MECHL, MTRLS AND ARSPC ENGRG (MMAE)

MMAE 501
Engineering Analysis I
Lecture: 3 Lab: 0 Credits: 3

MMAE 502
Engineering Analysis II
Lecture: 3 Lab: 0 Credits: 3

MMAE 503
Advanced Engineering Analysis
Selected topics in advanced engineering analysis, such as ordinary differential equations in the complex domain, partial differential equations, integral equations, and/or nonlinear dynamics and bifurcation theory, chosen according to student and instructor interest. Prerequisite(s): MMAE 502
Lecture: 3 Lab: 0 Credits: 3

MMAE 508
Perturbation Methods
Asymptotic series, regular and singular perturbations, matched asymptotic expansions, and WKBJ theory. Methods of strained coordinates and multiple scales. Application of asymptotic methods in science and engineering. Prerequisite(s): MMAE 501
Lecture: 3 Lab: 0 Credits: 3

MMAE 509
Introduction to Continuum Mechanics
A unified treatment of topics common to solid and fluid mechanics. Cartesian tensors. Deformation, strain, rotation and compatibility equations. Motion, velocity gradient, vorticity. Momentum, moment of momentum, energy, and stress tensors. Equations of motion, frame indifference. Constitutive relations for elastic, viscoelastic, and fluids and plastic solids. Prerequisite(s): MMAE 501
Lecture: 3 Lab: 0 Credits: 3

MMAE 510
Fundamentals of Fluid Mechanics
Lecture: 4 Lab: 0 Credits: 4

MMAE 511
Dynamics of Compressible Fluids
Low-speed compressible flow past bodies. Linearized, subsonic, and supersonic flow past slender bodies. Similarity laws. Transonic flow. Hypersonic flow, mathematical theory of characteristics. Applications including shock and nonlinear wave interaction in unsteady one-dimensional flow and two-dimensional, planar and axisymmetric supersonic flow. Prerequisite(s): MMAE 510
Lecture: 3 Lab: 0 Credits: 3

MMAE 512
Dynamics of Viscous Fluids
Navier-Stokes equations and some simple exact solutions. Oseen-Stokes flows. Boundary-layer equations and their physical interpretations. Flows along walls, and in channels. Jets and wakes. Separation and transition to turbulence. Boundary layers in unsteady flows. Thermal and compressible boundary layers. Mathematical techniques of similarity transformation, regular and singular perturbation, and finite differences. Prerequisite(s): MMAE 510
Lecture: 4 Lab: 0 Credits: 4

MMAE 513
Turbulent Flows
Lecture: 4 Lab: 0 Credits: 4
MMAE 514
Stability of Viscous Flows
Prerequisite(s): MMAE 510 and MMAE 502
Lecture: 4 Lab: 0 Credits: 4

MMAE 515
Engineering Acoustics
Characteristics of sound waves in two and three dimensions. External and internal sound wave propagation. Transmission and reflection of sound waves through media. Sources of sound from fixed and moving bodies. Flow-induced vibrations. Sound-level measurement techniques.
Lecture: 3 Lab: 0 Credits: 3

MMAE 516
Advanced Experimental Methods in Fluid Mechanics
Design and use of multiple sensor probes to measure multiple velocity components, reverse-flow velocities, Reynolds stress, vorticity components and intermittency. Simultaneous measurement of velocity and temperature. Theory and use of optical transducers, including laser velocimetry and particle tracking. Special measurement techniques applied to multiphase and reacting flows. Laboratory measurements in transitional and turbulent wakes, free-shear flows, jets, grid turbulence and boundary layers. Digital signal acquisitions and processing. Instructor's consent required.
Lecture: 2 Lab: 3 Credits: 3

MMAE 517
Computational Fluid Dynamics
Prerequisite(s): MMAE 510
Lecture: 3 Lab: 0 Credits: 3

MMAE 518
Spectral Methods in Computational Fluid Dynamics
Application of advanced numerical methods and techniques to the solution of important classes of problems in fluid mechanics. Emphasis is in methods derived from weighted-residuals approaches, like Galerkin and Galerkin-Tau methods, spectral and pseudospectral methods, and dynamical systems modeling via projections on arbitrary orthogonal function bases. Finite element and spectral element methods will be introduced briefly in the context of Galerkin methods. A subsection of the course will be devoted to numerical turbulence modeling, and to the problem of grid generation for complex geometries.
Prerequisite(s): MMAE 510 and MMAE 501
Lecture: 3 Lab: 0 Credits: 3

MMAE 520
Advanced Thermodynamics
Macroscopic thermodynamics: first and second laws applied to equilibrium in multicomponent systems with chemical reaction and phase change, availability analysis, evaluations of thermodynamic properties of solids, liquids, and gases for single and multicomponent systems. Applications to contemporary engineering systems. Prerequisite: An undergraduate course in applied thermodynamics.
Lecture: 3 Lab: 0 Credits: 3

MMAE 522
Nuclear, Fossil-Fuel, and Sustainable Energy Systems
Lecture: 3 Lab: 0 Credits: 3

MMAE 523
Fundamentals of Power Generation
Thermodynamic, combustion, and heat transfer analyses relating to steam-turbine and gas-turbine power generation. Environmental impacts of combustion power cycles. Consideration of alternative and sustainable power generation processes such as wind and tidal, geothermal, hydroelectric, solar, fuel cells, nuclear power, and microbial. Prerequisite: An undergraduate course in applied thermodynamics.
Lecture: 3 Lab: 0 Credits: 3
MMAE 524
Fundamentals of Combustion
Lecture: 3 Lab: 0 Credits: 3

MMAE 525
Fundamentals of Heat Transfer
Lecture: 3 Lab: 0 Credits: 3

MMAE 526
Heat Transfer: Conduction
Prerequisite(s): MMAE 525 and MMAE 502
Lecture: 3 Lab: 0 Credits: 3

MMAE 527
Heat Transfer: Convection and Radiation
Prerequisite(s): MMAE 525
Lecture: 3 Lab: 0 Credits: 3

MMAE 529
Theory of Plasticity
Prerequisite(s): MMAE 530
Lecture: 3 Lab: 0 Credits: 3

MMAE 530
Advanced Mechanics of Solids
Prerequisite(s): MMAE 501*, An asterisk (*) designates a course which may be taken concurrently.
Lecture: 3 Lab: 0 Credits: 3

MMAE 531
Theory of Elasticity
Prerequisite(s): MMAE 530
Lecture: 3 Lab: 0 Credits: 3

MMAE 532
Advanced Finite Element Methods
Continuation of MMAE 451/CAE 442. Covers the theory and practice of advanced finite element procedures. Topics include implicit and explicit time integration, stability of integration algorithms, unsteady heat conduction, treatment of plates and shells, small-strain plasticity, and treatment of geometric nonlinearity. Practical engineering problems in solid mechanics and heat transfer are solved using MATLAB and commercial finite element software. Special emphasis is placed on proper time step and convergence tolerance selection, mesh design, and results interpretation.
Prerequisite(s): CAE 442 or MMAE 451
Lecture: 3 Lab: 0 Credits: 3

MMAE 533
Fatigue and Fracture Mechanics
Lecture: 3 Lab: 0 Credits: 3
MMAE 535
Wave Propagation
This is an introductory course on wave propagation. Although the ideas are presented in the context of elastic waves in solids, they easily carry over to sound waves in water and electromagnetic waves. The topics include one dimensional motion of elastic continuum, traveling waves, standing waves, energy flux, and the use of Fourier integrals. Problem statement in dynamic elasticity, uniqueness of solution, basic solution of elastodynamics, integral representations, steady state time harmonic response. Elastic waves in unbounded medium, plane harmonic waves in elastic half-spaces, reflection and transmission at interfaces, Rayleigh waves, Stoneley waves, slow waves diagrams, dispersive waves in waveguides and phononic composites, thermal effects and effects of viscoelasticity, anisotropy, and nonlinearity on wave propagation.
Lecture: 3 Lab: 0 Credits: 3

MMAE 536
Experimental Solid Mechanics
Review of applied elasticity. Stress, strain and stress-strain relations. Basic equations and boundary value problems in plane elasticity. Methods of strain measurement and related instrumentation. Electrical resistance strain gauges, strain gauge circuits and recording instruments. Analysis of strain gauge data. Brittle coatings. Photoelasticity; photoelastic coatings; moire methods; interferometric methods. Applications of these methods in the laboratory. Prerequisite: An undergraduate course in mechanics of solids.
Lecture: 3 Lab: 2 Credits: 4

MMAE 540
Robotics
Prerequisite(s): MMAE 501* and MMAE 443, An asterisk (*) designates a course which may be taken concurrently.
Lecture: 3 Lab: 0 Credits: 3

MMAE 541
Advanced Dynamics
Prerequisite(s): MMAE 501*, An asterisk (*) designates a course which may be taken concurrently.
Lecture: 3 Lab: 0 Credits: 3

MMAE 542
Applied Dynamical Systems
This course will cover analytical and computational methods for studying nonlinear ordinary differential equations especially from a geometric perspective. Topics include stability analysis, perturbation theory, averaging methods, bifurcation theory, chaos, and Hamiltonian systems.
Prerequisite(s): MMAE 501
Lecture: 3 Lab: 0 Credits: 3

MMAE 543
Modern Control Systems
Prerequisite(s): MMAE 501*, An asterisk (*) designates a course which may be taken concurrently.
Lecture: 3 Lab: 0 Credits: 3

MMAE 544
Optimization Theory
Optimization theory and practice with examples. Finite-dimensional unconstrained and constrained optimization, Kuhn-Tucker theory, linear and quadratic programming, penalty methods, direct methods, approximation techniques, duality. Formulation and computer solution of design optimization problems in structures, manufacturing and thermofluid systems. Prerequisite: An undergraduate course in numerical methods.
Lecture: 3 Lab: 0 Credits: 3

MMAE 545
Advanced CAD/CAM
Prerequisite(s): MMAE 445
Lecture: 3 Lab: 0 Credits: 3

MMAE 546
Advanced Manufacturing Engineering
Introduction to advanced manufacturing processes, such as powder metallurgy, joining and assembly, grinding, water jet cutting, laser-based manufacturing, etc. Effects of variables on the quality of manufactured products. Process and parameter selection. Important physical mechanisms in manufacturing process. Prerequisite: An undergraduate course in manufacturing processes or instructor consent.
Lecture: 3 Lab: 0 Credits: 3
MMAE 547
Computer-Integrated Manufacturing Technologies
The use of computer systems in planning and controlling the manufacturing process including product design, production planning, production control, production processes, quality control, production equipment and plant facilities.
Lecture: 3 Lab: 0 Credits: 3

MMAE 550
Optimal State Estimation
Lecture: 3 Lab: 0 Credits: 3

MMAE 551
Experimental Mechatronics
Prerequisite(s): MMAE 443
Lecture: 2 Lab: 3 Credits: 3

MMAE 552
Introduction to the Space Environment
Lecture: 3 Lab: 0 Credits: 3

MMAE 554
Electrical, Magnetic and Optical Properties of Materials
Lecture: 3 Lab: 0 Credits: 3

MMAE 555
Introduction to Navigation Systems
Fundamental concepts of positioning and dead reckoning. Principles of modern satellite-based navigation systems, including GPS, GLONASS, and Galileo. Differential GPS (DGPS) and augmentation systems. Carrier phase positioning and cycle ambiguity resolution algorithms. Autonomous integrity monitoring. Introduction to optimal estimation, Kalman filters, and covariance analysis. Inertial sensors and integrated navigation systems.
Prerequisite(s): MMAE 501* and MMAE 443, An asterisk (*) designates a course which may be taken concurrently.
Lecture: 3 Lab: 0 Credits: 3

MMAE 557
Computer-Integrated Manufacturing Systems
Advanced topics in Computer-Integrated Manufacturing, including control systems, group technology, cellular manufacturing, flexible manufacturing systems, automated inspection, lean production, Just-In-Time production, and agile manufacturing systems.
Lecture: 3 Lab: 0 Credits: 3

MMAE 560
Statistical Quality and Process Control
Basic theory, methods and techniques of on-line, feedback quality control systems for variable and attribute characteristics. Methods for improving the parameters of the production, diagnosis, and adjustment processes so that quality loss is minimized. Same as CHE 560.
Lecture: 3 Lab: 0 Credits: 3

MMAE 561
Solidification and Crystal Growth
Lecture: 3 Lab: 0 Credits: 3

MMAE 562
Design of Modern Alloys
Phase rule, multicomponent equilibrium diagrams, determination of phase equilibria, parameters of alloy development, prediction of structure and properties. Prerequisite: A background in phase diagrams and thermodynamics.
Lecture: 3 Lab: 0 Credits: 3

MMAE 563
Advanced Mechanical Metallurgy
Analysis of the general state of stress and strain in solids. Analysis of elasticity and fracture, with a major emphasis on the relationship between properties and structure. Isotropic and anisotropic yield criteria. Testing and forming techniques related to creep and superplasticity. Deformation mechanism maps. Fracture mechanics topics related to testing and prediction of service performance. Static loading to onset of rapid fracture, environmentally assisted cracking fatigue, and corrosion fatigue. Prerequisite: A background in mechanical properties.
Lecture: 3 Lab: 0 Credits: 3

MMAE 564
Dislocations and Strengthening Mechanisms
Lecture: 3 Lab: 0 Credits: 3
MMAE 565  
Materials Laboratory  
Advanced synthesis projects studying microstructure and properties of a series of binary and ternary alloys. Gain hands-on knowledge of materials processing and advanced materials characterization through an integrated series of experiments to develop understanding of the processing-microstructure-properties relationship. Students arc melt a series of alloys, examine the cast microstructures as a function of composition using optical and electron microscopy, DTA, EDS, and XRD. The alloys are treated in different thermal and mechanical processes. The microstructural and mechanical properties modification and changes during these processes are characterized. Groups of students will be assigned different alloy systems, and each group will present their results orally to the class and the final presentation to the whole materials science and engineering group.  
Lecture: 1 Lab: 6 Credits: 3

MMAE 566  
Problems in High-Temperature Materials  
Prerequisite(s): MMAE 564  
Lecture: 3 Lab: 0 Credits: 3

MMAE 567  
Fracture Mechanisms  
Basic mechanisms of fracture and embrittlement of metals. Crack initiation and propagation by cleavage, microvoid coalescence, and fatigue mechanisms. Hydrogen embrittlement, stress corrosion cracking and liquid metal embrittlement. Temper brittleness and related topics. Prerequisite: Background in crystal structure, defects, and mechanical properties.  
Lecture: 3 Lab: 0 Credits: 3

MMAE 568  
Diffusion  
Theory, techniques and interpretation of diffusion studies in metals. Prerequisite: Background in crystal structures, defects, and thermodynamics.  
Lecture: 2 Lab: 0 Credits: 2

MMAE 569  
Advanced Physical Metallurgy  
Thermodynamics and kinetics of phase transformations, theory of nucleation and growth, metastability, phase diagrams. Prerequisite: Background in phase diagrams and thermodynamics.  
Lecture: 3 Lab: 0 Credits: 3

MMAE 570  
Computational Methods in Materials Science and Engineering  
Advanced theories and computational methods used to understand and predict material properties. This course will introduce energy models from classical and first-principles approaches, density functional theory, molecular dynamics, thermodynamic modeling, Monte Carlo simulations, and data mining in materials science. The course will also include case studies of computational materials research (e.g. alloy design, energy storage, nanoscale properties). The course consists of both lectures and computer labs. Background in thermodynamics is required.  
Lecture: 3 Lab: 0 Credits: 3

MMAE 576  
Materials and Process Selection  
Context of selection; decision analysis; demand, materials and processing profiles; design criteria; selection schemes; value and performance oriented selection; case studies.  
Lecture: 3 Lab: 0 Credits: 3

MMAE 578  
Fiber Composites  
Lecture: 3 Lab: 0 Credits: 3

MMAE 579  
Advanced Materials Processing  
Processing science and fundamentals in making advanced materials, particularly nanomaterials and composites. Applications of the processing science to various processing technologies including severe plastic deformation, melt infiltration, sintering, coprecipitation, sol-gel process, aerosol synthesis, plasma spraying, vapor-liquid-solid growth, chemical vapor deposition, physical vapor deposition, atomic layer deposition, and lithography.  
Lecture: 3 Lab: 0 Credits: 3
MMAE 585
Engineering Optics and Laser-Based Manufacturing
Fundamentals of geometrical and physical optics as related to problems in engineering design and research; fundamentals of laser-material interactions and laser-based manufacturing processes. This is a lecture-dominated class with around three experiments organized to improve students' understanding of the lectures. The topics covered include: geometrical optics (law of reflection and refraction, matrix method, etc.); physical optics (wave equations, interference, polarization, Fresnel equations, etc.); optical properties of materials and Drude theory; laser fundamentals; laser-matter interactions and laser-induced thermal and mechanical effects, laser applications in manufacturing (such as laser hardening, machining, sintering, shock peening, and welding). Knowledge of Heat & Mass Transfer required.
Lecture: 3 Lab: 0 Credits: 3

MMAE 589
Applications in Reliability Engineering I
This first part of a two-course sequence focuses on the primary building blocks that enable an engineer to effectively communicate and contribute as a part of a reliability engineering effort. Students develop an understanding of the long term and intermediate goals of a reliability program and acquire the necessary knowledge and tools to meet these goals. The concepts of both probabilistic and deterministic design are presented, along with the necessary supporting understanding that enables engineers to make design trade-offs that achieve a positive impact on the design process. Strengthening their ability to contribute in a cross functional environment, students gain insight that helps them understand the reliability engineering implications associated with a given design objective, and the customer's expectations associated with the individual product or product platforms that integrate the design. These expectations are transformed into metrics against which the design can be measured. A group project focuses on selecting a system, developing a flexible reliability model, and applying assessment techniques that suggest options for improving the design of the system.
Lecture: 3 Lab: 0 Credits: 3

MMAE 590
Applications in Reliability Engineering II
This is the second part of a two-course sequence emphasizing the importance of positively impacting reliability during the design phase and the implications of not making reliability an integrated engineering function. Much of the subject matter is designed to allow the students to understand the risks associated with a design and provide the insight to reduce these risks to an acceptable level. The student gains an understanding of the methods available to measure reliability metrics and develops an appreciation for the impact manufacturing can have on product performance if careful attention is not paid to the influencing factors early in the development process. The discipline of software reliability is introduced, as well as the influence that maintainability has on performance reliability. The sequence culminates in an exhaustive review of the lesson plans in a way that empowers practicing or future engineers to implement their acquired knowledge in a variety of functional environments, organizations and industries. The group project for this class is a continuation of the previous course, with an emphasis on applying the tools and techniques introduced during this second of two courses.
Lecture: 3 Lab: 0 Credits: 3

MMAE 591
Research and Thesis M.S.
Credit: Variable

MMAE 593
MMAE Seminar
Reports on current research. Full-time graduate students in the department are expected to register and attend.
Lecture: 1 Lab: 0 Credits: 0

MMAE 594
Project for Master of Engineering Students
Design projects for the master of mechanical and aerospace engineering, master of materials engineering, and master of manufacturing engineering degrees.
Credit: Variable

MMAE 597
Special Topics
Advanced topic in the fields of mechanics, mechanical and aerospace, metallurgical and materials, and manufacturing engineering in which there is special student and staff interest. (Variable credit)
Credit: Variable

MMAE 600
Continuance of Residence
Lecture: 0 Lab: 1 Credits: 1

MMAE 691
Research and Thesis Ph.D.
Credit: Variable
MMAE 704
Introduction to Finite Element Analysis
This course provides a comprehensive overview of the theory and practice of the finite element method by combining lectures with selected laboratory experiences. Lectures cover the fundamentals of linear finite element analysis, with special emphasis on problems in solid mechanics and heat transfer. Topics include the direct stiffness method, the Galerkin method, isoperimetric finite elements, equation solvers, bandwidth of linear algebraic equations and other computational issues. Lab sessions provide experience in solving practical engineering problems using commercial finite element software. Special emphasis is given to mesh design and results interpretation using commercially available pre- and post-processing software.
Lecture: 2 Lab: 0 Credits: 2

MMAE 705
Computer Aided Design with Pro Engineer
This course provides an introduction to Computer-Aided Design and an associated finite element analysis technique. A series of exercises and instruction in Pro/ENGINEER will be completed. The operation of Mecanica (the associated FEM package) will also be introduced. Previous experience with CAD and FEA will definitely speed learning, but is not essential.
Lecture: 2 Lab: 0 Credits: 2

MMAE 707
High-Temperature Structural Materials
Lecture: 2 Lab: 0 Credits: 2

MMAE 709
Overview of Reliability Engineering
This course covers the role of reliability in robust product design. It dwells upon typical failure mode investigation and develops strategies to design them out of the product. Topics addressed include reliability concepts, systems reliability, modeling techniques, and system availability predications. Case studies are presented to illustrate the cost-benefits due to pro-active reliability input to systems design, manufacturing and testing.
Lecture: 2 Lab: 0 Credits: 2

MMAE 710
Dynamic and Nonlinear Finite Element Analysis
Provides a comprehensive understanding of the theory and practice of advanced finite element procedures. The course combines lectures on dynamic and nonlinear finite element analysis with selected computer labs. The lectures cover implicit and explicit time integration techniques, stability of integration algorithms, treatment of material and geometric nonlinearity, and solution techniques for nonlinear finite element equations. The computer labs train student to solve practical engineering problems in solid mechanics and heat transfer using ABQUS and Hypermesh. Special emphasis is placed on proper time step and convergence tolerance selection, mesh design, and results interpretation. A full set of course notes will be provided to class participants as well as a CD-ROM containing course notes, written exercises, computer labs, and all worked out examples.
Prerequisite(s): MMAE 704
Lecture: 2 Lab: 0 Credits: 2

MMAE 713
Engineering Economic Analysis
Introduction to the concepts of Engineering Economic Analysis, also known as micro-economics. Topics include equivalence, the time value of money, selecting between alternative, rate of return analysis, compound interest, inflation, depreciation, and estimating economic life of an asset.
Lecture: 2 Lab: 0 Credits: 2

MMAE 715
Project Management
This course will cover the basic theory and practice of project management from a practical viewpoint. Topics will include project management concepts, recourses, duration vs. effort, project planning and initiation, progress tracking methods, CPM and PERT, reporting methods, replanning, team project concepts, and managing multiple projects. Microsoft Project software will be used extensively.
Lecture: 2 Lab: 0 Credits: 2

MMAE 724
Introduction to Acoustics
This short course provides a brief introduction to the fundamentals of acoustics and the application to product noise prediction and reduction. The first part focuses on fundamentals of acoustics and noise generation. The second part of the course focuses on applied noise control.
Lecture: 2 Lab: 0 Credits: 2