MECHANICAL ENGINEERING

Courses

MEE 101. Introduction to Mechanical Engineering II. 0 Hours
Second semester of introduction to Mechanical Engineering. Seminars on course selection, campus policies, safety, and health. Introductions to campus services for learning, counseling, coop and job placement.

MEE 104L. Solid Modeling in Design. 2 Hours
Introduction to engineering graphics and visualization. Instruction on sketching methods and proper techniques for parametric, solid modeling using computer aided design (CAD) software. Students will interpret and develop technical drawings that are used to communicate mechanical designs.

MEE 114L. Introduction to Programming. 1 Hour
Introduction to applications and use of computer programs for mechanical engineers with concentration on spreadsheets, plotting, data manipulation and basic programming.

MEE 198. Research & Innovation Laboratory. 0-6 Hours
Students participate in (1) selection and design, (2) investigation and data collection, (3) analysis, and (4) presentation of a research project. Research can include, but is not limited to, developing an experiment, collecting and analyzing data, surveying and evaluating literature, developing new tools and techniques including software, and surveying, brainstorming, and evaluating engineering solutions and engineering designs. Proposals from teams of students will be considered.

MEE 202. Engineering Thermodynamics. 3 Hours
This course provides an introduction to engineering thermodynamics, emphasizing the vital importance of energy generation and efficiency from the perspective of the Mechanical Engineering discipline. State descriptions of pure substances and mixtures. Control volume analysis and conservation principles applied to systems with respect to mass, energy, and entropy with applications to power, refrigeration and other energy conversion systems. Introduces a common problem-solving approach and processes to address real, open ended problems and creative application of theory. Prerequisites: MTH 168.

MEE 204. Introduction to Robot Design. 3 Hours
Mechanical design aspects of robotic and automation systems. Employing the innovation process as applied to automation systems with an emphasis on detailed mechanical design techniques, standards and guidelines. Experience is gained by completing individual and team design projects. Prerequisite(s): EGR 103 and MEE 104L.

MEE 205. Mechatronics. 3 Hours
This course provides an introduction to the cross-disciplinary topic of Mechatronics, a blend of Mechanical, Electrical, and Computer Engineering. Topics include principles of linear circuit analysis and problem solving techniques (both analytical and computer solutions) associated with analog circuits containing both passive and active components. Students are introduced to DC, AC, and transient circuit analyses. In addition to these fundamentals, the “mechatronics emphasis” involves practical experience in creating robotic and automated systems. Related to its Integrative component within CAP, students discuss and reflect on the social impact such technology has within their lives, their future profession, and the world as a whole. Building upon the course’s role as an elective within the Engineering in Human Rights Minor, these reflections focus on the role that mechatronics can and should play to foster human rights, such as protecting people from “dull, dirty, and dangerous” work, or ensuring how designers in mechatronics do not contribute to human rights violations. Ultimately, students scaffold their knowledge through a series of microprocessor programming modules which culminate in student teams designing, fabricating, and programming an autonomous system that could contribute to the enjoyment of human rights. Prerequisites: MTH 168 and MEE 114L.

MEE 214. Programming for Mechanical Engineers. 3 Hours
Detailed introduction to solving engineering problems through computational methods. Fundamentals of programming in MATLAB involving arrays, functions, decision making, loops, and graphing. Emphasis on numerical methods that are applied in engineering. Prerequisites: MTH 169; MEE 114L.

MEE 225. Introduction to Flight. 3 Hours
An introductory course designed to provide students with a basic understanding of the multitude of disciplines that comprise the aeronautical engineering profession. A background and brief history of flight are covered. Foundational knowledge of aerodynamics, propulsion, aerostructures, aircraft performance and aerospace vehicle design. Laboratory included. Prerequisite(s): PHY 206.

MEE 230. Introduction to Biomechanics. 3 Hours
Introduction to the field of biomechanical engineering with an emphasis on human movement. Application of engineering concepts to solve clinical, occupational, and sports biomechanics problems with a focus on experimental data analysis, kinematics, research, product design, and technical reporting. Corequisite: EGR 201 or permission of instructor. Prerequisite(s): PHY 206 or permission of instructor.

MEE 298. Research & Innovation Laboratory. 0-6 Hours
Students participate in (1) selection and design, (2) investigation and data collection, (3) analysis, and (4) presentation of a research project. Research can include, but is not limited to, developing an experiment, collecting and analyzing data, surveying and evaluating literature, developing new tools and techniques including software, and surveying, brainstorming, and evaluating engineering solutions and engineering designs. Proposals from teams of students will be considered.

MEE 300. Professional Development for Juniors. 0 Hours
Presentations on contemporary mechanical engineering subjects by students, faculty, and engineers in active practice; student involvement in professional and service activities. Registration required of all MEE juniors. Prerequisite(s): MEE 200 or COP 200 or EGR 200.

MEE 308. Fluid Mechanics. 3 Hours
An introductory course in fluid mechanics. Fundamental concepts including continuity, momentum, and energy relations. Control volume analysis and differential formulations. Internal and external flows in laminar and turbulent regimes. Prerequisite(s): MEE 202 OR EGR 202. Corequisite(s): MTH 219.

MEE 312. Engineering Materials I. 3 Hours
Atomic structure, bonding, and arrangement in solids. Mechanical and physical properties of solids, phase equilibria, and processing of solids. Strengthening methods in solids, principles of material selection, and characteristics of non-ferrous alloys, polymers, ceramic composites, and construction materials.

MEE 312L. Materials Laboratory. 1 Hour
Conducting mechanical and physical tests on solids including, but not limited to tension, compression, bending, hardness, and impact. Metallographic examination of surfaces. Test standards, data reduction, analysis, interpretation, and written and oral communication of test results. Corequisite(s): MEE 312.

MEE 321. Theory of Machines. 3 Hours
Analysis and synthesis of mechanisms using analytical and computer-based techniques. Applications include cams, gears, and linkages such as four-bar, slider-crank, and quick-return mechanisms. Gear train specification and force analysis. Position, velocity, and acceleration analysis and mechanical advantage of a wide variety of linkage systems. Prerequisites: EGR 201. Corequisites: MEE 214 or MEE 314 or ECE 203.

MEE 341. Engineering Experimentation. 3 Hours
Basic sensors and instrumentation, design of experiments, data acquisition and processing, and uncertainty and statistical analysis of data. Measurement of strain, motion, pressure, temperature, flow and sound. Measurement applications to engineering phenomena or systems. Course will utilize a mix of lecture, laboratory experiments, and demonstrations. Also a term project to provide design of experiment experience. Corequisites: EGR 203 or MEE 205 or ECE 201.

MEE 344. Manufacturing Processes. 3 Hours
Casting processes including casting defects and design of castings; metal working processes such as extrusion, forging, rolling and wire drawing; sheet metal forming; welding processes; powder metallurgy and design principles for P/M parts, metal removal processes; forming and shaping plastics and composite materials; rapid prototyping. Design principles for manufacturability. Includes laboratory. Prerequisite(s): MEE 312.

MEE 398. Research & Innovation Laboratory. 0-6 Hours
Students participate in (1) selection and design, (2) investigation and data collection, (3) analysis, and (4) presentation of a research project. Research can include, but is not limited to, developing an experiment, collecting and analyzing data, surveying and evaluating literature, developing new tools and techniques including software, and surveying, brainstorming, and evaluating engineering solutions and engineering designs. Proposals from teams of students will be considered.

MEE 400. Professional Development for Seniors. 1 Hour
Presentations on contemporary mechanical engineering subjects by students, faculty, and engineers in active practice; student involvement in professional and service activities. Registration required of all MEE seniors. Prerequisites: MEE 300 or COP 101.

MEE 401. Aerodynamics. 3 Hours
Fundamentals of steady and inviscid aerodynamic flows. Emphasis on force and moment determination for airfoils and finite wings. Prerequisite(s): MEE 308.

MEE 409. Aerospace Structures. 3 Hours
Structural properties of wing and fuselage sections. Nonsymmetrical bending of skin-stringer wing sections. Shear stresses in thin-walled and skin-stringer multiple-celled sections. Deflection by energy methods. Introduction to finite element stiffness method. Prerequisite(s): EGM 303.

MEE 410. Heat Transfer. 3 Hours
Fundamentals of conduction, convection, and thermal radiation energy transfer. Conduction of heat in steady and unsteady state. Principles of boundary layer theory applicable to free and forced convection heat transfer for internal and external flows. Radiation analysis with and without convection and conduction. Prerequisite(s): MEE 308.

MEE 413. Propulsion. 3 Hours
Principles of propulsive devices, aerothermodynamics, diffuser and nozzle flow, energy transfer in turbo-machinery; turbojet, turbo-fan, prop-fan engines; 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 225; MEE 308) or instructor permission.

MEE 417. Internal Combustion Engines. 3 Hours
Combustion and energy release processes. Applications to spark and compression ignition, thermal jet, rocket, and gas turbine engines. Emphasis on air pollution problems caused by internal combustion engines. Idealized and actual cycles studied in preparation for laboratory testing of I. C. engines. Prerequisite(s): EGR 202 or permission of instructor.

MEE 420. 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 421. Robot Modeling. 3 Hours
This course provides the fundamentals of modeling the movement of spatial systems with a focus on robots, particularly industrial robots. Topics include planar and spatial robotics, forward kinematics including the Denavit-Hartenberg formalism, inverse kinematics, manipulator velocities and the robotics-specific Jacobian, static loads in robots, and the product-of-exponentials formalism. Prerequisites: MEE 321 or (ECE 203 and third-year status in ECE).

MEE 425. Aerospace Design. 3 Hours
Capstone Air Vehicle Design project that involves both individual and team-based conceptual and preliminary design and sizing. This course integrates the knowledge acquired from the disciplinary subjects already taken (aerodynamics, aerospace structures, propulsion, flight dynamics and intro to flight) in order to size an air vehicle based on a set of requirements. Prerequisites: MEE 225; MEE 401 or AEE 501; MEE 440 or AEE 521 or permission of instructor.

MEE 427. Mechanical Design I. 3 Hours
Stress and deflection analysis of machine components; theories of failure; fatigue failure of metals. Design and analysis of mechanical components such as gears, shafts, bearings and springs. Prerequisite(s): EGM 303; MEE 321.

MEE 428. Mechanical Design II. 3 Hours
Advanced topics in stress and deflection analysis; analysis and design of mechanical elements such as gears, journal and ball bearings, belts, brakes, and clutches; principles of fracture mechanics; failure analysis; machinery construction principles. Contemporary design methods and issues associated with the product development cycle. Prerequisite(s): MEE 427.

MEE 430. 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.

MEE 431L. Multidisciplinary Design I. 2 Hours
Application of engineering fundamentals to sponsored multidisciplinary-team design projects. In a combination of lecture and lab experiences, students learn the product realization process and project management. Product realization topics include idea generation, proposal development, design specifications, conceptualization and decision analysis. Project management topics include cost estimation and intellectual property management. Design projects progress to the proof of concept and prototype development stages. Prerequisites: MEE Students: EGM 303 and MEE 321, ECE students: ECE 303 and (ECE 304 or ECE 314). Corequisites: (MEE 344 or MEE 473 or MEE 456 or MEE 401 or MEE 409).

MEE 432L. Multidisciplinary Design II. 3 Hours
One hour lecture and five hours of lab per week. Detailed evaluation of the Product Realization Process focusing on conceptual design, embodiment design, final design and prototyping is taught. Analysis of the design criteria for safety, ergonomics, environment, cost and sociological impact is covered. Periodic oral and written status reports are required. The course culminates in a comprehensive written report and oral presentation. Prerequisites: MEE majors: MEE 431L; CPE majors: ECE 431L and (2 of the following: ECE 334, ECE 340, CPS 356, ECE 449); ELE majors: ECE 431L and (2 of the following: ECE 415, ECE 334, ECE 340).

MEE 437. 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 design projects. Prerequisite(s): (ECE 201 or EGR 203) and (ECE 201L or EGR 203L) or MEE 205.

MEE 438. Applied Robotics. 3 Hours
Within this course, focus will be on project-based learning with robotic systems. Extensive usage of student kits and industrial robotic platforms will enable hands-on learning experiences, which will encourage students to think critically and deepen their knowledge through experimentation. Using a combination of online learning content and classroom lectures, multiple comprehensive projects will be covered, such as a drawing robot, a webcam-controlled rover or industrial arm, and/or a self-balancing motorcycle. Students will use software (MATLAB, Simulink, ROS) programming to implement model-based design, control systems, image and signal processing, and more. The major learning objective is for students to get prepared for real-life environments by using the same tools as industry professionals. Prerequisites: MEE 321.

MEE 439. Dynamic Systems & Controls. 3 Hours
Dynamic systems modeling with special emphasis on mechanical systems (one and two degrees of freedom). Covers both transfer function and state space modeling techniques. Analogues drawn between mechanical, electrical, fluid, and thermal physical domains. System nonlinearities and model linearization methods are discussed. Analytical solutions of linear ordinary differential equations using Laplace transformation and state space theory. Feedback control theory, including root locus and frequency response techniques. Prerequisite(s): EGM 202; MTH 219.

MEE 440. Flight Vehicle Performance. 3 Hours
This course is intended to introduce the student to the flight mechanics of aerospace vehicles. Some familiarity with aircraft performance, static stability and control is assumed, but not required. We will use modern analysis methods to develop the topical details including: 1) a study of aerodynamics involved in-flight vehicle motion to obtain an understanding of influence coefficients; 2) use of linear algebra to develop a rational approach to modeling aircraft dynamics; 3) an introduction to modern control theory methodology; and 4) problems and examples that illustrate the use of desktop computational tools currently available. Prerequisite(s): (EGM 202; MEE 225; MTH 219) or permission of instructor.

MEE 450. 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. Prerequisite(s): MEE 341 Engineering Experimentation or permission of instructor.

MEE 454. Biomechanical Modeling. 3 Hours
The course will focus on biomechanical modeling, specifically, computational modeling of the human body's bones, joints, and muscles and the motion of the human body. Emphasis on representing aspects of the body computationally (through equations and as mechanical systems) and applying modeling and simulation to analyze the motion of a human.

MEE 456. Energy Systems Engineering. 3 Hours
This course is aimed at providing fundamental knowledge of thermodynamics, fluid mechanics, and heat transfer in context of Energy Systems Engineering. A Just-in-Time approach to learning and applying these topics will be used. Projects will anchor all class activities. In addition to providing knowledge and experience of thermodynamics, fluid mechanics, and heat transfer, this course seeks to provide students the analysis skills necessary to determine the importance of energy conversion technologies, with special emphasis on energy efficiency and renewable energy (tidal, hydroelectric, wind, solar and geothermal). Corequisite(s): MEE 410.

MEE 457. Building Energy Informatics. 3 Hours
The focus of the course is the collection and analysis of energy data sets to reduce energy consumption and/or energy demand. Students will typically utilize monthly energy data from multiple buildings, real time energy data, and building energy audit data. Students will disaggregate/aggregate data to develop energy use benchmarks, identify priority buildings/actions for energy reduction, identify problems, and estimate savings. Programming in Matlab and an introduction to sql dbase management are covered. Corequisite(s): MEE 410.

MEE 460. Engineering Analysis. 3 Hours
Engineering Analysis: Entry into AI-supported modeling of engineering systems. Emphasis on open-ended projects leading to data-based machine learning models and subsequent application of models to develop new solutions and insights. Identification and problem definition are relative to provided data. Classification and regression model approaches are considered. Statistical analysis is used to characterize model domain applicability, correlation, and co-linearity. Stacking benefits to reduce over-fitting in model development is demonstrated. Post-model development analysis involving optimization and/or Monte Carlo analysis to quantify uncertainty is considered. Effective communication of modeling, simulation, results, and conclusions is expected. Prerequisites: MTH 219.

MEE 461. Solar Energy Engineering. 3 Hours
This course will cover the theory, design and application of two broad uses of solar energy: (i) direct thermal and (ii) electrical energy generation. The majority of the course will focus on thermal applications, with emphasis on system simulation and design for buildings and other systems. This course will expose students to the development and use of solar design and simulation tools. Most of the tools will be implemented in Excel and TRNSYS, but students are welcome to use other software tools such as Engineering Equation Solver, (EES) or MATLAB. Some of the class time will be devoted to demonstrate the development and use of these tools to solve homework problems. Corequisite(s): MEE 410.

MEE 462. Geothermal Energy Engineering. 3 Hours
This course will cover the theory and design of three broad uses of geothermal energy: (i) heat pump applications, (ii) direct uses, and (iii) electrical energy generation. The majority of the course will focus on heat pump applications, with emphasis on ground heat exchanger simulation and design for buildings and other systems. Closed-loop, open-loop, and hybrid geothermal heat pump systems will be examined. Heating, cooling, and electricity generating applications using hot geothermal reservoirs will also be discussed. This course will expose students to the development and use of geothermal design and simulation tools. Most of the tools will be implemented in Excel, but students are welcome to use other software tools such as Engineering Equation Solver (EES) or MATLAB. The course notes explain the development and use of these tools, which will be used to solve homework problems. Corequisite(s): MEE 410.

MEE 463. Wind Energy Engineering. 3 Hours
Introduction to wind energy engineering, including wind energy potential and its application to power generation. Topics include wind turbine components; turbine fluid dynamics and aerodynamics; turbine structures; turbine dynamics, wind turbine controls; fatigue; connection to the electric grid; maintenance; web site assessment; wind economics; and wind power legal, environmental, and ethical issues. Corequisite(s): MEE 410.

MEE 464. Sustainable Energy Systems. 3 Hours
Survey of conventional fossil-fuel and renewable energy with an emphasis on system integration. Basic concepts of climate physics will be addressed along with estimates of fossil resources. Corequisite(s): MEE 410.

MEE 472. Design for Environment. 3 Hours
Emphasis on design for environment over the life cycle of a product or process, including consideration of the mining, processing, manufacturing, use, and post-life stages. Course provides knowledge and experience in invention for the purpose of clean design, life cycle assessment strategies to estimate the environmental impact of products and processes, and cleaner manufacturing practices. Course includes a major design project.

MEE 473. 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 474. Sustainable Energy Systems in Developing Countries. 3 Hours
Overview of the importance of access to sustainable modern energy systems for developing countries. Both sustainable development and human rights will be important themes. Specific technologies will be studied, along with the benefits and challenges of these technologies to sustainable energy systems, with comparisons made to current energy systems. Energy system modeling will be used to explore options for energy system transformation in selected Least Developed Countries (LDCs) and Small Island Developing States (SIDS).

MEE 486. Human Movement Assessment. 3 Hours
Students will learn the practical skills to collect data about human movements. Students will learn the analysis skills to process that data and extract important metrics from the data. Students will be able to create and interpret common biomechanical metrics such as kinematic profiles. Human movements related to clinical applications and sports applications will be studied.

MEE 490. Special Topics in Mechanical & Aerospace Engineering. 3 Hours
Particular assignments to be arranged and approved by the department chairperson.

MEE 493. Honors Thesis. 3 Hours
Selection, design, investigation, and completion of an independent, original research study resulting in a document prepared for submission as a potential publication and a completed undergraduate thesis. Restricted to students in University Honors Program.

MEE 494. Honors Thesis. 3 Hours
Selection, design, investigation, and completion of an independent, original research study resulting in a document prepared for submission as a potential publication and a completed undergraduate thesis. Restricted to students in University Honors Program. Prerequisite(s): MEE 493.

MEE 498. Research & Innovation Laboratory. 0-6 Hours
Students participate in (1) selection and design, (2) investigation and data collection, (3) analysis, and (4) presentation of a research project. Research can include, but is not limited to, developing an experiment, collecting and analyzing data, surveying and evaluating literature, developing new tools and techniques including software, and surveying, brainstorming, and evaluating engineering solutions and engineering designs. Proposals from teams of students will be considered.

MEE 499. Special Problems in Mechanical & Aerospace Engineering. 1-6 Hours
Particular assignments to be arranged and approved by department chairperson.

MEE 500. Advanced Engineering Analysis. 3 Hours
Graduate-level course encompassing fundamental analytical concepts and methods of engineering analysis. Topics will be drawn based upon Linear Algebra, Differential Equations, Vector Calculus, Tensor Analysis, Tensor Calculus, Fourier Analysis, and Partial Differential Equations with emphasis on their engineering applications in areas including Aerospace, Biomechanics, Design, Dynamics and Control, Materials, and Thermo-Fluids.

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. Prerequisites: MEE 308 or equivalent, or instructor permission.

MEE 505. Mechanics of Soft Materials. 3 Hours
Constitutive modeling of soft materials capable of large elastic deformations such as natural rubber, elastomers, biomaterials, tissues, and gels. Rigorous development of the constitutive theory for isotropic large-strain elasticity (hyper-elasticity) using the principles of nonlinear continuum mechanics. Survey of popular strain energy functions for elastomers, both compressible and incompressible. Experimental methods for material characterization and model validation. Calibration of constitutive models to experimental test data, accounting for special considerations such as consistency with linear elasticity and stability. Implementation of constitutive models in commercial finite element analysis software. Analytical and computational solutions of quasi-static boundary-value problems. Advanced topics including viscoelasticity, temperature-dependent response, thermal aging, anisotropy, damage, fracture, and the Mullins effect. Required background: undergraduate strength of materials, undergraduate calculus (integral and differential) including partial differentiation, undergraduate differential equations. Prerequisites: MEE 503 or instructor permission.

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 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 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 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 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. Prerequisites: ELE 432 or MEE 439 or Equivalent.

MEE 528. Robot Modeling. 3 Hours
This course covers the fundamentals of modeling the movement of spatial systems with a focus on robots, particularly industrial robots. Topics include planar and spatial robotics, forward kinematics including the Denavit-Hartenberg formalism, inverse kinematics, manipulator velocities and the robotics-specific Jacobian, static loads in robots, and the product-of-exponentials formalism. Prerequisites: MEE 321 (or instructor approval).

MEE 529. Analysis of Linear Systems. 3 Hours
State variable representation of linear systems and its relationship to the frequency domain representation using transfer functions and the Laplace transform. State transition matrix and solution of the state equation, stability, controllability, observability, state feedback and state observers are studied. Students are expected to have completed an undergraduate controls class and a linear algebra class. Prerequisites: MEE 439 (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 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. Prerequisites: Undergraduate electronics course. Corequisites: 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 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 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 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. Prerequisites: MEE 439.

MEE 554. Biomechanical Modeling. 3 Hours
The course will focus on biomechanical modeling, specifically, computational modeling of the human body's bones, joints, and muscles and the motion of the human body. Emphasis on representing aspects of the body computationally (through equations and as mechanical systems) and applying modeling and simulation to analyze the motion of a human.

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 556. Applied Robotics. 3 Hours
Within this course, focus will be on project-based learning with robotic systems. Extensive usage of student kits and industrial robotic platforms will enable hands-on learning experiences, which will encourage students to think critically and deepen their knowledge through experimentation. Using a combination of online learning content and classroom lectures, multiple comprehensive projects will be covered, such as a drawing robot, a webcam-controlled rover or industrial arm, and/or a self-balancing motorcycle. Students will use software (MATLAB, Simulink, ROS) programming to implement model-based design, control systems, image and signal processing, and more. The major learning objective is for students to get prepared for real-life environments by using the same tools as industry professionals.

MEE 557. Non-Linear Systems & Control. 3 Hours
Introduction to nonlinear phenomena in dynamical systems. A study of the major techniques of nonlinear system analysis including phase plane analysis and Lyapunov stability theory. Application of the analytical techniques to control system design including feedback linearization, backstepping, and sliding mode control. Student are expected to have completed an undergraduate controls course. Prerequisites: MEE 439.

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 559. Engineering Systems for the Common Good. 3 Hours
In this course we will mathematically examine a number of social systems and develop quantitative models describing their behavior. We will review and learn fundamental systems theory concepts, such as block diagrams, feedback loops, and continuous and discrete-time dynamics, as needed. You will apply these concepts to mathematically model and analyze social systems, and in this process, you will learn how the powerful ideal of Human Rights is understood via social system models. You will learn how to study and numerically simulate social dynamics in a methodical, mathematical manner. You will use simulation software to numerically investigate and understand social systems such as sustainability, homelessness, environmental justice, the poverty cycle, and others. For each system, we will highlight its connections to specific human rights. At the conclusion of the course, you will have achieved a deeper understanding of the connection between engineering principles and tools, human rights, and the common good. Students are expected to have a background in differential equations. Prerequisites: MTH 219 (or equivalent).

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 562. Intermediate Thermodynamics. 3 Hours
Intermediate thermodynamics is the study of energy management and material property manipulation to design energy systems which achieve some engineering goal. This course expands upon the undergraduate engineering thermodynamics course, emphasizing the application of thermodynamic concepts towards energy system design. Over the duration of this course, students will gain a graduate-level understanding of undergraduate thermodynamics concepts. Additionally, new methods for applying basic undergraduate concepts will be introduced along with computational methods. Both analytical and computer solutions of engineering thermodynamics problems are emphasized.

MEE 563. Intermediate Heat Transfer. 3 Hours
In this course, student's will build on their knowledge of heat transfer gained in their first required undergraduate heat transfer course. This class will focus especially on 1) analytical solutions of fundamental heat transfer equations and 2) The analysis of more complicated heat transfer systems, including multi-modal problems, radiative enclosures and heat exchangers. All techniques will focus on pen-and-paper solutions but some computer programming will be necessary to determine final answers. This is a companion class to Applied Heat Transfer, a class focused on numerical solution of fundamental heat transfer equations and their application to real-world heat transfer problems.

MEE 564. Applied Heat Transfer. 3 Hours
In this course, student's will build on their knowledge of heat transfer gained in their first required undergraduate heat transfer course. This class will focus especially on numerical solutions of fundamental heat transfer equations, including conduction, convection and radiation. All techniques will focus on programmed solutions but pen and paper work will be necessary to determine final answers. This is a companion class to Intermediate Heat Transfer, a class focused on analytical solutions of fundamental heat transfer equations.

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 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 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 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 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 586. Human Movement Assessment. 3 Hours
Students will learn the practical skills to collect data about human movements. Students will learn the analysis skills to process that data and extract important metrics from the data. Students will be able to create and interpret common biomechanical metrics such as kinematic profiles. Human movements related to clinical applications and sports applications will be studied.

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. 0-6 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. 1-3 Hours
Mechanical Engineering Thesis.

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. 1-3 Hours
An original research effort which makes a definite contribution to technical knowledge. Results must be of sufficient importance to merit publication.