Mechanical Engineering (M E)

Courses primarily for undergraduates:

M E 160. Mechanical Engineering Problem Solving with Computer Applications.
(2-2) Cr. 3. F.S. *Prereq: MATH 142 or satisfactory scores on Mathematics placement examinations; credit or enrollment in MATH 165.*
Introduction to the field of Mechanical Engineering through problem-solving in a range of topics including statics, mechanics of materials and thermo-fluids. Techniques to professionally present and communicate solutions. Use of MATLAB computer programming to aid problem solving, including curve fitting and graphing. Only one of M E 160, ENGR 160, Aer E 160, C E 160, CPR E 185, E E 185, S E 185 and I E 148 may count towards graduation.

M E 170. Engineering Graphics and Introductory Design.
(2-2) Cr. 3. F.S. *Prereq: Satisfactory scores on mathematics placement assessments; credit or enrollment in MATH 142*
Integration of fundamental graphics, computer modeling, and engineering design. Applications of multiview drawings and dimensioning. Techniques for visualizing, analyzing, and communicating 3-D geometries. Application of the design process including written and oral reports. Freehand and computer methods.

M E 190. Learning Communities.
(1-0) Cr. 1. Repeatable. F.S.
Enrollment in M E learning communities.

M E 202. Mechanical Engineering - Professional Planning.
(1-0) Cr. R. F.S. *Prereq: Sophomore classification*
Preparation for a career in mechanical engineering; discussion of opportunities for leadership, undergraduate research, experiential learning.

M E 220. Globalization and Sustainability.
(Cross-listed with ANTHR, ENV S, GLOBE, MAT E, T SC, SOC). (3-0) Cr. 3. F.S.
An introduction to understanding the key global issues in sustainability. Focuses on interconnected roles of energy, materials, human resources, economics, and technology in building and maintaining sustainable systems. Applications discussed will include challenges in both the developed and developing world and will examine the role of technology in a resource-constrained world. Cannot be used for technical elective credit in any engineering department.
Meets International Perspectives Requirement.

M E 231. Engineering Thermodynamics I.
(3-0) Cr. 3. F.S.SS. *Prereq: MATH 265, CHEM 167, PHYS 222*
Fundamental concepts based on zeroth, first and second laws of thermodynamics. Properties and processes for ideal gases and solid-liquid-vapor phases of pure substances. Applications to vapor power cycles. Credit for either M E 231 or 330, but not both, may be applied toward graduation.

M E 270. Introduction to Mechanical Engineering Design.
(1-6) Cr. 3. F.S. *Prereq: M E 170 or equivalent, PHYS 221*
Overview of mechanical engineering design with applications to thermal and mechanical systems. Introduction to current design practices used in industry. Semester-long team project focused on addressing societal needs. Past projects include designing human powered charging systems and products for developing nations.

M E 298. Cooperative Education.
Cr. R. F.S.SS. *Prereq: Permission of department*
First professional work period in the cooperative education program. Students must register for this course before commencing work.

M E 324. Manufacturing Engineering.
(3-0) Cr. 3. F.S.SS. *Prereq: M E 270, E M 324, MAT E 273 and M E 324L or permission of instructor*
Fundamentals of manufacturing processes including forming, machining, casting and welding with emphasis on design considerations in manufacturing. Mechanical behavior of metallic materials. Modern manufacturing practices. Nonmajor graduate credit.

M E 324L. Manufacturing Engineering Laboratory.
(0-2) Cr. 1. F.S.SS. *Prereq: M E 270, MAT E 273*
Laboratory exercises in metrology, mechanical testing (tensile/compression and hardness tests), computer aided design (CAD), machining operations, metal welding, metal casting, and bulk/sheet metal forming.

M E 325. Machine Design.
(3-0) Cr. 3. F.S.SS. *Prereq: M E 170, E M 324*
Philosophy of design and design methodology. Consideration of stresses and failure models useful for static and fatigue loading. Analysis, selection and synthesis of machine elements. Nonmajor graduate credit.

M E 332. Engineering Thermodynamics II.
(3-0) Cr. 3. F.S.SS. *Prereq: M E 231*
Gas power cycles. Fundamentals of gas mixtures, psychrometry, and thermochemistry. Applications to one-dimensional compressible flow, refrigeration, air conditioning and combustion processes. Nonmajor graduate credit.

M E 335. Fluid Flow.
(3-2) Cr. 4. F.S.SS. *Prereq: Credit or enrollment in M E 332, E M 345, MATH 266 or MATH 267*
Incompressible and compressible fluid flow fundamentals. Dimensional analysis and similitude. Internal and external flow applications. Lab experiments emphasizing concepts in thermodynamics and fluid flow. Written reports are required. Nonmajor graduate credit.

M E 370. Engineering Measurements.
(2-3) Cr. 3. F.S.SS. *Prereq: E E 442, STAT 305*
Fundamentals of design, selection, and operation of components of measuring systems. Measurement processes, data acquisition systems, analysis of data, and propagation of measurement uncertainty. Nonmajor graduate credit.

M E 388. Sustainable Engineering and International Development.
(Cross-listed with A E, E E, C E, MAT E, BSE). (2-2) Cr. 3. F. *Prereq: Junior classification in engineering*
Multi-disciplinary approach to sustainable engineering and international development, sustainable development, appropriate design and engineering, feasibility analysis, international aid, business development, philosophy and politics of technology, and ethics in engineering. Engineering-based projects from problem formulation through implementation. Interactions with partner community organizations or international partners such as nongovernment organizations (NGOs). Course readings, final project/design report.
Meets International Perspectives Requirement.

M E 389. Applied Methods in Sustainable Engineering.
(Cross-listed with MAT E). (3-0) Cr. 3. Repeatable, maximum of 2 times. SS.
Learning how to work in a cross disciplinary engineering team to develop and implement appropriate solutions for cooking, lighting, farming, and sanitation in a rural village in Mali. Engineering principles necessary for the projects to be worked on including lighting solutions in a village without electricity, new construction materials, water, etc. Application of engineering principles from core courses. Design conception, feasibility, production, and implementation within context of local cultures and needs. Emphasis on creating real solutions that can be implemented with the constraints imposed by cost, time, manufacturing capability, and culture.
Meets International Perspectives Requirement.

M E 396. Summer Internship.
Cr. R. Repeatable. SS. *Prereq: Permission of department and Engineering Career Services*
Summer professional work period.

M E 397. Engineering Internship.
Cr. R. Repeatable. F.S. *Prereq: Permission of department and Engineering Career Services*
Professional work period, one semester maximum per academic year.

M E 398. Cooperative Education.
Cr. R. F.S.SS. *Prereq: M E 298, permission of department and Engineering Career Services*
Second professional work period in the cooperative education program. Students must register for this course before commencing work.

M E 410. Mechanical Engineering Applications of Mechatronics.
(2-2) Cr. 3. S. *Prereq: E E 442, E E 448, credit or enrollment in M E 421*
Fundamentals of sensor characterization, signal conditioning and motion control, coupled with concepts of embedded computer control. Digital and analog components used for interfacing with computer controlled systems. Mechanical system analysis combined with various control approaches. Focus on automation of hydraulic actuation processes. Laboratory experiences provide hands-on development of mechanical systems. Nonmajor graduate credit.

M E 411. Automatic Controls.
(2-2) Cr. 3. F. *Prereq: M E 421*
Methods and principles of automatic control. Pneumatic, hydraulic, and electrical systems. Representative applications of automatic control systems. Mathematical analysis of control systems. Nonmajor graduate credit.

M E 412. Ethical Responsibilities of a Practicing Engineer.
(3-0) Cr. 3. F. *Prereq: Credit or enrollment in M E 325*
The study of ethics in engineering design and the engineering profession. A comprehensive look at when ethical decisions must be made and an approach to make them. The approach takes into account moral, legal, technical, experiential, and standards to aid in ethical decision making. Each area will be studied through lectures, debates, guest speakers, class discussion, and case studies. Nonmajor graduate credit.

M E 413. Fluid Power Engineering.
(Cross-listed with A E). (2-2) Cr. 3. F. *Prereq: Credit or enrollment in E M 378 or M E 335, A E 216 or M E 270*
Properties of hydraulic fluids. Performance parameters of fixed and variable displacement pumps and motors. Hydraulic circuits and systems. Hydrostatic transmissions. Characteristics of control valves. Analysis and design of hydraulic systems for power and control functions. Nonmajor graduate credit.

M E 415. Mechanical Systems Design.
(0-6) Cr. 3. F.S. *Prereq: M E 324, M E 325*
Mechanical Engineering Capstone Design course. Team approach to solving design problems involving mechanical systems. Teams will use current design practices they will encounter in industry. Document decisions concerning form and function, material specification, manufacturing methods, safety, cost, and conformance with codes and standards. Solution description includes oral and written reports. Projects often worked with industry sponsors. Nonmajor graduate credit.

M E 417. Advanced Machine Design.
(Dual-listed with M E 517). (3-0) Cr. 3. S. *Prereq: M E 325, MAT E 273*
Stress life, strain life, and fracture mechanics approaches to fatigue life and design with metals, polymers and ceramics. Introduction to material selection in design of machine components. Thermal and structural considerations in design of machine components and hybrid materials. Course project and relevant literature review required for graduate credit. Nonmajor graduate credit.

M E 418. Mechanical Considerations in Robotics.
(Dual-listed with M E 518). (3-0) Cr. 3. S. *Prereq: Credit or enrollment in M E 421*
Three dimensional kinematics, dynamics, and control of robot manipulators, hardware elements and sensors. Laboratory experiments using industrial robots. Nonmajor graduate credit.

M E 419. Computer-Aided Design.
(3-0) Cr. 3. F. *Prereq: M E 325*
Theory and applications of computer- aided design. Computer graphics programming, solid modeling, assembly modeling, and finite element modeling. Mechanical simulation, process engineering, rapid prototyping and manufacturing integration. Nonmajor graduate credit.

M E 421. System Dynamics and Control.
(3-2) Cr. 4. F.S.SS. *Prereq: E E 442, E E 448, E M 345, MATH 267*
Modeling and simulation of mechanical, electrical, fluid, and/or thermal systems. Development of equations of motion and dynamic response characteristics in time and frequency domains. Fundamentals of classical control applications, including mathematical analysis and design for closed loop control systems. Introduction to computer interfacing for simulation, data acquisition, and control. Laboratory exercises for hands-on system investigation and control implementation. Nonmajor graduate credit.

M E 423. Creativity and Imagination for Engineering and Design.
(Dual-listed with M E 523). (3-0) Cr. 3. F.
Improve ability to think creatively and be innovative in designs. Understand and discuss creativity from different perspectives, learn to control your voice of judgment, identify personality traits that encourage and hinder creativity. Assignments include individual and team design projects; weekly readings; and, for graduate students, a semester-long research project on creativity and the development of a related teaching module.

M E 425. Optimization Methods for Complex Designs.
(Dual-listed with M E 525). (Cross-listed with HCI). (3-0) Cr. 3. S. *Prereq: M E 160, MATH 265*
Optimization involves finding the 'best' according to specified criteria. Review of a range of optimization methods from traditional nonlinear to modern evolutionary methods such as Genetic algorithms. Examination of how these methods can be used to solve a wide variety of design problems across disciplines, including mechanical systems design, biomedical device design, biomedical imaging, and interaction with digital medical data. Students will gain knowledge of numerical optimization algorithms and sufficient understanding of the strengths and weaknesses of these algorithms to apply them appropriately in engineering design. Experience includes code writing and off-the-shelf routines. Numerous case-studies of real-world situations in which problems were modeled and solved using advanced optimization techniques. Nonmajor graduate credit.

M E 433. Alternative Energy.
(3-0) Cr. 3. F. *Prereq: PHYS 221/PHYS 222 and CHEM 167*
Basic principles, performance, and cost analysis of alternative energy systems including biofuels, bioenergy, wind, solar, fuel cells, storage and other alternative energy systems. Performance analysis and operating principles of systems and components, and economic analysis for system design and operation will be taught. Emphasis is on alternative energy technologies needed to meet our future energy needs at various scales ranging from household to city to national levels. Nonmajor graduate credit.

M E 436. Heat Transfer.
(3-2) Cr. 4. F.S.SS. *Prereq: M E 335*
Heat transfer by conduction, convection, and radiation. Similarity concepts in heat, mass, and momentum transfer. Methods for determination of heat transfer coefficients. Combined modes of heat transfer. Heat exchangers. Lab experiments emphasizing concepts in thermodynamics and heat transfer. Written reports are required. Nonmajor graduate credit.

M E 437. Introduction to Combustion Engineering.
(3-0) Cr. 3. S. *Prereq: Credit in M E 332 or equivalent and credit or enrollment in M E 335 or equivalent*
Introduction to the fundamentals of combustion and the analysis of combustion systems for gaseous, liquid, and solid fuels-including biomass fuels. Combustion fundamentals are applied to the analysis of engines; turbines, biomass cookstoves; suspension, fixed-bed, and fluidized-bed furnaces; and other combustion devices.

M E 441. Fundamentals of Heating, Ventilating, and Air Conditioning.
(3-0) Cr. 3. F. *Prereq: Credit or enrollment in M E 436*
Space conditioning and moist air processes. Application of thermodynamics, heat transfer, and fluid flow principles to the analysis of heating, ventilating, and air conditioning components and systems. Performance and specification of components and systems. Nonmajor graduate credit.

M E 442. Heating and Air Conditioning Design.
(1-5) Cr. 3. S. *Prereq: M E 441*
Design criteria and assessment of building environment and energy requirements. Design of heating, ventilating, and air conditioning systems. System control and economic analysis. Oral and written reports required. Nonmajor graduate credit.

M E 444. Elements and Performance of Power Plants.
(3-0) Cr. 3. S. *Prereq: M E 332, credit or enrollment in M E 335*
Basic principles, thermodynamics, engineering analysis of power plant systems. Topics include existing power plant technologies, the advanced energyplex systems of the future, societal impacts of power production, and environmental and regulatory concerns. Nonmajor graduate credit.

M E 448. Fluid Dynamics of Turbomachinery.
(Cross-listed with AER E). (3-0) Cr. 3. S. *Prereq: M E 335 or equivalent*
Applications of principles of fluid mechanics and thermodynamics in performance analysis and design of turbomachines. Conceptual and preliminary design of axial and radial flow compressors and turbines using velocity triangles and through-flow approaches. Nonmajor graduate credit.

M E 449. Internal Combustion Engines.
(3-1) Cr. 3. F. *Prereq: M E 335*
Basic principles, thermodynamics, combustion, and exhaust emissions of spark-ignition and compression-ignition engines. Laboratory determination of fuel properties and engine performance. Effects of engine components and operating conditions on performance. Written reports required. Nonmajor graduate credit.

M E 451. Engineering Acoustics.
(Cross-listed with E M). (2-2) Cr. 3. Alt. S., offered 2012. *Prereq: PHYS 221 and MATH 266 or MATH 267*
Properties of sounds waves and noise metrics (pressure, power levels, etc). Sound sources and propagation. Principles of wave propagation in one-, two-, and three-dimensions. Wave reflection and transmission. Wave propagation in rectangular, cylindrical, and annular ducts. Acoustics fields for model noise sources. Introduction to aerodynamic noise sources in aircraft, aircraft engines, and wind turbines. Selected laboratory experiments. Nonmajor graduate credit.

M E 466. Multidisciplinary Engineering Design.
(Cross-listed with A E, AER E, CPR E, E E, ENGR, I E, MAT E). (1-4) Cr. 3. Repeatable. F.S. *Prereq: Student must be within two semesters of graduation and permission of instructor.*
Application of team design concepts to projects of a multidisciplinary nature. Concurrent treatment of design, manufacturing and life cycle considerations. Application of design tools such as CAD, CAM and FEM. Design methodologies, project scheduling, cost estimating, quality control, manufacturing processes. Development of a prototype and appropriate documentation in the form of written reports, oral presentations, computer models and engineering drawings.

M E 467. Multidisciplinary Engineering Design II.
(Cross-listed with AER E, CPR E, E E, I E, MAT E, ENGR). (1-4) Cr. 3. Repeatable, maximum of 2 times. F.S. *Prereq: Student must be within two semesters of graduation or receive permission of instructor.*
Build and test of a conceptual design. Detail design, manufacturability, test criteria and procedures. Application of design tools such as CAD and CAM and manufacturing techniques such as rapid prototyping. Development and testing of a full-scale prototype with appropriate documentation in the form of design journals, written reports, oral presentations and computer models and engineering drawings.

M E 475. Modeling and Simulation.
(3-0) Cr. 3. S. *Prereq: M E 421, credit or enrollment in M E 436*
Introduction to computer solution techniques required to simulate flow, thermal, and mechanical systems. Methods of solving ordinary and partial differential equations and systems of algebraic equations; interpolation, numerical integration; finite difference and finite element methods. Nonmajor graduate credit.

M E 479. Sustainability Science for Engineering Design.
(3-0) Cr. 3. S. *Prereq: Any engineering design course*
Scientific principles and quantitative methods concerning sustainability. Analysis of environmental issues associated with engineering design and product manufacturing in an economic and social context. Heuristic and analytical methods for assessing the sustainability of existing or potential product/service designs. Application to a design problem in teams. Nonmajor graduate credit.

M E 484. Technology, Globalization and Culture.
(Dual-listed with M E 584). (Cross-listed with WLC). (3-0) Cr. 3. F. *Prereq: senior classification for M E 484; graduate classification for M E 584*
Cross-disciplinary examination of the present and future impact of globalization with a focus on preparing students for leadership roles in diverse professional, social, and cultural contexts. Facilitate an understanding of the threats and opportunities inherent in the globalization process as they are perceived by practicing professionals and articulated in debates on globalization. Use of a digital forum for presenting and analyzing globalization issues by on-campus and off-campus specialists.
Meets International Perspectives Requirement.

M E 486. Appropriate Technology Design.
(3-0) Cr. 3. F. *Prereq: M E 231,M E 270, enrollment in M E 335; or permission of instructor.*
Hands-on design experience utilizing knowledge acquired in core mechanical engineering courses. Emphasis with engineering problem formulation and solution, oral and written communication, team decision-making and ethical conduct. Design projects include engineering considerations in appropriate technology which have multidisciplinary components in economics and sociology.

M E 490. Independent Study.
Cr. 1-6. Repeatable. *Prereq: Senior classification*
Investigation of topics holding special interest of students and faculty. Election of course and topic must be approved in advance by supervising faculty.

M E 490H. Independent Study: Honors.
Cr. 1-6. Repeatable. *Prereq: Senior classification*
Investigation of topics holding special interest of students and faculty. Election of course and topic must be approved in advance by supervising faculty.

M E 490J. Independent Study: Thermodynamics and Energy Utilization.
Cr. 1-6. Repeatable. *Prereq: Senior classification*
Investigation of topics holding special interest of students and faculty. Election of course and topic must be approved in advance by supervising faculty.

M E 490M. Independent Study: Nuclear Engineering.
Cr. 1-6. Repeatable. *Prereq: Senior classification*
Investigation of topics holding special interest of students and faculty. Election of course and topic must be approved in advance by supervising faculty.

M E 490O. Independent Study: Design and Optimization.
Cr. 1-6. Repeatable. *Prereq: Senior classification*
Investigation of topics holding special interest of student and faculty. Election of course and topic must be approved in advance by supervising faculty.

M E 490P. Dynamic Systems and Controls.
Cr. 1. Repeatable. *Prereq: Senior classification*
Investigation of topics holding special interest of student and faculty. Election of course and topic must be approved in advance by supervising faculty.

M E 490Q. Independent Study: Materials Processing and Mechanics.
Cr. 1-6. Repeatable. *Prereq: Senior classification*
Investigation of topics holding special interest of student and faculty. Election of course and topic must be approved in advance by supervising faculty.

M E 490R. Independent Study: Thermo-fluids.
Cr. 1-6. Repeatable. *Prereq: Senior classification*
Investigation of topics holding special interest of student and faculty. Election of course and topic must be approved in advance by supervising faculty.

M E 490S. Independent Study: Emerging Areas.
Cr. 1-6. Repeatable. *Prereq: Senior classification*
Investigation of topics holding special interest of student and faculty. Election of course and topic must be approved in advance by supervising faculty.

M E 498. Cooperative Education.
Cr. R. Repeatable. F.S.SS. *Prereq: M E 298, permission of department and Engineering Career Services*
Third and subsequent professional work periods in the cooperative education program. Students must register for this course before commencing work.

Courses primarily for graduate students, open to qualified undergraduates:

M E 511. Advanced Control Design.
(3-0) Cr. 3. S. *Prereq: M E 411*
Application of control design methods using continuous, discrete, and frequency-based models. Approaches include classical, pole assignment, model reference, internal model, and adaptive control methods. Mechanical design projects.

M E 517. Advanced Machine Design.
(Dual-listed with M E 417). (3-0) Cr. 3. S. *Prereq: M E 325, MAT E 273*
Stress life, strain life, and fracture mechanics approaches to fatigue life and design with metals, polymers and ceramics. Introduction to material selection in design of machine components. Thermal and structural considerations in design of machine components and hybrid materials. Course project and relevant literature review required for graduate credit.

M E 518. Mechanical Considerations in Robotics.
(Dual-listed with M E 418). (3-0) Cr. 3. S. *Prereq: Credit or enrollment in 421*
Three dimensional kinematics, dynamics, and control of robot manipulators, hardware elements and sensors. Laboratory experiments using industrial robots. Nonmajor graduate credit.

M E 520. Material and Manufacturing Considerations in Design.
(3-0) Cr. 3. F. *Prereq: M E 324, M E 325*
Integration of materials, design and manufacturing. Materials selection. Design for assembly and manufacturing (DFMA). Design and redesign to facilitate cost-effective manufacturing using material selection and DFMA software.

M E 521. Mechanical Behavior and Manufacturing of Polymers and Composites.
(Cross-listed with M S E). (3-0) Cr. 3. Alt. S., offered 2013. *Prereq: M E 324 or MAT E 272 and E M 324*
Effect of chemical structure and morphology on properties. Linear viscoelasticity, damping and stress relaxation phenomena. Structure and mechanics of filler and fiber reinforced composites. Mechanical properties and failure mechanisms. Material selection and designing with polymers. Processing of polymer and composite parts.

M E 523. Creativity and Imagination for Engineering and Design.
(Dual-listed with M E 423). (3-0) Cr. 3. F. *Prereq: Graduate classification*
Broad exposure to the study of creativity, both in scientific research and in engineering design practice. Exploration of the subject includes readings from a variety of fields; in-class discussion and activities; and individual and team projects that enable students to develop their creativity. Graduate students also will do independent research on creativity and develop a related teaching module.

M E 525. Optimization Methods for Complex Designs.
(Dual-listed with M E 425). (Cross-listed with HCI). (3-0) Cr. 3. S. *Prereq: ENGR 160, MATH 265*
Optimization involves finding the 'best' according to specified criteria. Review of a range of optimization methods from traditional nonlinear to modern evolutionary methods such as Genetic algorithms. Examination of how these methods can be used to solve a wide variety of design problems across disciplines, including mechanical systems design, biomedical device design, biomedical imaging, and interaction with digital medical data. Students will gain knowledge of numerical optimization algorithms and sufficient understanding of the strengths and weaknesses of these algorithms to apply them appropriately in engineering design. Experience includes code writing and off-the-shelf routines. Students will also be exposed to numerous case-studies of real-world situations in which problems were modeled and solved using advanced optimization techniques.

M E 527. Mechanics of Machining and Finishing Processes.
(3-0) Cr. 3. Alt. S., offered 2013. *Prereq: M E 324*
Mechanics of material removal for ductile materials. Shear zone theory. Oblique cutting. Heat transfer in machining. Milling and grinding. Mechanics of material removal for brittle materials. Optimal selection and design of cutting parameters. Control of machining processes. Principles of precision finishing. Design considerations for machining and finishing processes.

M E 528. Micro/Nanomanufacturing.
(3-0) Cr. 3. Alt. S., offered 2012. *Prereq: M E 324*
Concepts and applications of micro/nanotechnology appropriate to the manufacturing field. An overview of micro/nano-fabrication techniques including mechanical, EDM, laser and lithography. MEMS device fabrication. Scaling laws. Top down and bottom up approaches of nanomanufacturing. Experimental or theoretical project leading to potential submission of a manuscript for journal or conference.

M E 530. Advanced Thermodynamics.
(3-0) Cr. 3. F. *Prereq: M E 332*
Fundamentals of thermodynamics from the classical viewpoint with emphasis on the use of the first and second laws for analysis of thermal systems. Generalized thermodynamic relationships. Computer applications of thermodynamic properties and system analysis. Selected topics.

M E 532. Compressible Fluid Flow.
(Cross-listed with AER E). (3-0) Cr. 3. Alt. S., offered 2012. *Prereq: AER E 311*
Thermodynamics of compressible flow. Viscous and inviscid compressible flow equations. One dimensional steady flow; isentropic flow, normal shock waves oblique and curved shocks. Method of characteristics. Subsonic, transonic, supersonic and hypersonic flows. Compressible boundary layers.

M E 535. Thermochemical Processing of Biomass.
(Cross-listed with BRT). (3-0) Cr. 3. S. *Prereq: Undergraduate course work in thermodynamics and transport phenomena*
Introduction to thermal and catalytic processes for the conversion of biomass to biofuels and other biobased products. Topics include gasification, fast pyrolysis, hydrothermal processing, syngas to synfuels, and bio-oil upgrading. Application of thermodynamics, heat transfer, and fluid dynamics to bioenergy and biofuels.

M E 536. Advanced Heat Transfer.
(3-0) Cr. 3. S. *Prereq: M E 436*
Advanced treatment of heat transmission by conduction, convection, and radiation.

M E 538. Advanced Fluid Flow.
(3-0) Cr. 3. F. *Prereq: Credit or enrollment in M E 436*
Detailed analysis of incompressible/compressible, viscous/inviscid, laminar/turbulent, and developing fluid flows on a particle/point control volume basis.

M E 540. Solar Energy Systems.
(3-0) Cr. 3. F. *Prereq: M E 436*
Application of heat transfer, thermodynamics and photovoltaics to the design and analysis of solar energy collectors and systems.

M E 542. Advanced Combustion.
(3-0) Cr. 3. S. *Prereq: M E 332 or CH E 381*
Thermochemistry and transport theory applied to combustion. Gas phase equilibrium. Energy balances. Reaction kinetics. Flame temperatures, speed, ignition, and extinction. Premixed and diffusion flames. Combustion aerodynamics. Mechanisms of air pollution.

M E 543. Introduction to Random Vibrations and Nonlinear Dynamics.
(Cross-listed with E M). (3-0) Cr. 3. Alt. S., offered 2013. *Prereq: 444*
Vibrations of continuous systems. Nonlinear vibration phenomena, perturbation expansions; methods of multiple time scales and slowly-varying amplitude and phase. Characteristics of random vibrations; random processes, probability distributions, spectral density and its significance, the normal or Gaussian random process. Transmission of random vibration, response of simple single and two-degree-of-freedom systems to stationary random excitation. Fatigue failure due to random excitation.

M E 545. Thermal Systems Design.
(3-0) Cr. 3. Alt. F., offered 2012. *Prereq: M E 436*
Integrating thermodynamics, fluid mechanics, and heat transfer to model thermal equipment and to simulate thermal systems. Second law and parametric analysis; cost estimation, life cycle analysis and optimization. Some computer programming required.

M E 546. Computational Fluid Mechanics and Heat Transfer I.
(Dual-listed with M E 446). (3-0) Cr. 3. F. *Prereq: AER E 161, AER E 310*
Basic concepts of discretization, consistency, and stability. Explicit and implicit methods for ordinary diffential equations. Methods for each type of partial differential equation. Iterative solution methods; curvilinear grids. Examples of basic algorithms. Nonmajor graduate credit.

M E 547. Computational Fluid Mechanics and Heat Transfer II.
(Cross-listed with AER E). (3-0) Cr. 3. Alt. S., offered 2013. *Prereq: AER E 546 or AER E 546*
Application of computational methods to current problems in fluid mechanics and heat transfer. Methods for solving the Navier-Stokes and reduced equation sets such as the Euler, boundary layer, and parabolized forms of the conservation equations. Introduction to relevant aspects of grid generation and turbulence modeling.

M E 552. Advanced Acoustics.
(Cross-listed with E M). (3-0) Cr. 3. Alt. F., offered 2011. *Prereq: E M 451*
Theoretical acoustics: wave propagation in fluids; acoustic radiation, diffraction and scattering; nonlinear acoustics; radiation force; cavitation; and ray acoustics.

M E 557. Computer Graphics and Geometric Modeling.
(Cross-listed with CPR E, COM S). (3-0) Cr. 3. F.S. *Prereq: M E 421, programming experience in C*
Fundamentals of computer graphics technology. Data structures. Parametric curve and surface modeling. Solid model representations. Applications in engineering design, analysis, and manufacturing.

M E 561. Scanning Probe Microscopy.
(2-1) Cr. 3. Alt. F., offered 2012. *Prereq: First year physics, chemistry*
Introduction to the scanning probe microscope (SPM, also known as atomic force microscope or AFM) and associated measurement techniques. Overview or instrumentation system, basic principles of operation, probe-sample interaction and various operational modes to obtain micro/nanoscale structure and force spectroscopy of material surfaces. Examples of SPM significance and applications in science and engineering research, nanotechnology and other industries. Laboratory work involving use of a scanning probe microscope system is an integral part of the course.

M E 563. Micro and Nanoscale Mechanics.
(3-0) Cr. 3. Alt. F., offered 2011. *Prereq: E M 324 and M E 325*
Review of Fundamentals: (Elasticity, Electromagnetism, Mechanical response), Mechanics of thermally, electrostatically and magnetically actuated microsystems, Mechanics and design of nanostructured materials, mechanics of surface stress engineering and its implications to sensors and thin film structures.

M E 564. Fracture and Fatigue.
(Cross-listed with M S E, E M, AER E). (3-0) Cr. 3. Alt. F., offered 2012. *Prereq: E M 324 and either MAT E 216 or MAT E 273 or MAT E 392. Undergraduates: Permission of instructor*
Materials and mechanics approach to fracture and fatigue. Fracture mechanics, brittle and ductile fracture, fracture and fatigue characteristics, fracture of thin films and layered structures. Fracture and fatigue tests, mechanics and materials designed to avoid fracture or fatigue.

M E 566. Phase Transformation in Elastic Materials.
(Cross-listed with E M). (3-0) Cr. 3. S. *Prereq: EM 510 or EM 516 or EM 514*
Continuum thermodynamics and kinetics approaches to phase transformations. Phase field approach to stress- and temperature-induced martensitic transformations and twinning at the nanoscale. Nucleation and growth. Nanostructural evaluation. Analytical and numerical solutions. Surface stresses and energy. Surface-induced phase transformations. Large Strain formulation.

M E 573. Random Signal Analysis and Kalman Filtering.
(Cross-listed with E E, MATH, AER E). (3-0) Cr. 3. F. *Prereq: E E 324 or AER E 331 or M E 370 or M E 411 or MATH 341*
Elementary notions of probability. Random processes. Autocorrelation and spectral functions. Estimation of spectrum from finite data. Response of linear systems to random inputs. Discrete and continuous Kalman filter theory and applications. Smoothing and prediction. Linearization of nonlinear dynamics.

M E 574. Optimal Control.
(Cross-listed with AER E, MATH, E E). (3-0) Cr. 3. S. *Prereq: E E 577*
The optimal control problem. Variational approach. Pontryagin's principle, Hamilton-Jacobi equation. Dynamic programming. Time-optimal, minimum fuel, minimum energy control systems. The regulator problem. Structures and properties of optimal controls.

M E 575. Introduction to Robust Control.
(Cross-listed with MATH, AER E, E E). (3-0) Cr. 3. *Prereq: E E 577*
Introduction to modern robust control. Model and signal uncertainty in control systems. Uncertainty description. Stability and performance robustness to uncertainty. Solutions to the H2, Hoo, and l1 control problems. Tools for robustness analysis and synthesis.

M E 576. Digital Feedback Control Systems.
(Cross-listed with AER E, MATH, E E). (3-0) Cr. 3. F. *Prereq: E E 475 or AER E 432 or M E 411 or 414 or MATH 415; and MATH 267*
Sampled data, discrete data, and the z-transform. Design of digital control systems using transform methods: root locus, frequency response and direct design methods. Design using state-space methods. Controllability, observability, pole placement, state estimators. Digital filters in control systems. Microcomputer implementation of digital filters. Finite wordlength effects. Linear quadratic optimal control in digital control systems. Simulation of digital control systems.

M E 577. Linear Systems.
(Cross-listed with AER E, MATH, E E). (3-0) Cr. 3. F. *Prereq: E E 324 or AER E 331 or MATH 415; and MATH 307*
Linear algebra review. Least square method and singular value decomposition. State space modeling of linear continuous-time systems. Solution of linear systems. Controllability and observability. Canonical description of linear equations. Stability of linear systems. State feedback and pole placements. Observer design for linear systems.

M E 578. Nonlinear Systems.
(Cross-listed with AER E, MATH, E E). (3-0) Cr. 3. S. *Prereq: E E 577*
Linear vs nonlinear systems. Phase plane analysis. Bifurcation and center manifold theory. Lyapunov stability. Absolute stability of feedback systems. Input-output stability. Passivity theory and feedback linearization. Nonlinear control design techniques.

M E 580. Virtual Environments, Virtual Worlds, and Application.
(Cross-listed with HCI). (3-0) Cr. 3. F. *Prereq: Senior or Graduate status.*
A systematic introduction to the underpinnings of Virtual Environments (VE), Virtual Worlds, advanced displays and immersive technologies; and an overview of some of the applications areas particularly virtual engineering.

M E 584. Technology, Globalization and Culture.
(Dual-listed with M E 484). (Cross-listed with WLC). (3-0) Cr. 3. F. *Prereq: senior classification for M E 484; graduate classification for M E 584*
Cross-disciplinary examination of the present and future impact of globalization with a focus on preparing students for leadership roles in diverse professional, social, and cultural contexts. Facilitate an understanding of the threats and opportunities inherent in the globalization process as they are perceived by practicing professionals and articulated in debates on globalization. Use of a digital forum for presenting and analyzing globalization issues by on-campus and off-campus specialists.
Meets International Perspectives Requirement.

M E 590. Special Topics.
Cr. 1-8. Repeatable.

M E 590Q. Special Topics: Independent Literature Investigation.
Cr. 1-8. Repeatable.

M E 590T. Special Topics: Biological and Nanoscale Sciences.
Cr. 1-8. Repeatable.

M E 590U. Special Topics: Complex Fluid Systems.
Cr. 1-8. Repeatable.

M E 590V. Special Topics: Clean Energy Technologies.
Cr. 1-8. Repeatable.

M E 590W. Special Topics: Design and Manufacturing Innovation.
Cr. 1-8. Repeatable.

M E 590Z. Special Topics: Simulation and Visualization.
Cr. 1-8. Repeatable.

M E 599. Creative Component.
Cr. arr. Repeatable.

Courses for graduate students:

M E 600. Seminar.
Cr. R. Repeatable.
(1-0).

M E 625. Surface Modeling.
(3-0) Cr. 3. Alt. S., offered 2012. *Prereq: M E 557, programming experience in C*
Theory and implementation of contemporary parametric sculptured surface modeling technology. Non-uniform rational B-spline (NURBS) curves and surfaces. Fundamental computational algorithms. Construction techniques. Advanced modeling topics. Computer projects.

M E 632. Multiphase Flow.
(Cross-listed with CH E). (3-0) Cr. 3. Alt. S., offered 2013. *Prereq: M E 538*
Single particle, mutliparticle and two-phase fluid flow phenomena (gas-solid, liquid-solid and gas-liquid mixtures); particle interactions, transport phenomena, wall effects; bubbles, equations of multiphase flow. Dense phase (fluidized and packed beds) and ducted flows; momentum, heat and mass transfer. Computer solutions.

M E 637. Convection Heat Transfer.
(3-0) Cr. 3. Alt. F., offered 2012. *Prereq: M E 436*
Convection heat transfer to internal or external flows under laminar or turbulent conditions. Dimensionless parameters. Classical solutions of Newtonian viscous flows. Forced and free convection. Special topics.

M E 638. Radiation Heat Transfer.
(3-0) Cr. 3. F. *Prereq: M E 436*
Techniques for analysis of radiation in enclosures. Radiative properties of surfaces. Radiative transfer in participating media. Combined modes of transfer. Approximate methods of analysis.

M E 647. Advanced High Speed Computational Fluid Dynamics.
(Cross-listed with AER E). (3-0) Cr. 3. Alt. S., offered 2013. *Prereq: AER E 547*
An examination of current methods in computational fluid dynamics. Differencing strategies. Advanced solution algorithms for unstructured meshes. Grid generation. Construction of higher-order CFD algorithms. Parallel computing. Current applications. Use of state of the art CFD codes.

M E 690. Advanced Topics.
Cr. arr. Repeatable.
Investigation of advanced topics of special interest to graduate students in mechanical engineering.

M E 690A. Advanced Topics: Experimental Gas Dynamics.
Cr. arr. Repeatable.
Investigation of advanced topics of special interest to graduate students in mechanical engineering.

M E 690B. Advanced Topics: Fluid Mechanics.
Cr. arr. Repeatable.
Investigation of advanced topics of special interest to graduate students in mechanical engineering.

M E 690C. Advanced Topics: Heat Transfer.
Cr. arr. Repeatable.
Investigation of advanced topics of special interest to graduate students in mechanical engineering.

M E 690D. Advanced Topics: Thermodynamics and Energy Utilization.
Cr. arr. Repeatable.
Investigation of advanced topics of special interest to graduate students in mechanical engineering.

M E 690E. Advanced Topics: Turbomachinery.
Cr. arr. Repeatable.
Investigation of advanced topics of special interest to graduate students in mechanical engineering.

M E 690F. Advanced Topics: Vehicular Propulsion Systems.
Cr. arr. Repeatable.
Investigation of advanced topics of special interest to graduate students in mechanical engineering.

M E 690G. Advanced Topics: Advanced Machine Design.
Cr. arr. Repeatable.
Investigation of advanced topics of special interest to graduate students in mechanical engineering.

M E 690I. Advanced Topics: Automatic Controls.
Cr. arr. Repeatable.
Investigation of advanced topics of special interest to graduate students in mechanical engineering.

M E 690J. Advanced Topics: Operating and Environmental Considerations in Design.
Cr. arr. Repeatable.
Investigation of advanced topics of special interest to graduate students in mechanical engineering.

M E 690K. Advanced Topics: Mechanical Behavior of Materials.
Cr. arr. Repeatable.
Investigation of advanced topics of special interest to graduate students in mechanical engineering.

M E 690L. Advanced Topics: Manufacturing Processes.
Cr. arr. Repeatable.
Investigation of advanced topics of special interest to graduate students in mechanical engineering.

M E 690M. Advanced Topics: Tribology.
Cr. arr. Repeatable.
Investigation of advanced topics of special interest to graduate students in mechanical engineering.

M E 690N. Advanced Topics: Sensitivity Methods.
Cr. arr. Repeatable.
Investigation of advanced topics of special interest to graduate students in mechanical engineering.

M E 690O. Advanced Topics: Engineering Computation.
Cr. arr. Repeatable.
Investigation of advanced topics of special interest to graduate students in mechanical engineering.

M E 690P. Advanced Topics: Engineering Measurements and Instrumentation.
Cr. arr. Repeatable.
Investigation of advanced topics of special interest to graduate students in mechanical engineering.

M E 690Q. Advanced Topics: Independent Literature Investigation.
Cr. arr. Repeatable.
Investigation of advanced topics of special interest to graduate students in mechanical engineering.

M E 690R. Advanced Topics: Nuclear Engineering.
Cr. arr. Repeatable.
Investigation of advanced topics of special interest to graduate students in mechanical engineering.

M E 690S. Advanced Topics: CAD/CAM.
Cr. arr. Repeatable.
Investigation of advanced topics of special interest to graduate students in mechanical engineering.

M E 697. Engineering Internship.
Cr. R. Repeatable. *Prereq: Permission of Director of Graduate Education, graduate classification*
One semester and one summer maximum per academic year professional work period. Offered on a satisfactory-fail basis only.

M E 699. Research.
Cr. arr. Repeatable.
Offered on a satisfactory-fail basis only.