MAE - Mechanical and Aerospace Engineering

MECHANICAL AND AEROSPACE ENGINEERING Courses

MAE 111. Mechanical and Aerospace Engineering Information Literacy and Research. 2 Credits.
This course will introduce students to the needs, access, evaluation, use, impact and ethical/legal aspects of information, and to the application of information literacy and research in the fields of mechanical and aerospace engineering. Prerequisites: ENGN 110.

MAE 195. Topics. 1-3 Credits.
Permission of the chair required.

MAE 201. Materials Science. 3 Credits.
Principles of materials science with emphasis on the relationship between structure and properties and their control through composition and processing. Metals, polymers, ceramics, and composite materials are considered. Prerequisites: MATH 211 with a grade of C or better.

MAE 203. Mechanical Engineering Laboratory I - Materials Science. 1 Credit.
This laboratory involves experiments demonstrating lecture material covered in the MAE 201 course. Pre- or corequisite: MAE 201 and CS 150 or ENGN 150.

MAE 204. Engineering Mechanics I - Statics. 3 Credits.
Introduction to mechanical engineering problems and their solutions through the study of statics of particles and rigid bodies. Emphasis will be placed on the relationship of the static loads with the mechanical properties of the materials being considered. Introduction to the concepts of stress and strain and internal forces as applied to static bodies. Prerequisite: MATH 211 with a grade of C or better. Pre- or corequisite: PHYS 231N.

MAE 205. Dynamics. 3 Credits.
Introduction to engineering problems and their solutions through a study of the dynamics of particles and rigid bodies. General force systems are studied including friction. Prerequisite: A grade of C or better in MAE 204 or CEE 204. Pre- or corequisite: MATH 212.

MAE 220. Engineering Mechanics II - Solid Mechanics. 3 Credits.
Introduction to concepts of stress, strain and their relation to each other. Stress and strain in axially loaded members and circular rods and tubes subjected to torsion. Normal and shear stress in beams under bending loads. Additional topics include bending deflection, transformation of stress and strain, Mohr's circles, statically indeterminate problems, combined stress and thin walled pressure vessels. Prerequisite: A grade of C or better in MAE 204 or CEE 204.

MAE 225. Mechanical Engineering Laboratory II - Solid Mechanics. 1 Credit.

MAE 300. Mechanics of Fluids. 3 Credits.
Fundamental concepts, fluid statics, basic equations in integral form, open-channel flow, Bernoulli's equation, dimensional analysis and similitude, incompressible viscous flow, pipe friction, boundary layers, introduction to differential analysis. Prerequisites: MATH 307, MATH 312, and a grade of C or better in MAE 205.

MAE 305. Mechanical Engineering Laboratory III - Thermo/Fluids. 1 Credit.
An introduction to thermo-fluid experimentation and measurement; basic flow phenomena demonstrated; measurement techniques for flow temperature, pressure and properties; report writing and data reduction methods, including statistical treatment of data; formal oral reports. Prerequisite: Junior standing. Pre- or corequisite: MAE 303 and MAE 311.

MAE 311. Thermodynamics I. 3 Credits.
Essential definitions of thermodynamics, first law, physical properties, ideal and real gases, second law, reversibility, irreversibility and consequences of thermodynamic cycles. Prerequisites: MATH 312, and a grade of C or better in CHEM 121N.

MAE 312. Thermodynamics II. 3 Credits.
Concepts and principles dealing with thermodynamic cycles, relations and generalized charts, mixtures of fluids, chemical reactions, chemical and phase equilibrium, thermodynamic aspects of fluid flow; introduction to compressible flow, isentropic and normal shock wave relations. Prerequisites: MATH 307, and a grade of C or better in MAE 303, and a grade of C or better in MAE 311.

MAE 315. Heat and Mass Transfer. 3 Credits.
Fundamental laws of heat transfer by conduction, convection, and radiation; boundary-layer concepts; simultaneous heat, mass, and momentum transfer. Prerequisites: A grade of C or better in MAE 303, and a grade of C or better in MAE 311.

MAE 332. Mechanical Engineering Design I. 3 Credits.
Introduction to machine design including review of stress and deflection analysis. Statistical considerations in design, strength of mechanical elements with emphasis on theories of failure and fatigue design. Prerequisites: MAE 201, a grade of C or better in MAE 205, a grade of C or better in MAE 220, and MET 120. Pre- or corequisite: MAE 225.

MAE 336. Electromechanical Systems. 3 Credits.
Introduction to analog and digital circuits; sensors, actuators and signals; laboratory instrumentation (oscilloscope, function generator, etc.); data acquisition; and embedded microcontroller systems. Students will perform electronics experiments as homework assignments. Prerequisites: CS 150 or ENGN 150 and PHYS 232N.

MAE 340. Computational Methods in Mechanical Engineering. 3 Credits.
A survey of modern computing techniques for mechanical engineers. Numerical algorithms are presented to solve practical problems in mechanical engineering as found in solid mechanics, fluid mechanics, dynamics, and heat transfer. Emphasis is on providing computational experience in applied numerical methods using computers. Topics include roots of equations, simultaneous equations, differentiation, integration, regression analysis, interpolation and differential equations. Analysis, understanding, and quantification of computational errors are included in all topics and applications. Prerequisites: ENGN 150 or CS 150, MATH 307 and MATH 312.

MAE 367. Cooperative Education. 1-3 Credits.
Available for pass/fail grading only. Student participation for credit based on the academic relevance of the work experience, criteria, and evaluative procedures as formally determined by the department and Career Development Services prior to the semester in which the work experience is to take place. Prerequisites: Approval by department and Career Development Services in accordance with the policy for granting credit for Cooperative Education programs.

MAE 368. Internship. 1-3 Credits.
Available for pass/fail grading only. Academic requirements will be established by the department and will vary with the amount of credit desired. Allows students to gain short duration career-related experience. Prerequisites: Approval by department and Career Development Services.

MAE 369. Practicum. 1-3 Credits.
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 403/503. Flight Mechanics. 3 Credits.
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 404/504. Vibrations. 3 Credits.
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 406/506. Flight Vehicle Aerodynamics. 3 Credits.
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 407/507. Ground Vehicle Aerodynamics. 3 Credits.
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 411/511. Mechanical Engineering Power Systems Theory and Design. 3 Credits.
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 412/512. Environmental Control. 3 Credits.
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 413/513. Energy Conversion. 3 Credits.
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. Prerequisite: MAE 312.

MAE 414/514. Introduction to Gas Dynamics. 3 Credits.
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 416/516. Introduction to Solar Energy Engineering. 3 Credits.
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 417/517. Propulsion Systems. 3 Credits.
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 420/520. Aerospace Structures. 3 Credits.
Analysis of aircraft and space vehicle structural components. Effects of bending, torsion and shear on typical aerospace structural components, stastically 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 422/522. Modern Engineering Materials. 3 Credits.
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 thermostets; 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 431/531. Mechanisms Analysis and Design. 3 Credits.
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 433. Mechanical Engineering Design II. 3 Credits.
Statistical considerations in design, strength of mechanical elements with emphasis on theories of failure and fatigue design in mechanical elements such as screws, fasteners, connections, welded joints, and flexible mechanical elements. Kinematic analysis, force analysis, and design of spar, helical, worm, and bevel gears. Anti-friction bearings, lubrication and journal bearings, shaft design, mechanical spring design, design of clutches, brakes and couplings. Prerequisites: A grade of C or better in MAE 332 and senior standing.

MAE 434W. Project Design and Management I. 3 Credits.
This course prepares students to complete their design projects in MAE 435. Lecture topics include engineering economics; project planning; costing and risk analysis; and product realization techniques. Course involves written and oral presentations for students to improve communication and teamwork skills. This is a writing intensive course. Prerequisites: A grade of C or better in MAE 332, ENGL 211C or ENGL 221C or ENGL 231C. Pre- or corequisite: MAE 433.

MAE 435. Project Design and Management II. 3 Credits.
Conceptual design ideas are expanded into detailed design ideas. Product realization is applied to complete hardware. Course covers Gantt charts, preliminary design, evaluation and trading matrices, detailed design and analysis, oral and technical reporting including cost analysis. Ethics and patent issues are also included. Prerequisites: MAE 433 and MAE 434W.

MAE 436. Dynamic Systems and Control. 3 Credits.
Analysis and synthesis of feedback systems; functional description of dynamic systems; basic controllers; sensitivity, stability and error analysis; transient and steady-state response using computational techniques, root locus and frequency response methods; state-space analysis of control systems. Prerequisites: A grade of C or better in MAE 205; MAE 336, MATH 307 and MATH 312.

MAE 438/538. Applied Analog and Digital Control. 3 Credits.
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. Prerequisite: a grade of C or better in MAE 436.

MAE 440/540. Introduction to Finite Element Analysis. 3 Credits.
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 441. Computer-Aided Design of Mechanical Systems. 3 Credits. Case studies are used to introduce students to CAD software; design processes involving modeling, analysis and design, and verification. Typical case studies are beam and plate designs, turbine blade design, and pipe networks. Advanced topics include: thermal stress analysis and plates and shells. Prerequisites: ENGN 150 or CS 150, and a grade of C or better in MAE 220; MATH 312. Pre- or corequisite: MAE 332.

MAE 450/550. Principles of Naval Architecture. 3 Credits. 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 457/557. Motorsports Vehicle Dynamics. 3 Credits. 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 460/560. Introduction to Space Systems Engineering. 3 Credits. 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 467/567. Racecar Performance. 3 Credits. 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 477/577. High Performance Piston Engines. 3 Credits. 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 495/595. Topics in Mechanical and Aerospace Engineering. 1-3 Credits. 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 496. Topics in Mechanical and Aerospace Engineering. 1-3 Credits. Special topics of interest with emphasis placed on recent developments in mechanical engineering or engineering mechanics. (offered fall, spring, summer) Prerequisites: senior standing; permission of the chair is required.

MAE 497/597. Independent Study in Mechanical and Aerospace Engineering. 1-3 Credits. 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 503. Flight Mechanics. 3 Credits. 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 Credits. 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 Credits. 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 Credits. 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 Credits. 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.

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MAE 513. Energy Conversion. 3 Credits. 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 Credits. 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 Credits. 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 Credits. 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. Prerequisite: MAE 312 or MAE 414.

MAE 520. Aerospace Structures. 3 Credits. 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 Credits.
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 thermostos; 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 Credits.
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 Credits.
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. Prerequisite: a grade of C or better in MAE 436.

MAE 540. Introduction to Finite Element Analysis. 3 Credits.
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 Credits.
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 Credits.
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 Credits.
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 Credits.
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 Credits.
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. Prerequisite: MAE 312, MAE 315 or MET 300, MET 350.

MAE 595. Topics in Mechanical and Aerospace Engineering. 1-3 Credits.
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 Credits.
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 Credits.
Applications of linear algebra, ordinary and partial differential equations, and complex variables to engineering problems.

MAE 602. Fluid Dynamics and Aerodynamics. 3 Credits.
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 Credits.
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 Credits.

MAE 605. Advanced Classical Thermodynamics. 3 Credits.
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 Credits.
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 Credits.

MAE 620. Heat Transfer I. 3 Credits.
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 Credits.

MAE 667. Cooperative Education in Mechanical and Aerospace Engineering. 1-3 Credits.
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 Credits.
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 609. Practicum in Mechanical and Aerospace Engineering. 1-3 Credits.
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 Credits.
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 Credits.
Study of principles of concurrent engineering with emphasis on the design/ manufacture interface for single products; Rapid prototyping projects; Design of injection-molded and stamped parts for cost.

MAE 685. Projects Design and Manufacturing. 3 Credits.
Projects 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.
Regular tutorials on recent topics of interest in mechanical and aerospace engineering and engineering mechanics.

MAE 695. Topics in Mechanical and Aerospace Engineering. 3 Credits.
Special topics of interest with emphasis placed on recent developments in mechanical and aerospace engineering or engineering mechanics.

MAE 696. Experimental Research Project. 3 Credits.
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 Credits.
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 Credits.
Individual project, investigation under the direction of the student’s major professor.

MAE 699. Thesis Research in Mechanical and Aerospace Engineering. 1-6 Credits.
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 Credits.
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 Credits.
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 Credits.
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 Credits.
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 Credits.

MAE 715. Boundary Layer Theory. 3 Credits.
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 Credits.
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 Credits.
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 Credits.
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 Credits.
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 Credits.
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 Credits.
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 Credits.
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 Credits.

MAE 733. Nonlinear Aerospace Structures. 3 Credits.
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 Credits.
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 Credits.
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 Credits.
Kinematics, dynamics and control of complex non-linear electro-mechanical systems, particularly robotic manipulators.

MAE 741. Optimal Control Theory. 3 Credits.
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 Credits.
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 Credits.
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 Credits.
Principles governing the dynamics and control of vehicles in atmospheric flight. Equations of motion development and solution including inertial/gravitational/aerodynamic/propulsive 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 Credits.
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. Orbital 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 design苟用ness momentum wheels, and nonlinear phase-plane design using thrusters. Prerequisites: MAE 604 and MAE 640.

MAE 746. Advanced Control Methodologies. 3 Credits.
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-infity, Eigenspace Assignment and other advanced methods. Prerequisites: MAE 640.

MAE 747. Aerospace Vehicle Performance. 3 Credits.
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 Credits.
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 Credits.
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 Credits.
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 Credits.
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 Credits.
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 Credits.
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 Credits.
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 Credits.
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 Credits.
Introduction to advanced CAD software for finite element modeling and analysis, multidomain 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 Credits.
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 Credits.
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 Credits.
Treatment of the next generation of manufacturing technology. Topics include additive manufacturing; rapid prototyping; 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 Credits.
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 Credits.
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 Credits.
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 795. Topics in Mechanical and Aerospace Engineering. 3 Credits.
Selected topics in mechanical and aerospace engineering or engineering mechanics.

MAE 797. Independent Study in Mechanical and Aerospace Engineering. 3 Credits.
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 Credits.
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 Credits.
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 Credits.
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 Credits.
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 Credits.

MAE 815. Boundary Layer Theory. 3 Credits.
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 Credits.
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 Credits.
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 Credits.
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 Credits.
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 Credits.
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 Credits.
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 Credits.
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.

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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.

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MAE 835. Experimental Structural Dynamics. 3 Credits.
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 Credits.
Kinematics, dynamics and control of complex non-linear electro-mechanical systems, particularly robotic manipulators.

MAE 841. Optimal Control Theory. 3 Credits.
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 Credits.
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 Credits.
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 Credits.
Principles governing the dynamics and control of vehicles in atmospheric flight. Equations of motion development and solution including inertial/gravitational/aerodynamic/propulsive 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 Credits.
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. Orbital 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, Lambart targeting, linear designing using momentum wheels, and nonlinear phase-plane design using thrusters. Prerequisites: MAE 604 and MAE 640.

MAE 846. Advanced Control Methodologies. 3 Credits.
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 Credits.
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 Credits.
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 gyro's. 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 Credits.
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 Credits.
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 Credits.
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 Credits.
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 Credits.
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 Credits.
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 Credits.
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.

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. Prerequisites: Permission of the instructor.

MAE 883. Robots and Manufacturing Automation, 3 Credits.
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 884. Computer Integrated Manufacturing, 3 Credits.
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 885. Advanced Manufacturing Technology, 3 Credits.
Treatement of the next generation of manufacturing technology. Topics include additive manufacturing; rapid prototyping; electronic manufacturing; micro and nanofabrication; process simulation; product life cycle management; and sustainable design and manufacturing. Prerequisites: MAE 682 or consent of instructor.

MAE 887. Life Cycle Engineering, 3 Credits.
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 888. Computational Intelligence for Engineering Design Optimization Problems, 3 Credits.
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 889. Engineering Design with Uncertainties, 3 Credits.
An introduction to managing uncertainties and risk in strength design of mechanical components, including the study of theoretical background, computational implementation, and applications of reliability-based methods for engineering analysis and design. Prerequisites: MAE 608.

MAE 895. Topics in Mechanical and Aerospace Engineering, 3 Credits.
Selected topics in mechanical and aerospace engineering or engineering mechanics.

MAE 897. Independent Study in Mechanical and Aerospace Engineering, 3 Credits.
Individual analytical, computational and/or experimental study in an area selected by the student. Supervised and approved by the advisor.

MAE 899. PhD Dissertation Research in Mechanical and Aerospace Engineering, 1-9 Credits.
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.
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.
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.