Department of Mechanical and Aerospace Engineering

Web Site: http://www.odu.edu/mae (http://www.odu.edu/mae/)

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Overview

The Department of Mechanical and Aerospace Engineering strives to provide the highest quality engineering education at the undergraduate and graduate levels, to engage in scholarly research at the forefront of mechanical and aerospace engineering, and to serve the professions of mechanical and aerospace engineering. Graduate degrees in mechanical engineering and aerospace engineering include the Master of Engineering, Master of Science, and Doctor of Philosophy degrees and are designed to prepare graduates for professional practice in teaching, research and development, design, and consulting. Graduates are prepared for challenging and rewarding employment in high-technology industries, research organizations, consulting firms and government agencies. These programs are also designed to serve both full-time and part-time graduate students. The department is closely associated with area industries, consulting firms, government agencies and research laboratories, which add relevance to the graduate engineering curricula, creating a stimulating environment for the pursuit of graduate studies. The students also benefit from the University's affiliation with NASA Langley Research Center, the Jefferson National Laboratory, the National Institute of Aerospace, and the Virginia Modeling Analysis and Simulation Center. All degree programs offered by the department can be utilized as components within the linked Baccalaureate-Master's and Baccalaureate-Doctoral degree programs offered through the Batten College of Engineering and Technology. For additional information about the educational and research opportunities available please visit our website at http://www.odu.edu/mae. *This program is available on-campus and online.*

List of Degrees and Certificates

- Master of Engineering - Mechanical Engineering
- Master of Science, Engineering - Mechanical Engineering
- Master of Engineering - Aerospace Engineering
- Master of Science, Engineering - Aerospace Engineering
- Doctor of Philosophy, Engineering - Mechanical Engineering
- Doctor of Philosophy, Engineering - Aerospace Engineering
- Graduate Certificate - Naval Architecture and Marine Engineering

Graduate Course Portfolio

Core Graduate Courses

MAE 601	Engineering Mathematics	3
MAE 602	Fluid Dynamics and Aerodynamics	3
MAE 603	Advanced Mechanics of Solids	3
MAE 604	Analytical Dynamics	3
MAE 605	Advanced Classical Thermodynamics	3
MAE 607	Continuum Mechanics	3
MAE 620	Heat Transfer I	3
MAE 640	Modern Control Theory	3
MAE 672	Design of Experiments	3
MAE 682	Concurrent Engineering	3

Aerodynamics and Fluids Graduate Courses

MAE 503	Flight Mechanics	3
MAE 506	Flight Vehicle Aerodynamics	3
MAE 507	Ground Vehicle Aerodynamics	3
MAE 517	Propulsion Systems	3
MAE 557	Motorsports Vehicle Dynamics	3
MAE 560	Introduction to Space Systems Engineering	3
MAE 567	Racecar Performance	3
MAE 706/806	Real-Time Signals and Systems	3
MAE 710/810	Supersonic Flow	3
MAE 711/811	Hypersonic Aerodynamics	3
MAE 712/812	Experimental Aerodynamics	3
MAE 713/813	Turbulent Flow	3
MAE 715/815	Boundary Layer Theory	3
MAE 716/816	Computational Fluid Dynamics I	3
MAE 718/818	Aerospace Test Facilities	3
MAE 772/872	Response Surface Methodology	3

Thermodynamics and Energy Graduate Courses

MAE 511	Mechanical Engineering Power Systems Theory and Design	3
MAE 512	Environmental Control	3
MAE 513	Energy Conversion	3
MAE 514	Introduction to Gas Dynamics	3
MAE 720/820	Heat Transfer II	3
MAE 722/822	Theory and Design of Turbomachines	3
MAE 723/823	Nuclear Engineering	3
MAE 724/824	Energy Utilization and Conservation	3

Materials and Structures Graduate Courses

MAE 522	Modern Engineering Materials	3
MAE 730/830	Finite Element Analysis	3
MAE 731/831	Mechanics of Composite Structures	3
MAE 733/833	Nonlinear Aerospace Structures	3
MAE 734/834	Theory of Vibrations	3
MAE 735/835	Experimental Structural Dynamics	3
MAE 750/850	Nanoscale Mechanical and Structural Properties of Materials	3
MAE 751/851	Fatigue and Fracture	3
MAE 752/852	Mechanical Behavior of Materials	3
MAE 753/853	Composite Materials	3

Dynamics and Controls Graduate Courses

MAE 504	Vibrations	3
MAE 531	Mechanisms Analysis and Design	3
MAE 538	Applied Analog and Digital Control	3
MAE 740/840	Autonomous and Robotic Systems Analysis and Control	3
MAE 741/841	Optimal Control Theory	3
MAE 742/842	Multibody Dynamics: Theories and Applications	3
MAE 743/843	Kinematic Synthesis of Mechanisms	3
MAE 744/844	Atmospheric Flight Dynamics and Control	3
MAE 745/845	Space Flight Dynamics and Control	3
MAE 746/846	Advanced Control Methodologies	3
MAE 747/847	Aerospace Vehicle Performance	3

Design/Manufacturing Graduate Courses

MAE 780/880	Engineering Optimization	3
MAE 781/881	Advanced Design	3
MAE 782/882	Engineering Software for Computer-Aided Analysis and Design	3
MAE 783/883	Robots and Manufacturing Automation	3
MAE 784/884	Computer Integrated Manufacturing	3
MAE 785/885	Advanced Manufacturing Technology	3
MAE 787/887	Life Cycle Engineering	3
MAE 788/888	Computational Intelligence for Engineering Design Optimization Problems	3
MAE 789/889	Engineering Design with Uncertainties	3

Programs

Doctor of Philosophy Programs

- Engineering with a Concentration in Aerospace Engineering (PhD) (http://catalog.odu.edu/graduate/engineering-technology/mechanical-aerospace-engineering/engineering-aerospace-phd/)
- Engineering with a Concentration in Mechanical Engineering (PhD) (http://catalog.odu.edu/graduate/engineering-technology/mechanical-aerospace-engineering/engineering-mechanical-phd/)

Master of Engineering Programs

- Engineering with a Concentration in Aerospace Engineering (ME) (http://catalog.odu.edu/graduate/engineering-technology/mechanical-aerospace-engineering/engineering-aerospace-me/)
- Engineering with a Concentration in Mechanical Engineering (ME) (http://catalog.odu.edu/graduate/engineering-technology/mechanical-aerospace-engineering/engineering-mechanical-me/)

Master of Science Programs

- Engineering with a Concentration in Aerospace Engineering (MS) (http://catalog.odu.edu/graduate/engineering-technology/mechanical-aerospace-engineering/engineering-aerospace-ms/)
- Engineering with a Concentration in Mechanical Engineering (MS) (http://catalog.odu.edu/graduate/engineering-technology/mechanical-aerospace-engineering/engineering-mechanical-ms/)

Certificate Program

- Naval Architecture and Marine Engineering Certificate (http://catalog.odu.edu/graduate/engineering-technology/mechanical-aerospace-engineering/naval-architecture-marine-engineering-certificate/)

Courses

Mechanical and Aerospace Engineering (MAE)

MAE 503 Flight Mechanics (3 Credit Hours)
Aircraft concepts including performance prediction and optimization, flight and maneuver envelopes, and steady flight performance. Additional topics: longitudinal static stability and trim; aircraft dynamics; development, separation and solution of aircraft equations of motion; natural modes; dynamic stability; sensors and actuators; and design of stability augmentation and autopilot systems.
Prerequisites: MAE 303 with a grade of C or better and MAE 340
Pre- or corequisite: MAE 436

MAE 504 Vibrations (3 Credit Hours)
Free and forced vibrations of undamped and damped, single-degree of freedom, multi-degree of freedom, and continuous systems. Exact and approximate methods to find natural frequencies.
Prerequisites: A grade of C or better in MAE 205, a grade of C or better in MAE 220; MAE 340 and MATH 312

MAE 506 Flight Vehicle Aerodynamics (3 Credit Hours)
Inviscid flow concepts including: Euler equations, stream function, velocity potential, singularities, vorticity and circulation laws. Viscous flow topics including boundary layers separation, and turbulent flow. In addition, external flows, lift and drag, thin airfoil theory, finite wing theory and airfoil design will be discussed.
Prerequisites: A grade of C or better in MAE 303; MAE 312 and MAE 340

MAE 507 Ground Vehicle Aerodynamics (3 Credit Hours)
Review of basic fluid mechanics of the incompressible flow of air. Introduction to bluff body aerodynamics, production and performance (race car) automotive aerodynamics, as well as truck and bus aerodynamics. Discussion of experimental and computational methods for evaluating vehicle aerodynamic performance. Optimization of high performance vehicle design for low drag and/or high downforce and the facilities and techniques required. Introduction to the aerodynamics of other surface vehicles such as sailboats and trains. Lecture and wind tunnel experiments.
Prerequisites: A grade of C or better in MAE 303 or MET 330 or CEE 330

MAE 511 Mechanical Engineering Power Systems Theory and Design (3 Credit Hours)
Thermodynamic properties of gases and vapors relating to power generating devices, work-energy relations, combustion, and heat exchangers. Performance analyses and design concepts of gas turbines, internal combustion engines, steam power plants and heat exchanger equipment from theoretical and applied viewpoints.
Prerequisites: MAE 312 and MAE 315

MAE 512 Environmental Control (3 Credit Hours)
Engineering principles as applied to the analysis and design of systems for automatically controlling man or machine environments. Course encompasses fundamentals of heating, ventilating, air conditioning, refrigeration, cryogenics, and design of building energy systems.
Prerequisites: MAE 312 and MAE 315

MAE 513 Energy Conversion (3 Credit Hours)
Introduction of relevant kinetic theory, solid state, and thermodynamic principles; operation and analysis of thermoelectric, photovoltaic, thermionic, magnetohydrodynamic devices, fuel cell, isotopic, and solar power generators. Course seeks to define engineering limits of converter efficiency and other performance criteria.
Prerequisites: MAE 312

MAE 514 Introduction to Gas Dynamics (3 Credit Hours)
One-dimensional compressible flow considering isentropic flow, normal shocks, flow in constant area ducts with friction, flow in ducts with heating and cooling, oblique shocks, Prandtl-Meyer expansions, shock-expansion theory, flow around diamond shaped airfoils, and wind tunnel mechanics.
Prerequisites: A grade of C or better in MAE 303 and a grade of C or better in MAE 311

MAE 516 Introduction to Solar Energy Engineering (3 Credit Hours)
Basic solar radiation processes, engineering analysis of solar collectors, energy storage methods, system design and simulation, applications to heating, cooling, and power generation.
Prerequisites: MAE 315

MAE 517 Propulsion Systems (3 Credit Hours)
Basic principles of design, operation and performance of propulsion systems - including turbojet, turboprop, turbofan, and ramjet engines. Introduction to chemical rockets, ion and plasma thrusters.
Prerequisites: MAE 312 or MAE 414

MAE 520 Aerospace Structures (3 Credit Hours)
Analysis of aircraft and space vehicle structural components. Effects of bending, torsion and shear on typical aerospace structural components, statically indeterminate beams, shear center and shear flow. Introduction to typical aerospace structures. Introduction to composite structures.
Prerequisites: MAE 332 with a grade of C or better

MAE 522 Modern Engineering Materials (3 Credit Hours)
Limitations of conventional materials; inter-relationship among materials, design and processing, material selection criteria and procedures; strengthening mechanisms in metals; superelasticity; shape memory effect, amorphous metals; structure-property relationship in polymers; polymers crystallinity; thermoplastic and thermosets; high-temperature restraint polymers; ceramics; toughening mechanisms in ceramics.
Prerequisites: MAE 201, MAE 203, and a grade of C or better in MAE 220; MAE 332

MAE 531 Mechanisms Analysis and Design (3 Credit Hours)
Basic relations necessary for analysis of plane motion mechanisms, numerical and analytical solutions for some of the basic mechanisms, methods of calculating rolling and sliding velocities and accelerations of contacting bodies, cams, and gears.
Prerequisites: A grade of C or better in MAE 205, a grade of C or better in MAE 332, and MATH 312 or MATH 285

MAE 538 Applied Analog and Digital Control (3 Credit Hours)
Computer-aided analysis and design of practical control systems. Introduction to state-space, digital signal processing and digital control. Laboratory sessions on aliasing, analog, system identification, and real-time control.
Prerequisites: a grade of C or better in MAE 436

MAE 540 Introduction to Finite Element Analysis (3 Credit Hours)
Basic concepts of finite-element method, method of weighted residuals, interpolation functions, numerical implementation of finite-element method, applications to engineering problems such as beam deflection, heat conduction, and plane elastic problems.
Prerequisites: MAE 340

MAE 550 Principles of Naval Architecture (3 Credit Hours)
Basic principles of naval architecture related to ship geometry, stability, strength, resistance, propulsion, vibration and motions in waves and controllability.
Prerequisites: MATH 212 with a grade of C or better

MAE 557 Motorsports Vehicle Dynamics (3 Credit Hours)
Basic mechanics governing vehicle dynamic performance. Analytical methods in vehicle dynamics. Laboratory consists of various vehicle dynamics tests on model vehicles and full-size racecars.
Prerequisites: A grade of C or better in MAE 205 or MET 310

MAE 560 Introduction to Space Systems Engineering (3 Credit Hours)
Introduction to spacecraft systems starting from mission design and space environment considerations and proceeding through propulsion, altitude control, spacecraft structural design, thermal control, power and communications for spacecraft.
Prerequisites: MATH 307 and PHYS 232N

MAE 567 Racecar Performance (3 Credit Hours)
On-track performance of typical racecars (Legends and Baby Grand) to demonstrate and evaluate the interplay between vehicle aerodynamics, suspension system geometry adjustments, tire selection and operating pressure on overall racecar performance and handling. Laboratory testing via on-board instrumentation during skid pad and road course evaluation; computer simulation to investigate various car set-ups.
Prerequisites: MAE 303 with a grade of C or better, or MET 330 and MAE 205 with a grade of C or better, or MET 310

MAE 577 High Performance Piston Engines (3 Credit Hours)
A study of the fundamental principles and performance characteristics of spark ignition and diesel internal combustion engines. Overview of engine types and their operation, engine design and operating parameters; ideal and semi-empirical models of engine cycles; combustion, fluid flow and thermal considerations in engine design and performance. Laboratory evaluation of engine performance using flow and dynamometer systems.
Prerequisites: MAE 312, MAE 315 or MET 300, MET 350

MAE 595 Topics in Mechanical and Aerospace Engineering (1-3 Credit Hours)
Special topics of interest with emphasis placed on recent developments in mechanical and aerospace engineering or engineering mechanics. (offered fall, spring, summer)
Prerequisites: Senior standing; Permission of the chair is required

MAE 597 Independent Study in Mechanical and Aerospace Engineering (1-3 Credit Hours)
Individual analytical, computational, and/or experimental study in an area selected by student. Supervised and approved by the advisor.
Prerequisites: Senior standing; permission of the chair is required

MAE 601 Engineering Mathematics (3 Credit Hours)
Applications of linear algebra, ordinary and partial differential equations, and complex variables to engineering problems.

MAE 602 Fluid Dynamics and Aerodynamics (3 Credit Hours)
Conservation laws for viscous and inviscid flows. Boundary conditions; analytical and numerical solution of viscous flow problems; boundary-layer theory; 2 and 3-dimensional potential flows; applications to airfoils, wings, and internal flows; introduction to turbulence.
Prerequisites: MAE 601 or MATH 691

MAE 603 Advanced Mechanics of Solids (3 Credit Hours)
Stress, strain, equilibrium for deformable solids; material behavior of elasticity, hyperelasticity, plasticity and viscoelasticity; failure criteria, fracture; thermal effect; energy methods and their applications to bars and beams for static, stability and dynamic problems.

MAE 604 Analytical Dynamics (3 Credit Hours)
Advanced kinematics with moving reference frames. Euler equations of motion. Gyroscopic theory. Principle of virtual work, D'Alembert's principle, Hamilton's principle, Lagrange's equations of motion and rigid body dynamics.

MAE 605 Advanced Classical Thermodynamics (3 Credit Hours)
Rigorous development of the macroscopic theory of thermodynamics; structural basis for equations of state and general properties of matter; phase and chemical equilibria.
Prerequisites: MAE 601 or MATH 691

MAE 607 Continuum Mechanics (3 Credit Hours)
Indicial notations and tensor calculus; strain and stress tensors, rate of deformation tensor, Eulerian and Lagrangian descriptions, conservation principles, constitutive formulations for elastic solids and viscous fluids, formulation of fluid mechanics and solid mechanics problems. Simple applications.
Pre- or corequisite: MATH 691 or MAE 601

MAE 608 Applied Mathematics for Engineers (3 Credit Hours)
Linear algebra. Vectors and matrices. Partial differential equations. Curve fittings. Applied probabilities. Statistics of distributions. Testing of hypotheses and decisions. Quality control.

MAE 620 Heat Transfer I (3 Credit Hours)
Aspects of conduction, convection and radiation heat transfer, including governing equations, boundary layer flows, analytical and numerical solutions to one-, two-, and three-dimensional problems.
Prerequisites: MAE 602

MAE 640 Modern Control Theory (3 Credit Hours)
Formulation of state space equations governing dynamics and stability of linear systems. Controllability; observability. State feedback control design. Optimal control methods. State observers and estimators.

MAE 667 Cooperative Education in Mechanical and Aerospace Engineering (1-3 Credit Hours)
Student participation for credit based on academic relevance of the work experience, criteria, and evaluative procedures as formally determined by the department and the Cooperative Education program prior to the semester in which the work experience is to take place.
Prerequisites: Approval by Department and Career Development Services

MAE 668 Internship in Mechanical and Aerospace Engineering (1-3 Credit Hours)
Academic requirements will be established by the department and will vary with the amount of credit desired. Allows students an opportunity to gain short duration career-related experience.
Prerequisites: Approval by Department and Career Development Services

MAE 669 Practicum in Mechanical and Aerospace Engineering (1-3 Credit Hours)
Academic requirements will be established by the department and will vary with the amount of credit desired. Allows students an opportunity to gain short duration career-related experience. Student is usually already employed--this is an additional project within the organization.
Prerequisites: Approval by Department and Career Development Services

MAE 672 Design of Experiments (3 Credit Hours)
This course will focus on formal experiment design. Topics to be discussed will include review of statistics, ANOVA, multiple comparisons, residuals, modal adequacy checking, randomized complete block designs, factorial designs, 2^k factorial and fractional factorial designs, random and mixed effects in factorials, and optimization. The course will also provide an introduction to response surface methods. Laboratory exercises will use designed experiments as applied to aerospace testing, including wind tunnel testing and instrument calibration.

MAE 682 Concurrent Engineering (3 Credit Hours)
Study of principles of concurrent engineering with emphasis on the design/manufacture interface for single products; Rapid prototyping projects; Designof injection-molded and stamped parts for cost.

MAE 685 Projects Design and Manufacturing (3 Credit Hours)
Project(s) course to allow graduate students to complete a practical engineering assignment in design and manufacturing areas.
Prerequisites: Permission of the instructor

MAE 690 Mechanical and Aerospace Engineering Seminar (1 Credit Hour)
Regular tutorials on recent topics of interest in mechanical and aerospace engineering and engineering mechanics.

MAE 695 Topics in Mechanical and Aerospace Engineering (3 Credit Hours)
Special topics of interest with emphasis placed on recent developments in mechanical and aerospace engineeringor engineering mechanics.

MAE 696 Experimental Research Project (3 Credit Hours)
An independent laboratory experience in the area of either aerodynamics, structural dynamics or applied automatic control. Results will be reported in a format and quality similar to a technical conference paper.

MAE 697 Independent Study in Mechanical and Aerospace Engineering (3 Credit Hours)
Individual analytical, computational and/or experimental study in an area selected by the student. Supervised and approved by the advisor.

MAE 698 Master’s Project in Mechanical and Aerospace Engineering (1-3 Credit Hours)
Individual project, investigation under the direction of the student's major professor.

MAE 699 Thesis Research in Mechanical and Aerospace Engineering (1-6 Credit Hours)
Thesis research in mechanical and aerospace engineering or engineering mechanics leading to the Master of Science degree.
Prerequisites: instructor approval required

MAE 706 Real-Time Signals and Systems (3 Credit Hours)
Introduction to random and harmonic processes, fast Fourier transforms, digital filters, digital signal processing methods, as well as sensors and transducers. Review of the theory and practice of data acquisition. Modeling of linear, lumped and distributed parameter systems. Use of LabVIEW and MATLAB/Simulink for real-time control and dynamic system simulations. Applications to modal analysis, experimental aerodynamics, and real-time control of electro-mechanical systems.

MAE 710 Supersonic Flow (3 Credit Hours)
This course will examine governing equations for supersonic flow, including full potential equations, small disturbance theory, hodographs, and method of characteristics. It will also serve as an introduction to three-dimensional flows, compressible boundary layer flows, internal flows in nozzles and diffusers, airfoil flows, slender bodies of revolution flows, conical flows, and wing flows.
Prerequisites: MAE 514 and MAE 602

MAE 711 Hypersonic Aerodynamics (3 Credit Hours)
General consideration of hypersonic flow and similarity principles, hypersonic flow past slender bodies with sharp and blunt leading edges. Hypersonic blunt-body flow. Real gas, viscous and low density effects, and consideration of nonequilibrium phenomena in hypersonic flows.
Prerequisites: MAE 710

MAE 712 Experimental Aerodynamics (3 Credit Hours)
This course will examine techniques for static and dynamic measurement of pressure, temperature, and velocity. Experiment control and statistical treatment of data will be discussed, as will probe methods, including multi-hole pressure probes and hot-wire anemometers, and non-intrusive methods, including laser Doppler velocimetry and other optical methods. Surface and stream flow visualization and surface measurements will also be covered.
Prerequisites: MAE 602 and MAE 710

MAE 713 Turbulent Flow (3 Credit Hours)
Isotropic and homogeneous turbulence. Mixing length theories, Equilibrium turbulence models, Two-equation models (k-epsilon). Large eddy simulation. Reynold's stress transport models. Numerical simulations. Compressible and non-equilibrium turbulence effects.
Prerequisites: MAE 602 and MAE 715 or MAE 815

MAE 715 Boundary Layer Theory (3 Credit Hours)
Boundary layer equations; method of matched asymptotic expansions; body oriented coordinates, finite-difference solutions; separations, wake and jet flows; thermal and compressible boundary layers, transformations and finite-difference solutions, unsteady boundary layers. Introduction to hydrodynamic stability and turbulence.
Prerequisites: MAE 602

MAE 716 Computational Fluid Dynamics I (3 Credit Hours)
This course will cover the following topics: classification of single partial differential equations; finite difference methods; stability analysis, including convergence, consistency, and efficiency; basics of finite volume methods; model equations of hyperbolic, parabolic and elliptic type; and explicit and implicit schemes, central and upwind schemes, and weak solutions of quasi-linear hyperbolic equations.
Prerequisites: MAE 601 or MATH 691

MAE 718 Aerospace Test Facilities (3 Credit Hours)
A comprehensive examination of aerodynamic test facilities for use in subsonic, transonic, supersonic and hypersonic flow regimes. Aspects of wind tunnel design and operation will be discussed, as will flow quality and wall and support interferences. Advanced concepts including cryogenic wind tunnels, adaptive wall test sections and magnetic suspension will be examined, in addition to dynamic testing. There will be a review of flight test methods, including extraction of aerodynamic parameters from flight test data, a review of engine test facilities, and a review of ground test facilities for space structures and other space systems.
Prerequisites: Permission of the instructor

MAE 720 Heat Transfer II (3 Credit Hours)
Aspects of conduction, convection and radiation heat transfer, including governing equations, boundary layer flows, analytical and numerical solutions to one-, two- and three-dimensional problems.
Prerequisites: MAE 620

MAE 722 Theory and Design of Turbomachines (3 Credit Hours)
This course will examine real cycles, fluid motion in turbomachines, the theory of diffusers and nozzles, fluid-rotor energy transfer, radial equilibrium, transonic stages, and combustion chambers. Other types of turbines will also be discussed including axial and centrifugal turbines. Performance and design criteria will also be examined, as well as cavitation and two-phase flows.
Prerequisites: MAE 514 and MAE 602

MAE 723 Nuclear Engineering (3 Credit Hours)
This course will consider nuclear power plant systems, and will introduce power reactor control kinetic behavior including safety coefficients, accumulative poisons, and temperature control parameters. It will also examine primary and secondary plant as a transient system.

MAE 724 Energy Utilization and Conservation (3 Credit Hours)
This course provides an overview of the scope of efficient energy utilization in industrial, commercial, transportation, and power generation fields. It introduces power plant waste-heat utilization, district heating, combined gas and steam cycle, organic fluid-bottoming cycle, and total energy concept for residential and commercial buildings. In addition, it also examines system management, on-line computer evaluation, and energy analysis.
Prerequisites: Permission of instructor

MAE 730 Finite Element Analysis (3 Credit Hours)
This course provides an understanding of the finite element method (FEM) as derived from an integral formulation perspective. It demonstrates the solutions of (1-D and 2-D) continuum mechanics problems such as solid mechanics, fluid mechanics and heat transfer. It also provides insight into the theoretical formulation and numerical implementation of finite element methods.

MAE 731 Mechanics of Composite Structures (3 Credit Hours)
Stress-strain relations for a lamina; failure theories. Micro-mechanical behavior of a lamina. Constitutive relations of a laminate. Bending, buckling and vibration of laminated plates. Approximate and finite element methods of solution.

MAE 733 Nonlinear Aerospace Structures (3 Credit Hours)
Classical and finite element analysis methods for nonlinear aerospace structures of beams, plates, and shallow shells. Application to problems of large bending deflection, thermal post-buckling, large amplitude free vibration, nonlinear panel flutter, and nonlinear random response.

MAE 734 Theory of Vibrations (3 Credit Hours)
This course will introduce applied modal analysis, modes of vibration of discrete systems, modal coordinates, transfer functions in frequency domain, modes of vibration of continuous systems, and approximate systems response. It will also examine Finite Elements methods and nonlinear vibrations. Applications will be extended to rods, beams, plates and shells.
Prerequisites: MAE 504 and MAE 601 or MATH 691

MAE 735 Experimental Structural Dynamics (3 Credit Hours)
This course will examine experimental techniques and methods for structural dynamics and modal analysis. It will introduce a variety of instruments including electrodynamic shakers, impact hammers, accelerometers, laser vibrometers, signal analyzers, signal filters, and force transducers. Time and frequency domain data acquisition, assessment, and post-processing will be studied. The development of mathematical models from experimental data will also be conducted.

MAE 740 Autonomous and Robotic Systems Analysis and Control (3 Credit Hours)
Kinematics, dynamics and control of complex non-linear electro-mechanical systems, particularly robotic manipulators.

MAE 741 Optimal Control Theory (3 Credit Hours)
Parameter optimization, optimization problem for dynamic systems with terminal and path constraints; optimal feedback control with and without the presence of uncertainty; nonlinear optimal control system.
Prerequisites: MAE 640

MAE 742 Multibody Dynamics: Theories and Applications (3 Credit Hours)
Basic theories are presented for formulation of equations of kinematics and dynamics of systems made of interconnected bodies. Topics include constrained motion, principle of virtual work and constrained dynamics. Examples cover robotic motion and biomechanics applications such as human locomotion.
Prerequisites: Permission of instructor

MAE 743 Kinematic Synthesis of Mechanisms (3 Credit Hours)
Classification of mechanisms; type and number synthesis, application of graph theory, expert systems for synthesis; introduction to dimensional synthesis via path and function generation; finite displacement theory including concept of poles, circlepoint, and centerpoint curves; structural error minimization using Chebychev's approximation; optimization approaches, current applications to robot manipulators, robot hands, space structures, and combustion engines.
Prerequisites: Permission of instructor

MAE 744 Atmospheric Flight Dynamics and Control (3 Credit Hours)
Principles governing the dynamics and control of vehicles in atmospheric flight. Equations of motion development and solution including inertial/gravitational/aerodynamic/propulvsive loads, linear longitudinal and lateral-directional motions, and nonlinear trim and simulation. Flight control system design and analysis incorporating flying quality requirements, linear conventional/contemporary and frequency/time domain techniques for control and guidance functions, validation with nonlinear simulation, gain scheduling.
Prerequisites: MAE 403 or MAE 503 and MAE 604

MAE 745 Space Flight Dynamics and Control (3 Credit Hours)
Principles governing the dynamics and control of vehicles in space flight. Equations of motion development and solution including inertial/gravitational/aerodynamic/propulsive loads, decoupled translational and attitude motions. Ortibal mechanics including elements, initial-value propagation, adjustments/transfers, Lambert boundary-value problem, perturbations, and nonlinear simulation. Attitude dynamics including torque free, gravity moment, axisymmetric/unsymmetric vehicles, and dual spinners. Flight control system design and analysis including impulsive velocities, finite burns, Lambert targeting, linear designusing momentum wheels, and nonlinear phase-plane design using thrusters.
Prerequisites: MAE 604 and MAE 640

MAE 746 Advanced Control Methodologies (3 Credit Hours)
Review of multivariable dynamic math models including state space, transfer function, and matrix fractions. Multivariable design criteria including stability, performance,and robustness. Theory and application of multivariable control design techniques including LQR/LQG/LTR, H-infinity, Eigenspace Assignment and other advanced methods.
Prerequisites: MAE 640

MAE 747 Aerospace Vehicle Performance (3 Credit Hours)
This course will study the flight performance of aerospace vehicles, including a review of aerodynamic and propulsion characteristics. Range, flight and maneuver envelopes for vehicles in atmospheric flight will also be examined. It will introduce various methods of design for trajectory optimization, including launch vehicles. An open-ended, design-oriented project will be required.
Prerequisites: MAE 602 and MAE 514 or MAE 710

MAE 748 Flight Control Actuators and Sensors (3 Credit Hours)
This course will provide an overview of the governing principles and operations of actuator and sensor hardware used in aircraft and spacecraft flight control systems. Hydraulic, electro-hydraulic and electric actuators will be examined, as well as control jets and momentum wheels, accelerometers, and rate gyros. Other topics include air-data systems, inertial navigation systems and satellite navigation systems. The course will also examine dynamic model development, analysis and simulation, nonlinear hardware characteristics, and the influence on closed-loop vehicle behavior.
Prerequisites: MAE 503, MAE 538, and MAE 604

MAE 750 Nanoscale Mechanical and Structural Properties of Materials (3 Credit Hours)
Elastic and plastic properties of nanoscale materials, strain gradient dislocation plasticity, nanoindentation and nanoindentation creep, thin film mechanical and structural properties, kinetic-based investigations of hardening mechanisms in nanolayer composites.

MAE 751 Fatigue and Fracture (3 Credit Hours)
Divided into areas of fatigue and fracture; stress-controlled and strain-controlled fatigue; effect of mean stresses, notches, etc.; multiaxial stresses; variable amplitude loading; ductile and brittle fracture; linear elastic fracture mechanics; crack-tip plasticity; fracture testing; applications to fatigue life estimation. Requires permission of the instructor.

MAE 752 Mechanical Behavior of Materials (3 Credit Hours)
This course will examine the macroscopic behavior of materials with respect to elasticity, plasticity, and viscoelasticity. Other topics include yield criteria, fracture, the influence of high and low temperatures, and corrosion and radiation.
Prerequisites: Permission of instructor

MAE 753 Composite Materials (3 Credit Hours)
This course will examine reinforcements, matrices, particulate-composites, short-fiber and continuous-fiber reinforced composites. Directionally solidified composites will also be studied, including the prediction of elastic failure properties. Other topics to be covered include design considerations and experimental work.
Prerequisites: Permission of the instructor

MAE 772 Response Surface Methodology (3 Credit Hours)
An applied course in response surface methodology with aerospace applications. Empirical model building, method of least squares, second order models, model adequacy checking, canonical analysis. Method of steepest ascent, multiple response optimization. Rotatable, cuboidal and small run designs. Design optimality and efficiency metrics, robust design, restrictions on randomization. Laboratory exercises include RSM applied to wind tunnel testing and optimization.
Prerequisites: MAE 672

MAE 780 Engineering Optimization (3 Credit Hours)
Formulation and solution algorithms for Linear Programming (LP) problems. Unconstrained and constrained nonlinear programming (NLP) problems. Optimum solution for practical engineering systems.

MAE 781 Advanced Design (3 Credit Hours)
Concepts, principles and procedures related to analysis of stresses and strains in machine components. Consideration of function of parts along with factors such as forces, life required, maximum cost, weight and space restrictions, number of parts to be produced, material selection, kinematics,environmental restrictions. Finite element analysis to illustrate different aspects of stress analysis. Requires permission of the instructor.

MAE 782 Engineering Software for Computer-Aided Analysis and Design (3 Credit Hours)
Introduction to advanced CAD software for finite element modeling and analysis, multibody dynamic analysis, kinematic analysis and design optimization. MSC/NASTRAN, PATRAN, DADS, GENESIS and other commercially available software will be discussed.
Prerequisites: Permission of the instructor

MAE 783 Robots and Manufacturing Automation (3 Credit Hours)
This course will introduce the engineering of industrial robots used for manufacturing automation. Topics to be covered include spatial descriptions and transformations of manipulators, manipulator kinematics and inverse kinematics; manipulator velocities; static forces; and dynamics and trajectory generation. Other topics to be covered include design and on-line computer control of the manipulator.

MAE 784 Computer Integrated Manufacturing (3 Credit Hours)
Study of the design, control, and management of integrated production/manufacturing systems. Topics include modeling of production systems; fundamentals of CAD/CAM; robotics, flexible manufacturing systems, group technology, process planning, concurrent engineering, and shop floor control; CIM architecture and communication. Requires permission of the instructor.

MAE 785 Advanced Manufacturing Technology (3 Credit Hours)
Treatment of the next generation of manufacturing technology. Topics include additive manufacturing; rapid prototypying; electronic manufacturing; micro and nanofabrication; process simulation; product life cycle management; and sustainable design and manufacturing.
Prerequisites: MAE 682 or consent of instructor

MAE 787 Life Cycle Engineering (3 Credit Hours)
Study of environmental impacts of engineering products and processes throughout their life cycle. Emphasis on life cycle assessment, recycling, reusing, remanufacturing, and economic considerations.
Prerequisites: MAE 682

MAE 788 Computational Intelligence for Engineering Design Optimization Problems (3 Credit Hours)
The concepts and algorithms of computational intelligence and their application to engineering design are discussed, including artificial neural networks, evolutionary optimization, and swarm intelligence. Both single and multi-objective optimization problems with continuous and/or discrete variables are also discussed.

MAE 789 Engineering Design with Uncertainties (3 Credit Hours)
An introduction to managing uncertainties and risk in strength design of mechanical components, including the study of the theoretical background, computational implementation, and applications of reliability-based methods for engineering analysis and design.
Prerequisites: MAE 608

MAE 794 Cellular Biomechanics (3 Credit Hours)
A broad introduction to the field of cellular biomechanics. Topics include overview of cell architecture, cytoskeleton, adhesion and molecular motors, biomolecular/biopolymer dynamics and mechanics, techniques to measure cell mechanical properties, techniques to mechanically stimulate cells, models of cell mechanical behavior, mechanobiology and mechanotransduction. Will include discussion of classic and current research articles. Course content will aim to cater to students with diverse backgrounds – students with biological science background will be exposed to physical science concepts and analysis; students with engineering/physical science background will be exposed to biological phenomena and concepts.
Prerequisites: MATH 212

MAE 795 Topics in Mechanical and Aerospace Engineering (3 Credit Hours)
Selected topics in mechanical and aerospace engineering or engineering mechanics.

MAE 797 Independent Study in Mechanical and Aerospace Engineering (3 Credit Hours)
Individual analytical, computational and/or experimental study in an area selected by the student. Supervised and approved by the advisor.

MAE 806 Real-Time Signals and Systems (3 Credit Hours)
Introduction to random and harmonic processes, fast Fourier transforms, digital filters, digital signal processing methods, as well as sensors and transducers. Review of the theory and practice of data acquisition. Modeling of linear, lumped and distributed parameter systems. Use of LabVIEW and MATLAB/Simulink for real-time control and dynamic system simulations. Applications to modal analysis, experimental aerodynamics, and real-time control of electro-mechanical systems.

MAE 810 Supersonic Flow (3 Credit Hours)
This course will examine governing equations for supersonic flow, including full potential equations, small disturbance theory, hodographs, and method of characteristics. It will also serve as an introduction to three-dimensional flows, compressible boundary layer flows, internal flows in nozzles and diffusers, airfoil flows, slender bodies of revolution flows, conical flows, and wing flows.
Prerequisites: MAE 514 and MAE 602

MAE 811 Hypersonic Aerodynamics (3 Credit Hours)
General consideration of hypersonic flow and similarity principles, hypersonic flow past slender bodies with sharp and blunt leading edges. Hypersonic blunt-body flow. Real gas, viscous and low density effects, and consideration of nonequilibrium phenomena in hypersonic flows.
Prerequisites: MAE 710

MAE 812 Experimental Aerodynamics (3 Credit Hours)
This course will examine techniques for static and dynamic measurement of pressure, temperature, and velocity. Experiment control and statistical treatment of data will be discussed, as will probe methods, including multi-hole pressure probes and hot-wire anemometers, and non-intrusive methods, including laser Doppler velocimetry and other optical methods. Surface and stream flow visualization and surface measurements will also be covered.
Prerequisites: MAE 602 and MAE 710

MAE 813 Turbulent Flow (3 Credit Hours)
Isotropic and homogeneous turbulence. Mixing length theories, Equilibrium turbulence models, Two-equation models (k-epsilon). Large eddy simulation. Reynold's stress transport models. Numerical simulations. Compressible and non-equilibrium turbulence effects.
Prerequisites: MAE 602 and MAE 715 or MAE 815

MAE 815 Boundary Layer Theory (3 Credit Hours)
Boundary layer equations; method of matched asymptotic expansions; body oriented coordinates, finite-difference solutions; separations, wake and jet flows; thermal and compressible boundary layers, transformations and finite-difference solutions, unsteady boundary layers. Introduction to hydrodynamic stability and turbulence.
Prerequisites: MAE 602

MAE 816 Computational Fluid Dynamics I (3 Credit Hours)
This course will cover the following topics: classification of single partial differential equations; finite difference methods; stability analysis, including convergence, consistency, and efficiency; basics of finite volume methods; model equations of hyperbolic, parabolic and elliptic type; and explicit and implicit schemes, central and upwind schemes, and weak solutions of quasi-linear hyperbolic equations.
Prerequisites: MAE 601 or MATH 691

MAE 818 Aerospace Test Facilities (3 Credit Hours)
A comprehensive examination of aerodynamic test facilities for use in subsonic, transonic, supersonic and hypersonic flow regimes. Aspects of wind tunnel design and operation will be discussed, as will flow quality and wall and support interferences. Advanced concepts, including cryogenic wind tunnels, adaptive wall test sections and magnetic suspension will be examined, in addition to dynamic testing. There will be a review of flight test methods, including extraction of aerodynamic parameters from flight test data, a review of engine test facilities, and a review of ground test facilities for space structures and other space systems.
Prerequisites: Permission of the instructor

MAE 820 Heat Transfer II (3 Credit Hours)
Aspects of conduction, convection and radiation heat transfer, including governing equations, boundary layer flows, analytical and numerical solutions to one-, two- and three-dimensional problems.
Prerequisites: MAE 620

MAE 822 Theory and Design of Turbomachines (3 Credit Hours)
This course will examine real cycles, fluid motion in turbomachines, the theory of diffusers and nozzles, fluid-rotor energy transfer, radial equilibrium, transonic stages, and combustion chambers. Other types of turbines will be discussed including axial and centrifugal turbines. Performance and design criteria will also be examined, as well as cavitation and two-phase flows.
Prerequisites: MAE 514 and MAE 602

MAE 823 Nuclear Engineering (3 Credit Hours)
This course will consider nuclear power plant systems, and will introduce power reactor control kinetic behavior including safety coefficients, accumulative poisons, and temperature control parameters. It will also examine primary and secondary plant as a transient system.

MAE 824 Energy Utilization and Conservation (3 Credit Hours)
This course provides an overview of the scope of efficient energy utilization in industrial, commercial, transportation, and power generation fields. It introduces power plant waste-heat utilization, district heating, combined gas and steam cycle, organic fluid-bottoming cycle, and total energy concept for residential and commercial buildings. It also examines system management, on-line computer evaluation, and energy analysis.
Prerequisites: Permission of instructor

MAE 830 Finite Element Analysis (3 Credit Hours)
This course provides an understanding of the finite element method (FEM) as derived from an integral formulation perspective. It demonstrates the solutions of (1-D and 2-D) continuum mechanics problems such as solid mechanics, fluid mechanics and heat transfer. It also provides insight into the theoretical formulation and numerical implementation of finite element methods.

MAE 831 Mechanics of Composite Structures (3 Credit Hours)
Stress-strain relations for a lamina; failure theories. Micro-mechanical behavior of a lamina. Constitutive relations of a laminate. Bending, buckling and vibration of laminated plates. Approximate and finite element methods of solution.

MAE 833 Nonlinear Aerospace Structures (3 Credit Hours)
Classical and finite element analysis methods for nonlinear aerospace structures of beams, plates, and shallow shells. Application to problems of large bending deflection, thermal post-buckling, large amplitude free vibration, nonlinear panel flutter, and nonlinear random response.

MAE 834 Theory of Vibrations (3 Credit Hours)
This course will introduce applied modal analysis, modes of vibration of discrete systems, modal coordinates, transfer functions in frequency domain, modes of vibration of continuous systems, and approximate systems response. It will also examine Finite Elements methods and nonlinear vibrations. Applications will be extended to rods, beams, plates and shells.
Prerequisites: MAE 504 and MAE 601 or MATH 691

MAE 835 Experimental Structural Dynamics (3 Credit Hours)
This course will examine experimental techniques and methods for structural dynamics and modal analysis. It will introduce a variety of instruments, including electrodynamic shakers, impact hammers, accelerometers, laser vibrometers, signal analyzers, signal filters, and force transducers. Time and frequency domain data acquisition, assessment, and post-processing will be studied. The development of mathematical models from experimental data will also be conducted.

MAE 840 Autonomous and Robotic Systems Analysis and Control (3 Credit Hours)
Kinematics, dynamics and control of complex non-linear electro-mechanical systems, particularly robotic manipulators.

MAE 841 Optimal Control Theory (3 Credit Hours)
Parameter optimization, optimization problem for dynamic systems with terminal and path constraints; optimal feedback control with and without the presence of uncertainty; nonlinear optimal control system.
Prerequisites: MAE 640

MAE 842 Multibody Dynamics: Theories and Applications (3 Credit Hours)
Basic theories are presented for formulation of equations of kinematics and dynamics of systems made of interconnected bodies. Topics include constrained motion, principle of virtual work and constrained dynamics. Examples cover robotic motion and biomechanics applications such as human locomotion.
Prerequisites: Permission of instructor

MAE 843 Kinematic Synthesis of Mechanisms (3 Credit Hours)
Classification of mechanisms; type and number synthesis, application of graph theory, expert systems for synthesis; introduction to dimensional synthesis via path and function generation; finite displacement theory including concept of poles, circlepoint, and centerpoint curves; structural error minimization using Chebychev's approximation; optimization approaches, current applications to robot manipulators, robot hands, space structures, and combustion engines.
Prerequisites: Permission of instructor

MAE 844 Atmospheric Flight Dynamics and Control (3 Credit Hours)
Principles governing the dynamics and control of vehicles in atmospheric flight. Equations of motion development and solution including inertial/gravitational/aerodynamic/propulvsive loads, linear longitudinal and lateral-directional motions, and nonlinear trim and simulation. Flight control system design and analysis incorporating flying quality requirements, linear conventional/contemporary and frequency/time domain techniques for control and guidance functions, validation with nonlinear simulation, gain scheduling.
Prerequisites: MAE 403 or MAE 503 and MAE 604

MAE 845 Space Flight Dynamics and Control (3 Credit Hours)
Principles governing the dynamics and control of vehicles in space flight. Equations of motion development and solution including inertial/gravitational/aerodynamic/propulsive loads, decoupled translational and attitude motions. Ortibal mechanics including elements, initial-value propagation, adjustments/transfers, Lambert boundary-value problem, perturbations, and nonlinear simulation. Attitude dynamics including torque free, gravity moment, axisymmetric/unsymmetric vehicles, and dual spinners. Flight control system design and analysis including impulsive velocities, finite burns, Lambert targeting, linear designusing momentum wheels, and nonlinear phase-plane design using thrusters.
Prerequisites: MAE 604 and MAE 640

MAE 846 Advanced Control Methodologies (3 Credit Hours)
Review of multivariable dynamic math models including state space, transfer function, and matrix fractions. Multivariable design criteria including stability, performance,and robustness. Theory and application of multivariable control design techniques including LQR/LQG/LTR, H-infinity, Eigenspace Assignment and other advanced methods.
Prerequisites: MAE 640

MAE 847 Aerospace Vehicle Performance (3 Credit Hours)
This course will study the flight performance of aerospace vehicles, including a review of aerodynamic and propulsion characteristics. Range, flight and maneuver envelopes for vehicles in atmospheric flight will be examined. It will introduce various methods of design for trajectory optimization, including launch vehicles. An open-ended, design-oriented project will also be required.
Prerequisites: MAE 602 and MAE 514 or MAE 610

MAE 848 Flight Control Actuators and Sensors (3 Credit Hours)
This course will provide an overview of the governing principles and operations of actuator and sensor hardware used in aircraft and spacecraft flight control systems. Hydraulic, electro-hydraulic and electric actuators will be examined, as well as control jets and momentum wheels, accelerometers, and rate gyros. Other topics include air-data systems, inertial navigation systems and satellite navigation systems. The course will also examine dynamic model development, analysis and simulation, nonlinear hardware characteristics, and the influence on closed-loop vehicle behavior.
Prerequisites: MAE 503, MAE 538, and MAE 604

MAE 850 Nanoscale Mechanical and Structural Properties of Materials (3 Credit Hours)
Elastic and plastic properties of nanoscale materials, strain gradient dislocation plasticity, nanoindentation and nanoindentation creep, thin film mechanical and structural properties, kinetic-based investigations of hardening mechanisms in nanolayer composites.

MAE 851 Fatigue and Fracture (3 Credit Hours)
Divided into areas of fatigue and fracture; stress-controlled and strain-controlled fatigue; effect of mean stresses, notches, etc.; multiaxial stresses; variable amplitude loading; ductile and brittle fracture; linear elastic fracture mechanics; crack-tip plasticity; fracture testing; applications to fatigue life estimation. Requires permission of the instructor.

MAE 852 Mechanical Behavior of Materials (3 Credit Hours)
An examination of the macroscopic behavior of materials with respect to elasticity, plasticity, and viscoelasticity; yield criteria; fracture; influence of high and low temperatures; and corrosion and radiation.
Prerequisites: Permission of instructor

MAE 853 Composite Materials (3 Credit Hours)
This course will examine reinforcements, matrices, particulate-composites, short-fiber and continuous-fiber reinforced composites. Directionally solidified composites will also be studied, including the prediction of elastic failure properties. Other topics to be covered include design considerations and experimental work.
Prerequisites: Permission of the instructor

MAE 872 Response Surface Methodology (3 Credit Hours)
An applied course in response surface methodology with aerospace applications. Empirical model building, method of least squares, second order models, model adequacy checking, canonical analysis. Method of steepest ascent, multiple response optimization. Rotatable, cuboidal and small run designs. Design optimality and efficiency metrics, robust design, restrictions on randomization. Laboratory exercises include RSM applied to wind tunnel testing and optimization.
Prerequisites: MAE 672

MAE 880 Engineering Optimization (3 Credit Hours)
Formulation and solution algorithms for Linear Programming (LP) problems. Unconstrained and constrained nonlinear programming (NLP) problems. Optimum solution for practical engineering systems.

MAE 881 Advanced Design (3 Credit Hours)
Concepts, principles and procedures related to analysis of stresses and strains in machine components. Consideration of function of parts along with factors such as forces, life required, maximum cost, weight and space restrictions, number of parts to be produced, material selection, kinematics,environmental restrictions. Finite element analysis to illustrate different aspects of stress analysis. Requires permission of the instructor.

MAE 882 Engineering Software for Computer-Aided Analysis and Design (3 Credit Hours)
An introduction to advanced CAD software for finite element modeling and analysis, multibody dynamic analysis, kinematic analysis, and design optimization. MSC/NASTRAN, PATRAN, DADS, GENESIS and other commercially available software will be discussed.
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MAE 899 PhD Dissertation Research in Mechanical and Aerospace Engineering (1-9 Credit Hours)
Based on the Ph.D candidate's dissertation research in mechanical and aerospace engineering topics under the direction of the candidate's advisor.
Prerequisites: Instructor approval required

MAE 998 Master's Graduate Credit (1 Credit Hour)
This course is a pass/fail course for master's students in their final semester. It may be taken to fulfill the registration requirement necessary for graduation. All master's students are required to be registered for at least one graduate credit hour in the semester of their graduation.

MAE 999 Doctoral Graduate Credit (1 Credit Hour)
This course is a pass/fail course doctoral students may take to maintain active status after successfully passing the candidacy examination. All doctoral students are required to be registered for at least one graduate credit hour every semester until their graduation.