ENME - ENGINEERING, MECHANICAL

ENME201 Careers in Mechanical Engineering (1 Credit)
The Mechanical Engineering Curriculum, Career Paths. Research areas in the Mechanical Engineering Department. The Mechanical Engineering Profession.

ENME202 Computing Fundamentals for Engineers (3 Credits)
Introduction to computer programming for the solution of engineering problems. Python & MATLAB languages including flow control, functions, file handling, arrays, and data structures. Students will be introduced to computing fundamentals, principles of software engineering, object-oriented programming, and algorithms.
Corequisite: Must be concurrently enrolled in MATH141.
Restriction: Permission of ENGR-Mechanical Engineering department.
Credit Only Granted for: ENAE202 or ENME202.

ENME207 Fabrication and Machine Tool Practices for Engineering (2 Credits)
In order to make the best decisions in product design and development, it is important to understand the capabilities and limitations of different fabrication techniques. Students will learn to identify machine parts and functions, define machine shop terminology, calculate shop formulas and theories, execute machine operations, and apply proper measuring tools.
Prerequisite: PHYS161. And ENME272; or students who have taken courses with comparable content may contact the department.
Restriction: Permission of ENGR-Mechanical Engineering department.

ENME208 Introduction to Automotive Engineering and Design (2 Credits)
Selected concepts in automotive engineering and design at the introductory level utilizing the Terps Racing Baja SAE student project as a learning instrument. This class compliments ENME408, Automotive Design, which focuses on the Terps Racing Formula SAE car.
Prerequisite: ENES100.
Recommended: ENES220; and ENES221.
Restriction: Permission of ENGR-Mechanical Engineering department.
Repeatable to: 4 credits if content differs.

ENME272 Introduction to Computer Aided Design (2 Credits)
Fundamentals of CAD, using solid modeling packages (Pro/E, SolidWorks, and Autodesk Inventor). Two and three dimensional drawing. Dimensioning and specifications. Introduction of CAD based analysis tools. Students will complete a design project.
Prerequisite: Must have completed or be concurrently enrolled in MATH141.
Restriction: Permission of ENGR-Mechanical Engineering department.
Credit Only Granted for: ENME414 or ENME272.

ENME289 Exploring Topics in Mechanical Engineering (2 Credits)
Introductory Design Topics in the Field of Mechanical Engineering.
Repeatable to: 4 credits if content differs.

ENME299 Topics in Mechanical Engineering (1-3 Credits)
Introductory topics in the field of mechanical engineering.
Restriction: Permission of ENGR-Mechanical Engineering department.
Repeatable to: 6 credits if content differs.

ENME299Q Quantum Steampunk Science-Fiction Workshop (3 Credits)
Steampunk is a science-fiction genre in which futuristic technologies populate Victorian-era settings. Recently, steampunk has come to life in the scientific field of quantum thermodynamics. Thermodynamics, the study of energy, grew out of the Industrial Revolution. Two centuries later, quantum physics is transforming computing and cryptography. Quantum science is now revolutionizing 19th-century thermodynamics in quantum thermodynamics, which features quantum engines, automata, and more. Quantum thermodynamics inspired the growing subgenre of quantum steampunk. In this course, you will read science fiction, write quantum steampunk short stories, receive feedback, and critique classmates' writing. In parallel, you will learn about quantum physics, technologies, and thermodynamics.
Cross-listed with: ARHU270, CMSC298Q, PHYS299Q.
Credit Only Granted for: ARHU270, ARHU298Q, CHEM298Q, CMSC298Q, ENME299Q or PHYS299Q.

ENME331 Fluid Mechanics (3 Credits)
Principles of fluid mechanics. Mass, momentum and energy conservation. Hydrostatics. Control volume analysis. Internal and external flow. Boundary layers. Modern measurement techniques. Computer analysis. Laboratory experiments.
Prerequisite: ENES232 and ENES221.
Credit Only Granted for: BIOE331, ENCE305, ENFP300, or ENME331.

ENME332 Transfer Processes (3 Credits)
The principles of heat transfer. Conduction in solids. Convection. Radiation. Modern measurement techniques. Computer analysis.
Prerequisite: ENME331.
Credit Only Granted for: ENME332 or ENFP312.

ENME350 Electronics and Instrumentation I (3 Credits)
Modern instrumentation. Basic circuit design, standard microelectronic circuits. Digital data acquisition and control. Signal conditioning. Instrumentation interfacing. Designing and testing of analog circuits. Laboratory experiments.
Prerequisite: PHYS271 and PHYS270.

ENME351 Electronics and Instrumentation II (3 Credits)
Continuation of ENME 350. Modern instrumentation. Basic circuit design, standard microelectronic circuits. Digital data acquisition and control. Signal conditioning. Instrumentation interfacing. Designing and testing of analog circuits. Laboratory experiments.
Prerequisite: PHYS271, ENME350, and PHYS270.

ENME361 Vibration, Controls and Optimization I (3 Credits)
Fundamentals of vibration, controls and optimization. Analysis and design in time, Laplace and frequency domains. Mathematical description of system response, system stability, control and optimization. Optimal design of mechanical systems.
Prerequisite: ENES220, ENES221, and MATH246; and (MATH206 or ENME202).
Restriction: Must be in Engineering: Mechanical program.

ENME371 Product Engineering and Manufacturing (3 Credits)
Business aspects of engineering product development. Relationship of design and manufacturing. Product specification. Statistical process control. Design team development. The development process.
Prerequisite: ENES221; and (ENME392 or STAT400).
Restriction: Must be in Engineering: Mechanical program.

ENME382 Introduction to Materials Engineering (3 Credits)
Structure of materials, chemical composition, phase transformations, corrosion and mechanical properties of metals, ceramics, polymers and related materials. Materials selection in engineering applications.
Prerequisite: ENES100; and permission of ENGR-Mechanical Engineering department.
Corequisite: MATH241.
Recommended: PHYS261 and PHYS260.
Restriction: Permission of ENGR-Mechanical Engineering department. Cross-listed with ENMA300.
Credit Only Granted for: ENMA300 or ENME382.

ENME392 Statistical Methods for Product and Processes Development (3 Credits)
Integrated statistical methodology for the improvement of products and processes in terms of performance, quality and cost. Designed experimentation. Statistical process control. Software application. Laboratory activities.
Prerequisite: MATH241.

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.
Cross-listed with: ENES401.
Restriction: Must have senior standing and permission of instructor.
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.
Jointly offered with: ENME745.
Restriction: Permission of ENGR-Mechanical Engineering department.
Credit Only Granted for: ENME745, ENME808B, ENME417 or ENME489J.
Formerly: ENME489J.

ENME420 Energy Audit for Decarbonization and Sustainability Enhancement (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: ENES232; and must have completed or be concurrently enrolled in ENME332 .
Jointly offered with: ENME742.
Restriction: Permission of ENGR-Mechanical Engineering department.
Credit Only Granted for: ENME424 or ENME742.

ENME425 Energy Conversion Systems for Sustainability (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 Integrity (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.

ENME434 Engineering Quantum Systems and Sensors (3 Credits)
Designed for students interested in learning quantum mechanics from a technological perspective, illustrated through specific examples from quantum engineering at the nanoscale and from discrete quantum systems. The focus is not on textbook examples such as hydrogen atom solutions and angular momentum algebra. Instead, focus areas would be quantum sensors and systems, description and control of quantum noise, which should elicit particular appeal across many areas of engineering and physical sciences. The course will prepare students for emerging quantum technologies besides computing and cryptography that are part of the Quantum 2.0 revolution.
Prerequisite: PHYS270 and MATH141.
Recommended: Any MATH 240, MATH 461, MATH341, or ENEE290 or equivalent courses covering linear algebra, eigenvalues, and eigenvectors.
Jointly offered with: ENME692.
Restriction: Permission of Mechanical Engineering department.
Credit Only Granted for: ENME434 or ENME692.

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, CO_2 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.

ENME437 Data Science in Manufacturing Quality Control (3 Credits)
Introduces manufacturing quality management in the big data era. Students will learn quality improvement philosophies, statistical modeling of process quality (statistical process control and control charts), and measurement system analysis (gauge repeatability and reproducibility). Students will also explore the application of machine learning towards quality prediction and classification of manufactured products, and understand the limitations of applied supervised and unsupervised machine learning in the realm of manufacturing quality control.
Prerequisite: A minimum grade of C- in ENME202 and ENME392.
Jointly offered with: ENME697.
Restriction: Permission of ENGR-Mechanical Engineering department .
Credit Only Granted for: ENME437 or ENME697.

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.
Jointly offered with: ENME743.
Restriction: Permission of ENGR-Mechanical Engineering department.
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.
Cross-listed with: ENES467.
Restriction: Junior standing or higher.
Credit Only Granted for: ENES467 or ENME467.
Additional Information: Students in the Mechanical Engineering (ENME) major should register for ENME467, all other majors should register under ENES467.

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 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.
Prerequisite: ENME351.
Jointly offered with: ENME690.
Restriction: Permission of the Department of Mechanical Engineering.
Credit Only Granted for: ENME473 or ENME690.

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.

ENME479 Selected Topics in Mechanical Engineering (1-3 Credits)
Covers current topics in mechanical engineering and related fields.
Restriction: Permission of the Department of Mechanical Engineering.
Repeatable to: 6 credits if content differs.

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.
Credit Only Granted for: ENME480 or ENMT380.

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.
Jointly offered with: ENME657.
Restriction: Permission of ENGR-Mechanical Engineering department.
Credit Only Granted for: ENME484 or ENME657.

ENME485 Industrial Artificial Intelligence (3 Credits)
Introduces students to advanced technologies such as machine learning and tools, prognostics and health management (PHM), and data-centric engineering analytics - that ultimately enable the conversion of industrial big data into decision-ready information that can be used to improve the design, the productivity and the efficiency of industrial systems.,
Prerequisite: ENME202 or equivalent, experience using Python, or permission of the instructor.
Jointly offered with: ENME691.
Restriction: Permission of ENGR-Mechanical Engineering Department.
Credit Only Granted for: ENME485 or ENME691.

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.