MAE 506: Advanced System Modeling, Dynamics, and Control
Pre-/co-requisite: MAE 501 or APM 505
Linear algebra topics that are entailed in the co-requisite: Matrix arithmetic, determinants, matrix inversion, basis of a vector space, change of basis, linear transformations, range and null space, matrix rank, eigenvalues and eigenvectors, similarity transformations, diagonalization, vector norms

MAE 507: Modern Optimal Control
Prerequisite: MAE 506, EEE 582 or equivalent
Required concepts: Linear Algebra; State Space; Linear Systems.

MAE 510: Dynamics and Vibrations
Detailed course description: Rigid body dynamics. Derivation of the equations of motion of particles, rigid bodies, and systems of rigid bodies in 2D and 3D using Newton's equations and Lagrange equations in various frames of reference. Equilibrium positions and stability of motions/vibrations around equilibrium positions.
Prerequisite: Good undergraduate understanding of dynamics of particles and rigid bodies in 2D

MAE 512: Random Vibrations
Required concepts: Free and forced harmonic response of single degree of freedom system, Duhamel integral, modes and natural frequencies of multi degree of freedom systems.

MAE 515: Structural Dynamics
Detailed course description: Analysis of multi degree of freedom systems – free response, forced harmonic response, forced general response – when undamped, classically damped, and non-classically damped. Introduction to vibrations of continuous systems. Introduction to rotor dynamics. Component mode synthesis techniques.
Prerequisite: AEE 415, MAE 598 Vibrations Analysis or equivalent
Required concepts: Free and forced vibrations of single degree of freedom systems

MAE 525: Mechanics of Smart Structures and Materials
Detailed course description: Fundamental understanding and background in the evolving area of smart materials, adaptive structures and intelligent systems. The use of smart sensors and actuators in interdisciplinary applications will be discussed. Particular emphasis is placed on demonstrating the relationships between the physical system and the mathematical analysis. Some of the topics that are covered include: (i) fundamentals of smart materials and integrated smart systems; (ii) modeling issues related to smart materials, such as piezoceramics, magnetostrictives, electrostrictives, electro-rheological fluids, shape memory alloys and fiber optics; (ii) coupled field equations for modeling these materials as sensors and actuators, (ii) analysis of integrated smart structural systems; (iii) control system design and (iv) engineering applications. Applications include vibration and shape control, damage detection, etc. The students will have opportunities to identify novel applications of smart sensors or actuators in their respective research areas and develop project topics.
Prerequisite: MAE 520 solid mechanics or equivalent, AEE 415, MAE 598 Vibrations Analysis or equivalent, undergraduate control class (MAE 318 or equivalent)

MAE 536: Combustion

Detailed course description: Classification of combustion processes, concepts of stoichiometry, mixture fraction, adiabatic flame temperature, chemical equilibrium, chemical kinetics, reaction mechanisms, systematic reduction of reaction mechanisms, ignition and extinction, large activation energy asymptotics, premixed combustion, burning velocity, premixed flame structure, flammability limits, flame instabilities, diffusion flames, flamelets, quenching, and turbulent combustion.

Pre-/co-requisites: undergraduate fluid mechanics and thermodynamics

MAE 547: Modeling and Control of Robots

Pre/co-requisite: MAE 501 or APM 505

Linear algebra topics that are entailed in the co-requisite: Matrix arithmetic, determinants, matrix inversion, basis of a vector space, change of basis, linear transformations, range and null space, matrix rank, eigenvalues and eigenvectors, similarity transformations, diagonalization, vector norms.

MAE 557: Mechanics of Composite Materials

Prerequisite: Continuum Mechanics (MAE 598), MAE 520, MAE 524 or equivalent

Topics entailed in the prerequisite: Fundamental principles and solution techniques used in the stress analysis of elastic solids and structures Cartesian tensors for formulations of general deformations and states of stress Constitutive relations and field equations Solution of two dimensional problems using stress function and other approaches Energy methods and approximate solutions using variational principles

MAE561: Computational Fluid Mechanics

Detailed course description: Classifying PDEs, deriving finite difference formulas, determining truncation errors, coding solvers for and solving elliptic, parabolic, and hyperbolic equations and systems of linear equations using time advancement explicit and implicit schemes and iterative methods, determining the accuracy, consistency and stability of differencing schemes, coding solvers for and solving the incompressible Navier-Stokes equations in two dimensions using a fractional step method, performing code verification using the Method of Manufactured Solutions, performing solution verification and code validation, and using a commercial CFD package to obtain flow solutions.

Prerequisites: undergraduate fluid mechanics; a good understanding of programming principles using either Matlab, Fortran, or C++ is a requirement to be successful in this course.

MAE 564: Advanced Aerodynamics

Prerequisites: Undergraduate aerodynamics, aerospace materials & structures, numerical methods courses. This class requires a foundational background in aircraft aerodynamics; it is not an introductory class but one targeted to those with an interest in design. Not recommended for non-aerospace degree candidates. Strong programming background expected (Matlab will be useful, but exposure to other classical languages such as FORTRAN is also desired). Aerospace Systems Design (AEE/MAE 468) would be a useful co-requisite for undergraduates.

MAE 570: Thermodynamics

Prerequisites: A good understanding of basic thermodynamic principles, such as the first law of thermodynamics is a requirement to be successful in this course.

MAE 571: Fluid Mechanics

Detailed course description: Governing equations, boundary and interfacial conditions, and methods of solution for the motion of incompressible Newtonian fluids and their applications in engineering. Topics include unidirectional flows; low Reynolds number flows and lubrication theory; capillary flows; large Reynolds number flows and boundary layer theory. Emphasis will be placed on fundamental concepts and modeling techniques using such tools as dimensional analysis, matched asymptotic expansions, and numerical solutions.

Prerequisites: Undergraduate fluid mechanics and thermodynamics, advanced calculus; MAE 502 or equivalent (pre- or co-requisite). A good understanding of continuum mechanics principles is a requirement to be successful in this course.

MAE 581: Advanced Thermodynamics

Prerequisites: A good understanding of basic thermodynamic principles, such as the first and second laws of thermodynamics is a requirement to be successful in this course.

MAE 587: Radiation Heat Transfer

Prerequisites: A good understanding of energy balance principles and basic heat transfer concepts is a requirement to be successful in this course.

MAE598: Advanced CFD: Interfaces

Detailed course description: Numerical methods for interfaces in low Mach number flows including level set methods, volume of fluid methods, interface tracking, ghost fluid methods, and immersed boundary methods. The course will include coding of the covered numerical techniques and applications to the dynamics of liquid/gas phase interfaces, premixed flames, and flows in complex geometries.

Prerequisites: Computational Fluid Dynamics (MAE 471/MAE 561) or equivalent. Prior classes in fluid mechanics, multiphase flows, and combustion are recommended, but not required A good understanding of programming principles using either Matlab, Fortran, or C++ is a requirement to be successful in this course.

MAE598: Multiphase Flows

Detailed course description: Models for dispersed multiphase flows including solid/liquid, solid/gas, and liquid/gas flows. Topics include the dispersed phase mass, momentum and energy equations, particle-fluid and particle-particle interactions, droplet collisions and coalescence, primary and secondary atomization, and numerical and experimental methods for analyzing multiphase flows.

Pre-/co-requisites: MAE 571 or equivalent

MAE 598: Digital Control: Design and Implementation

Pre-/co-requisite: MAE 501 or APM 505

Linear algebra topics that are entailed in the co-requisite: Matrix arithmetic, determinants, matrix inversion, basis of a vector space, change of basis, linear transformations, range and null space, matrix rank, eigenvalues and eigenvectors, similarity transformations, diagonalization, vector norms