COURSES FOR AEROSPACE ENGINEERING AND MECHANICS

Aerospace Engineering and Mechanics Courses

AEM500 Intermediate Fluid Mechanics
Hours 3

Development and use of the integral and differential forms of the equations of continuity, momentum, and energy with ideal fluids, viscous fluids and compressible fluids. Advanced topics in fluid mechanics, including potential flow, viscous flow and compressible flow.

AEM508 Propulsion Systems
Hours 3

Basic propulsion dynamics, thermodynamics of fluid flow, combustion kinetics, air-breathing engines, rockets, design criteria, performance, and advanced propulsion systems.

AEM513 Compressible Flow
Hours 3

Fundamentals of high-speed aerodynamics theory discussed. Topics covered include: normal and oblique shock waves, heat addition and friction effects in one-dimensional flow, expansion waves in two-dimensional flow, quasi 1-D nozzle flow, unsteady compressible flow calculations using method of characteristics, shock tube relations.

AEM514 Experimental Aerodynamics
Hours 3

The course provides a laboratory counterpart to concepts discussed in aerodynamics and fluid mechanics. Course topics include statistical and uncertainty analysis techniques, design of experiments, computer-based data-acquisition, sensors for fluid mechanic measurements, and aerodynamic measurement techniques and facilities.

AEM516 Helicopter Theory
Hours 3

Critical examination of the propulsive airscrew, including induced velocity relations, flow patterns, and similarity. Practical applications approached through existing theory and practice.

AEM518 Uncrewed Aircraft Systems
Hours 3

The objectives of this course are to teach the remote sensing applications, design, and operation of uncrewed aircraft systems. General design criteria will be developed for radio communication, propulsion, avionics, airframe, and integration. Regulatory and operational procedures will be given for communication, and command & control with an emphasis on safety.

AEM520 Computational Fluid Dynamics
C

Hours 3

Introduction to basic mathematical concepts and engineering problems associated with numerical modeling of fluid systems. Application of the state of the art numerical models to engineering problems. Fundamentals of Finite Difference and Finite Volume Methods and their applications in fluid dynamics and heat transfer problems will be covered. Computing proficiency is required for a passing grade in this course.

Computer Science

AEM525 Spacecraft Dynamics and Control
Hours 3

Formulate, understand, and apply rigid body dynamics to a spacecraft. Determine the orientation of the spacecraft. Demonstrate the ability stabilize a spacecraft (gravity gradient, momentum-bias, spin stabilization). Perform analytic and numerical analysis to understand its behavior.

AEM528 Space Propulsion
Hours 3

Students are introduced to different types of space propulsion systems in this class. Different rockets, such as: monopropellant, bi-propellant, solid, liquid, nuclear and electric rockets are discussed in detail. Working principles of these rockets, their intended use and their design are discussed. Power limited and energy limited rocket working principles are given. Several rocket design projects are assigned throughout the class.

AEM530 Continuum Mechanics
Hours 3

Introduction to tensor analysis. Analysis of stress and strain at a point. Development of the equations representing conservation laws for a continuum. Study of constitutive relationships for fluids and solids. Application of field equations to simple boundary value problems in solid mechanics and fluid mechanics.

AEM535 Applied Finite Element Analysis
Hours 3

Applications of the finite element method to static stress analysis, heat transfer, natural frequency and Eigen-mode determination, for linear, hyper-elastic, and elastic-plastic materials. The course includes a basic background on finite element theory as well as usage of current finite element software.

AEM546 Intermediate Solid Mechanics
Hours 3

Two-dimensional theory of elasticity; exact and approximate solutions of bending, torsion, and buckling for bars; open sections and curved beams; stresses in axisymmetric members; and finite-element and energy methods.

AEM548 Stochastic Mechanics
Hours 3

This course develops, analyzes and discusses the application of uncertainty quantification in engineering systems and design methodologies to include uncertainties in the systems. Topics include: classification of uncertainties and methods of quantification, perturbation approaches, polynomial chaos, sampling techniques, random processes and Bayesian analysis.

AEM552 Composite Materials
Hours 3

First exposure to composite materials. Focus on how heterogeneity/anisotropy in composites influence thermomechanical behavior. The behavior of both continuous and short fiber reinforced composites will be emphasized. Stress analysis for design, manufacturing processes and test methods of composite materials will be covered.

AEM553 Multiscale Analysis of Advanced Composites
Hours 3

Concepts of multiscale analysis, nano-mechanics, micromechanics - principles of analysis of heterogeneous systems, information transfer between multiple spatial and temporal scales, including atomistic-to-continuum coupling, continuum-to-continuum coupling, and temporal bridging.

AEM555 Nondestructive Evaluation
Hours 3

Fundamental theories, limitations and instrumentation of nondestructive test methods used for metal, polymer and composites materials. The ultrasonic, acoustic emission, vibration, thermography, eddy current, penetrant, and radiography methods are emphasized.

AEM562 Intermediate Dynamics
Hours 3

Dynamics of systems in moving coordinate frames; Lagrangian formulation and Hamilton's principle; stability and perturbation concepts for rigid body motion; motion of systems of rigid bodies in three dimensions.

AEM566 Optimal Control & Estimation
Hours 3

Optimal parameter estimation; linear least-squares; nonlinear least-squares; constrained least-squares; optimal control problem; linear-quadratic regulator; h∞ optimal control; h2 optimal control; convex optimization for control; receding horizon control; linear-quadratic-gaussian; separation principle; optimal state estimation; kalman filter; extended kalman filter; sigma-point kalman filters; bayes filter; particle filter.

AEM569 Orbital Mechanics
Hours 3

Introduction to engineering application of celestial mechanics; to formulate, understand, and apply fundamentals in orbital mechanics to trajectory design process. Perform analytic and numerical analysis to understand its behavior. Kepler's laws, coordinate transformations, and related studies.

AEM570 Mechanical Vibrations
Hours 3

Free and forced vibrations, both undamped and damped. Systems with many degrees of freedom are formulated and analyzed by matrix methods. Experimental techniques of vibration measurement are introduced.

AEM574 Structural Dynamics
Hours 3

Study of dynamic behaviors of elastic structures (interaction of elastic and inertial forces) with emphasis on aeronautical applications. Introduction of concepts and tools used in structural dynamics, including the Newtonian and variational methods. Basic numerical integration schemes to solve time-domain responses of elastic structures.

AEM575 Fundamentals of Aeroelasticity
Hours 3

Study of fluid-structure interactions between aerodynamic loads and static and/or dynamic deformations of flexible wings, as well as the influence of the interactions on aircraft performance. Concepts such as divergence, buffeting, and flutter, and rejection of external disturbances (e.g., gust alleviation) are introduced.

AEM582 Space Systems
Hours 3

Concepts in systems engineering of space systems: systems engineering, space systems, satellites, space transportation systems, space environment, attitude determination and control, telecommunications, space structures, rocket propulsion, and spacecraft systems.

AEM584 Space Environment
Hours 3

This course provides an introduction to the effects of the space environment on spacecraft. The harsh space environment introduces several unique challenges to the spacecraft designer. Focus on the impact of this environment and how best to mitigate these effects through early design choices will give the satellite designer better tools. Topics include: geomagnetic field, gravitational field of the Earth, Earth's magnetosphere, vacuum, solar UV, atmospheric drag, atomic oxygen, free and trapped radiation particles, plasma, spacecraft charging, micrometeoroids.

AEM588 Advanced Space Propulsion and Power
Hours 3

This course will explore concepts, theory, and performance of electrical, nuclear, and exotic space propulsion systems for use in space. This exploration will include fundamental physical processes exploited by these propulsion schemes. The course will also include concept, theory and performance of power generation methods in space. Systems studied will include low and high-power systems intended for short term or long term applications. Thermal, solar and nuclear devices and the energy conversion means for converting energy from these sources into useful electrical power will be studied.

AEM589 Space Law
Hours 3

Discussion-based course that provides an examination of legal and ethical issues regarding outer space. Topics discussed include: the historical development of international and domestic space law; international treaties, principles, and resolutions; specific issues relevant to contemporary space law; and US statutes governing space flight and resources.

AEM591 Special Problems
SP

Hours 1-6

Independent investigations of special problems. Credit is based on the amount of work undertaken.

Special Topics Course

AEM592 Special Problems
SP

Hours 1-6

Independent investigations of special problems. Credit is based on the amount of work undertaken.

Special Topics Course

AEM593 Special Topics
SP

Hours 1-3

Planning, executing, and presenting results of an individual project involving a research design, analysis, or similar undertaking; pass/fail designation.

Special Topics Course

AEM594 Special Projects
SP

Hours 1-6

Planning, executing, and presenting results of an individual project involving a research design, analysis, or similar undertaking.

Special Topics Course

AEM598 Non-Thesis Research
Hours 1-3

Research not related to thesis.

AEM599 Thesis Research
Hours 1-6

This independent research course partially fulfills required master's-level research thesis hours toward the master's degree Aerospace Engineering and Mechanics. The course is conducted under the guidance of the thesis advisor. Material covered or studied will be of an advanced nature aimed at providing master's students with an understanding of the latest research and current developments within the field. Discussion and advisor guidance will be directed towards readings of research articles and development of research methodology, with the aim of producing an original research contribution that represents a novel development in the field, or a novel perspective on a pre-existing topic in the field.

AEM606 Physical Gas Dynamics
Hours 3

Introduction to the behavior of gases. Gases are treated as interacting particles and the collective behavior is studied as an ensemble of semi-random events. The evolution of gas properties from the molecular viewpoint to the continuum viewpoint will be examined. Applications of interest include chemical reactions important to hypersonic aircraft, scramjet engines, current and future high pressure ratio gas turbine engines as well as rocket propulsion.

AEM614 Airfoil and Wing Theory
Hours 3

This course covers incompressible and compressible airfoil and wing theories and their applications to aircraft aerodynamic design. It also discusses viscous effects, unsteady aerodynamics, and topics of current interest. Specific contents of this course include flow-field modeling, compressible aerodynamic theory, viscous effects, unsteady aerodynamics, classical and swept wings, and an introduction to super- and hyper-sonic aerodynamics.

AEM621 Viscous Flow
Hours 3

Development of basic boundary layer equations and concepts. Classical incompressible solutions for laminar boundary layer, approximate solutions, and concepts of turbulence.

AEM622 Turbulent Flows
Hours 3

Introduction to the physics and modeling of turbulent flows. This course will cover the governing equations of multi-species viscous laminar flows, origin and characteristics of turbulence, mathematical methods for obtaining the governing equations of turbulent flows, various modeling techniques for resolving closure problems associated with the governing equations of turbulent flows.

AEM624 Hypersonic Flow
Hours 3

This course develops, analyzes and discusses the application of hypersonic flow theory. Topics include: Hypersonic shock/expansion wave relations, approximate methods to calculate lift and drag on hypersonic vehicles, boundary layer equations for hypersonic flow, hypersonic viscous interactions, and topics of current interest.

AEM635 Finite Element Methods
Hours 3

Finite-element formulations in the areas of solid mechanics, fluid mechanics, and heat conduction; isoparametric elements; assembly process; solution of stiffness equations; and convergence of results.

AEM637 Theory Of Elasticity
Hours 3

Equations of linear elasticity, principal stresses and strains, stress and displacement potentials, energy principles, and numerical methods. Boundary value problems of elasticity.

AEM638 Introduction to Experimental Mechanics
Hours 3

Theory and application of electrical resistance strain gauges for stress analysis and for use as transducers. Study of circuits and instruments used for strain measurement. Theory and application of photoelasticity for measurement of stress. Fundamentals of servohydraulic testing.

AEM644 Engineering Fracture Mechanics
Hours 3

Linear elastic and elastic-plastic fracture mechanics. Fracture analysis using Griffith's criterion, stress intensity factors, CTOD methods, and the J-Integral.

AEM648 Theory of Plasticity
Hours 3

Theory of plastic deformation of metals and other materials. Development of yield criteria, application of flow rules, and yield surface based plasticity theories. Application to engineering structures, including computer programming assignments and finite element analysis assignments.

AEM649 Fatigue Analysis
Hours 3

Presentation of the strain life and fracture mechanics approaches to fatigue analysis. Review of damage parameters, mean stress effects, and cycle counting methods for uniaxial and multiaxial loading.

AEM655 Advanced Composite Materials
Hours 3

Advanced topics in composite materials, including theories of linear orthotropic elasticity, micro-mechanics of composites, nano-composites, and sandwich structures.

AEM662 Multibody Dynamics
Hours 3

This course presents the fundamentals of multibody dynamics: kinematics and dynamics of multibody systems, analytical dynamics, constrained dynamical systems, and flexible multibody dynamics.

Prerequisite(s): Instructor's consent.

AEM667 Navigation & Target Tracking
Hours 3

The objectives of this course are to teach the concepts and algorithms of state estimation for vehicles; both for itself, i.e. navigation, and others, i.e. target tracking. This course will use a model-based theoretic to explain these concepts and develop algorithms using state estimation theory to derive filters to accomplish these two tasks using a variety of sensor systems. These algorithms will be used in the design of modern timing, positioning, navigation, and target tracking systems.

AEM668 Adv. Flight Dynamics & Control
Hours 3

The objective of this is to teach advanced concepts related to flight dynamics and control including rotary-wing and rocket flight vehicles. This course will provide high fidelity nonlinear modeling for flight vehicle dynamics including vibrations, rotating and variable mass, unsteady atmosphere, variable gravity, rotating and ellipsoidal Earth, and multivariate model uncertainties using structured singular values. To address these model uncertainties for feedback control system design, robust optimal control techniques using H2, Hꝏ, robust servomechanism, and #-synthesis will be introduced.

AEM669 Advanced Astrodynamics
Hours 3

The main objective of this course is to formulate, understand, and apply fundamentals of dynamical systems theory to spacecraft trajectory design process. Understand the behavior of a spacecraft under gravitational and non-gravitational forces and design cost-effective trajectories. Perform analytic and numerical analysis to understand spacecraft behavior beginning with the three-body problem.

Prerequisite(s): AEM 469 or AEM 569

AEM685 Engineering Optimization
Hours 3

This graduate course introduces the techniques of design optimization of engineering systems. Topics include: Basic principles of optimization theory, parameter optimization problems, linear and nonlinear programming. Unconstrained and constrained problems treated by simplex, penalty function, generalized reduced gradient methods, global optimization techniques, and surrogate modeling.

AEM691 Special Problems
SP

Hours 1-3

Independent investigations of special problems. Credit is based on the amount of work undertaken.

Special Topics Course

AEM693 Special Topics
SP

Hours 1-3

Planning, executing, and presenting results of an individual project involving a research design, analysis, or similar undertaking.

Special Topics Course

AEM694 Special Project
SP

Hours 1-6

Planning, executing, and presenting results of an individual project involving a research design, analysis, or similar undertaking.

Special Topics Course

AEM698 Non-Dissertation Research
Hours 1-3

Research not related to dissertation.

AEM699 Dissertation Research
Hours 1-12

Research related to dissertation.