural parameter i dentification are presented with emphasis on Eigensystem Realization Algorithms (ERA) and Auto-regression models (AR). Different active control algorithms are then applied to beams/piezo-actuator systems. Among thes e algorithms are: direct velocity feedback, impedancematchingcontrol, modal control methods & sliding mode controllers. Particular focus is given to feedforward Leat Mean Square (LMS) algorithm & filtered-X LMS. O ptimal placement strategies of sensor & actuators are then introduced & applied to beam/piezo-actuator systems.
Prerequisite: ENME662 and ENME602; or students who have taken courses with comparable content may contact the department.
Recommended: Completion of coursework or background in Vibrations and Control recommended.
Restriction: Must be in a major in ENGR-A. James Clark School of Engineering.

ENME707 Combustion and Reacting Flow (3 Credits)
This course covers thermochemistry and chemical kinetics of reacting flows in depth. In particular, we focus on the combustion of hydrocarbonf uels in both a phenomenological and mechanistic approach. The course co vers the specifics of premixed and nonpremixed flame systems, as wellasignition and extinction. Combustion modeling with equilibrium and chemical kinetic methods will be addressed. Environmental impact and emissi ons minimization will be covered in detail. Finally, the course will co ver available combustion diagnostic methods and their application in laboratory and real-world systems.
Prerequisite: ENME331 and ENME332; or students who have taken courses with comparable content may contact the department.

ENME710 Applied Finite Elements (3 Credits)
Application of finite element methods to the solution of engineering problems - such as stress analysis, thermal conductivity, fluid flow anlaysis, electro-magnetic field analysis and coupled boundary value problems. Emphasis is on the application of the techniques to the solution of pr oblems. Basic theory is covered at beginning of course.
Prerequisite: ENME331 and ENME332.
Restriction: Must be in one of the following programs (Engineering: Mechanical; Engineering: Aerospace; Engineering: Civil).

ENME711 Vibration Damping (3 Credits)
This course aims at introducing the different damping models that describe the behavior of viscoelastic materials. Emphasis will be placedon m odeling the dynamics of simple structures (beams, plates & shells) with Passive Constrained Layer Damping (PCLD). Considerations will also be g iven to other types of surface treatments such as Magnetic Constrained Layer Damping (MCLD), Shunted Network Constrained Layer Damping (SNCLD),Active Constrained Layer Damping (ACLD) and Electrorheological Constrained Layer Damping (ECLD). Energy dissipation characteristics of the damp ing treatments will be presented analytically & by using the modal strain energy approach as applied to finite element models of vibrating structures.
Prerequisite: ENME662; or students who have taken courses with comparable content may contact the department.
Recommended: Completion of coursework or background in Vibrations recommended.
Restriction: Must be in a major in ENGR-A. James Clark School of Engineering.

ENME712 Measurement, Instrumentation and Data Analysis for Thermo-Fluid Processes (3 Credits)
This course is designed to offer systemic coverage of the methodologies for measurement and data analysis of thermal and fluid processes at the graduate level. The course materials will cover three broad categories: (1) Fundamentals of thermal and fluid processes in single phase and multi phase flows as relates to this course; Measurement and Instrumentation techniques for measurement of basic quantities such as pressure, temperature, flow rate, heat flux, etc., and (3) Experimental Design and Planning, sources of errors in measurements, and uncertainty analysis.

ENME713 Nanoparticle Aerosol Dynamics (3 Credits)
Covers the basic science of nanoparticle formation, growth, and transport; the science and engineering of measurement; and the environmental impact and industrial use of nanoparticles.
Restriction: Permission of instructor.
Credit Only Granted for: ENME713 or ENME808M.
Formerly: ENME808M.

ENME722 Equilibrium Modeling in Engineering (3 Credits)
Provide motivation and introduction to equilibrium models involving economics and engineering. We will concentrate on models involving markets (Nash-Cournot, etc.), those wherein the activities are spatially diverse, those involving energy activities or traffic flow, as well as selected other examples in mechanical engineering. Areas that will be covered include:Review of relevant optimization theory, presentation of the mixed complementarity problem (MCP) and variational inequality problem (VIP) formats to solve equilibrium problems as well as introduction to existence and uniqueness results, review of relevant game theory notions, presentation of specific models for engineering-economic applications, presentations for algorithms to solve these equilibrium problems.
Credit Only Granted for: ENCE722 or ENME722.

ENME725 Probabilistic Optimization (3 Credits)
Provide an introduction to optimization under uncertainty. Chance-constrained programming, reliability programming, value of information, two stage problems with recourse, decomposition methods, nonlinear and linear programming theory, probability theory. The objectives of this course are to provide understanding for studying problems that involve optimization under uncertainty, learn about various stochastic programming formulations (chance constrained programs, two stage methods with recourse, etc.) relevant to engineering and economic settings, present theory for solutions to such problems, and present algorithms to solve these problems.
Prerequisite: An advanced undergraduate course in probability and a graduate course in optimization or permission of the instructor required. Cross-listed with ENCE725.
Credit Only Granted for: ENME725 or ENCE725.

ENME737 Application of AI in Reliability: Prognostics and Systems Health Management (PHM) (3 Credits)
Prognostics and health management (PHM) is an enabling discipline consisting of technologies and methods to assess the reliability of a product in its actual life cycle conditions to determine the advent of failure and mitigate system risk. PHM permits the reliability of a system to be evaluated and predicted in its actual application conditions. In recent years, prognostics and health management (PHM) has emerged as a key enabling technology to provide an early warning of failure; to forecast maintenance as needed; to reduce maintenance cycles; to assess the potential for life extensions; and to improve future designs and qualification methods. In the future, PHM will enable systems to assess their own real-time performance (self-cognizant health management and diagnostics) under actual usage conditions and adaptively enhance life cycle sustainment with risk-mitigation actions that will virtually eliminate unplanned failures.
Credit Only Granted for: ENME737 or ENME808A.
Formerly: ENME808A.

ENME740 Lab-on-a-Chip Microsystems (3 Credits)
Fundamentals and application of lab-on-a-chip and microfluidic technologies. A broad view of the field of microfluidics, knowledge of relevant fabrication methods and analysis techniques, and an understanding of the coupled multi-domain phenomena that dominate the physics in these systems.
Credit Only Granted for: ENME 481, ENME 808E, ENME 740.
Formerly: ENME 808E.

ENME741 Operations Research Models in Engineering (3 Credits)
A survey of the fundamentals of operations research models and methods in engineering including: optimization using linear programming, nonlinear programming, integer programming, as well as equilibrium/ game theory via mixed complementarity problems. Examples of specialized course items include: specifics of optimizing power and gas networks, discussion of other network optimization problems, resource-constrained problems, two-level optimization as an example of mixed integer nonlinear programming (MINLP) programming problems as well as algorithms to solve the above types of problems."
Prerequisite: (ENCE302; or (ENME271 and ENME392)); and (MATH140 and MATH240). Or permission of instructor.
Credit Only Granted for: ENME738, ENME741, or ENCE603.
Formerly: ENME738.

ENME742 Urban Microclimate and Energy (3 Credits)
Examines urban microclimate from the perspective of transient heat and mass transfer using building energy simulations for building clusters. The focus is on understandingbuilding energy consumption and environmental impacts from the individual building scale (~100) to a neighborhood scale (~103). Emerging morphological properties of building clustersmodulate transient convective and radiative heat transfer resulting in different localmicroclimatic conditions. At the neighborhood scale, these conditions are analyzed using heatand mass transfer simulations in building clusters to provide boundary conditions for transient building energy simulations. At the individual building scale, besides the energy consumption,this course examines connection between indoor and outdoor environments.Jointly offered with ENME424.
Credit Only Granted for: ENME808I, ENME42 4 or ENME742.
Formerly: ENME808I.

ENME743 Applied Machine Learning for Engineering and Design (3 Credits)
Learn how to apply techniques from Artificial Intelligence and Machine Learning to solve engineering problems and design new products or systems. Design and build a personal or research project that demonstrates how computational learning algorithms can solve difficult tasks in areas you are interested in. Master how to interpret and transfer state-of-the-art techniques from computer science to practical engineering situations and make smart implementation decisions.
Prerequisite: Must have completed undergraduate level Statistics (ENME392 or equivalent), or permission of the instructor. Jointly offered with: ENME440.
Credit Only Granted for: ENME440 OR ENME743.

ENME744 Additive Manufacturing (3 Credits)
Develop a comprehensive understanding of fundamental additive manufacturing-alternatively, "three-dimensional (3D) printing-approaches, including extrusion-based deposition, stereolithography, powder bed-based melting, and inkjet-based deposition. Cultivate a "design-for-additive manufacturing" skill set for combining computer-aided design (CAD) and computer-aided manufacturing (CAM) methodologies to produce successful 3D prints. Fabricate 3D mechanical objects using a variety of 3D printing technologies on campus. Execute a design project that demonstrates how additive manufacturing technologies can overcome critical limitations of traditional manufacturing processes.
Prerequisite: ENME272 and ENME331; or students who have taken courses with comparable content may contact the department. Jointly offered wit h ENME416.
Credit Only Granted for: ENME 416 OR ENME 744.

ENME745 Numerical Methods in Engineering (3 Credits)
Fundamental aspects of how to apply analytical mathematical concepts to discrete data. The course is aimed at graduate students in any area of engineering, and treats the material in a general manner that is not specific to any application or field of specialization.Jointly offered with: ENME417.
Credit Only Granted for: ENME745, ENME808B, ENME417 or ENME489J.
Formerly: ENME808B.

ENME746 Medical Robotics (3 Credits)
The evolution of robotics in surgery is a new and exciting development. Surgical robotics brings together many disparate areas of research such as development and modeling of robotic systems, design, control, safety in medical robotics, haptics (sense of touch), ergonomics in minimally invasive procedures, and last but not the least, surgery. The primary goal of this course is to acquaint the students with the fundamentals of robot design and control and different areas of research that lead to the development of medical robotic systems. As a result, the course will cover basic robot kinematics such as forward and inverse kinematics as well as velocity and acceleration analysis. We will also cover additional topics specific to medical robotics such as medical image guidance. The course will include a project, where students will learn to develop, build, and control a medical robot.
Prerequisite: ENME361.
Credit Only Granted for: ENME808M, ENME489C or ENME746.
Formerly: ENME808M, ENME489C.

ENME750 Applied System Identification (3 Credits)
An introductory graduate level course on system identification, which concerns various methods and techniques for data-driven modeling and estimation of dynamical systems.
Credit Only Granted for: ENME808R or ENME750.
Formerly: ENME 808R.

ENME751 Applied Nonlinear Control (3 Credits)
An introductory graduate level course on nonlinear control design, which concerns various methods and techniques for the analysis and synthesis of nonlinear control systems.
Credit Only Granted for: ENME808B or ENME751.
Formerly: ENME808B.

ENME753 Indoor Environment and Mechanical Systems (3 Credits)
Fundamentals of indoor air quality and its measurements. Exploration of air cleaning technologies for gaseous, particulate and infectious agent contaminants. Simulations of air flow and contaminants with multi-zone models to allow testing of both contaminant dispersion in buildings and effectiveness of air cleaning technologies.Jointly offered with: ENME422.
Credit Only Granted for: ENME422, ENME753, or ENME808U.
Formerly: ENME808U.

ENME765 Thermal Issues in Electronic Systems (3 Credits)
This course addresses a range of thermal issues associated with electronic products life cycle. Computational modeling approaches for various levels of system hierarchy. Advanced thermal management concepts including: single phase and phase change liquid immersion, heat pipes, and thermoelectrics.
Prerequisite: ENME331 and ENME332.
Corequisite: ENME473; or students who have taken courses with comparable content may contact the department.

ENME770 System Sustainment: The Science and Policy of Sustaining Critical Systems (3 Credits)
Introduces the important attributes of system sustainment (system maintenance, support and upgrade) by integrating data analytics, cost analysis and public policy. Topics include: acquisition, reliability, maintenance, availability, inventory management, supply chain, life-cycle cost and contracting.
Credit Only Granted for: PLCY798J or ENME770.

ENME775 Manufacturing Technologies for Electronic Systems (3 Credits)
This highly multi-disciplinary course presents the mechanical fundamentals of manufacturing processes used in electronics assemblies. The emphasis is on quantitative modeling of the intrinsic impact that processing has on structure, properties, performance and durability. Students will learn how to quantitatively model many of the key manufacturing steps from mechanistic first principles, so that sensitivity studies and process optimization can be performed in a precise manner. Processes considered include: wafer-level processes such as polishing, lithography, etching and dicing; packaging operations such as die attachment, wirebonding, flip chip bonding, and plastic encapsulation; multilevel high-density substrate fabrication processes; assembly processes such as reflow and wave soldering of surface-mount components to electronic substrates.
Prerequisite: ENME690.

ENME780 Mechanical Design of High Temperature and High Power Electronics (3 Credits)
This course will discuss issues related to silicon power device selection (IGBT, MCT, GTO, etc.), the characteristics of silicon device operation at temperatures greater thatn 125C, and the advantages of devices based on SOI and SiC. It will also discuss passive components and packaging materials selection for distributing and controlling power, focusing on the critical limitations to use of many passive components and packaging materials at elevated temperatures. In addition it will cover packaging techniques and analysis to minimize the temperature elevation caused by power dissipation. Finally, models for failure mechanisms in high temperature and high power electronics will be presented together with a discussion of design options to mitigate their occurrence.
Prerequisite: ENME382, ENME473, or ENME690.

ENME788 Seminar (1-3 Credits)
First or second semester. Credit in accordance with work outlined by mechanical engineering staff.

ENME799 Master's Thesis Research (1-6 Credits)

ENME808 Advanced Topics in Mechanical Engineering (2-3 Credits)

ENME898 Pre-Candidacy Research (1-8 Credits)

ENME899 Doctoral Dissertation Research (1-8 Credits)