

## ***Mechanical Engineering Courses***

### ***MECH 5301 Mathematical Methods for Mechanical Engineers (3-0)***

The primary objective of this class is to give grounding in some basic mathematical analysis methods that are most relevant to mechanical engineers. Topics include linear algebra and vector spaces, tensorial calculus, ordinary and partial differential equations,

### ***MECH 5302 Solid Mechanics I (3-0)***

An introduction to continuum mechanics, elasticity, stress, strain and constitutive models for solid mechanics problems.

### ***MECH 5303 Heat Transfer I (3-0)***

Introduction to heat conduction and convection; steady state and transient solutions, analytical and numerical methods.

### ***MECH 5304 Heat Transfer II (3-0)***

Advanced topics in heat conduction, convection and radiation; Turbulent effects free convection, boundary layers.

### ***MECH 5305 Computational Fluid Mechanics (3-0)***

Flow models and governing equations, mathematical behavior of partial differential equation, discretization technique: finite difference and finite volume, basics of numerics: algorithms for solving systems of linear algebraic equations, numerical stability, heat conduction, convection and diffusion, calculation of the flowfield: SIMPLE and SIMPLER algorithm, grids and transformation, post processing.

### ***MECH 5306 Fluid Mechanics (3-0)***

Survey of the principal concepts of fluid mechanics, statics, continuity, momentum and energy relations for continuum fluids, kinematics of fluid motion, governing equations for motion of non-viscous fluid, vorticity and circulation, and Kelvin's theorem. Helmholtz theorem, Crocco's theorem, stream function, potential flow, conformal transformation, theory of lift, and wave phenomena in fluids.

### ***MECH 5310 Thermodynamics (3-0)***

Applications of general thermodynamic relations; study and applications of time-dependent energy relationships; analysis of power, refrigeration, cryogenic and direct energy conversion systems.

### ***MECH 5311 Nonlinear Finite Element Analysis (3-0)***

This class will give an introduction to theory and application of advanced nonlinear finite element analysis. Topics covered include Eulerian and Lagrangian grids, explicit and implicit schemes, solution methods, large deformations and nonlinear materials, and contact.

### ***MECH 5312 Solid Mechanics II (3-0)***

Advanced topics in solid mechanics; inelastic material response; continuum mechanics; fracture mechanics; computational mechanics; finite elasticity; micro-mechanics.

### ***MECH 5313 Mechanics of Composite Materials (3-0)***

Analysis, design and applications of laminated and fiber reinforced composites. Micro- and macro-mechanical analysis of elastic constants, failure modes and environmental degradation.

**MECH 5318 Analytical Dynamics (3-0)**

Velocity and acceleration analysis, motion of a point in space, rotating coordinate systems, balancing of masses; generalized coordinates, work and energy, and impulse and momentum.

**MECH 5328\* Fracture Mechanics (0-0-3)**

Overview of linear elastic fracture mechanics as well as small scale plastic fracture mechanics; near tip fields; stress intensity factors, crack energetics and energy release rate; basics of computational fracture mechanics; J-integral. *Prerequisites:* MECH 5302.

**MECH 5334 Space System Design (3-0)**

Space Mission Designs and Requirements. Orbital Mechanics. Propulsion. Space Environment. Structural Design and Thermal Control. Power and Communication Systems.

**MECH 5335 Aerospace Propulsion (3-0)**

Fundamentals of airbreathing and rocket propulsion. Parametric Cycle Analysis of ideal and real engines. Engine Performance Analysis. Turbomachinery. Inlet, Nozzles, and Combustion System.

**MECH 5336 Aerospace Structures (3-0)**

Advanced mechanics of materials analysis of spacecraft and aircraft structural components: elasticity; torsion and bending of beams, analysis and design of thin-walled beams; failure modes; elastic buckling.

**MECH 5337 Aerospace Dynamics and Control (3-0)**

Flight mechanics, Flight dynamics, systems and control theories. Controller Design. System design considerations.

**MECH 5390 Special Topics in Mechanical Engineering (3-0)**

Advanced topics of contemporary interest in mechanical engineering. May be repeated for credit when topic varies.

**MECH 5391 Individual Studies (0-0-3)**

Individual variable-credit for non-thesis related research, design, or analysis on advanced phases of Mechanical Engineering problems conducted under the direct supervision of a faculty member. A maximum of 3 credit hours may be applied towards the MS degree. *Prerequisites:* Department approval.

**MECH 5396 Graduate Projects (0-0-3)**

Individual research, design, or analysis on advanced phases of engineering problems conducted under the direct supervision of a faculty member. *Prerequisite:* Department approval.

**MECH 5397 Graduate Projects (0-0-3)** Individual research, design, or analysis on advanced phases of engineering problems conducted under the direct supervision of a faculty member.

*Prerequisites:* Department approval.

**MECH 5398 Thesis (0-0-3)**

Initial work on the thesis. *Prerequisites:* Department approval.

**MECH 5399 Thesis (0-0-3)**

Continuous enrollment required while work on the thesis continues. *Prerequisites:* Department approval.

***MECH 6306\* Principles of Experimental and Engineering Development (0-0-3)***

Various topics related to how to transfer engineering research advances into products and to industry. Proposal writing and strategies to be competitive in proposal writing, business plans, technology roadmaps, SBIR and STTR programs. *Prerequisites:* Department approval.

***MECH 6307\* Engineering Regulation and Policy (0-0-3)***

An overview on how various regulatory policies affect product development and engineering research as well as how such regulations and policies are drafted and who are the driving constituents behind the policies. This class is intended to give the students a perspective on policy and regulation in the context of the development of engineering research and intellectual property. *Prerequisites:* Department approval.

***MECH 6308\* Product Development in Entrepreneurial Ventures (0-0-3)***

A survey course on some of the basics of developing products and transitioning research to the marketplace. There is focus on topics such as intellectual property strategy, business plans, the venture capital method and alternatives, product concept testing, as well as negotiation and leadership vision. *Prerequisites:* Department approval.

***MECH 6323\* Micromechanics (0-0-3)***

Basic theories, analytical techniques, and mathematical foundations of micromechanics; physical micromechanics; dislocations, and cohesive fracture models; Eshelby's eigenstrain theory; theoretical composite material micromechanics and homogenization with periodic structures. *Prerequisites:* MECH 5302.

***MECH 6343\* Advanced Manufacturing (0-0-3)***

Basic mechanics of various manufacturing processes. Metal forming, composite manufacturing techniques, mechanics and processing of additive manufacturing. *Prerequisites:* MECH 5302.

***MECH 6363\* Turbomachinery (0-0-3)***

Application of basics of fluid dynamics, mass transport and heat transfer to various turbomachinery systems. *Prerequisites:* MECH 5306 and MECH 5310.

***MECH 6364\* Turbulence I (0-0-3)***

Background on Turbulence: Description of turbulence, Kinematics of fluid motion, Reynolds averaged Navier-Stokes (RANS) equations, Scaling of turbulent flows (free shear layers and boundary layers). Turbulence Modeling: Hierarchy of turbulence simulations, Direct numerical simulation (DNS), Large-eddy simulation (LES) approaches. *Prerequisites:* MECH 5306.

***MECH 6396 Doctoral Research (0-0-3)*** Individual research, design, or analysis on advanced phases of engineering problems conducted under the direct supervision of a faculty member.

***MECH 6398 Dissertation I (0-0-3)***

Initial work on the dissertation. *Prerequisites:* Department approval.

***MECH 6399 Dissertation II (0-0-3)***

Continuous enrollment required while work on the thesis continues. *Prerequisites:* Department approval.

## ***Courses from other programs***

### ***CE 5304 Advanced Design of Structural Systems***

Advanced Design of Structural Systems Behavior and design concepts for concrete, steel, and composite structural systems. Topics include a detailed review of design specifications, detailing of frames, floor systems, and bracing components. Students will also be exposed to computational design tools. *Prerequisite:* CE 4335 and CE 4361.

### ***CE 5305 Advanced Structural Analysis***

Linear and nonlinear analysis of structural systems; plastic analysis; introduction to structural stability; and computational aspects of linear and nonlinear structural analysis. *Prerequisite:* CE 3343.

### ***CE 5307 Finite Element Method (3-0)***

Theory of the Finite Elements Method and its application to the solution of engineering problems. Topics include the strong and weak formulation, boundary conditions, basis functions and error estimates. Concepts will be applied to the solution of one, two and three-dimensional boundary-value steady-state problems in linear elasticity, heat conduction, and flow. Students will also be exposed to the use of commercial FE software. *Prerequisites:* CE 3343 or equivalent and instructor approval.

### ***CE 5320 Advanced Geotechnical Engineering***

Advanced treatment of topics in geotechnical engineering, including the engineering response to loading, shear strength of sands and clays, consolidation and settlement analysis, and dynamic soil properties including liquefaction. *Prerequisite:* Department Approval.

### ***CE 5325 Design for Dynamic Loads***

Vibration theory, behavior of structures and foundation members under dynamic loads. Design of structures and foundations for dynamic loads, wind loads, earthquakes and machine vibration. *Prerequisite:* Department Approval.

### ***CE 5327 Continuum Mechanics I***

Mathematical description of continuum mechanics principles, including: tensor analysis, generalized description of kinematics and motion, conservation laws for mass and momentum; invariance and symmetry principles; application to generalized formulation of constitutive expressions for various fluids and solids.

### ***CE 5329 Air Pollution Modeling***

Atmospheric boundary layer, atmospheric turbulence, air pollution meteorology, turbulent diffusion in the atmosphere, Eulerian diffusion equations, Gaussian models, USEPA regulatory air pollution models, modeling considerations, urban air pollution, and recent developments in air pollution modeling. *Prerequisite:* Department approval.

### ***CE 5333 Plates and Shells***

The theory and designs of plates and shell structures by the membrane and bending stress theories. *Prerequisite:* Department approval.

***MASE 5340 Advanced Failure Analysis (3-0)***

An advanced study of structural failure processes to include topics in fracture mechanics, fatigue, and environmental assisted cracking. Analysis of failures using metallographic, electron microscopy, and microanalytic techniques will be covered. Fracture of specific materials: steels, nonferrous alloys, composites, and nonmetallics will be included.

***MASE 5344 Interfacial Phenomena in Materials Systems (3-0)***

Thermodynamics of solid interfaces and interfacial equilibria. Interfacial free energy concepts and measurements. Structure of interfaces: solid surfaces, grain boundaries, phase boundaries, and system interfaces. Properties of interfaces and their role in materials performance. Offered in alternate years. *Prerequisites:* MME 5401, MME 5305, MME 5304 and MME 5305 or department approval.

***MFG 6321 Advanced Materials in Manufacturing Processes \* (3-0)***

Topics cover advanced engineering materials and materials selection, including recent advances in development and applications of metals, polymers, ceramics, and composites with emphasis on the relationships between structures, properties, processes, and performance. In addition, the different types and uses of materials in rapid net shape manufacturing processes are explored (advanced metal casting, powder metallurgy and power forming processes, sheet metal forming processes, forging and extrusion, and plastics forming processes).

***MFG 5311 Design for Manufacturability (3-0)***

Theoretical and practical aspects of the implications that the manufacturing process has on the design activities will be studied. Issues such as rapid prototyping, tolerancing, geometric modeling, capabilities of manufacturing processes, design for quality and maintainability and others will be covered. The course will consist of lectures, class discussions, and student projects.

***MFG 5321 Modeling and Analysis of Manufacturing Processes (3-0)***

This course is designed to be a capstone course for the graduate students of manufacturing engineering. The student will be expected to use the appropriate analytical tools to formulate, model, and solve real-life manufacturing problems. At the end of the course the student will give an open presentation of the results of the term project.

***MFG 5359 Computer-Aided Manufacturing (3-0)***

Modern concepts of using computers for manufacturing, including the theory of computer numerical control (CNC) and direct numerical control (DNC), CNC milling, CNC tuning and computer-aided process design. *Prerequisite:* Instructor approval.

***MME 5304 Phase Transforming and Microstructures (3-0)***

The theory of the nucleation and growth kinetics of solid materials, solid-solid transformations and mechanisms. Rate processes, decomposition and ordering reactions and microstructures. Diffusionless transformations, eutectoid, and martensitic transformations are covered along with associated microstructural morphologies and property/ performance control by microstructure control in materials. *Prerequisite:* MME 3406 and 3407, or equivalent, MME 5401, or department approval.

***MME 5308 Mechanical Behavior of Materials***

The underlying principles of elastic and plastic deformation of metals, ceramics, polymers, and composite materials will be developed. Topics include dislocation theory, slip, twinning, microstructures, high and low temperature deformation behavior (tensile properties, creep and

fatigue) of crystal line and amorphous materials. Offered in alternate years. *Prerequisite:* MME 2303 or MET 3203, or equivalent, or department approval.

***MME 5401 Microstructural and Microchemical Characterization of Materials (3-3)***

An interdisciplinary approach to the theory and applications of techniques for characterizing chemical (microchemical) and microstructural features of solid materials. Techniques that will be stressed include X-ray diffraction, optical metallography, scanning and transmission electron microscopy (emphasizing analytical transmission electron microscopy), electron probe microanalysis, and surface and near surface surface microanalysis (Auger electron spectroscopy, ESCA, SIMS, etc.). Sample preparation techniques will be covered and students will be encouraged to examine materials which may have some application to their research problems. Offered in alternate years. *Prerequisite:* MME 4413 or MET 4413.

***MME 5403 Advanced Concepts in Materials Science and Engineering (4-0)***

A blend of contemporary solid state physics and chemistry emphasizing structure and properties and including processing (synthesis) and performance, illustrated by various classes of materials: structural, electronic, magnetic, photonic, and superconducting. Fundamental issues and applications will include: crystal structure and crystal chemistry; disorder/order imperfections; phase equilibria, phase diagrams, phase transformation; reaction rates, kinetics, thermodynamics; microstructures in processing and performance; materials design/materials by design. *Prerequisites:* MME 2306, MME 2308, and MME 3406.