# MECHANICAL ENGINEERING (MEEG)

**MEEG 2201 Engineering Statics** **3 Credits**
**Prerequisite:** PHYS 1171.
This introduction to rigid body mechanics using vector representation covers free body diagrams and static equilibrium in two- and three-dimensional space; solves problems in trusses, frames, and simple mechanisms; and develops methods in problem-solving techniques using computer-based approaches. Students perform lab experiments to support lecture theories and prepare professional-level reports. Previously ME 0201.

**MEEG 2203 Kinematics and Dynamics** **3 Credits**
**Prerequisites:** MEEG 2201.
This course presents kinematics principles applied to particles and rigid body elements. Topics include analysis of forces and motion using Newton's second and third laws of motion; theory of kinetics of particles and rigid body elements under rectilinear and curvilinear motion, vector methods; principles of work, energy, and power; and momentum and impact. Previously ME 0203.

**MEEG 2206L Mechanics Lab** **1 Credit**
**Fee:** $120 Engineering Lab Fee
**Corequisite:** MEEG 2201.
Students do mechanics experiments for two- and three-dimensional structures under static loading conditions. Concepts include vectors, equilibrium, moments, truss analysis, forces, and center of gravity of objects. This course includes topics in engineering materials, such as hardness, toughness, microscopic analysis, machinability and thermal properties. The course introduces strain gages, instrumentation, and statistical data analysis. Students perform experiments and prepare laboratory reports. Previously ME 0206L.

**MEEG 2207 Materials Science** **3 Credits**
**Attributes:** EVME Environmental Studies Major Elective, EVNS Environmental Studies: Natural Science, EVPE Environmental Studies Elective
**Corequisite:** CHEM 1171.
This course covers chemical and physical properties of metals, polymers, and ceramics. Subjects include atomic structure, crystallography, strengthening mechanisms, microstructure, chemical composition, diffusion, binary phase diagrams, transformation diagrams, corrosion and materials science protection. Importance of the interrelationship between a material's processing, microstructure, and properties is discussed. The lab demo portion examines material science testing and microstructure analyses. Sample preparation and metallographic techniques are also learned. Previously ME 0207.

**MEEG 2307L Dynamics Systems Lab** **1 Credit**
**Fee:** $120 Engineering Lab Fee
**Corequisites:** MEEG 2203, MEEG 3308.
Students perform experiments covering the concepts of kinematics, dynamics, and mechanisms. Concepts included are: Newton's Laws, momentum, mechanical energy, impact, and friction. The course includes concepts in the area of strength of materials, such as: stress, strain, loading, modulus of elasticity, and fatigue. It also covers analysis of beams, photoelastic studies, and statistical data analysis. Students complete written lab reports. Previously ME 0307L.

**MEEG 3241 Principles of Thermodynamics** **3 Credits**
**Prerequisite:** PHYS 1171.
This course on macroscopic thermodynamics with applications covers conservation of energy for open and closed systems, equations of state and pure substances, first and second law of thermodynamics, including the concepts of internal energy, as well as enthalpy and entropy as applied to aero-thermal components. Tables of thermodynamic properties, ideal gases and elements of cycle analysis, and applications of thermodynamic cycles, such as Carnot and Rankine, are discussed. Previously ME 0241.

**MEEG 3308 Strength of Materials** **3 Credits**
**Prerequisites:** MATH 1142, MEEG 2201.
This course examines concepts of two-dimensional stress and strain, factors of safety, thermal strain, static indeterminacy, stress concentration, bending including normal and shearing stresses, torsion, direct shear, principal stresses; Mohr's Circle; thin-walled pressure vessels; beam theory including shear and bending moment diagrams; deflection; elastic curves; indeterminate beams; energy methods; the use of superposition; and impact effects and column theory. Lab experiments reinforce these aspects of theory. This course includes a design project. Previously ME 0308.

**MEEG 3311 Machine Design** **3 Credits**
**Prerequisite:** MEEG 3308.
This course applies the fundamentals of mechanical engineering design to analyze, design, and/or select components typically used in the design of complete mechanical systems. The course covers the design process and analysis of stress and deflection; material properties and loading (steady state and variable) as they relate to failure prevention; and the procedures for design and analysis of common machine elements such as columns, gears, fasteners, and springs. In team reverse-engineering projects, students apply the course topics to real hardware. The course emphasizes computer techniques and responsible design (safety factors and ethics). Previously ME 0311.

**MEEG 3318 Finite Element Analysis** **3 Credits**
**Prerequisites:** ENGR 2130, MATH 3332, MEEG 3308.
An introduction to concepts in finite element analysis; this course covers one- and two-dimensional element formulation and structural analysis. This finite element analysis is extended to three dimensional problems in mechanics and materials. This course will provide an overview of the complimentary topic of computational fluid dynamics (CFD). Students solve problems both manually and with the use of modern computer finite element software, Ansys and Fluent. Previously ME 0318.

**MEEG 3342 Applications of Thermodynamics** **3 Credits**
**Prerequisite:** MEEG 3241.
This course applies concepts learned in MEEG 3241. Topics include mixtures of ideal gases and vapors; psychrometry; combustion analysis of common power generating, refrigeration, and air conditioning cycles; figures of merit including thermal efficiency; continuity equation, basic energy relations for turbomachinery; fundamentals of compressor and turbine design; and application and synthesis of design using thermodynamic principles. This course includes a lab segment. Previously ME 0342.

**MEEG 3347 Fluid Mechanics** **3 Credits**
**Prerequisites:** MATH 3332, MEEG 3241.
Topics in this course include incompressible fluids at rest and in motion; Bernoulli's theorem and the principle of similarity flow through orifices, nozzles, and pipes; flow through open channels; energy relationships as applied to pipe lines, pumps, and turbines; acceleration of fluid masses; losses in fluid flow systems; fluid dynamics; the momentum theorem in turbomachinery; and introduction to compressible fluid flow. This course emphasizes design solutions using computer analysis and synthesis. The course includes a design project of a system that applies the principles of fluid flow. Previously ME 0347.

**MEEG 3348L Thermal and Fluids Lab** **1 Credit**
**Fee:** $120 Engineering Lab Fee
**Corequisites:** MEEG 3342, MEEG 3347.
This laboratory learning experience provides the opportunity to explore various components, such as the compressor, condenser, and evaporator, in a series of experiments using refrigeration equipment. Students investigate lift and drag in a wind tunnel, pressure losses in duct flow, and the Bernoulli principle. Also, students determine the efficiency of a centrifugal pump, plot PV diagrams for the Otto Cycle, and study a Pelton Wheel Hydraulic Turbine. The course emphasizes statistical analysis, test planning, data evaluation, and report writing. Previously ME 0348L.

**MEEG 4310L Product Manufacturing Lab** **1 Credit**
**Fee:** $120 Engineering Lab Fee
**Corequisite:** MEEG 4312.
This laboratory provides practical concepts of machining processes, including milling, turning, and cutting. Students develop the knowledge and skills required in CNC programming, machine setup and operation, manual machining, and metrology. Students machine metal parts by cutting, drilling, pocketing, and contouring. This laboratory emphasizes the practical application of CNC machine tools and manual machining, involving set-ups and operation procedures. Graduate equivalent: MEEG 5310L. Previously ME 0310L.

**MEEG 4312 Advanced Product Design and Manufacturing** **3 Credits**
**Corequisite:** MEEG 4310L.
**Prerequisite:** Senior Standing.
This hands-on course presents design principles, design for manufacturing, and assembly (DFMA) mythologies. Students learn to choose the best manufacturing process and appropriate material for a product considering shape, size, weight, production rate, and tolerances. The course also covers geometric dimensioning and tolerancing components (GD&T). The concepts of computer-aided design (CAD) and computer-aided manufacturing (CAM) are covered using SolidWorks and Mastercam software. Students are taught CNC programming (G-code, M-code) applied on CNC lathes and mills. Students apply their knowledge within the semester by designing and fabricating a product. The course comprises lectures, a computer lab, a machine tool lab, a group project, and individual assignments.

**MEEG 4319 Applications of Finite Element Analysis** **3 Credits**
**Prerequisite:** MEEG 3318.
This course examines applications of finite element analysis in modern engineering including structural analysis, fluid flow and heat transfer. It is an introduction to the concepts of dynamics as applied to structure. Finite element formulations covering 1-, 2-, and 3-dimensional elements as well as energy methods are reviewed. Students develop techniques for application of finite element method in structural design, dynamic system response, fluid and thermal analyses. Application of methodology to fluid flow is presented. Students solve example and design problems manually and using modern finite element analysis software, Ansys and Fluent. Graduate equivalent: MEEG 5319. Previously ME 0319.

**MEEG 4321 Theory and Applications of Robot Kinematics** **3 Credits**
**Prerequisite:** MEEG 2203.
Topics in advanced kinematics include introduction to basic concepts and definitions related to kinematics, commonly used links and joints, kinematic analysis of mechanisms, introduction to robotic mechanisms, homogeneous transformations, Euler angles, Denavit-Hartenberg representation of forward kinematics of robots, inverse kinematics solution of robots, degeneracy and dexterity, and differential motion and velocity relations. Industrial application of kinematics will also be covered and the course will include a laboratory or project component. Graduate equivalent: MEEG 5321. Previously ME 0321.

**MEEG 4322 Advanced Dynamics** **3 Credits**
**Prerequisite:** MEEG 2203.
The topics in the area of dynamics include degrees of freedom, generalized coordinates, constraints, physics of failure, flexures, and optical mechanics. The course will focus on practical applications of advanced dynamics, including linkages, cams, and kinematic mechanisms, as well as computer applications and project design. Graduate equivalent: MEEG 5322. Previously ME 0322.

**MEEG 4323 Thermal Management of Microdevices** **3 Credits**
This course addresses the thermal design in electronic assemblies which includes thermal characteristics, heat transfer mechanisms and thermal failure modes. Thermal design of electronic devices enables engineers to prevent heat-related failures, increase the life expectancy of the system, and reduce emitted noise and energy consumption. This course provides the required knowledge of heat transfer for such analysis and various options available for thermal management of electronics. This course also presents advanced methods of removing heat from electronic circuits, including heat pipes, liquid immersion and forced convection. Graduate equivalents: ECEG 5323, MEEG 5323. Previously ME 0323.

**MEEG 4324 Micro and Nano Manufacturing** **3 Credits**
**Prerequisites:** CHEM 1171, MEEG 2207, PHYS 1171, Senior standing.
This course will introduce students to the latest advancements in micro and nano manufacturing. The course will enable students to become familiar with advanced manufacturing techniques in light of the global emphasis on micro and nano manufacturing. Topics to be covered include lithography, mechanical micromachining, laser fabrication, polymers and nanocomposites, and nano imprinting. The important topics of metrology and process control at the micro and nano scale will also be discussed. Students will conduct a class project integrating the different processes for an application in electromechanical or biomedical field. A lab component is also present where students get a hands-on experience with material processing and characterization tools. Graduate equivalent: MEEG 5324. Previously ME 0324.

**MEEG 4325 Engineering Systems Dynamics** **3 Credits**
**Prerequisites:** MEEG 3318.
The student will become familiar with the analysis of the dynamic response of structures, structural components to transient loads, and foundation excitation. Course includes single-degree-of-freedom and multiple-degree-of-freedom systems, frequency response concepts, and introduction to modal analysis. Basic concepts of vibration control and control theory will be introduced. Previously ME 0325.

**MEEG 4327 Fracture Mechanics** **3 Credits**
**Prerequisite:** MEEG 3308.
This course covers fracture mechanics concepts for design, materials selection, and failure analysis. The fundamental principles of fracture parameters and criteria, stress field at the tip of a crack, fracture toughness, thickness effect, plastic zone concept, and crack growth under cyclic loading and aggressive environment will be presented. Emphasis will be placed on the practical applications of fracture mechanics by incorporation of a failure investigation study where the students utilize the skills developed with the course to root cause a real world failure. Taking a holistic approach, each student will have their own case study and learn to incorporate fracture mechanics, material science, mechanics of materials, computer simulation, and manufacturing techniques and knowledge into their project. Graduate equivalent: MEEG 5327. Previously ME 0327.

**MEEG 4330 Mechanics of Composite Materials** **3 Credits**
**Prerequisite:** MEEG 3308.
Engineered composite materials are finding increased use in many high-technology applications such as aerospace, automotive, sporting goods, and structural components as robust durable systems. This course is designed to provide a comprehensive understanding of classification, processing, properties, selection, design, and failure of polymer, metal, and ceramic based composite materials. Micro-mechanical and macro-mechanical analysis capabilities will be used to assess composite structures. Stiffness and strength evaluation, software simulation, and optimization are used in a laminated composite design application. Graduate equivalent: MEEG 5330. Previously ME 0330.

**MEEG 4346 Energy Conversion** **3 Credits**
**Prerequisite:** MEEG 3347.
This course covers the major topics in energy conversion, including fuels used in energy conversion; solar energy; gas turbine engines and applications; internal combustion engines; heat pumps; classic and novel power and refrigeration cycles; system analysis; system economics; and environmental considerations. The course includes computer simulation of power plant performance to optimize energy conversion efficiency. Students will be required to conduct a research on the environmental impacts of the major current energy conversion systems. Graduate equivalent: MEEG 5346. Previously ME 0346.

**MEEG 4349 Heat Transfer** **3 Credits**
**Prerequisites:** MATH 3332, MEEG 3347.
This course covers one- and two-dimensional heat conduction, the electrical analogy in heat transfer, steady state heat transfer by conduction and convection through multiple planar, cylindrical, and spherical layers and the concept of critical radius. Heat transfer solutions for extended surfaces and solutions for transient problems; convection heat transfer in laminar and turbulent flows; fundamental radiation concepts; laws of thermal radiation; radiation exchange; heat exchangers and electrical analogies. In the lab, students investigate heat transfer in plane surfaces, enhanced heat transfer in extended surfaces, and heat exchanger effectiveness. This course includes a practical design project of a system that applies the principles of heat transfer. Previously ME 0349.

**MEEG 4350L Energy Transfer Lab** **1 Credit**
**Fee:** $120 Engineering Lab Fee
**Corequisites:** MEEG 4325, MEEG 4349.
A laboratory experience for engineering students utilizing hands-on experiments to explore energy transfer methods related to transmitted forces in vibrating systems, as well as thermal transfer gradients in mechanical, electrical, and electronic systems. Students use simulation and modeling software for many experiments, including conduction and convection heat transfer processes. The course emphasizes statistical analysis, instrumentation, and report writing. Previously ME 0350L.

**MEEG 4353 Computational Fluid Dynamics** **3 Credits**
**Prerequisites:** ENGR 2145, MEEG 3347.
This course is an introduction to computational methods used for the solution of advanced fluid dynamics problems, using commercially available ANSYS-Fluent software. Emphasis is placed on concepts in finite difference methods as applied to various ordinary and partial differential model equations in fluid mechanics, fundamentals of spatial discretization, numerical integration, and numerical linear algebra. There is a focus on the engineering and scientific computing environment. Topics may include waves, advanced numerical methods (e.g. spectral, finite element, finite volume), non-uniform grids, turbulence modeling, and methods complex boundary conditions. Students will work on a final computational project and will present findings to the class. Graduate equivalent: MEEG 5353. Previously ME 0353.

**MEEG 4354 Heat and Mass Transfer** **3 Credits**
**Prerequisite:** MEEG 4349.
This course covers the concepts of conduction, convection, and radiation heat transfer as well as mass transfer. Boiling and condensation; design and performance of selected thermal systems (including heat exchangers); and laminar and turbulent flows as related to forced and free convection are all studied. Mathematical modeling of engineering systems using modern analytical and computational solution methods are also covered. Graduate equivalent: MEEG 5354. Previously ME 0354.

**MEEG 4356 Renewable Wind Energy** **3 Credits**
**Prerequisites:** MEEG 3308, MEEG 3347.
This course will give students a comprehensive introduction to wind energy systems, a practical means of extracting green and renewable energy. Topics covered include a historical perspective of wind turbines, aerodynamics of wind turbines, Mechanics and dynamics, material and components, aeroelasticity and control systems, statistical wind modeling, wind energy system economics, and environmental considerations such as noise and aesthetics. Graduate equivalent: MEEG 5356.

**MEEG 4358 Heating, Ventilation, and Air Conditioning Systems Design** **3 Credits**
**Prerequisite:** MEEG 3342.
Heat loss and heat gain calculations for commercial and industrial buildings using Trane Engineering software. Students will learn how to layout and design HVAC systems per given building architectural plans, using computer software, codes, standards, and owner's requirements. Students will select appropriate HVAC equipment, size duct and piping systems, and conduct economic analysis. Energy estimating methods will be studied and an analysis of an actual building conducted. Current federal, state, and local codes and ASHRAE standards will be examined. Graduate equivalent: MEEG 5358.

**MEEG 4362 Gas Turbine Aerodynamics** **3 Credits**
**Prerequisite:** MEEG 3347.
The theoretical basis and the fundamentals of modern turbomachinery for aerospace (helicopter, aircraft) and power generation (marine, industrial) applications are studied. Brayton engine cycle analysis and performance improvement are reviewed. Applications of the principles of fluid mechanics and thermodynamics to the design of turbines and compressors are examined, as well as component analysis and velocity diagram for axial compressors, centrifugal compressors and axial turbines. Discussion of combustion and environmental emissions. This course carries a design/research project. Graduate equivalent: MEEG 5362. Previously ME 0362.

**MEEG 4364 Combustion** **3 Credits**
**Prerequisite:** MEEG 3342.
An introduction to combustion, this course covers the study of combustion science based on the background of thermodynamics, fluid mechanics, and heat transfer. Basic principles of combustion, including thermochemical equilibrium, flame temperature, energy of reaction, chemical kinetics, and flame structure are discussed. Graduate equivalent: MEEG 5364. Previously ME 0364.

**MEEG 4372 Applications of Theory of Elasticity** **3 Credits**
**Prerequisite:** MEEG 3308.
This course covers theory of elasticity (stress, strain, and generalized Hooke's law), strain energy methods (Castigliano's theorem), thin shells of revolution (equilibrium equations, pressure vessels), thin plates (rectangular and circular plates, moment-curvature relations), beams of elastic foundations and buckling. Graduate equivalent: MEEG 5372. Previously ME 0372.

**MEEG 4376 Stability of Structures** **3 Credits**
**Prerequisite:** MEEG 3308.
This course will give students a comprehensive introduction to the fundamentals and principles in the stability analysis of structures. The course provides a strong foundation for understanding the stability criteria and their application in everyday practice. The topics include a comprehensive overview of different stability analysis methods and their applications in columns, beam-columns, torsional stabilities, plate elements, and cylindrical shells. Graduate equivalent: MEEG 5376.

**MEEG 4990 Independent Study** **1-3 Credits**
**Prerequisite:** Completion of non-elective mechanical engineering courses and at least one major elective.
During this design course emphasizing individual creativity, undergraduate students (working with a faculty mentor) develop project objectives and performance specifications. At review meetings, students present progress on the project including analytic and experimental results to date. A final report and presentation demonstrates the accomplishments and significant conclusions. Faculty involvement creates a realistic engineering development environment. Students may take this course as independent study once the prerequisites have been met. Enrollment by departmental approval only. Previously ME 0382.

**MEEG 5301 Feedback and Control Systems** **3 Credits**
This course emphasizes analysis and synthesis of closed loop control systems using both classical and state-space approaches with an emphasis on electro-mechanical systems. The mathematical requirements include the Laplace transform methods of solving differential equations, matrix algebra and basic complex variables. The discussion of classical control system design includes the modeling of dynamic systems, block diagram representation, time and frequency domain methods, transient and steady state response, stability criteria, controller action [Proportional (P), proportional and integral (PI), Proportional, integral and derivative (PID) and pseudo-derivatives feedback], root locus methods, the methods of Nyquist and Bode and dynamics compensation techniques. The discussion of state-space methods includes formulation and solution (analytical and computer-based) of the state equations and pole-placement design. The course integrates the use of computer-aided analysis and design tools (MATLAB) so as to ensure relevance to the design of real world controlled electro-mechanical systems using case studies and applications to electrical and mechanical systems. Includes hands-on lab (hardware-based) exploration of PID control systems. Undergraduate equivalent: ENGR 4301. Previously ME 0400.

**MEEG 5303 Industrial Automation** **3 Credits**
This hands-on course teaches students about components in automation systems and automated production lines. Students learn and practice with industrial sensors, actuators, PLCs, robot arms, pneumatics devices, and electro-pneumatic components. Students create, simulate, and assemble pneumatics, electric, electronics, and electro-pneumatic control circuits. Automation software, ladder logic programming, and robot programming are also discussed. The course comprises lectures, an automation lab, individual assignments, two group projects, and an individual project. Advanced topics are assigned. Undergraduate equivalent: ENGR 4303. Previously ME 0403.

**MEEG 5305 Design of Mechatronics Systems** **3 Credits**
This course covers development of mechatronics theory and applications to systems dependent upon the integration of mechanical, electrical and computer engineering. Students assemble hardware components to create a product design that fulfills a specified task in a mechatronics system. Students develop design skills in mechanisms, electrical devices, and software to create, test, and verify system function. Sessions include lab projects. Students will be challenged to develop a publication-worthy white paper as a final deliverable along with their final project. Undergraduate equivalent: ENGR 4305. Previously ME 0405.

**MEEG 5310L Product Manufacturing Lab** **1 Credit**
**Fee:** $120 Engineering Lab Fee
This laboratory provides practical concepts of machining processes, including milling, turning, and cutting. Students develop the knowledge and skills required in CNC programming, machine setup and operation, manual machining, and metrology. Students machine parts by cutting, drilling, pocketing, and contouring. This laboratory emphasizes the practical application of CNC machine tools and manual machining, involving set-ups and operation procedures. Undergraduate equivalent: MEEG 4310L. Previously ME 0410L.

**MEEG 5312 Advanced Product Design and Manufacturing 3 Credits**
**Corequisite:** MEEG 5310L.
This hands-on course presents design principles, design for manufacturing, and assembly (DFMA) mythologies. Students learn to choose the best manufacturing process and appropriate material for a product considering shape, size, weight, production rate, and tolerances. The course also covers geometric dimensioning and tolerancing components (GD&T). The concepts of computer-aided design (CAD) and computer-aided manufacturing (CAM) are covered using SolidWorks and Mastercam software. Students are taught CNC programming (G-code, M-code) applied on CNC lathes and mills. Students apply their knowledge within the semester by designing and fabricating a product. The course comprises lectures, a computer lab, a machine tool lab, a group project, and individual assignments. Students will work on a class research project.

**MEEG 5319 Applications of Finite Element Analysis 3 Credits**
This course examines applications of finite element analysis in modern engineering including structural analysis, fluid flow, heat transfer, and dynamics. Finite element formulations covering two- and three-dimensional elements as well as energy methods are reviewed. Students develop techniques for application of finite element method in structural design, dynamic system response, fluid and thermal analyses. Application of methodology to fluid flow is presented. Students solve example and design problems manually and using modern finite-element analysis software, Ansys and Fluent. Students are required to conduct an independent research on one of the new and emerging energy sources, write a research report and make a class presentation on their research. Undergraduate equivalent: MEEG 4319. Previously ME 0470.

**MEEG 5321 Theory and Applications of Robot Kinematics 3 Credits**
Topics in advanced kinematics include introduction to basic concepts and definitions related to kinematics, commonly used links and joints, kinematic analysis of mechanisms, introduction to robotic mechanisms, homogeneous transformations, Euler angles, Denavit-Hartenberg representation of forward kinematics of robots, inverse kinematics solution of robots, degeneracy and dexterity, and differential motion and velocity relations. Industrial application of kinematics will also be covered and the course will include a laboratory or project component. Undergraduate equivalent: MEEG 4321. Previously ME 0411.

**MEEG 5322 Advanced Dynamics 3 Credits**
The topics in the area of dynamics include degrees of freedom, generalized coordinates, constraints, physics of failure, flexures, and optomechanics. The course will focus on practical applications of advanced dynamics, including linkages, cams, and kinematics mechanisms, as well as computer applications and project design. Students will be challenged to develop a publication-worthy white paper as a final deliverable along with their final project. Undergraduate equivalent: MEEG 4322. Previously ME 0412.

**MEEG 5323 Thermal Management of Microdevices 3 Credits**
This course addresses the thermal design in electronic assemblies which includes thermal characteristics, heat transfer mechanisms and thermal failure modes. Thermal design of electronic devices enables engineers to prevent heat-related failures, increase the life expectancy of the system, and reduce emitted noise and energy consumption. This course provides the required knowledge of heat transfer for such analysis and various options available for thermal management of electronics. This course also presents advanced methods of removing heat from electronic circuits, including heat pipes, liquid immersion, and forced convection. Undergraduate equivalent: MEEG 4323. Previously ME 0423.

**MEEG 5324 Micro and Nano Manufacturing 3 Credits**
This course will introduce students to the latest advancements in micro and nano manufacturing. The course will enable students to become familiar with advanced manufacturing techniques in light of the global emphasis on micro and nano manufacturing. Topics to be covered include lithography, mechanical micromachining, laser fabrication, polymers and nanocomposites, and nano imprinting. The important topics of metrology and process control at the micro and nano scale will also be discussed. Students will conduct a class project integrating the different processes for an application in electromechanical or biomedical field. A lab component is also present where students get a hands-on experience with material processing and characterization tools. Undergraduate equivalent: MEEG 4324. Previously ME 0424.

**MEEG 5327 Fracture Mechanics 3 Credits**
This course covers fracture mechanics concepts for design, materials selection, and failure analysis. The fundamental principles of fracture parameters and criteria, stress field at the tip of a crack, fracture toughness, thickness effect, plastic zone concept, and crack growth under cyclic loading and aggressive environment will be presented. Emphasis will be placed on the practical applications of fracture mechanics by incorporation of design problems and laboratory demonstrations in the course. Emphasis will be placed on the practical applications of fracture mechanics by incorporation of a failure investigation study where the students utilize the skills developed with the course to root cause a real world failure. Taking a holistic approach each student will have their own case study and learn to incorporate fracture mechanics, material science, mechanics of materials, computer simulation, and manufacturing techniques and knowledge into their project. Students select a related research topic, identify a technical paper to review, and give a class presentation. Undergraduate equivalent: MEEG 4327. Previously ME 0427.

**MEEG 5330 Mechanics of Composite Materials 3 Credits**
Engineered composite materials are finding increased use in many high-technology applications such as aerospace, automotive, electronics, sporting goods, and structural components as robust durable systems. This course is designed to provide a comprehensive understanding of classification, processing, properties, selection, design, and failure of polymer, metal, and ceramic based composite materials. Micro-mechanical and macro-mechanical analysis capabilities will be used to assess composite structures. Stiffness and strength evaluation, software simulation, and optimization are used in a laminated composite design application. Students select a related research topic, identify a technical paper to review, and give a class presentation. Undergraduate equivalent: MEEG 4330. Previously ME 0444.

**MEEG 5346 Energy Conversion 3 Credits**
This course covers selected topics in energy conversion, including fuels used in energy conversion, solar energy, gas turbine engines and applications, internal combustion engines, battery power, heat pumps, classic and novel power and refrigeration cycles, system analysis, system economics, and environmental considerations. The course includes computer simulation of power plant performance to optimize energy conversion efficiency. A research report and class presentation of an independent research on one of the emerging sources of energy is an essential part of this course. Undergraduate equivalent: MEEG 4346. Previously ME 0451.

**MEEG 5353 Computational Fluid Dynamics** **3 Credits**
This course is an introduction to computational methods used for the solution of advanced fluid dynamics problems, using commercially available ANSYS-FLUENT software. Emphasis is placed on concepts in finite difference methods as applied to various ordinary and partial differential model equations in fluid mechanics, fundamentals of spatial discretization, numerical integration, and numerical linear algebra. There is a focus on the engineering and scientific computing environment. Topics may include waves, advanced numerical methods (like spectral, finite element, finite volume), non-uniform grids, turbulence modeling, and methods complex boundary conditions. Students will learn how to build and implement a working computational fluid dynamics code. Students will also work on a final computational project and will present findings to the class. Undergraduate equivalent: MEEG 4353. Previously ME 0428.

**MEEG 5354 Heat and Mass Transfer** **3 Credits**
This course covers the basic concepts of conduction, convection, and radiation heat transfer. Boiling and condensation, design and performance of selected thermal systems (including heat exchangers), and laminar and turbulent flows as related to forced and free convection are all studied. Mathematical modeling of engineering systems using modern analytical and computational solution methods are also covered. Students are required to conduct an independent research on one of the new and emerging energy sources, write a research report, and make a class presentation on their research. Undergraduate equivalent: MEEG 4354. Previously ME 0452.

**MEEG 5356 Renewable Wind Energy** **3 Credits**
This course will give students a comprehensive introduction to wind energy systems, a practical means of extracting green and renewable energy. Topics covered include a historical perspective of wind turbines, aerodynamics of wind turbines, Mechanics and dynamics, material and components, aeroelasticity and control systems, statistical wind modeling, wind energy system economics, and environmental considerations such as noise and aesthetics. Students will work on a class research project. Undergraduate equivalent: MEEG 4356.

**MEEG 5358 Heating, Ventilation, and Air Conditioning Systems Design** **3 Credits**
Heat loss and heat gain calculations for commercial and industrial buildings using Trane Engineering software. Students will learn how to layout and design HVAC systems per given building architectural plans, using computer software, codes, standards, and owner's requirements. Students will select appropriate HVAC equipment, size duct and piping systems, and conduct economic analysis. Energy estimating methods will be studied and an analysis of an actual building conducted. Current federal, state, and local codes and ASHRAE standards will be examined. Students will work on a class research project. Undergraduate equivalent: MEEG 4358.

**MEEG 5362 Gas Turbine Aerodynamics** **3 Credits**
Theory and fundamentals of modern turbomachinery for aerospace (helicopter, aircraft) and power generation (marine, industrial) applications. Brayton engine cycle analysis and performance improvement are examined. Applications of the principles of fluid mechanics and thermodynamics to the design of turbines and compressors are discussed; analysis and velocity diagram for axial compressors, centrifugal compressors and axial turbines. Discussion of combustion and environmental emissions is included. Students are required to conduct an independent research on one of the new and emerging energy sources, write a research report, and make a class presentation on their research. Undergraduate equivalent: MEEG 4362. Previously ME 0453.

**MEEG 5364 Combustion** **3 Credits**
An introduction to combustion, this course covers the study of combustion science based on the background of thermodynamics, fluid mechanics, and heat transfer. Basic principles of combustion, including thermochemical equilibrium, flame temperature, energy of reaction, chemical kinetics, and flame structure are discussed. This course also introduces some important chemical mechanisms and combustion modifications for pollutant control. Undergraduate equivalent: MEEG 4364. Previously ME 0464.

**MEEG 5372 Applications of Theory of Elasticity** **3 Credits**
This course covers theory of elasticity (stress, strain, and generalized Hooke's law), strain energy methods (Castigliano's theorem), thin shells of revolution (equilibrium equations, pressure vessels), thin plates (rectangular and circular plates, moment-curvature relations), beams of elastic foundations and buckling. Students are required to complete a group project on an advanced topic covered in class and write a research report. Undergraduate equivalent: MEEG 4372. Previously ME 0472.

**MEEG 5376 Stability of Structures** **3 Credits**
This course will give students a comprehensive introduction to the fundamentals and principles in the stability analysis of structures. The course provides a strong foundation for understanding the stability criteria and their application in everyday practice. The topics include a comprehensive overview of different stability analysis methods and their applications in columns, beam-columns, torsional stabilities, plate elements, and cylindrical shells. Students will work on class project/research. Undergraduate equivalent: MEEG 4376.

**MEEG 5410 Vibration Analysis** **3 Credits**
Fundamental laws of mechanics. Free and forced vibration of discrete single and multi-degree-of-freedom systems. Periodic and harmonic motion, viscous damping, and measures of energy dissipation. Modal analysis for linear systems. Computational methods in vibration analysis. Natural frequencies and mode shapes. Analytical dynamics and Lagrange equation. Longitudinal, torsional, and flexural vibration of continuous elastic systems, (strings, rods, beams). Energy methods. Approximate methods for distributed parameter systems. Dynamic response by direct numerical integration methods. ANSYS modeling will be covered. Students are required to conduct an independent research on one of the new and emerging energy sources, write a research report and make a class presentation on their research. Previously ME 0410.

**MEEG 5415 Engineering Applications of Numerical Methods** **3 Credits**
This course provides students with the theoretical basis to proceed in future studies. Topics include root-finding, interpolation, linear algebraic systems, numerical integration, numerical solution of ordinary and partial differential equations, modeling, simulation, initial boundary value problems, and two point boundary value problems. Undergraduate equivalent: ENGR 4415. Crosslisted with ECEG 5415. Previously ME 0415.

**MEEG 5990 Independent Study** **3 Credits**
Graduate students conduct a well-planned program of individual study under the supervision of a faculty member. Enrollment by departmental approval only. Previously ME 0495.

**MEEG 6971 Thesis I** **3 Credits**
The master's thesis is intended to be a test of the student's ability to formulate a problem, solve it, and communicate the results. The thesis is supervised on an individual basis by a faculty member. A thesis involves the ability to gather information, examine it critically, think creatively, organize effectively, and write convincingly; it is a project that permits the student to demonstrate skills that are basic to both academic and work in industry. The student must also submit a paper for possible inclusion in a refereed journal appropriate to the topic. Previously ME 0550.

**MEEG 6972 Thesis II** **3 Credits**

The master's thesis is intended to be a test of the student's ability to formulate a problem, solve it, and communicate the results. The thesis is supervised on an individual basis by a faculty member. A thesis involves the ability to gather information, examine it critically, think creatively, organize effectively, and write convincingly; it is a project that permits the student to demonstrate skills that are basic to both academic and work in industry. The student must also submit a paper for possible inclusion in a refereed journal appropriate to the topic. Previously ME 0551.