Course Descriptions

An asterisk (*) following the four-digit number indicates the course is approved for graduate credit.

ENSC 2113
Statics
Prerequisites: MATH 2144 and either PHYS 1114 or 2014. Resultants of force systems, static equilibrium of rigid bodies, statics of structures, and fluid statics. Shear and moment diagrams.

ENSC 2123
Elementary Dynamics
Prerequisite: ENSC 2113. Kinematics and kinetics of particles, systems of particles, and rigid bodies from a Newtonian viewpoint using vector algebra and calculus. Work-energy and impulse-momentum principles. Planar and three-dimensional kinetics and kinematics of rigid bodies.

ENSC 2143
Strength of Materials
Prerequisite: ENSC 2113. Bending moments, deformation and displacement in elastic and plastic deformable bodies. Axial, torsional and shear loads. Buckling stress transformations and combined loads.

ENSC 2213
Thermodynamics
Prerequisites: CHEM 1314, 1414 or 1515, MATH 2144, PHYS 2014. Properties of substances and principles governing changes in form of energy. First and second laws.

ENSC 2613
Introduction to Electrical Science
Prerequisites: MATH 2153 and PHYS 2114. Elements of electrical engineering; AC and DC circuits, mesh and node formulation of network equations, steady-state response to sinusoids, energy, power and power factor.

ENSC 3213
Computer Based Systems in Engineering
Prerequisite: CS 1113 or ENSC 1412 and sophomore or higher standing. A comprehensive introduction to technology and application of microprocessors, concepts of computer and computation, interfacing and communication, data acquisition and representation. Applications of general-purpose and embedded processors in various disciplines of engineering and engineering problem solving.

ENSC 3233
Fluid Mechanics
Prerequisites: ENSC 2113, MATH 2153. The study of fluid properties, statics, conservation equations, dimensional analysis and similitude, viscous flow in ducts, inviscid flow, boundary layer theory, open channel flow, turbomachinery and fluid measurement techniques.

ENSC 3313
Materials Science
Prerequisite: CHEM 1314 or 1414 or 1515. Introductory level. Relationship between structure and properties of materials and engineering applications. Atomic, microscopic and macroscopic properties.

MAE 3013
Mechanical and Aerospace Engineering Analysis
Prerequisites: MATH 2233, ENSC 2123, 2143, 2213, 2613, 3233. Setup and solution of equations which govern mechanical engineering systems. Application and solution of the governing equations to describe the steady state, transient, or harmonic behavior of dynamics, thermodynamics, mechanics, heat transfer and circuit problems. Behavior will be described with linear sets of equations, differential equations, and partial differential equations. Solutions of these equations may be simplified by using complex numbers, Fourier and Laplace transforms. In some cases only numerical solutions will be feasible.

MAE 3033
Engineering Design
Lab 2. Prerequisite: ENGR 1332. Design methodology and practice. Design process, with emphasis on the broad range of technical, economic, and societal factors considered in design decision-making. Designing and building a machine to participate in a design competition.

MAE 3113
Measurements and Instrumentation
Lab 4. Prerequisites: ENSC 2123 and ENSC 2613. Application of basic electronic laboratory measurement equipment. Selection and testing of transducers for measurement of displacement, time frequency, velocity, pressure, force, temperature, flow-rate, and vibration, for machine design applications. Considerations of accuracy, uncertainty and repeatability. Design projects involving the use of analog and digital integrated circuits and construction of prototype sensors. Practice in the use of signal processing, including digital filtering and applications of Fast Fourier Transform theory. Practice in the use of computer-based data acquisition systems. Preparation of formal reports, including the presentation of plots, figures and tables.

MAE 3123
Manufacturing Processes
Prerequisites: ENSC 2143 and 3313 or equivalent. An introduction to manufacturing processes including the fundamental processes of casting, forging, rolling, extrusion, drawing and metal cutting. Quantitative relationships to identify important parameters which influence a given process.

MAE 3223
Thermodynamics II
Prerequisite: ENSC 2213. A continuation of ENSC 2213. Irreversibility and availability, power cycles, refrigeration cycles, mixtures and solutions, chemical reactions, phase and chemical equilibrium, and introduction to compressible flow.

MAE 3233
Heat Transfer
Prerequisite: ENSC 3233. Mechanisms of heat transfer. Steady and transient conduction, free and forced convection, heat exchanger design and analysis, radiation and multiphase behavior. Numerical methods, dimensional analysis and boundary layer theory.

MAE 3253
Applied Aerodynamics and Performance
Prerequisites: ENSC 3233, MATH 2233. Relevant fluid properties; standard atmospheres; mathematical models of flows about bodies. Characteristic parameters of airfoils and wings. Thin airfoil theory and flows about finite wings. Boundary layers. Propeller theory. Supersonic and hypersonic flows about wings and lifting bodies. Drag polars. Power required for level flight. Rate of climb and descent. Steady turns. Maximum range and endurance. Design applications.

MAE 3293
Compressible Fluid Flow
Prerequisites: ENSC 2213, 3233, MATH 2233. Gas flows in one and two dimensions. Basic thermodynamic and dynamic equations. Nozzle and duct flows, choking, plane and oblique shock waves, Prandtl-Meyer expansions, rocket propulsion, frictional high-velocity flows and heat addition effects. Two-dimensional ideal fluid flow, stream function, velocity potential, linearized flows and method of characteristics.

MAE 3323
Mechanical Design I
Prerequisites: ENSC 2113, 2143. Introduction to the design process. Consideration of reliability, factors of safety, product liability, and economics. Use of codes, standards, and other design resources. Design stress analysis of mechanical components such as beams, rings, cylinders, and shafts. Analysis of stiffness and deflection of straight and curved beams, columns, and links. Consideration of failure theories for various types of engineering materials. Application of fatigue analyses in the design process.

MAE 3403
Computer Methods in Analysis and Design
Prerequisite: ENGR 1412. Application of computer methods in the design, analysis, and simulation of mechanical, thermal and fluid systems. Linear algebra and numerical methods. Applied statistics.

MAE 3723
Systems I
Prerequisites: ENSC 2123, 2613 and MATH 2233. Physical and mathematical modeling of electrical and mechanical dynamic systems. Transient response of first- and second-order systems. Laplace transform technique for solving differential equations; transfer functions, frequency response and resonance. (Same course as ECEN 3723)

MAE 4010*
Mechanical Engineering Projects
1-6 credits, max 6, Lab variable. Prerequisite: Consent of instructor. Special projects and independent study in mechanical engineering.

MAE 4053*
Automatic Control Systems
Prerequisite: MAE 3723 or ECEN 3723. Properties of feedback control systems, mathematical models of basic components, state-variable models of feedback systems, design specifications of control systems, time-domain analysis, stability, stability robustness, transform analysis, frequency domain techniques, root-locus, design of single-input-single-output systems and compensation techniques for engineering systems. (Same course as ECEN 4413*)

MAE 4063*
Mechanical Vibrations
Prerequisites: MAE 3723. Lumped parameter analysis of multi-mode vibrating systems. Analysis techniques including classical analytical methods, matrix methods and numerical methods. Selection and design of vibration isolation systems. Selection of vibration instrumentation. Machine dynamics, including balancing, whirl, nonlinear effects, and self-excited vibrations.

MAE 4223*
Aerospace Engineering Laboratory
Lab 6. Prerequisites: MAE 3113, MAE 3253, MAE 4283. Experimental study of aerospace principles including topics in aeronautics and astronautics. State-of-the-art instrumentation, diagnostics, and computerized data acquisition equipment and techniques applied to experiments including application of low speed wind tunnel testing techniques, rocket propulsion and control-jet experiments, fundamentals of supersonic nozzles, and flight test evaluation of performance, stability, control, and handling qualities of a propeller-driven airplane.

MAE 4243*
Gas Power Systems
Prerequisite: ENSC 3233. Power and propulsion engines utilizing a gas as the working fluid. Thermodynamic and dynamic equations of one-dimensional compressible flow, including shock waves. Design and analysis of overall aircraft engine systems and individual components of the aircraft engine, as well as engine component matching, using design software packages. Centrifugal and axial flow turbines and compressors.

MAE 4263*
Vapor Power Systems
Prerequisites: MAE 3223, MAE 3233. Vapor power cycles, combustion processes applied to power production, power plants, and auxiliary systems associated with power plants. Overall design of power plants as well as component design. Power system economics and loan analysis. Extensive use of software design and analysis packages.

MAE 4273*
Experimental Fluid Dynamics
Lab 3. Prerequisites: MAE 3113 and ENSC 3233. Experimental study of basic and applied fluid dynamics systems with comparisons to analytical predictions. Fluid dynamics instrumentation, digital data acquisition and processing, design of facilities and experiments, technical report writing and design project with experimental verification.

MAE 4283*
Aerospace Vehicle Stability and Control
Prerequisites: MAE 3253, MAE 3723, ENSC 2123. Motion and control of aerospace vehicles. Derivation of equations of motion for aircraft and spacecraft. Aerodynamic stability derivatives. Static and dynamic aircraft stability and control. Handling qualities. Satellite orbital and attitude dynamics. Satellite attitude control. Design experience for stability and control in aeronautical and astronautical vehicles.

MAE 4313*
Advanced Processing of Engineered Materials
Prerequisite: ENSC 3313. Introduction of novel processing methods for a range of engineered materials, such as electro-slag remelting, vacuum melting, melting to remove tramp elements, precision casting, sintering, hot-pressing, directional solidification, mechanical alloying, liquid infiltration, net-shaped finishing, superplastic forming, sol-gel processing, float glass process, tape laying, microwave processing, laser processing, CVD and PVD, sputtering, ion plating, ultraprecision machining and grinding, polishing and lapping, multilayer coatings, Czhochralski single crystal growth, processing of nanocrystalline materials, engineered surfaces and surface modification, and layer processing for electronic materials.

MAE 4333*
Mechanical Metallurgy
Lab 2. Prerequisite: ENSC 3313. Mechanical deformation processes and strengthening mechanisms in engineering materials. Material failure modes including creep, fatigue, stress corrosion, ductile and brittle fractures.

MAE 4344*
Design Projects
Lab 4. Prerequisites: MAE 3033, MAE 3113, MAE 3323. Students work in small teams on a semester-long design project sponsored by a company, agency, or individual. Team members work with mentors from sponsors and with faculty members in fields related to their topics. Presentations on safety, patent law, product liability, report writing, oral presentations, scheduling and ideation. Oral presentations, progress reports, and a professional log book documenting personal activity and contributions.

MAE 4353*
Mechanical Design II
Prerequisites: MAE 3033, MAE 3323 and MAE 3403. Design of power transmission systems, including belts, chains and gears. Selection and application of hydraulic and pneumatic components in machine design applications. Selection of electric motors, actuators, encoders, and related electromechanical components. Design practice in the form of short projects integrating segments of the course. (Same course as BAE 4353*)

MAE 4354*
Aerospace Systems Design for Mechanical Engineers
Lab 8. Prerequisites: MAE 3033, MAE 3113 and MAE 3323. Multidisciplinary design of aerospace vehicles. Multidisciplinary teams that work on a semester-long project that includes the design, construction, and a flight test of an aerospace vehicle optimized for a given set of requirements. Teamwork, leadership and presentation skills emphasized. Students from all appropriate disciplines who wish to participate in this course are encouraged to do so by enrolling in MAE 4010.

MAE 4363*
Experimental Methods in Design
Lab6. Prerequisites: MAE 3113 and MAE 3323. Laboratory techniques for the experimental analysis of vibration, stress, force and motion. Projects involve the use of strain gages, brittle lacquer techniques, reflection and transmission polariscopes, load cells and accelerometers.

MAE 4374*
Aerospace Systems Design
Lab 8. Prerequisites: MAE 4243, MAE 4283, MAE 4513. Multidisciplinary design of aerospace vehicles. Multidisciplinary teams that work on a semester-long project that includes the design, construction, and a flight test of an aerospace vehicle optimized for a given set of requirements. Teamwork, leadership and presentation skills emphasized. Students from all appropriate disciplines who wish to participate in this course are encouraged to do so by enrolling in MAE 4010.

MAE 4383*
Nanotechnology for Engineers
Prerequisites: MATH 2163, CHEM 1414 or 1515, PHYS 2114. Size and shape dependence of material properties at the nanoscale. Top-down and bottom-up nanofabrication and self-assembly. Interaction, functionalization, binding, and immobilization of nanostructures. Properties applications and synthesis of well-studied building blocks; quantum dots (semiconductor nanocrystals), carbon nanostructures (nanotubes and fullerines), semiconductor nanowires, metal nanoparticles and nanowire. Supramolecular structures, nanophase films, and nanocomposites. Characterization of nanostructures.

MAE 4513*
Aerospace Structures I
Prerequisites: MAE 3323 and 3403. Design and analysis of flight structures. Topics from two and three-dimensional elasticity. Behavior of composite materials. Stress and deflection analysis of thin-skinned stiffened structures. Introduction to the finite element method and its applicability in the design process.

MAE 4623*
Biomechanics
Prerequisites: MATH 2163, ENSC 2143, ENSC 3233. To introduce non-bioengineering students to the field of biomechanics. This class will serve as a foundation for further biomechanics investigation at senior undergraduate and graduate level. At the end of this class students will be able to apply engineering principles to describe the mechanical properties of biological systems.

MAE 4703*
Design of Indoor Environmental Systems
Prerequisites: MAE 3223, MAE 3233. Design of heating, ventilating and air conditioning systems. Calculation of heating and cooling loads.

MAE 4713*
Thermal Systems Design, Simulation and Optimization
Prerequisites: MAE 3233, MAE 3223; ENSC 3233; Co-requisite: MAE 3403. Design, modeling, simulation and optimization of thermal systems. Analysis and modeling of components such as fans, pumps, ducts, pipes, fittings, heat exchangers, compressors, thermal storage equipment.

MAE 4733*
Mechatronics Design
Prerequisites: MAE 3113 and 3403. Design of mechanical and electrical components, including sensors and actuators into an integrated environment using microcontrollers. Software design using an easy-to-program microcontroller embodies the importance of software implementation into the overall engineering system. Design practice with given design projects to build up skills plus an open-ended term design project of the student's choosing.

MAE 5000*
Thesis
1-6 credits, max 6. A student studying for a master's degree who elects to write a thesis must enroll in this course.

MAE 5003*
Advanced Biomaterials Science and Engineering
Prerequisites: Graduate standing or consent of instructor. Engineering issue that are implicit in understanding the interactions of living tissue and processed materials will be introduced. Emphasis is on identifying the processes in which cells interact with surfaces and particulate matter and the outcome of these interactions. Highlighted biological responses will include inflammation and coagulation. Also, biomaterial issues related to drug delivery and tissue engineering will be discussed. (Same course CHE 5003)

MAE 5010*
Mechanical Engineering Projects
1-12 credits, max 12. Project in research or design selected by the student, or assigned by the instructor. A student who wishes to complete a master's degree under Plan III must enroll in this course.

MAE 5013*
Basic Physiology and Physiological System Analysis for Engineers
Prerequisite: Graduate standing or consent of instructor. The goals of this class are: 1) to introduce the basic physiology concepts used widely in biomedical engineering research; 2) to introduce and develop engineering concepts and approaches for quantitative analysis of physiological systems. Engineering principles will be applied to study mechanical properties of various tissue and organ systems under normal and diseased conditions. Knowledge obtained from this class can help engineers to apply engineering principles to the design and development of medical devices for disease treatments. (Same course as CHE 5013)

MAE 5030*
Engineering Practice
1-12 credits, max 12. Prerequisites: Senior or graduate standing and consent of instructor. Solution of real-life engineering design and development problems in an actual or simulated industrial environment. Activities include application of design and testing procedures, economic evaluation and periodic oral and written reporting on one or more assigned problems. Activities must be approved in advance by the adviser.

MAE 5033*
Advanced Biomedical Engineering
Prerequisite: Consent of instructor. Principles and engineering analysis of biomedical processes. Artificial organs, biomaterials, tissue engineering, transport in biological systems, biomedical imaging and drug delivery systems. (Same course as CHE 5293)

MAE 5073*
Advanced Mechanical Vibrations
Prerequisite: MAE 4063 or consent of instructor. Analysis of nonlinear vibrations, classical analysis of continuous systems and numerical methods.

MAE 5083*
Engineering Acoustics
Prerequiste: Graduate standing or consent of instructor. Acoustical analysis and measurement techniques, with emphasis on design applications for noise and vibration control in machinery and in buildings.

MAE 5093*
Numerical Engineering Analysis
Prerequisites: Undergraduate course in computer programming and consent of professor. Practical digital methods for obtaining steady-state and transient solutions to lumped and distributed mechanical, fluid and thermal problems.

MAE 5113*
Diffraction for Non-destructive Materials Evaluation
Prerequisite: Graduate standing or consent of instructor. Introduction to crystallography and diffraction with an emphasis on X-ray diffraction, some exposure to Neutron diffraction. Applications will focus on mechanical properties measurements. New methods will be surveyed with an emphasis on current research.

MAE 5123*
Metal Cutting
Prerequisites: ENSC 3313, MAE 3123 and graduate standing or consent of instructor. Understanding the fundamental principles and practice (mechanics and material aspects) of machining and grinding of materials. Historical aspects; physics of metal cutting, mechanics of machining (orthogonal and oblique); shear stress and shear strain in machining, dynamometry; tool materials, tool wear, tool life, and machinability; vibrations in machining; thermal aspects of machining, cutting fluids; economics; surface finish accuracy and surface integrity, and grinding.

MAE 5133*
Mechanical Behavior of Materials
Prerequisite: ENSC 3313 or equivalent. A unified approach to the behavior and response of engineering materials to applied loads. Mechanical and metallurgical fundamentals of deformation processes. Spatial scales of atomic physics, micromechanics and continuum mechanics.

MAE 5143*
Tribology
Prerequisite: Graduate standing or consent of instructor. The principles of tribology. Definition of tribology, contact of solids, surface topography, real area of contact, friction of various materials, basic mechanisms of friction, mechanisms of wear (adhesion, abrasion, fatigue, erosion, and fretting), hardness of solids, frictional heating and surface temperatures, material properties that influence surface interactions, surface roughness measurement, surface integrity residual stresses and subsurface deformation, application of tribology to manufacturing, wear resistant materials, wear-resistant coatings, experimental methods in tribology, surface analytical tools in tribology, scanning tunneling microscopy/atomic force microscopy, wear monitoring and wear prevention, and systems approach to tribology.

MAE 5153*
Precision Engineering I
Prerequisite: Graduate standing or consent of instructor. An integrated approach to underlying engineering principles governing product and process designs requiring accuracies typically better than 1 part in 106. Design and control of precision machines and instruments, dimensional and surface metrology, scanning probe microscopy, ultra-precision machining and grinding, and precision assembly.

MAE 5233*
Viscous Fluid Dynamics
Prerequisite: ENSC 3233. The dynamics of viscous flow over external surfaces, inside channels, and in free shear layers. Boundary layer solutions. Theory of similarity. Approximation methods.

MAE 5243*
Micro Flows
Prerequisite: Graduate standing or consent of instructor. Fundamentals and simulation of micro flows including governing equation, slip models, shear- and pressure-driven micro flows. Thermal effects in micro scales. Applications; MEMS and micro propulsion. Numerical methods for continuum simulation and atomistic simulation.

MAE 5253*
Multiphase Flow
Prerequisite: Graduate standing. Theory, methods and practical experience for studying complex transient multiphase flows: basic concepts and definition, dynamics of bubbles, drops and rigid particles, gas-liquid transport in ducts, fluid-solid transport in ducts, aerosol and spray systems, foam, fluidization, particle separation systems multiphase flow in porous media, breakup of liquid sheets and jets, modeling, advanced experimental techniques for multiphase flow.

MAE 5263*
Combustion
Prerequisite: MAE 3233. Theory, design and performance of combustion systems. Fundamentals of aerothermochemistry fluid dynamics, heat transfer and combustion. Laminar and turbulent flows. Diffusion and premixed flames. Pollutant reduction. Numerical simulation and solution.

MAE 5403*
Computer-aided Analysis and Design
Prerequisites: Undergraduate course in computer programming and consent of professor. Theory, application and implementation of digital-computer-oriented algorithms for the synthesis, simulation, analysis and design of engineering systems. Advanced FORTRAN methods for optimization, simulation and data analysis. Implementation of these methods uses program libraries, batch processing, remote terminals and graphic display units.

MAE 5413*
Optimal Control
Prerequisite: MAE 5713 or ECEN 5713. Optimal control theory for modern systems design. Specification of optimum performance indices. Dynamic programming, calculus of variations and Pontryagin's minimum principle. Iterative numerical techniques for trajectory optimization. (Same course as ECEN 5413*)

MAE 5433*
Robotics, Kinematics, Dynamics and Control
Prerequisite: MAE 4053 or ECEN 4413 or consent of instructor. Kinematic and dynamic analysis of robot manipulators. Inverse kinematics, motion planning and trajectory generation. Industrial practice in robot servo control. Dynamics and control in the presence of constraints. Actuators and sensors. Force sensors and vision systems. Robotic force control and its applications in industry. Passivity based control algorithms. Advanced control techniques for motion and force control. (Same course as ECEN 5433*)

MAE 5463*
Nonlinear System Analysis and Control
Prerequisite: MAE 4053 or ECEN 4413. Failure of superposition of effects; phase-plane analysis; limit-cycles; Lyapunov stability; hyperstability and input-output stability; controllability and observability of nonlinear systems; feedback linearization; robust nonlinear control system design. (Same course as ECEN 5463*)

MAE 5473*
Digital Control Systems
Prerequisite: MAE 4053 or ECEN 4413. Input output and state space representations of linear discrete-time systems. Approximate methods in discrete-time representation. Stability methods. Controllability, observability, state estimation, and parameter identification. Design and analysis of feedback control system using frequency-domain and state-space methods. Introduction to optimal control. (Same course as ECEN 5473*)

MAE 5483*
Digital Data Acquisition and Control
Prerequisite: Undergraduate course in programming. Use of microcomputers operating in real-time applied to engineering systems for data acquisition and control, use of analog to digital, digital to analog, and digital input/output, synchronous and asynchronous programming. Competence in the engineering use of microcomputers through lectures and laboratory applications. (Same course as ECEN 5483*)

MAE 5503*
Mechanics of Advanced Composites for Structural Design
Prerequisites: ENSC 2113, ENSC 2143 or consent of instructor. Basic principles governing the micro-mechanics of a lamina, and the macro-mechanics of a laminate are discussed in detail. Analysis of continuous fiber, short-fiber, and woven-fiber polymer matrix composites. A computer program for a analysis and design of composite laminates is developed.

MAE 5513*
Stochastic Systems
Prerequisites: ECEN 3513 and 4503 or STAT 4033 or MAE 4053 or MAE 4063 or consent of instructor. Theory and applications involving probability, random variables, functions of random variables, and stochastic processes, including Gaussian and Markov processes. Correlation, power spectral density, and non-stationary random processes. Response of linear systems to stochastic processes. State-space formulation and covariance analysis.
(Same course as ECEN 5513*)

MAE 5523*
Estimation Theory
Prerequisite: MAE 5513 or ECEN 5513. Stochastic model development, parameter estimation and state estimation. The linear model, model order determination, least squares, estimation, maximum likelihood estimation, Bayesian estimation. Gaussian random vectors, estimation in linear and Gaussian models, state estimation, the Kalman filter, prediction and smoothing. (Same course as ECEN 5523*)

MAE 5533*
Analysis of Structural Systems
Prerequisite: MAE 3323. Computer-oriented matrix methods in the analysis of linear structural systems; energy principles; matrix equations for static and dynamic analyses of elastic systems; stability.

MAE 5543*
Modern Materials
Prerequisite: ENSC 3313. Properties, applications and recent innovations of structural engineering materials. Metals, ceramics, polymers and composites considered.

MAE 5553*
Fatigue and Fracture Mechanics
Prerequisite: MAE 4333 or consent of instructor. Fracture processes in engineering materials including design considerations, failure avoidance and predictability. Fatigue processes and high-strength, toughness-limited materials.

MAE 5563*
Finite Element Methods
Prerequisite: Graduate standing or consent of instructor. Introduction to the finite element method in mechanical engineering. Numerical and mathematical formulations including an introduction to variational methods. Computer applications in solid mechanics, heat transfer and fluid mechanics.

MAE 5573*
Continuum Mechanics
Prerequisite: Consent of instructor. Principles governing the mechanics of continua. Kinematics of deformation, including the Lagrangian and Eulerian descriptions. Development of stress and strain tensors. Conservation principles to derive field equations describing solid and fluid mechanics. Application to problems in linear elasticity and viscous fluid flow.

MAE 5583*
Corrosion Engineering
Lab 2. Prerequisite: ENSC 3313. Modern theory of corrosion and its applications in preventing or controlling corrosion damage economically and safely in service.

MAE 5593*
Theory of Viscoelasticity
Prerequisite: Consent of instructor. Advanced stress analysis in solids exhibiting time-dependent behavior. Material characterization and thermodynamic foundation of the constitutive behavior of time-dependent materials such as polymers, solid propellants and metals near their melting points; time-temperature; superposition principle for thermo-rheologically simple materials; correspondence principle for linearly viscoelastic and associated linearly elastic solutions; integral formulation for quasistatic boundary value problems; treatment of time-varying boundary conditions such as moving boundaries and moving loads; linearly viscoelastic stress waves and approximate methods of linearly viscoelastic stress analysis.

MAE 5633*
Advanced Thermal Systems
Prerequisites: MAE 3223, MAE 3233, ENSC 3233. Analysis, design, simulation and optimization of thermal systems. Engineering applications to HVAC systems, refrigeration systems, ground-source heat pump systems.

MAE 5653*
Refrigeration
Prerequisite: MAE 3223. Thermal engineering or refrigeration and heat pump systems, vapor compression systems, absorption refrigeration cycles, cryogenics, compressors, heat exchangers, refrigerant control devices, laboratory simulators and measurements, socio-economic and environmental impact of systems and refrigerants.

MAE 5663*
Advanced Finite Element Analysis
Prerequisite: MAE 5563 or consent of instructor. Development of three-dimensional isoparametric solid elements using Lagrange and serendipity family of elements, solution of three-dimensional thermoelasticity problems, linear time dependent problems, variational formulation and computer implementation of structural dynamics analysis using implicitly operators, implementation of three-dimensional diffusion and heat transfer analysis, solution of a nonlinear system of equations, and finite element analysis using commercial software packages.

MAE 5673*
Mechanics of Fracture, Contact and Friction
Prerequisite: Graduate standing or consent of instructor. Rigorous derivation and presentation of the equations of fracture mechanics, contact and friction. Equations of solid mechanics and mathematical preliminaries, elastic stress field near a crack tip, stress intensity factors, fracture toughness, Griffith solution and J-integral, elastic-plastic fracture, fatigue, Dugdale model and cohesive zone laws, experimental techniques in fracture mechanics, contact mechanics, friction modeling. More advanced topics and projects will be chosen from interfacial crack growth, subsonic and intersonic dynamic fracture, rate- and state-dependent friction laws, fracture and friction at the small scales (nanomechanics), and finite-element analysis using commercial packages.

MAE 5683*
Advanced Materials Science I
Notions of energy, entropy, equilibrium, macrostates, and microstates and their relation to material processes and properties. Deriving material properties from equations of state: Maxwell relations. Statistical thermodynamics: predicting material properties from microstates. Partition function. Phase transformations. Thermodynamics of surfaces and defects. Electrochemistry.

MAE 5703*
Optimization Applications
Prerequisite: Graduate standing. A survey of various methods of unconstrained and constrained linear and non-linear optimization. Applications of these methodologies using hand-worked examples and available software packages. Intended for engineering and science students. (Same course as CHE 5703*, ECEN 5703* & IEM 5023*)

MAE 5713*
Linear Systems
Prerequisite: Graduate standing or consent of instructor. Introduction to the fundamental theory of finite-dimensional linear systems with emphasis on the state-space representation. Mathematical representations of systems; linear dynamic solutions; controllability, observability, and stability; linearization and realization theory; and state feedback and state observer. (Same course as ECEN 5713*)

MAE 5733*
Neural Networks
Prerequisite: Graduate standing. Introduction to mathematical analysis of networks and learning rules, and on the application of neural networks to certain engineering problems image and signal processing and control systems. (Same course as CHE 5733* & ECEN 5733*)

MAE 5743*
Geometric Modeling for Design and Manufacturing
Prerequisite: C programming or consent of instructor. Application of parametric geometry for engineering design and manufacturing. Representation of curves, surfaces and solids. Analytic and relational properties. Fundamentals of solid modeling.

MAE 5773*
Intelligent Systems
Prerequisite: MAE 5733 or ECEN 5733. Introduction to the state-of-the art intelligent control and system successfully deployed to industrial and defense applications. Emerging intelligent algorithms (e.g., bottom-up, top-down, seminotics); reinforcement learning and hybrid systems; and case studies and design projects. (Same course as ECEN 5773*)

MAE 5803*
Advanced Thermodynamics I
Prerequisite: MAE 3223. A rigorous examination of the fundamental principles of engineering thermodynamics; the First Law, the pure substance, flow processes, Second Law availability, properties of substances, thermochemistry, mixtures and equilibrium.

MAE 5823*
Radiation Heat Transfer
Prerequisites: MAE 3233 or equivalent and graduate standing or consent of instructor. The mechanism of the transfer of energy by thermal radiation; radiant properties of materials, energy transfer prediction methods and solar energy topics.

MAE 5843*
Conduction Heat Transfer
Prerequisite: ENSC 3233. Advanced heat transfer analysis and design, with primary emphasis on conduction.

MAE 5853*
Computational Heat Transfer
Prerequisite: MAE 3233, graduate standing, knowledge of FORTRAN. Computational techniques for the solution of two-dimensional heat transfer, fluid flow and related processes in problems of practical interest. A general-purpose computer program used to demonstrate the capabilities of the numerical method through a wide variety of engineering problems.

MAE 5863*
Building Heat Transfer and Simulation
Prerequisites: MAE 3223, MAE 3233, ENSC 3233. Conduction, convection and radiation heat transfer applied to building thermal simulation. Solar radiation.

MAE 5873*
Advanced Indoor Environmental System
Prerequisite: MAE 4703. Heating, air-conditioning, ventilation and refrigeration systems. System and component analysis, design and simulation.

MAE 5913*
Advanced Aerodynamics
Prerequisite: ENSC 3233 or equivalent. Aerodynamics of the subsonic, transonic, supersonic, and hypersonic flow regimes. Derivation of governing equations and fundamental principles. Analytical and computational analysis methods. Recent developments.

MAE 5923*
Guidance and Control of Aerospace Vehicles
Prerequisite: MAE 4053 or ECEN 4413 or equivalent. Navigation, guidance and attitude control of aircraft, launch vehicles and spacecraft. Inertial navigation mechanizations and error analysis. Stability augmentation systems.

MAE 5933*
Aeroelasticity
Prerequisite: Graduate standing or consent of instructor. Interaction between fluid dynamic, inertial and elastic forces. Development of analytical and computational methods for analysis. Application to a broad range of problems in engineering.

MAE 5943*
Unsteady Aerodynamics and Aeroacoustics
Prerequisite: ENSC 3233 or equivalent. Development of governing fluid dynamic equations for unsteady flows; linear unsteady aerodynamics for isolated and cascaded lifting surfaces; acoustics in moving media; three-dimensional duct acoustics; sound generation from isolated airfoils, cascaded airfoils, rotor-stator interactions, multiple pure-tone sources, propellers and jets.

MAE 5993*
Microstructural Mechanics
Prerequisite: Graduate standing or consent of instructor. Build a framework to understand the various microstructures of materials with their respective roles in controlling mechanical properties. Grain size, orientation, surface facets, compositional gradients, and second or multiple phases, in combination with the three-dimensional arrangement of the various types of imperfections, together constitute the microstructure of a material. An emphasis will be placed on new research areas and exposure to methods for controlling and probing microstructures.

MAE 6000*
Research and Thesis
1-15 credits, max 30. Prerequisites: Consent of the head or the graduate committee of the School and approval by the student's advisory committee. Independent research under the direct supervision of a member of the graduate faculty. For students pursuing study beyond the level of the MS degree.

MAE 6010*
Advanced Study
1-12 credits, max 12. Prerequisites: Approval of the student's advisory committee. Study and investigation under the supervision of a member of the faculty along lines of interest well advanced of and supported by the 5000-series courses.

MAE 6123*
Non-traditional Machining
Prerequisites: MAE 3123, MAE 5123 and graduate standing or consent of instructor. Rationale for non-traditional machining; various non-traditional machining processes, including electro-discharge machining, electro-chemical machining, plasma arc-, microwave-, and laser assisted processing, waterjet (abrasive) cutting, ultrasonic machining, chemical machining, thermal assisted processing and electron beam machining.

MAE 6133*
Surface Mechanics
Prerequisite: Consent of instructor. Models and solutions basic to surface studies. Equations of continuum mechanics, thermal field solutions at sliding interfaces, elasticity, plasticity. Applications of solution techniques to surface, surface layer and interface phenomena.

MAE 6143*
Thermal Analysis of Manufacturing Processes
Prerequisites: Graduate standing and consent of instructor. Thermal analysis of various moving heat source problems encountered in a variety of manufacturing processes, including machining, grinding, polishing, casting, welding, energy beam cutting and other tribological applications such as meshing of gears, cams, bearings. Analysis of both transient and steady state conditions.

MAE 6233*
Turbulent Fluid Dynamics
Prerequisites: MAE 5233. Isotropic turbulence, turbulent wakes and jets, bound turbulent shear flows, transition, hydrodynamic stability and integral calculation methods for turbulent boundary layers.

MAE 6263*
Computational Fluid Dynamics
Prerequisite: MAE 5233. Steam function-vorticity and pressure-velocity simulations of incompressible and compressible flows. Temperature and concentration solutions. Applications to various external and internal flow problems.

MAE 6423*
System Identification
Prerequisite: MAE 5473 or MAE 5713 or ECEN 5473 or ECEN 5713. Linear and nonlinear system modeling of random systems. Models of linear time-invariant systems, nonparametric methods and preliminary model development, parameter estimation methods, convergence and consistency, asymptotic distributions of parameter estimates, nonlinear modeling. (Same course as ECEN 6423*)

MAE 6453*
Adaptive Control
Prerequisite: MAE 5473 or ECEN 5473 or ECEN 5713 or MAE 5713. Analysis and design of control techniques which modify their performance to adapt to changes in system operation. Review of systems analysis techniques, including state variable representations, linearization, discretization, covariance analysis, stability, and linear quadratic gaussian design. On-line parameter estimation, model reference adaptive systems, self-tuning regulators, stable adaptive systems.
(Same course as ECEN 6453*)

MAE 6463*
Advances in Nonlinear Control
Prerequisite: MAE 5463 or ECEN 5463. Introduction to vector fields and Lie algebra; controllability and observability of nonlinear systems; local decompositions; input-output and state-space representation on non-linear systems; feedback linearization; controlled invariance and distribution; control of Hamiltonian systems. (Same course as ECEN 6463*)

MAE 6483*
Robust Multivariable Control Systems
Prerequisite: MAE 5713 or ECEN 5713. Introduction to multivariable systems: SISO robustness vs. MIMO robustness; multivariable system poles and zeros; MIMO transfer functions; multivariable frequency response analysis; multivariable Nyquist theorem; performance specifications; stability of feedback systems; linear fractional transformations (LFT's); parameterization of all stabilizing controllers; structured singular value; algebraic ricatti equations; H2 optimal control; H-infinity controller design. (Same course as ECEN 6483*)

MAE 6823*
Advanced Radiative Transfer
Prerequisite: MAE 5823. Radiative energy transfer within participating media and among real surfaces. Anisotropic scattering, emission, refractive index effects, and wavelength-dependent analysis. Current solution techniques—approximate and exact. Relationship of electric fields to radiative transfer. Combined radiation with conduction and/or convection. A project concerned with a unique radiative transfer problem.

MAE 6843*
Convection Heat Transfer
Prerequisite: MAE 5233 or equivalent. Advanced convective heat transfer in laminar and turbulent flows over external surfaces and inside channels. Heat transfer at high velocities, free convection boundary layers, and mass transfer.