

# MEEN - MECHANICAL ENGINEERING

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## MEEN 601 Advanced Product Design

**Credits 3. 3 Lecture Hours.**

Design methodology, functional design, innovation, parameter analysis, design for reliability, manufacturability and strength; design project.

**Prerequisite:** MEEN 402 or equivalent.

## MEEN 602 Modeling and Analysis of Mechanical Systems

**Credits 3. 3 Lecture Hours.**

State spaces and vector algebra with applications to static, dynamic and controls systems, state evolution, trajectories, ordinary differential equations; global and local balance laws and vector calculus to describe flowing/deforming systems; steady state and transient PDEs, statics and vibrations of strings and membranes, and the heat equation; numerical methods.

**Prerequisite:** Graduate classification.

## MEEN 603/AERO 605 Theory of Elasticity

**Credits 3. 3 Lecture Hours.**

Analysis of stress and strain in two and three dimensions, equilibrium and compatibility equations, strain energy methods; torsion of noncircular sections; flexure; axially symmetric problems.

**Prerequisite:** Mechanics of Materials, Advanced Calc Different Equations.

**Cross Listing:** AERO 605/MEEN 603.

## MEEN 604 Time Frequency Nonlinear Vibration Control

**Credits 3. 3 Lecture Hours.**

Deployment of simultaneous vibration and frequency control in real-time to efficiently negate nonlinear dynamic instability; nonlinear vibrations in the joint time-frequency domain; theories on incorporating nonlinear dynamics and nonlinear time-frequency control into the control of bifurcation and route-to-chaos; integration on basic and advance topics from several engineering disciplines into the creation of an innovative, new control theory effective in denying bifurcation and chaotic state from emerging.

**Prerequisite:** Graduate classification.

## MEEN 605 Gas Dynamics

**Credits 3. 3 Lecture Hours.**

Overview of gas flows at Mach numbers wherein the fluid can no longer be assumed incompressible; aerospace and mechanical engineering applications ranging from external aerodynamics to internal flows for applications such as propulsion and airframe designs for jets, rockets, missiles and other devices; includes supersonic flows, shock waves, expansion waves, shock tubes, supersonic wind tunnels, gas flows with friction and gas flows with heat transfer.

**Prerequisite:** MEEN 344 or equivalent.

## MEEN 606/MSEN 626 Polymer Laboratories

**Credits 3. 2 Lecture Hours. 3 Lab Hours.**

Introduction to basic experimental skills relating to polymers; experiments include polymerization, molecular weight determination, FTIR, tensile test, NMR, DSC, swelling index, viscosity, x-ray diffraction.

**Cross Listing:** MSEN 626/MEEN 606.

## MEEN 607/MSEN 607 Polymer Physical Properties

**Credits 3. 3 Lecture Hours.**

Macromolecular concepts; molecular weight characterization; solubility parameters; phase diagrams; viscoelasticity; rheology; thermal behavior; damage phenomena, morphology; crystallization; liquid crystallinity; nanocomposites.

**Prerequisite:** MEEN 222/MSEN 222 or equivalent.

**Cross Listing:** MSEN 607/MEEN 607.

## MEEN 608/MEMA 602 Continuum Mechanics

**Credits 3. 3 Lecture Hours.**

Development of field equations for analysis of continua (solids as well as fluids); conservation laws: kinematics, constitutive behavior of solids and fluids; applications to aerospace engineering problems involving solids and fluids.

**Prerequisite:** Graduate classification.

**Cross Listing:** MEMA 602/AERO 603.

## MEEN 609 Materials Science

**Credits 3. 3 Lecture Hours.**

Structure and properties of solid materials.

**Prerequisites:** Undergraduate level Materials, Science and Engineering course.

## MEEN 610 Applied Polymer Science

**Credits 3. 3 Lecture Hours.**

Macromolecular concepts, molecular weight, tacticity, theory of solutions, rubber elasticity, thermal transitions, rheology, crystallinity, heterogeneous systems and relation of mechanical and physical characteristics to chemical structure; applications to polymer blends, thermosetting resins, structural adhesives and composites; design and processing of fibrous composites.

**Prerequisite:** Graduate classification; ENGR 213.

## MEEN 611 Advanced Internal Combustion Engines

**Credits 3. 3 Lecture Hours.**

Advanced thermodynamics of cycles for internal combustion engines, including fuels and combustion; performance characteristics of various types of engines.

**Prerequisite:** MEEN 344 or equivalent.

## MEEN 612 Mechanics of Robot Manipulators

**Credits 3. 3 Lecture Hours.**

Kinematics, dynamics and control of industrial robot manipulators.

**Prerequisites:** MEEN 364 and MEEN 411 or approval of instructor.

## MEEN 613 Engineering Dynamics

**Credits 3. 3 Lecture Hours.**

Three dimensional study of dynamics of particles and rigid bodies and application to engineering problems; introduction to Lagrange equations of motion and Hamilton's principle.

**Prerequisites:** MEEN 363; MATH 308.

## MEEN 614 Design and Modeling of Viscoelastic Structures

**Credits 3. 3 Lecture Hours.**

To provide the mechanical and mathematical basis for modeling linear viscoelastic materials.

**Prerequisite:** CVEN 305 or equivalent.

## MEEN 615 Advanced Engineering Thermodynamics

**Credits 3. 3 Lecture Hours.**

Theories of thermodynamics and their application to more involved problems in engineering practice and design; equilibrium, Gibbs' function, nonideal gases and various equations of state; second law analysis and statistical theory.

**Prerequisite:** MEEN 421 or equivalent.

**MEEN 616/MSEN 616 Surface Science****Credits 3. 2 Lecture Hours. 2 Lab Hours.**

Properties of surfaces, principles of classic and contemporary surface characterization techniques, recent development and roles of surface science in advanced technology.

**Prerequisite:** Graduate classification.**Cross Listing:** MSEN 616/MEEN 616.**MEEN 617 Mechanical Vibrations****Credits 3. 3 Lecture Hours.**

Theory of linear vibrations of finite and infinite number of degree of freedom systems via Lagrange, Newtonian and Energy approaches. Engineering applications.

**Prerequisites:** MEEN 364; MATH 308.**MEEN 618 Energy Principles and Variational Methods in Applied Mechanics****Credits 3. 3 Lecture Hours.**

Principles of virtual work, minimum total potential energy and extremum mixed variational principles; energy theorems of structural mechanics; Hamilton's principle for dynamical systems; Rayleigh-Ritz Galerkin and weighted-residual methods; applications to linear and nonlinear problems in mechanics (bars, beams, frames, plates and general boundary value problems).

**Prerequisites:** MATH 601 or concurrent enrollment.**MEEN 619 Conduction and Radiation****Credits 3. 3 Lecture Hours.**

Solutions of steady and transient problems with method of separation of variables, finite difference numerical methods, Duhamel's Theorem, Green's function, and Laplace transform, the phase change problems. View factors; radiative properties of surfaces and participating media, radiative exchange; gas radiation; and advanced solution methods for thermal radiation.

**Prerequisite:** MEEN 461.**MEEN 620/MSEN 620 Kinetic Processes in Materials Science****Credits 3. 3 Lecture Hours.**

Atomistic and mesoscale levels; foundation for microstructural evolution and behavior of materials; basic and irreversible thermodynamics; diffusion equations solutions; atomistic diffusion, nucleation; phase transformations: gas-solid, liquid-solid and solid-solid reactions; FiPy (finite volume solver for PDE) to simulate kinetic processes.

**Prerequisites:** MEEN 222/MSEN 222 or equivalent materials science course; preliminary general thermodynamics course is not necessary.**Cross Listing:** MSEN 620/MEEN 620.**MEEN 621 Fluid Mechanics****Credits 3. 3 Lecture Hours.**

Dynamics of two-dimensional incompressible and compressible fluids; viscous flow in laminar and turbulent layers, the Navier-Stokes equations and boundary layer theory.

**Prerequisite:** MEEN 344 or equivalent.**MEEN 622 Advanced Fluid Mechanics****Credits 3. 3 Lecture Hours.**

Laminar viscous flows; hydrodynamic stability; transition to turbulence; special topics include atomization, two-phase flows and non-linear theories.

**Prerequisites:** MEEN 621 or equivalent; MATH 601 or equivalent.**MEEN 624 Two-Phase Flow and Heat Transfer****Credits 3. 3 Lecture Hours.**

Current status of two-phase flow and heat transfer for application to design; basic one dimensional treatment of two-phase flows and the current state of the art in liquid-vapor phase change heat transfer.

**Prerequisite:** Undergraduate courses in fluid mechanics and heat transfer.**MEEN 625/MSEN 625 Mechanical Behavior of Materials****Credits 3. 3 Lecture Hours.**

Examination of deformation and microstructure mechanisms responsible for deformation and failure in metals; fatigue, creep, and fracture mechanisms of materials; emphasis on microstructural-mechanical property relationship.

**Prerequisite:** Undergraduate-level materials science course.**Cross Listing:** MSEN 625/MEEN 625.**MEEN 626 Lubrication Theory****Credits 3. 3 Lecture Hours.**

Development of Reynolds equation from Navier-Stokes equation for study of hydrodynamic lubrication theory as basis for bearing design; application to simple thrust and journal bearings and pads of various geometries; hydrostatic lubrication, floating ring bearing, compressible fluid (gas) lubrication, grease lubrication, dynamically loaded bearings, half speed whirl and stability.

**Prerequisites:** MEEN 344 or equivalent; MATH 308.**MEEN 627 Heat Transfer-Conduction****Credits 3. 3 Lecture Hours.**

Mathematical theory of steady-state and transient heat conduction; solution of the governing differential equations by analytical and numerical methods; applications to various geometric configurations.

**Prerequisites:** MEEN 461; MATH 601 or registration therein.**MEEN 628 Heat Transfer-Convection****Credits 3. 3 Lecture Hours.**

Mathematical theory of convection energy transport; applications to the design of heat-transfer apparatus.

**Prerequisites:** MEEN 461; MATH 601 or registration therein.**MEEN 629 Heat Transfer-Radiation****Credits 3. 3 Lecture Hours.**

Mathematical theory of thermal radiation with design applications; ideal and nonideal radiating surfaces, heat transfer in enclosures, solar radiation; analytical, numerical and analogical methods stressed in problem solving.

**Prerequisites:** MEEN 461; MATH 601 or registration therein.**MEEN 630 Intermediate Heat Transfer****Credits 3. 3 Lecture Hours.**

Application of basic laws to the analysis of heat and mass transfer; exact and approximate solutions to conduction, convection and radiation problems; current status of single and two-phase heat transfer for application to design.

**Prerequisites:** Undergraduate courses in fluid mechanics and heat transfer.**MEEN 631 Microscale Thermodynamics****Credits 3. 3 Lecture Hours.**

An understanding of thermodynamics and transport properties from a microscopic viewpoint; principles of quantum mechanics; atomic and molecular contribution to thermodynamic properties; kinetic theory and transport properties.

**Prerequisite:** Graduate classification.

**MEEN 632 Advanced Computer-Aided Engineering****Credits 3. 3 Lecture Hours.**

An integrated learning environment that is responsive to industrial need for mechanical engineers with multi-disciplinary design skills; three essentials emphasized in strong teamwork environment; design concept development, design optimization and effective communication via engineering drawings.

**Prerequisite:** Graduate classification in mechanical engineering.

**MEEN 633 Combustion Science and Engineering****Credits 3. 3 Lecture Hours.**

Fuels and combustion, mass transfer, transport properties, conservation laws, droplet, particle and slurry combustion, sprays, combustion in flow systems flammability, ignition, extinction, flame stability, laminar and detonation waves, premixed flames, application to burners—residential, utility and transportation, fluidized bed combustors, and fire and flame spread of modern building materials.

**Prerequisites:** MEEN 421, MEEN 344, MEEN 461 or equivalents.

**MEEN 634 Dynamics and Modeling of Mechatronic Systems****Credits 3. 3 Lecture Hours.**

Mechatronic interactions in lumped-parameter and continuum systems. Review of integral and differential electromagnetic laws, including motions. Lumped elements and dynamic equations of motion. Linear and non-linear actuators and transducers. Field transformation and moving media. Electromagnetic force densities and stress tensors.

**Prerequisites:** MEEN 364, MATH 308, MEEN 357.

**MEEN 635/MSEN 635 Flow and Fracture of Polymeric Solids****Credits 3. 3 Lecture Hours.**

Relationship of molecular structure to flow and fracture in polymeric materials; introduction of viscoelastic fracture mechanics; micromechanisms of fracture including crazing; fatigue behavior of polymeric materials.

**Cross Listing:** MSEN 635/MEEN 635.

**MEEN 636 Turbulence: Theory and Engineering Applications****Credits 3. 3 Lecture Hours.**

Characteristics, concepts, and relationships of detailed turbulent flow analysis and measurement; turbulence origin, energy production, cascade and dissipation; correlation functions, spectra and length scales; closure modeling of the Reynolds-averaged governing equations.

**Prerequisites:** MEEN 621.

**MEEN 637 Turbulence Measurement and Analysis****Credits 3. 3 Lecture Hours.**

Instrumentation and measurement techniques used in turbulent flow field analysis with emphasis on understanding the characteristics of the turbulence. Pressure probes, hot-wire/hot-film anemometry, laser anemometry, spectral and temporal analysis techniques, conditional sampling and computer applications.

**Prerequisite:** MEEN 344.

**MEEN 638 Mechanics of Non-Linear Fluids****Credits 3. 3 Lecture Hours.**

Introduction to classifications of flows, constitutive theory, fluids of the differential type.

**Prerequisites:** Graduate classification and approval of instructor.

**MEEN 639 Dynamics of Rotating Machinery****Credits 3. 3 Lecture Hours.**

Dynamic stability, critical speeds and unbalanced response of rotor-bearing systems; special problems encountered in modern applications operating through and above critical speeds.

**Prerequisites:** MEEN 363 or equivalent and graduate classification or approval of the instructor.

**MEEN 640/MSEN 640 Thermodynamics in Materials Science****Credits 3. 3 Lecture Hours.**

Use of thermodynamic methods to predict behavior of materials; codification of thermodynamic properties into simplified models; principles, methods, and models to generate accurate equilibrium maps through computational thermodynamics software; applications to bulk metallic, polymeric and ceramic materials, defects, thin films, electrochemistry, magnetism.

**Prerequisites:** MEEN 222/MSEN 222 or equivalent; graduate classification.

**Cross Listing:** MSEN 640/MEEN 640.

**MEEN 641 Quantitative Feedback Theory****Credits 3. 3 Lecture Hours.**

Benefits of feedback and cost of feedback; understanding extent to which available design theories meet realistic design constraints; treating the synthesis problem from a quantitative viewpoint; quantitative feedback theory as an effective tool for realistic feedback design problems for multivariable systems having both minimum and non-minimum phase zeros.

**Prerequisite:** MEEN 651 or equivalent.

**MEEN 642 Gas Turbine Heat Transfer and Cooling Technology****Credits 3. 3 Lecture Hours.**

Focus on the range of gas turbine heat transfer issues and associated cooling technologies; fundamentals, turbine heat transfer, turbine film cooling, turbine internal cooling with rotation, experimental methods, numerical modeling and final remarks; provide solid background for research and design in turbomachinery heat transfer.

**Prerequisites:** MEEN 344, MEEN 461, and graduate standing.

**MEEN 643 Experimental Methods in Heat Transfer and Fluid Mechanics****Credits 3. 3 Lecture Hours.**

Experimental methods including experiment planning and design, mechanics of measurements, error and uncertainty analysis, standards and calibration, temperature measurement, interferometry, flow rate measurement, hot wire anemometry, subsonic and supersonic flow visualization and data analysis; selected experiments conducted.

**Prerequisite:** Graduate classification.

**MEEN 644/NUEN 644 Numerical Heat Transfer and Fluid Flow****Credits 3. 3 Lecture Hours.**

Convection-diffusion, up-wind, exponential, exact solution, power law schemes, false diffusion; staggered grid concept; development of simple and simpler algorithms; periodically developed flows.

**Prerequisites:** MEEN 357 and MEEN 461; NUEN 430 or equivalent.

**Cross Listing:** NUEN 644/MEEN 644.

**MEEN 645 Mechanics of Compliant Materials****Credits 3. 3 Lecture Hours.**

Introduction to mechanics; three-dimensional analysis tools and techniques needed to model the linear behavior of fluids and solids in their response to imposed loads and deformations.

**Prerequisites:** Grade of C or better in CVEN 305, MEEN 368, or equivalent.

**MEEN 646 Aerothermodynamics of Turbomachines****Credits 3. 3 Lecture Hours.**

Fluid mechanics and thermodynamics as applied to the design of rotating systems; development of turbomachinery equations; detailed aerodynamic design of compressors and turbines.

**Prerequisites:** MEEN 414 and MEEN 472; MATH 601 or approval of instructor.

**MEEN 647 Fundamentals of Energy Storage****Credits 3. 3 Lecture Hours.**

Fundamental concepts of energy storage; fundamentals of mechano-physicochemical mechanisms and interactions that underlie electrodes in an energy storage system (e.g. battery, supercapacitor); thermodynamics, kinetics and transport phenomena of species and charge, thermal and mechanical behavior; performance, degradation and safety of such systems based on the aforementioned fundamental mechanisms.

**Prerequisite:** Graduate classification.**MEEN 648/ISEN 654 Manufacturing Systems Planning and Analysis****Credits 3. 3 Lecture Hours.**

The system perspective of a computer integrated manufacturing system; manufacturing and its various levels and the planning and control of product movement through the production system in the context of using realtime control, multiprocessor systems, network architectures and databases.

**Prerequisite:** ISEN 420.**Cross Listing:** ISEN 654/MEEN 648.**MEEN 649 Nonlinear Dynamical Systems****Credits 3. 3 Lecture Hours.**

Exact and approximate solutions to nonlinear differential equations; multiple time scales, Lindstedt Poincare, KB, Harmonic balance and other approximate solution techniques; limit cycles, Lyapunov stability theorems, stability of parametrically excited systems, coexisting harmonic solutions, bifurcation theory, shooting approaches for harmonic solutions, chaos, Lyapunov exponents, paths to chaos, synchronization, fractals, practical applications.

**Prerequisites:** Course in differential equations; graduate classification or approval of instructor.**MEEN 650/ISEN 655 Control Issues in Computer Integrated Manufacturing****Credits 3. 3 Lecture Hours.**

Examines the nature of computer aided manufacturing systems with emphasis in control; presentation of architecture for control of CAM systems; control issues; study and development of problems and procedures to control CAM systems.

**Prerequisite:** ISEN 654/MEEN 648 or approval of instructor.**Cross Listing:** ISEN 655/MEEN 650.**MEEN 651 Control System Design****Credits 3. 3 Lecture Hours.**

Frequency domain design of SISO systems for performance and sensitivity reduction; applications of Kalman filter and LQG/LTR techniques; design of sample-data systems; active control of vibration in distributed parameter systems; describing function and relay controls; application of control principles to engineering design.

**Prerequisite:** MEEN 411.**MEEN 652 Multivariable Control System Design****Credits 3. 3 Lecture Hours.**

Advanced issues relevant to the design of multivariable control systems using hybrid (time and frequency domain) design methodologies; design using the LQG/LTR method and advanced practical applications using various robust control system design techniques.

**Prerequisite:** MEEN 651 or ECEN 605.**MEEN 653 Scientific Writing****Credits 3. 3 Lecture Hours.**

Topics include origin and development of scientific writing, research methods, outlines, paper organization, journal selection, strategies to build a productive personal writing culture, effective communication, critical reviews and submission; preparation of an original manuscript for submission to a peer-reviewed journal by the end of the semester.

**Prerequisites:** Graduate classification and approval of instructor.**MEEN 654 Tribology-Mechanical Interface Design****Credits 3. 3 Lecture Hours.**

History and significance of tribology, rough surfaces, hertzian contact, rough surfaces in contact, friction of surfaces in contact, surface failures/wear, boundary lubrication, fluid properties, thick film lubrication, thin film lubrication, micro and nano tribology.

**Prerequisite:** Graduate classification.**MEEN 655 Design of Nonlinear Control Systems****Credits 3. 3 Lecture Hours.**

Design controllers for nonlinear and uncertain systems; apply the designs to mechanical systems.

**Prerequisites:** Graduate classification, MEEN 651 or equivalent.**MEEN 656/MSEN 656 Mechanical and Physical Properties of Thin Films****Credits 3. 3 Lecture Hours.**

Mechanical properties (hardness, stress, strain, delamination, fracture) of films; nanomechanical testing techniques; electrical properties of thin films; electrical properties measurement techniques; magnetic properties of films; magnetic properties measurement techniques; laboratory includes (1) thin film fabrication (sputtering, PVD); (2) nanomechanical testing; (3) electrical/magnetic measurement.

**Prerequisite:** MEEN 222/MSEN 222, MSEN 601, or basic materials science background.**Cross Listing:** MSEN 656/MEEN 656.**MEEN 657 Viscoelasticity of Solids and Structures I****Credits 3. 3 Lecture Hours.**

Linear, viscoelastic mechanical property characterization methods, time-temperature equivalence, multiaxial stress-strain equations; viscoelastic stress analysis; the correspondence principle, approximate methods of analysis and Laplace transform inversion, special methods; static and dynamic engineering applications; nonlinear behavior.

**Prerequisite:** Mechanics of Materials (CVEN 305 or equiv).**MEEN 658/MSEN 658 Fundamentals of Ceramics****Credits 3. 3 Lecture Hours.**

Atomic bonding; crystalline and glassy structure; phase equilibria and ceramic reactions; mechanical, electrical, thermal, dielectric, magnetic, and optical properties; ceramic processing.

**Prerequisite:** MEEN 222/MSEN 222 or equivalent or approval of instructor.**Cross Listing:** MSEN 658/MEEN 658.**MEEN 659 Sound and Vibration Measurements****Credits 3. 3 Lecture Hours.**

Basic acoustics; review of vibration theory, wave propagation in vibration systems, sound radiation from vibrating systems, sound and vibration sensors and instrumentation, data acquisition systems, measurement techniques, spectral analysis and spatial FFT analysis; design of experiments with vibro-acoustic systems and applications.

**Prerequisites:** Graduate classification; MATH 308 and MEEN 363.

**MEEN 660 Corrosion Engineering****Credits 3. 3 Lecture Hours.**

Aqueous corrosion phenomena of the mixed potential theory; basics of electrochemical reactions; corrosion measurement; surface engineering and protection; case studies.

**Prerequisite:** MEEN 360, MEEN 475 or Graduate classification.

**MEEN 661/MEMA 613 Principles of Composite Materials****Credits 3. 3 Lecture Hours.**

Classification and characteristics of composite materials; micromechanical and macromechanical behavior of composite laminae; macromechanical behavior of laminates using classical laminate theory; interlaminar stresses and failure modes; structural design concepts, testing and manufacturing techniques.

**Prerequisites:** CVEN 305 or equivalent.

**Cross Listing:** MEMA 613/MSEN 610.

**MEEN 662 Energy Management in Industry****Credits 3. 3 Lecture Hours.**

Energy systems and components frequently encountered in industrial environments; application of basic principles of thermodynamics, heat transfer, fluid mechanics and electrical machinery to the analysis and design of industrial system components and systems. Improved energy utilization.

**Prerequisites:** MEEN 421 and MEEN 461 or approval of instructor.

**MEEN 663 Cogeneration Systems****Credits 3. 3 Lecture Hours.**

Design and analysis of cogeneration systems; selection of prime mover-steam turbine, gas turbine, or reciprocating engine; environmental assessments; economic and financial evaluations; legal and institutional considerations; case studies.

**Prerequisite:** MEEN 421 or equivalent.

**MEEN 664 Energy Management in Commercial Buildings****Credits 3. 3 Lecture Hours.**

Basic heating, ventilating and air conditioning system design/selection criteria for air conditioning and heat system and design/selection of central plant components and equipment.

**Prerequisites:** MEEN 421 and MEEN 461 or approval of instructor.

**MEEN 665 Application of Energy Management****Credits 3. 3 Lecture Hours.**

Continuation of MEEN 662 and 664; case studies by students of energy conservation opportunities using energy audits and building load computer simulation.

**Prerequisites:** MEEN 662 and MEEN 664 or approval of instructor.

**MEEN 666 Plasticity Theory****Credits 3. 3 Lecture Hours.**

Theory of plastic yield and flow of two and three-dimensional bodies; classical plasticity theories, unified viscoplastic theories, numerical considerations; applications and comparisons of theory to experiment.

**Prerequisite:** MEMA 602/AERO 603, MEEN 689 or equivalent.

**Cross Listing:** MSEN 641 and MEMA 641.

**MEEN 667 Mechatronics****Credits 3. 2 Lecture Hours. 3 Lab Hours.**

Mechatronics; logic circuits in mechanical systems; electrical-mechanical interfacing; analysis and applications of computerized machinery.

**Prerequisite:** Graduate classification in engineering.

**MEEN 668 Rotordynamics****Credits 3. 3 Lecture Hours.**

Teaches the phenomena which occur in rotordynamics of turbomachinery, modeling techniques for turbomachines, and analysis techniques for rotordynamics analysis of real machines.

**Prerequisite:** Graduate classification.

**MEEN 669 Alternative Energy Conversion****Credits 3. 3 Lecture Hours.**

Design and analysis of alternative energy conversion processes and systems based on converting energy directly (e.g. fuel cells, photovoltaics); utilizing non-combustible heat sources (e.g. geothermal, ocean gradients, solar, and nuclear fission and fusion); obtaining energy from the environment (e.g. wind, hydroelectric, ocean tides and waves).

**Prerequisite:** Graduate classification.

**MEEN 670 Compressible Flow****Credits 3. 3 Lecture Hours.**

Compressible flow (also known as gas dynamic and/or high speed aerodynamics); gas flows at high enough Mach number wherein the fluid can no longer be assumed incompressible; aerospace and mechanical engineering applications ranging from external aerodynamics to internal flows for applications such as propulsion and airframe designs for jets, rockets, missiles, and many other devices; supersonic flows; shock waves; expansion waves; shock tubes; supersonic wind tunnels; gas flows with friction; gas flows with heat transfer.

**Prerequisite:** MEEN 344.

**MEEN 672 Introduction to Finite Element Method****Credits 3. 3 Lecture Hours.**

Weak or variational formulation of differential equations governing one- and two- dimensional problems of engineering; finite element model development and analysis of standard problems of solid mechanics (bars, beams, and plane elasticity), heat transfer and fluid mechanics; time-dependent problems; computer implementation and use of simple finite element codes in solving engineering problems.

**Prerequisite:** Senior or graduate classification.

**MEEN 673/MEMA 648 Nonlinear Finite Element Methods in Structural Mechanics****Credits 3. 3 Lecture Hours.**

Tensor definitions of stress and strain, finite strain, geometric and material nonlinearities; development on nonlinear finite element equations from virtual work; total and updated Lagrangian formulations; solution methods for nonlinear equations; computational considerations; applications using existing computer programs.

**Prerequisites:** MEMA 647/MEEN 670.

**Cross Listing:** MEMA 648.

**MEEN 674/ECEN 608 Modern Control****Credits 3. 3 Lecture Hours.**

Vector Norms, Induced Operator Norm;  $L_p$  stability; the small gain theorem; performance/robustness tradeoffs;  $L_1$  and  $H_{\infty}$  optimal control as operator norm minimization;  $H_2$  optimal control.

**Prerequisite:** ECEN 605 or equivalent.

**Cross Listing:** ECEN 608/MEEN 674.

**MEEN 675/ECEN 609 Adaptive Control****Credits 3. 3 Lecture Hours.**

Basic principles of parameter identification and parameter adaptive control; robustness and examples of instability; development of a unified approach to the design of robust adaptive schemes.

**Prerequisite:** ECEN 605 or equivalent.

**Cross Listing:** ECEN 609/MEEN 675.

**MEEN 676/CSCE 639 Fuzzy Logic and Intelligent Systems****Credits 3. 3 Lecture Hours.**

Introduces the basics of fuzzy logic and its role in developing intelligent systems; topics include fuzzy set theory, fuzzy rule inference, fuzzy logic in control, fuzzy pattern recognition, neural fuzzy systems, and fuzzy model identification using genetic algorithms.

**Prerequisite:** CSCE 625 or approval of instructor.**Cross Listing:** CSCE 639/MEEN 676.**MEEN 677/NUEN 677 Aerosol Science****Credits 3. 3 Lecture Hours.**

Multidisciplinary survey of methods for describing aerosol particles and systems: gas kinetics and transport theory, formation and growth thermodynamics, electrical properties, coagulation, light scattering; selected topics from current literature.

**Prerequisite:** Graduate classification in engineering or approval of instructor.**Cross Listing:** NUEN 677/MEEN 677.**MEEN 678 Aerosol Mechanics****Credits 3. 3 Lecture Hours.**

Provides the basis for understanding and modeling aerosol behavior; mechanical, fluid dynamical, electrical, optical and molecular effects are considered; applications include sprays and atomization, aerosol collection, aerosol sampling and visibility.

**Prerequisite:** Graduate classification in engineering or approval of instructor.**MEEN 679 Spectral Methods in Heat Transfer and Fluid Flow****Credits 3. 3 Lecture Hours.**

Introduces theoretical and applications aspects of spectral and multi-domain spectral methods for computational heat transfer and fluid flow problems.

**Prerequisites:** MEEN 357, MEEN 344, MEEN 461; graduate classification.**MEEN 680 Optical Techniques for Engineers****Credits 3. 3 Lecture Hours.**

Basic optical theories and their practical applications with an emphasis on flow visualization for thermal and fluid engineering; operating principles and applications of at least seven different optical diagnostic instruments.

**Prerequisite:** Graduate classification.**MEEN 681 Seminar****Credit 1. 1 Lab Hour.**

Current research in a wide range of fields described by guest lecturers who are prominent in their fields. Discussion period at the end of each lecture will permit the students to learn more about the lecturer and his/her work.

**Prerequisite:** Graduate classification in mechanical engineering.**MEEN 683 Multidisciplinary System Analysis and Design Optimization**  
**Credits 3. 3 Lecture Hours.**

Overview of principles, methods and tools in multidisciplinary system analysis and design optimization; engineering systems modeling for analysis, design and optimization; design variable selection, objective functions and constraints; subsystem identification and interface design; gradient-based and heuristic search methods; multi-objective optimization and Pareto optimality.

**Prerequisite:** Graduate classification.**MEEN 684 Professional Internship****Credits 1 to 16. 1 to 16 Other Hours.**

Supervised work in an area closely related to the specialized field of study undertaken by a Master of Engineering, Master of Science or Doctoral candidate.

**Prerequisite:** Admission to a specialized Master of Engineering, Master of Science or Doctoral program in mechanical engineering.**MEEN 685 Directed Studies****Credits 1 to 12. 1 to 12 Other Hours.**

Content will be adapted to interest and needs of group enrolled.

**MEEN 686/MSEN 618 Composite Materials Processing and Performance****Credits 3. 3 Lecture Hours.**

Fundamental science and design; processing and design interaction regarding multiphase composites; processing science, experimental characterization, laminate analysis; design structure and process.

**Prerequisite:** Elasticity, continuum mechanics, or equivalent.**Cross Listing:** MSEN 618/MEEN 686.**MEEN 687 Additive and Subtractive Processes in Custom Manufacturing****Credits 3. 3 Lecture Hours.**

Machining theory; traditional and non-traditional machining processes; CNC machines and tools; geometric dimensioning and tolerance (GD&T); additive manufacturing systems and processes; materials in additive manufacturing.

**Prerequisites:** MEEN 361 & MEEN 360 or equivalent.**MEEN 688 Advanced Solid Mechanics****Credits 3. 3 Lecture Hours.**

Derive approximate solutions of engineering mechanics problems by using suitable assumptions; understand the nature of the approximations and their effects on the accuracy of the resulting mechanics-of-materials solutions; apply the principles of advanced mechanics of materials to analyze deformation and failure problems common in engineering design and materials science; prepare for success in more advanced mechanics courses such as elasticity, energy methods, continuum mechanics and plasticity.

**Prerequisite:** Mechanics of materials, advanced calculus, differential equations.**MEEN 689 Special Topics in...****Credits 1 to 4. 1 to 4 Lecture Hours.**

Special topics in an identified area of mechanical engineering. May be repeated for credit.

**Prerequisite:** Approval of instructor.**MEEN 691 Research****Credits 1 to 23. 1 to 23 Other Hours.**

Methods and practice in mechanical engineering research for thesis or dissertation.

**MEEN 692 Professional Study****Credits 1 to 9. 1 to 9 Other Hours.**

Approved professional study or project; may be taken more than once, but not to exceed 6 hours of credit toward a degree. Must be taken on a satisfactory/unsatisfactory basis.

**Prerequisite:** Approval of instructor.