MECHANICAL ENGINEERING

Kelly Kissock, Department Chairperson

Doctor of Engineering, Mechanical Engineering (MEE)

See the Doctoral Degree Requirements section on the School of Engineering page and consult with the department chair.

Doctor of Philosophy in Engineering, Mechanical Engineering (MEE)

See the Doctoral Degree Requirements section on the School of Engineering page and consult with the department chair.

Master of Science in Mechanical Engineering (MEE)

The program of study leading to the Master of Science in Mechanical Engineering degree, developed by the student in conjunction with her/his advisor, must include a minimum of 30 semester hours. The program of study must include 18 or more semester hours of MEE/AEE/RCL credits and a minimum of 3 semester hours of mathematics. Students may pursue a thesis or non-thesis option. A thesis option requires 6 semester hours of MEE 599 Mechanical Engineering Thesis credits, which includes both an oral defense and a written thesis.

Students may elect to include an area of focus in their program of study by selecting courses from these areas:

Materials	
MEE 501	Principles of Materials I
MEE 502	Principles of Materials II
MEE 503	Introduction to Continuum Mechanics
MEE 505	Thermodynamics of Solids
MEE 506	Mechanical Behavior of Materials
MEE 508	Principles of Material Selections
MEE 509	Introduction to Polymer Science-Thermoplastics
MEE 525	Principles in Corrosion
MEE 541	Experimental Mechanics of Composite Materials
MEE 542	Advanced Composites
MEE 543	Analytical Mechanics of Composite Materials
MEE 544	Mechanics of Composite Structures
MEE 570	Fracture Mechanics
MEE 575	Fracture & Fatigue of Metals & Alloys I
MEE 576	Fracture & Fatigue of Metals & Alloys II
Thermo-Fluids	
MEE 503	Introduction to Continuum Mechanics
MEE 504	Fundamentals of Fluid Mechanics
MEE 505	Thermodynamics of Solids
MEE 511	Advanced Thermodynamics
MEE 512	Microscopic Thermodynamics
MEE 513	Propulsion
MEE 514	Physical Gas Dynamics with Aerospace Applications
MEE 515	Conduction Heat Transfer
MEE 516	Convection Heat & Mass Transfer
MEE 517	Radiation Heat Transfer
MEE 540	Tribology
MEE 552	Boundary Layer Theory
MEE 553	Compressible Flow
MEE 555	Turbulence
MEE 558	Computational Fluid Dynamics
MEE 565	Fundamentals of Fuels & Combustion
MEE 566	Combustion Theory
MEE 567	Smart Structures & Materials Overview
MEE 568	Internal Combustion Engines
MEE 569	Energy Efficient Buildings
AEE 501	Fundamental Aerodynamics
AEE 502	Advanced Aerodynamics
AEE 556	Hypersonic Aerodynamics
AEE 558	Computational Fluid Dynamics
Solid Mechanics	
MEE 503	Introduction to Continuum Mechanics
MEE 519	Analytical Dynamics
MEE 533	Theory of Elasticity
MEE 534	Theory of Plates & Shells
MEE 535	Advanced Mechanical Vibrations
MEE 536	Random Vibrations
MEE 538	Introduction to Aeroelasticity
MEE 539	Theory of Plasticity
MEE 543	Analytical Mechanics of Composite Materials
MEE 544	Mechanics of Composite Structures
MEE 545	Computational Methods for Design
MEE 546	Finite Element Analysis I
MEE 547	Finite Element Analysis II
MEE 548	Energy Methods in Solid Mechanics
MEE 549	Theory of Elastic Stability
MEE 570	Fracture Mechanics
MEE 575	Fracture & Fatigue of Metals & Alloys I
Design and Manufacturing	
MEE 503	Introduction to Continuum Mechanics
MEE 506	Mechanical Behavior of Materials
MEE 520	Theoretical Kinematics
MEE 521	Kinematic Principles in Design
MEE 522	Geometric Methods in Kinematics
MEE 523	Engineering Design Optimization
MEE 527	Automatic Control Theory
MEE 533	Theory of Elasticity
MEE 534	Theory of Plates & Shells
MEE 535	Advanced Mechanical Vibrations
MEE 536	Random Vibrations
MEE 537	Autonomous Systems

MEE 538	Introduction to Aeroelasticity
MEE 539	Theory of Plasticity
MEE 540	Tribology
MEE 545	Computational Methods for Design
MEE 546	Finite Element Analysis I
MEE 547	Finite Element Analysis II
MEE 551	Noise & Vibration Control
MEE 570	Fracture Mechanics
MEE 572	Design for Environment
MEE 574	Virtual Prototyping of Products & Processes
MEE 575	Fracture & Fatigue of Metals & Alloys I
MEE 577	Robotics & Numerically Controlled Machines
MEE 579	Computer Aided Mechanical Design
MEE 582	Automated Design
MEE 585	Design for Producibility
MEE 587	Lean Manufacturing

See also Master's Degree Requirements in School of Engineering section in the catalog and consult with the advisor.

Courses

MEE 500. Advanced Engineering Analysis. 3 Hours
Detailed analysis of engineering problems using laws of nature, fundamental engineering principles, mathematics, computers, and practical experience to construct, resolve, and test analytic models of physical events. Emphasis is on the use of the professional engineering approach which includes formulation of the problem, assumptions, plan or method of attack, solving the problem, checking and generalizing the results.

MEE 501. Principles of Materials I. 3 Hours
Structure of engineering materials from electronic to atomic and crystallographic considerations. Includes atomic structure and interatomic bonding, imperfections, diffusion, mechanical properties, strengthening mechanisms, failure, phase diagrams, phase transformations and processing. Prerequisite(s): MTH 219; college chemistry; college physics.

MEE 502. Principles of Materials II. 3 Hours
Structure, behavior and processing of metal alloys, ceramics, polymers, and composites to include: mechanical behavior, corrosion, electrical, magnetic, and optical properties. Prerequisite(s): MEE 501 or equivalent.

MEE 503. Introduction to Continuum Mechanics. 3 Hours
Tensors, calculus of variations, Lagrangian and Eulerian descriptions of motion. General equations of continuum mechanics, constitutive equations of mechanics, thermodynamics of continua. Specialization to cases of solid and fluid mechanics. Prerequisite(s): EGM 303 or EGM 330.

MEE 504. Fundamentals of Fluid Mechanics. 3 Hours
An advanced course in fluid mechanics with emphasis on the derivation of conservation equations and the application of constitutive theory. Navier-Stokes equations. Ideal fluid approximation. Exact and approximate solutions to classical viscous and inviscid problems. Compressible and incompressible flows. Prerequisite(s): MEE 503.

MEE 505. Thermodynamics of Solids. 3 Hours
Laws of thermodynamics, auxiliary functions, thermodynamic relations, phase transitions, thermodynamic equilibrium, thermodynamic properties of solid solutions, surfaces and interfaces. Prerequisite(s): MEE 501 or permission of instructor.

MEE 506. Mechanical Behavior of Materials. 3 Hours
Fundamental relationships between the structure and mechanical behavior of materials. Includes fundamentals of stress and strain, the physical basis for elastic deformation, elementary dislocation theory and plastic deformation, strengthening mechanisms, yield criteria and their application to biaxial and multi-axial behavior and failure, fracture and toughening mechanisms, creep and creep rupture, behavior and failure of cellular solids and fatigue. Prerequisite(s): (MAT 501, MAT 502) or permission of instructor.

MEE 507. Materials for Advanced Energy Applications. 3 Hours
Successful long-term application of many advanced energy technologies is ultimately based on utilization of materials in 'real world' environmental conditions. The physical/mechanical properties and application of various materials (k.e. superalloys, refractory metal alloys, ceramics) being employed in advanced energy applications are discussed. Several advanced energy technologies (i.e. fuel cells, nuclear energy, and others) are covered with emphasis on how the selection of advanced materials enhances their commercial application. Prerequisite(s): MAT 501 and MAT 502 or permission of instructor.

MEE 508. Principles of Material Selections. 3 Hours
Basic scientific and practical considerations involved in the intelligent selection of materials for specific applications. Impact of new developments in materials technology and analytical techniques. Prerequisite(s): MEE 501 or permission of instructor.

MEE 509. Introduction to Polymer Science-Thermoplastics. 3 Hours
Broad technical overview of the nature of synthetic macromolecules, including the formation of polymers and their structure - property relationships, ploymer characterization and processing, and the application of ploymers. Fundamental topics such as viscoelasticity, the glassy state, time-temperature superposition, polymer transitions, and free volume will also be reviewed. The course focuses on thermoplastic polymers. Prerequisite(s): Organic chemistry; college physics, differential equations.

MEE 510. Biomaterials. 3 Hours
The course introduces students with engineering materials used in dentistry, manufacture of surgical devices, prosthetics, and repair of tissues. Topics include bonding and atomic arrangement in materials, material selection, testing, and characterization, biocompatibility, tissue response to materials, and failutre analysis. A spectrum of materials including metals, polymers, ceramics, and composites used in biomedical applications will be considered.

MEE 511. Advanced Thermodynamics. 3 Hours
Equilibrium, first law, second law, state principle, and zeroth law; development of entropy and temperature from availability concepts; chemical potential, chemical equilibrium, and phase equilibrium. Thermodynamics of irreversible processes; Onsager reciprocal relations; application of these concepts to direct energy conversion.

MEE 512. Microscopic Thermodynamics. 3 Hours
Microscopic thermodynamics; kinetic theory; virial theorem of Clausius; transport phenomena; Gibbs, Boltzman, Bose-Einstein, Fermi-Dirac statistics. Connection between statistical and thermodynamic quantities. Applications to perfect and real gases, liquids, crystalline solids, and thermal radiation. Irreversible thermodynamics.

MEE 513. Propulsion. 3 Hours
Principles of propulsive devices, aerothermodynamics; diffuser and nozzle flow; energy transfer in turbo-machinery; turbojet, turbo-fan, prop-fan engines; and turbo-prop and turboshaft engines. RAM and SCRAM jet analysis and a brief introduction to related materials and air frame-propulsion interaction. Prerequisite(s): MEE 418.

MEE 514. Physical Gas Dynamics with Aerospace Applications. 3 Hours
Physical Gas Dynamics: The basic elements of kinetic theory, chemical thermodynamics, and statistical mechanics. Emphasis is placed on the application of these molecular theories for analyzing thermodynamic and transport phenomena, as they pertain to the modeling of 'real gas effects' in high temperature flows. The course assumes material media in local equilibrium in the gaseous state but some non-equilibrium behavior will also be considered. The equilibrium topics include kinetic theory and concepts related to microscopic, molecular collisions, macroscopic chemical thermodynamics, the law of mass action, internal molecular structure and quantum energy states, general statistical mechanics applied to the prediction of thermodynamic properties of monatomic and diatomic gases, chemically reacting mixtures, and the dissociation and ionization of gases. Prerequisite(s): Background in fluid mechanics, thermodynamics, and compressible flow or permission of instructor.

MEE 515. Conduction Heat Transfer. 3 Hours
Steady state and transient state conduction. Evaluation of temperature fields by formal mathematics and numerical analysis. Emphasis on approximate solution techniques.

MEE 516. Convection Heat & Mass Transfer. 3 Hours
Development of governing differential equations for convection. Methods of solution including similarity methods, integral methods, superposition of solutions, eigenvalue problems. Turbulent flow convection; integral methods, eddy diffusivities for heat and momentum. Extensions to mass transfer. Prerequisite(s): MEE 410 or equivalent.

MEE 517. Radiation Heat Transfer. 3 Hours
Fundamental relationships of radiation heat transfer. Radiation characteristics of surfaces. Geometric considerations in radiation exchange between surfaces. Emissivity and absorptivity of gases. Introduction to radiative exchange in gases.

MEE 518. Phase Change Heat Transfer & Interfacial Phenomena. 3 Hours
Interfacial thermodynamics of liquid-vapor-solid systems; surface wetting statics and dynamics; interfacial and phase stability; homogeneous and heterogeneous nucleation; and boiling heat transfer. Application to liquid-vapor phase change.

MEE 519. Analytical Dynamics. 3 Hours
Dynamical analysis of a system of particles and rigid bodies; Lagrangian and Hamiltonian formulation of equations of motion; classical integrals of motion. Stability analysis of linear and nonlinear systems. Prerequisite(s): (EGM 202; MTH 219) or equivalent.

MEE 520. Theoretical Kinematics. 3 Hours
Introduction to the mathematical theory underlying the analysis of general spatial motion. Analysis of mechanical systems including robots, mechanisms, walking machines and mechanical hands using linear algebra, quaternion and screw formulations. Fundamental concepts include forward and inverse kinematics, workspace, Jacobians, and singularities.

MEE 521. Kinematic Principles in Design. 3 Hours
Study of the use of kinematic principles in the design of mechanical systems including robots, planar and spatial mechanisms, robotic platforms and systems modeled by jointed rigid bodies. The formulation and solution of design problems involving the sizing and placement of these mechanical systems to accomplish specific tasks is the primary goal. Mathematicl tools are introduced to account for singularity avoidance and joint limitations.

MEE 522. Geometric Methods in Kinematics. 3 Hours
Trajectories and velocities of moving bodies are designed and analyzed via the principles of classical differential and algebraic geometry. Fundamentals include centrodes, instantaneous invariants, resultants and center point design curves. Curves, surfaces, metrics, manifolds and geodesics in spaces of more than three dimensions are analyzed to study multi-parameter systems.

MEE 523. Engineering Design Optimization. 3 Hours
Introduction to the theory and algorithms of nonlinear optimization with an emphasis on applied engineering problems. Fundamentals include Newton's method, line searches, trust regions, convergence rates, and linear programming. Advanced topics include penalty, barrier, and interior-point methods.

MEE 524. Electrochemical Power. 3 Hours
The course will cover fundamental as well as engineering aspects of fuel cell technology. Specifically, the course will cover basic principles of electrochemistry, electrical conductivity (electronic and ionic) of solids, and development/design of major fuel cells (alkaline, polymer electrolyte, phosphoric acid, molten carbonate, and solid oxide). A major part of the course will focus on solid oxide fuel cells (SOFC), as it is emerging to be dominant among various fuel cell technologies. The SOFC can readily and safely use many common hydrocarbon fuels such as natural gas, diesel, gasoline, alcohol, and coal gas. Prerequisite(s): MEE 301, MEE 312, or permission of instructor.

MEE 525. Principles in Corrosion. 3 Hours
Theoretical and practical application of electrochemical principles to the field of corrosion covering thermodynamics, kinetics, forms of corrosion in areas of biomedical engineering, aerospace, automotive and marine environments. Prerequisite(s): MEE 501.

MEE 526. Aerospace Fuels Science. 3 Hours
Basic elements of hydrocarbon fuel production including petroleum based fuels and alternative fuels. Fuel properties, specifications, handling, and logistics. Introduction to chemical kinetics and the chemistry associated with liquid phase thermal-oxidative degradation of fuels. Introduction to the computational modeling of fuel thermal stability and fuel systems. Prerequisite(s): Permission of instructor.

MEE 527. Automatic Control Theory. 3 Hours
Stability and performance of automatic control systems. Classical methods of analysis including transfer functions, time-domain solutions, root locus and frequency response methods. Modern control theory techniques including state variable analysis, transformation to companion forms, controllability, pole placement, observability and observer systems. Prerequisite(s): ELE 432 or MEE 435 or equivalent.

MEE 530. Biomechanical Engineering. 3 Hours
Application of engineering principles to clinical, occupational, and sports biomechanics topics. The course focuses on biomechanical analysis, particularly kinematics and kinetics of human movement, with emphasis on both research and product design. Prerequisite(s): EGM 202; EGR 201.

MEE 531. Experimental Methods in Biomechanics. 3 Hours
This course is focused on developing and applying advanced experimentation skills with a specific focus on techniques associated with the study of human movement. Emphasis on equipment and technology, data analysis and interpretation, statistical methods, and technical reporting.

MEE 533. Theory of Elasticity. 3 Hours
Three-dimensional stress and strain at a point; equations of elasticity in Cartesian and curvilinear coordinates; methods of formulation of equations for solution; plane stress and plane strain; energy formulations; numerical solution procedures. Prerequisite(s): EGM 303 or EGM 330. Corequisite(s): MEE 503.

MEE 534. Theory of Plates & Shells. 3 Hours
Theory of plates: small and large displacement theories of thin plates; shear deformation; buckling; sandwich plate theory. Thin shell theory: theory of surfaces; thin shell equations in orthogonal curvilinear coordinates; bending, membrane, and shallow shell theories. Prerequisite(s): MEE 533.

MEE 535. Advanced Mechanical Vibrations. 3 Hours
Review of undamped, damped, natural and forced vibrations of one and two degrees of freedom systems. Lagrange's equation, eigenvalue/ eigenvector problem, modal analysis for discrete and continuous systems. Computer application for multi-degree of freedom, nonlinear problems. Prerequisite(s): MEE 319; computer programming.

MEE 536. Random Vibrations. 3 Hours
Introduction to probability distribution; characterization of random vibrations; harmonic analysis; auto- and cross-correlation and spectral density; coherence; response to single and multiple loadings; Fast Fourier Transform (FFT); applications in vibrations, vehicle dynamics, fatigue, etc. Prerequisite(s): MEE 319; computer programming.

MEE 537. Autonomous Systems. 3 Hours
At the intersection of mechanical engineering, electrical engineering, and computer science, autonomous systems involve the implementation of mechatronic technologies which operate independently (autonomously) from human intervention. This course emphasizes the practical implementation of modern control systems for the purposes of creating fully- or semi-autonomous systems. Topics include programming syntax and structure, integration of peripherals (sensors and actuators) with controllers, and data communications both within and external to the systems. Equal mix of lecture and laboratory with significant time dedicated to advanced design projects. Prerequisite(s): Undergraduate electronics course. Co-requisite(s): Course in controls.

MEE 538. Introduction to Aeroelasticity. 3 Hours
Study of the effect of aerodynamic forces on a flexible aircraft. Flexibility coefficients and natural modes of vibration. Quasi-steady aerodynamics. Static aeroelastic problems; wing divergence and dynamic aeroelasticity; wing flutter. An introduction to structural stability augmentation with controls. Prerequisite(s): AEE 501.

MEE 539. Theory of Plasticity. 3 Hours
Fundamentals of plasticity theory including elastic, viscoelastic, and elastic-plastic constitutive models; plastic deformation on the macroscopic and microscopic levels; stress-strain relations in the plastic regime; strain hardening; limit analysis; numerical procedures. Prerequisite(s): MEE 503 or MEE 533.

MEE 540. Tribology. 3 Hours
Theoretical aspects of lubrication; determination of pressure distribution in bearings from viscous flow theory; application of hydrodynamic and hydrostatic bearing theories to the design of bearings; high-speed bearing design problems; properties of lubricants; methods of testing.

MEE 541. Experimental Mechanics of Composite Materials. 3 Hours
Introduction to the mechanical response of fiber-reinforced composite materials with emphasis on the development of experimental methodology. Analytical topics include stress-strain behavior of anisotropic materials, laminate mechanics, and strength analysis. Theoretical models are applied to the analysis of experimental techniques used for characterizing composite materials. Lectures are supplemented by laboratory sessions in which characterization tests are performed on contemporary composites. Prerequisite(s): EGM 303 or EGM 330.

MEE 542. Advanced Composites. 3 Hours
Materials and processing. Comprehensive introduction to advanced fiber reinforced polymeric matrix composites. Constituent materials and composite processing will be emphasized with special emphasis placed on structure-property relationships, the role of the matrix in composite processing, mechanical behavior and laminate processing. Specific topics will include starting materials, material forms, processing, quality assurance, test methods and mechanical behavior. Prerequisite(s): (MEE 501 or MEE 509) or permission of instructor.

MEE 543. Analytical Mechanics of Composite Materials. 3 Hours
Analytical models are developed to predicting the mechanical and thermal behavior of fiber-reinforced composite materials as a function of constituent material properties. Both continuous and discontinuous fiber-reinforced systems are considered. Specific topics include basic mechanics of anisotropic materials, micromechanics, lamination theory, free-edge effects, and failure criteria. Prerequisite(s): EGM 303 or EGM 330.

MEE 544. Mechanics of Composite Structures. 3 Hours
Comprehensive treatment of laminated beams, plates, and sandwich structures. Effect of heterogeneity and anisotropy on bending under lateral loads, buckling, and free vibration are emphasized. Shear deformation and other higher-order theories and their range of parametric application are also considered. Prerequisite(s): MEE 543 or permission of instructor.

MEE 545. Computational Methods for Design. 3 Hours
Modeling of mechanical systems and structures, analysis by analytical and numerical methods, development of mechanical design criteria and principles of optimum design, selected topics in mechanical design and analysis, use of the digital computer as an aid in the design of mechanical elements. Prerequisite(s): Computer programming.

MEE 546. Finite Element Analysis I. 3 Hours
Fundamental development of the Finite Element Method (FEM), and solution of field problems and comprehensive structural problems, variational principles and weak-forms; finite element discretization; shape functions; finite elements for field problems; bar, beam, plate, and shell elements; isoparametric finite elements; stiffness, nodal force, and mass matrices; matrix assembly procedures; computer dosing techniques; modeling decisions; program output interpretation. Course emphasis on a thorough understanding of FEM theory and modeling techniques. Prerequisite(s): MEE 503 or MEE 533.

MEE 547. Finite Element Analysis II. 3 Hours
Advanced topics: heat transfer; transient dynamics; nonlinear analysis; substructuring and static condensation; effects of inexact numerical integration and element incompatibility; patch test; frontal solution techniques; selected topics from the recent literature. Prerequisite(s): MEE 546.

MEE 548. Energy Methods in Solid Mechanics. 3 Hours
Development of fundamental energy principles; virtual displacements, strain energy, Castigliano's theorems, minimum potential energy principles. Applications to engineering problems; redundant structures, buckling, static and dynamic analysis. Prerequisite(s): MEE 503 or MEE 533.

MEE 549. Theory of Elastic Stability. 3 Hours
Introduction to stability theory: buckling of plates and shells; influence of initial imperfections; nonlinear analysis: numerical solutions methods. Prerequisite(s): MEE 533.

MEE 551. Noise & Vibration Control. 3 Hours
The concepts of noise and vibration control applied to mechanical systems. Methodologies covered will include: passive treatments using resistive elements (sound absorbers, vibration damping) and reactive elements (tailoring of material stiffness and mass); active control of sound and vibration; and numerical analysis. Prerequisite(s): MEE 319 or MEE 439.

MEE 552. Boundary Layer Theory. 3 Hours
Development of the Prandtl boundary layer approximation in two and three dimensions for both compressible and incompressible flow. Exact and approximate solutions for laminar flows. Unsteady boundary layers. Linear stability theory and transition to turbulence. Empirical and semi-empirical methods for turbulent boundary layers. Higher-order boundary layer theory. Prerequisite(s): MEE 504 or equivalent.

MEE 553. Compressible Flow. 3 Hours
Fundamental equations of compressible flow. Introduction to flow in two and three dimensions. Two-dimensional supersonic flow, small perturbation theory, method of characteristics, oblique shock theory. Introduction to unsteady one-dimensional motion and shock tube theory. Method of surface singularities. Prerequisite(s): MEE 504 or equivalent.

MEE 555. Turbulence. 3 Hours
Origin, evolution, and dynamics of fully turbulent flows. Description of statistical theory, spectral dynamics, and the energy cascade. Characteristics of wall-bounded and free turbulent shear flows. Reynolds stress models. Prerequisite(s): MEE 504 or equivalent.

MEE 558. Computational Fluid Dynamics. 3 Hours
Numerical solution to Navier-Stokes equations and approximations such as the boundary layer equations for air-flow about a slender body. Numerical techniques for the solution of the transonic small disturbance equations. Numerical determination of fluid instabilities. Prerequisite(s): MEE 504 or permission of instructor.

MEE 560. Propulsion Systems. 3 Hours
Introduction and history, types of propulsion systems, thermodynamics review and simple cycle analysis, thermodynamics of high speed gas flow, aircraft gas turbine engine, parametric cycle analysis of various types of gas turbine engines, component and engine performance analyses (inter-turbine burners), advanced cycles with regeneration, reheating, and inter-cooling, variable and inverse cycle engines, hybrid propulsion systems (turbo-ramjets, rocket-ram-scramjets, etc.) advanced propulsion systems, pulse detonation engine theory and concepts, thermal management of high-speed flight, energy management and vehicle synthesis. Prerequisite(s): (MEE 413 or MEE 513) or permission of instructor.

MEE 565. Fundamentals of Fuels & Combustion. 3 Hours
Heat of combustion and flame temperature calculations; rate of chemical reaction and Arrhenius relationship; theory of thermal explosions and the concept of ignition delay and critical mass; phenomena associated with hydrocarbon-air combustion; specific applications of combustion.

MEE 566. Combustion Theory. 3 Hours
Theory of detonation (Rankine-Hugoniot relationships) and flame propagation rates in pre-gas mixed systems; turbulent flames and the well stirred reactor; theory of diffusion flames; fuel droplet combustion; steady burning of solid materials, ignition and flame spreading across solid materials.

MEE 567. Smart Structures & Materials Overview. 3 Hours
Smart structures and materials overview. Components of materials, sensing, actuation, and modeling. Electro-mechanical and thermo-mechanical modeling of SMA and piezo-ceramic materials. Elements of control, sensing, and vibration theory. Examples of using piezo-ceramic and shape memory alloy (SMA) based structures for actuation, vibration, position, and shape control with applications in automotive, aircraft, and satellites. Prerequisite(s): Background in materials, electronics, vibrations, and controls or instructor's consent. MEE 312 or instructor's consent.

MEE 568. Internal Combustion Engines. 3 Hours
Study of combustion and energy release processes. Applications to spark and compression ignition, jet, rocket, and gas turbine engines. Special emphasis given to understanding of air pollution problems caused by internal combustion engines. Idealized and actual cycles are studied in preparation for laboratory testing of internal combustion engines.

MEE 569. Energy Efficient Buildings. 3 Hours
Provides knowledge and skills necessary to design and operate healthier, more comfortable, more productive, and less environmentally destructive buildings; A specific design target of E/3 (typical energy use divided by three) is established as a goal. Economic, thermodynamic, and heat transfer analyses are utilized. Extensive software development. Prerequisite(s): MEE 410.

MEE 570. Fracture Mechanics. 3 Hours
Application of the principles of fracture mechanics to problems associated with fatigue and fracture in engineering structures. The course will cover the development of models that apply to a range of materials, geometries, and loading conditions. Prerequisite(s): MEE 506 or permission of instructor.

MEE 571. Design of Thermal Systems. 3 Hours
Integration of thermodynamics, heat transfer, engineering economics, and simulation and optimization techniques in a design framework. Topics include design methodology, energy analysis, heat exchanger networks, thermal-system simulation, and optimization techniques.

MEE 572. Design for Environment. 3 Hours
Emphasis on design for environment over the life cycle of a product or process, including consideration of mining, processing, manufacturing, use, and post-life stages. Course provides knowledge and experience in invention for the purpose of clean design, life cycle asessment strategies to estimate the environmental impact of products and processes, and cleaner manufacturing practices. Course includes a major design project.

MEE 573. Renewable Energy Systems. 3 Hours
Introduction to the impact of energy on the economy and environment. Engineering models of solar thermal and photovoltaic systems. Introduction to wind power. Fuel cells and renewable sources of hydrogen.

MEE 574. Virtual Prototyping of Products & Processes. 3 Hours
The use of virtual prototyping for validating/optimizing the product design and the corresponding manufacturing process(es) before building the physical prototype will be practiced. Prerequisite(s): MEE 427.

MEE 575. Fracture & Fatigue of Metals & Alloys I. 3 Hours
This course will cover the effects of microstructure on the fracture and fatigue behavior of engineering metals and alloys, with a special emphasis on static and dynamic brittle and ductile failures and static fatigue crack initiation. Alloy fracture resistance, fracture toughness, fatigue behavior, and methods to improve fracture and fatigue behavior will be discussed in detail. The role of materials reliability in life management of advanced alloys in turbine engines and aircraft will be reviewed, and key practical aspects will be discuss. Various analytical techniques for failure analysis of structural components will be presented. Prerequisite(s): (MEE 501 or MEE 506) or permission of instructor.

MEE 576. Fracture & Fatigue of Metals & Alloys II. 3 Hours
This course will cover the areas of the effects of microstructure on fatigue crack propagation and on final fracture by fatigue. This will include fatigue life prediction, using damage-tolerance approach to component-design and microstructural and structural synthesis for optimum behavior. Specific material-related aspects of fatigue crack propagation mechanisms for optimum damage tolerant behavior, and the related reliability and failure analysis, will be covered. A comprehensive project in failure-analysis of aerospace metallic components will also be conducted. Prerequisite(s): MEE 575 or equivalent.

MEE 577. Robotics & Numerically Controlled Machines. 3 Hours
Introduction to robots. Design and analysis of wrist mechanisms and grippers. Robot kinematics and trajectory planning. Sensors and vision systems. Implementation and applications of robotics. Robot cell design and control. Interaction of robot with the environment. NC and CNC machines and machining centers. Fundamentals of rapid prototyping. Prerequisite(s): MEE 435 or equivalent.

MEE 578. Energy Efficient Manufacturing. 3 Hours
This course presents a systematic approach for improving energy efficiency in the manufacturing sector. Current patterns of manufacturing energy use, the need for increased energy efficiency, and models for sustainable manufacturing are reviewed. The lean-energy paradigm is applied to identify energy efficiency opportunities in industrial electrical, lighting, space conditioning, motor drive, compressed air, process heating, process cooling, and combined heat and power systems. Prerequisite(s): Thermodynamics MEE 310 and Heat Transfer MEE 410.

MEE 579. Computer Aided Mechanical Design. 3 Hours
Introduction to computer methods used to facilitate mechanical design. Design using the finite element method, mechanism design, and statistical techniques. Design of components (shafts, springs, etc.) using computer techniques will be combined with the design process to design mechanical systems. Integration of manufacturer's literature into the design. Team design project will be included. Prerequisite(s): (MEE 427, MEE 432) or equivalent.

MEE 580. Statistical Process Control by Feedback Adjustment. 3 Hours
Process monitoring using standard quality control techniques provides an ongoing check on the stability of the process and points to problems whose elimination can reduce variation and permanently improve the system. Process adjustment uses feedback control to compensate for those sources of drifting variation that cannot be eliminated in this way. Clearly the two approaches are complementary and considerable advantage is to be gained by augmenting the more commonly used quality control techniques with feed back methods. Prerequisite(s): Background in statistics or permission of instructor.

MEE 582. Automated Design. 3 Hours
Examine, discuss, and apply enabling design technologies, methodologies and computer tools to various mechanical product design and manufacturing process design projects. Address selected design topics and how they are used in Product Development Cycle. Model, simulate, and evaluate various mechanical products and manufacturing process designs.

MEE 584. Integrated Manufacturing Systems. 3 Hours
Treatment of topics associated with the design, implementation, planning and control of fixed and flexible manufacturing and assembly systems in conjunction with communications and computer technologies. Discuss issues associated with group technology and systems integration.

MEE 585. Design for Producibility. 3 Hours
Concurrent treatment of product design and manufacturing process issues. Application of various methodologies, tools, and evaluation schemes on various product design, manufacturing, and assembly-related activities.

MEE 587. Lean Manufacturing. 3 Hours
Introduction to lean manufacturing and waste elimination. Dynamics of team formation: participation, leadership, communication, and conflict resolution. Concepts of work standardization. Process flow mapping techniques. Setup reduction: reduction of cycle time and inventory in manufacturing operations. Design of lean manufacturing work cells: basic work motions, applied ergonomics, and time studies. Just-in-time. Pull production: Kanbans and their effect on reducing inventory and lead-time. Error proofing: error detection, feedback, corrective and preventive actions. Value added vs. non-value added analysis. Prerequisite(s): MEE 344 or equivalent.

MEE 590. Special Problems in Mechanical Engineering. 1-6 Hours
Special assignments in mechanical engineering subject matter to be approved by the student's faculty advisor and the department chair.

MEE 595. Mechanical Engineering Project. 1-6 Hours
Student participation in a departmental research, design, or development project under the direction of a project advisor. The student must show satisfactory progress as detemined by the project advisor and present a written report at the conclusion of the project.

MEE 599. Mechanical Engineering Thesis. 1-6 Hours
Mechanical Engineering Thesis.

MEE 604. Nanostructured Materials. 3 Hours
Graduate-level course covering the fundamental physics, properties, and applications of nanostructured materials. Includes carbon nanotubes, nanostructured ceramics, metals, and semiconductor materials. Prerequisite(s): College physics; fundamental physical and chemical properties of materials.

MEE 605. Introduction to Carbon Nanotechnology. 3 Hours
Graduate-level course covering the fundamental and applied aspects of Carbon Nanoscale Science and Technology. The course has three goals: (1) an overview of the current development in carbon science and technology (2) an introduction to the surface science as a means to understand the surface interaction at molecular scale, and (3) to provide some explicit links between macro, micro, and nano scale technologies. Some of the medical field, structural and friction applications will be addressed. This course is aimed at both science and engineering students.

MEE 690. Selected Readings in Mechanical Engineering. 1-6 Hours
Directed readings in a designated area arranged and approved by the student's doctoral advisory committee and the department chair. May be repeated. (A) Materials, (B) Thermal Sciences, (C) Fluid Mechanics, (D) Solid Mechanics (E) Mechanical Design, or (F) Integrated Manufacturing.

MEE 698. DE Dissertation. 1-15 Hours
An original investigation as applied to mechanical engineering practice. Results must be of sufficient importance to merit publication.

MEE 699. PHD Dissertation. 1-15 Hours
An original research effort which makes a definite contribution to technical knowledge. Results must be of sufficient importance to merit publication.