MEEN - MECHANICAL ENGINEERING

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 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 and MEMA 601.

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 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 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:** AERO 603 and MEMA 602.

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, or graduate classification.

MEEN 612 Mechanics of Robot Manipulators

Credits 3. 3 Lecture Hours. Forward and inverse kinematics and differential kinematics of robot manipulators, path planning, motion planning, dynamics of robot manipulators, control algorithms; PD/PID control, computed torque algorithm, robust and adaptive control algorithms, feedback linearization. **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 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 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 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 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 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:** Graduate classification.

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 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 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 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 Finite Volume Techniques for Heat Transfer and Fluid Flow

Credits 3. 3 Lecture Hours. Introduction to finite volume techniques, iterative techniques and grid convergence index, advection-diffusion, two-node and three-node formulations, staggered and non-staggered grid concept, SIMPLE family of algorithms and periodically fully developed flow and heat transfer. **Prerequisite:** 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 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 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 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 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 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. Emphasis on details of HVAC secondary systems, primary systems, and control systems needed to simulate and optimize the energy consumption during operation of large commercial building systems; calibration of energy simulations to measured energy consumption data. **Prerequisites:** Graduate classification.

MEEN 665 Application of Energy Management

Credits 3. 3 Lecture Hours. Introduction to existing building commissioning process to identify operational practices and component problems, and remedies to improve operating efficiency and comfort in commercial buildings; assess potential benefits of process in a real building; introduction to other energy efficiency measures for commercial buildings. **Prerequisites:** Graduate classification.

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 671 Human Sensing Technologies

Credits 3. 3 Lecture Hours. Exploration of cutting-edge human sensing technologies; investigation of sensing methodologies for human presence detection, counting, identification and activity tracking; design, signal processing, communication, firmware, software development, integration and testing of emerging sensing technologies; human sensing mechanisms, application scenarios, market potentials and industrial outlooks; implementation of engineering practice in integration with machine learning, environmental and human factors. **Prerequisites:** Graduate classification.

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 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

Credits 0-1. 0-1 Other Hours. 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. Directed individual study of selected topics in the field of mechanical engineering.

MEEN 686 Composite Materials Processing and Performance

Credits 3. 3 Lecture Hours. Basic composite materials technologies; reinforcing fibers and matrix materials, mechanics of laminates, testing for composite mechanical properties, failure theories, structural analysis and design, manufacturing methods and non-destructive evaluation. **Prerequisites:** Graduate classification.

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:** Graduate classification.

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 690 Entrepreneurship in Nano and Energy Systems

Credits 3. 3 Lecture Hours. Exploring the various aspects of entrepreneurship, from discovery to commercialization, with a focus on nanotechnology and the energy sector; exposure to idea generation incorporating technical design and comparative analysis to existing technologies, raising early stage capital, staffing the enterprise, developing the business plan and selling the product. **Prerequisite:** Graduate classification in the College of Engineering.

MEEN 691 Research

Credits 1 to 23. 1 to 23 Other Hours. Methods and practice in mechanical engineering research for thesis or dissertation.

MEEN 693 Solar Energy Engineering

Credits 3. 3 Lecture Hours. Introduction to solar energy; solar angles and radiation; solar photovoltaics; solar cell manufacturing; solar thermal systems; solar water heating and space heating; concentrated solar power; solar energy storage; economic analysis. **Prerequisites:** Graduate classification.

MEEN 694 Comparative Biomechanics

Credits 3. 3 Lecture Hours. Application of concepts and methods of mechanics to aspects of animal life with a focus on structure and movement; how life forms have evolved different solutions to accomplish terrestrial locomotion, flight, motion in water, heat transfer, procurement of energy, structural stability and function, work and nutrient transport. **Prerequisites:** Graduate classification.

MEEN 696 Bio-inspired Design

Credits 3. 3 Lecture Hours. Expand design space available to engineering by developing an understanding of how nature solves problems; study of effective bio-inspired design and biomimetic applications to draw solutions from nature; enhance concept generation through the use of bio-inspired design; use current state of the art methods in bio-inspired design; view nature's solutions to different problems from an engineering perspective. **Prerequisites:** Graduate classification.

MEEN 697 Innovation Mindset and Skillsets for Design and Research

Credits 3. 3 Lecture Hours. Exploration of the key behaviors of innovators and how to increase innovativeness in one's work; exploration of additional learning orientations, including design thinking and lean experimentation, and leadership practices to increase innovation in teams. **Prerequisite:** Graduate classification or approval of instructor.

MEEN 698 Computational Fluid Dynamics for Engineering and Biological Applications

Credits 3. 3 Lecture Hours. Numerical techniques for solving engineering and biological problems; survey of relevant governing equations such as Navier-Stokes and biochemical and species transport and reactions equations, and the numerical methods to solve them with a primary focus on finite difference methods; discussion of the non-Newtonian behavior of biological flows and their different viscosity models; introduction of rigorous methods for analysis of the methods and their results; hands-on experience in development of computer codes for computational fluid dynamics and transport phenomena. **Prerequisites:** Graduate classification.

MEEN 699 Plasma Engineering and Applications

Credits 3. 3 Lecture Hours. Basic plasma properties, interactions and confinement techniques; single particle orbits in electric and magnetic fields, moments of Boltzmann equation and introduction to fluid theory; wave phenomena in plasmas and introduction to plasma kinetic theory; analysis of laboratory plasmas and plasma applications including fusion, electric propulsion, materials processing and plasma enhanced chemistry. **Prerequisites:** Graduate classification.

MEEN 700 Robotic Perception

Credits 3. 3 Lecture Hours. Focus on sensors (Inertial Measurement Unit - IMU, Global Position System - GPS, and Light Detection and Ranging - LIDAR); sensor modeling; error modeling; calibration; sensor fusion; linear and extended Kalman and Particle filters; sensing and sensor fusion for autonomous vehicles. **Prerequisites:** MEEN 602 or equivalent.

MEEN 701 Principles of Precision Machine Design

Credits 3. 3 Lecture Hours. 1 Lab Hour. Contemporary precision machine systems for manufacturing, metrology and industrial automation are integration of all aspects of mechanical engineering knowledge such as engineering mechanics, dynamics, vibration, fluid mechanics, control, sensing and measurement, and even heat transfer. To accomplish high precision motion and control accuracy within micrometer or nanometer level, in this course, among the above fields very frequently encountered issues in both real machine and experimental system are introduced in this course. **Prerequisites:** Graduate classification.