# Mechanical & Aerospace Engr (MAE)

**MAE 200 Introduction to Mechanical Engineering Design** (1 credit hours)
Introduction to mechanical engineering and its application in professional practice. Includes mechanical engineering vocabulary, measurement concepts, safety training, demonstration of basic machine components and systems, dissection of mechanical engineering devices, simple drawing and sketching, 3d printing, technical communication, design, creation of Online Portfolio. (5-week course)

Restriction: Sophomore standing in Mechanical Engineering
*Typically offered in Fall, Spring, and Summer*

**MAE 201 Engineering Thermodynamics I** (3 credit hours)
Introduction to the concept of energy and the laws governing the transfers and transformations of energy. Emphasis on thermodynamic properties and the First and Second Law analysis of systems and control volumes. Integration of these concepts into the analysis of basic power cycles is introduced.

Prerequisite: MA 242, PY 208 or 202
*Typically offered in Fall, Spring, and Summer*

**MAE 206 Engineering Statics** (3 credit hours)
Basic concepts of forces in equilibrium. Distributed forces, frictional forces. Inertial properties. Application to machines, structures, and systems. Credit is not allowed for both MAE 206 and CE 214.

Prerequisite: C or better in both MA 241 and PY 205
*Typically offered in Fall, Spring, and Summer*

**MAE 208 Engineering Dynamics** (3 credit hours)
Kinematics and kinetics of particles in rectangular, cylindrical, and curvilinear coordinate systems; energy and momentum methods for particles; kinetics of systems of particles; kinematics and kinetics of rigid bodies in two and three dimensions; motion relative to rotating coordinate systems.

Prerequisite: MA 242 and C- or better in MAE 206 or CE 214
*Typically offered in Fall, Spring, and Summer*

**MAE 214 Solid Mechanics** (3 credit hours)
Concepts and theories of internal force, stress, strain, and strength of structural element under static loading conditions. Constitutive behavior for linear elastic structures. Deflection and stress analysis procedures for bars, beams, and shafts.Introduction to matrix analysis of structures.

Prerequisites: MA 242 and C- or better in (MAE 206 or CE 214)
*Typically offered in Fall, Spring, and Summer*

**MAE 250 Introduction to Aerospace Engineering** (1 credit hours)
The objective of this course is to introduce students to the fundamental concepts associated with aerospace engineering. This will be done through lectures focused on fluid flow, structures, dynamics, and complex system design. Students will also engage in hands-on mini-projects that will provide a design experience. Final efforts will culminate in a design portfolio project. 14AE BS Majors only.

*Typically offered in Fall only*

**MAE 251 Aerospace Vehicle Performance** (3 credit hours)
Introduction to the problem of performance analysis in aerospace engineering. Aircraft performance in gliding, climbing, level, and turning flight. Calculation of vehicle take-off and landing distance, range and endurance. Elementary performance design problems. Introduction to space flight.

Prerequisite: Cumulative GPA 2.0 or higher and a grade of C or better in both MA 241 and PY 205; Corequisite: CSC 113
*Typically offered in Fall only*

**MAE 252 Aerodynamics I** (3 credit hours)
Fundamentals of perfect fluid theory with applications to incompressible flows over airfoils, wings, and flight vehicle configurations.

Prerequisites: MA 242 and C- or better in MAE 251
*Typically offered in Spring only*

**MAE 253 Experimental Aerodynamics I** (1 credit hours)
Subsonic wind tunnel, instrumentation, data acquisition techniques, technical report preparation. Experiments involve pressure and force/moment measurements of various aerospace vehicle components with supplemental flow visualization.

Corequisites: MAE 252
*Typically offered in Spring only*

**MAE 302 Engineering Thermodynamics II** (3 credit hours)
Continuation of Engineering Thermodynamics I with emphasis on the analysis of power and refrigeration cycles and the application of basic principles to engineering problems with systems involving mixtures of ideal gases, psychrometrics, nonideal gases, chemical reactions, combustion, chemical equilibrium cycle analysis, and one-dimensional compressible flow.

Prerequisites: CSC 113, C- or better in MAE 201
*Typically offered in Fall, Spring, and Summer*

**MAE 305 Mechanical Engineering Laboratory I** (1 credit hours)
Theory and practice of measurement and experimental data collection. Laboratory evaluation and demonstration of components of the generalized measurement system and their effects on the final result. Applications of basic methods of data analysis aswell as basic instrumentation for sensing, conditioning and displaying experimental qualities. (Instruction and practice in technical report writing.)

*Typically offered in Fall, Spring, and Summer*

**MAE 306 Mechanical Engineering Laboratory II** (1 credit hours)
Continuation of MAE 305 into specific types of measurements. Students evaluate and compare different types of instrumentation for measuring the same physical quantity on the basis of cost, time required, accuracy, etc. (Oral and written presentation of technical material).

Prerequisite: MAE 305
*Typically offered in Fall, Spring, and Summer*

**MAE 308 Fluid Mechanics** (3 credit hours)
Development of the basic equations of fluid mechanics in general and specialized form. Application to a variety of topics including fluid statics; inviscid, incompressible fluid flow; design of Fluid dynamic system.

Prerequisite: MA 242 and C- or better in MAE 208
*Typically offered in Fall, Spring, and Summer*

**MAE 310 Heat Transfer Fundamentals** (3 credit hours)
Analysis of steady state and transient one and multidimensional heat conduction employing both analytical methods and numerical techniques. Integration of principles and concepts of thermodynamics and fluid mechanics to the development of practicalconvective heat transfer relations relevant to mechanical engineers. Heat transfer by the mechanism of radiation heat transfer.

Prerequisite: MA 341 and C- or better in MAE 201
*Typically offered in Fall, Spring, and Summer*

**MAE 315 Dynamics of Machines** (3 credit hours)
Application of dynamics to the analysis and design of machine and mechanical components. Motions resulting from applied loads, and the forces required to produce specified motions. Introduction to mechanical vibration, free and forced response of discrete and continuous systems.

Prerequisite: MA 341 and C- or better in MAE 208
*Typically offered in Fall, Spring, and Summer*

**MAE 316 Strength of Mechanical Components** (3 credit hours)
Analysis and design of mechanical components based on deflection, material, static strength and fatigue requirements. Typical components include beams, shafts, pressure vessels and bolted and welded joints. Classical and modern analysis and design techniques. Computer analysis using the finite element method. Material and manufacturing considerations in design.

Prerequisite: C- or better in MAE 214 or CE 313
*Typically offered in Fall, Spring, and Summer*

**MAE 342 Introduction to Automotive Engineering** (3 credit hours)
Fundamental aspects of automotive engineering. Examines various automotive systems [engine, brakes, suspension etc.] as well as their interactions in such areas as safety and performance. Current practices and development for the future.

Prerequisite: MAE 206, MAE 208, MAE 201, MAE 308, MAE 315
*Typically offered in Spring only*

**MAE 351 Aerodynamics II** (3 credit hours)
Concepts of thermodynamics, compressible fluid flow, and shock waves with application to computing the aerodynamic characteristics of airfoils, wings and flight configurations at high speed.

Prerequisites: MAE 252 and C- or better in MAE 201
*Typically offered in Spring only*

**MAE 352 Experimental Aerodynamics II** (1 credit hours)
Advanced stability and control experiments in the subsonic wind tunnel and external compressible flow experiments in the supersonic wind tunnel.

Prerequisite: MAE 253, Corequisite: MAE 351
*Typically offered in Spring only*

**MAE 361 Dynamics & Controls** (3 credit hours)
Dynamics and linear feedback control of aerospace and mechanical systems. Concepts from linear system theory, kinematics, particle dynamics, first- and second-order systems, system dynamics, vibrations, and computational techniques. Feedback controlby root-locus, Nyquist, Bode plots, servo-mechanisms, gain and phase margin, and compensation. Control system design emphasized.

Prerequisite: MA 341 and C- or better in MAE 208
*Typically offered in Fall only*

**MAE 371 Aerospace Structures I** (3 credit hours)
Determination of appropriate analysis techniques for Aerospace Structures. Introduction of governing equations and selected solutions for typical structures. Use of these concepts in the design of a representative structural component.

Prerequisite: C- or better in MAE 214 or CE 313
*Typically offered in Fall only*

**MAE 372 Aerospace Vehicle Structures Lab** (1 credit hours)
Demonstration and application of the concepts that have been presented in MAE 371 and MAE 472. Fabrication techniques and the design and construction of a structural component will be emphasized.

Corequisite: MAE 371
*Typically offered in Fall only*

**MAE 403 Air Conditioning** (3 credit hours)
Design of a complete air conditioning system for a building. Introduction, Design Objectives - Building Description, Review of Psychrometrics and Air Conditioning Processes, Cooling and Heating Load Calculation, Space Air diffusion, Duct Lay-out and Design, Equipment Selection, Pipe Sizing, Life-cycle Cost Analysis.

Prerequisite: MAE 302, MAE 310, MAE 308
*Typically offered in Spring only*

**MAE 405 Controls Lab** (1 credit hours)
Laboratory experiments demonstrate the essential features of classical and modern control theory for single-input and single-output systems.

Corequisite: MAE 435
*Typically offered in Fall, Spring, and Summer*

**MAE 406 Energy Conservation in Industry** (3 credit hours)
Application of energy conservation principles to a broad range of industrial situations with emphasis on typical equipment encountered as well as the effect of recent environmental regulations. Topics covered include: steam generators, pollution control, work minimization, heat recovery, steam traps, industrial ventilation, electrical energy management, and economics. Field trip to conduct tests and evaluate operation at three NCSU steam plants.

Prerequisite: MAE 302, MAE 310
*Typically offered in Fall only*

**MAE 407 Steam and Gas Turbines** (3 credit hours)
Fundamental analysis of the theory and design of turbomachinery flow passages; control and performance of turbomachinery; gas-turbine engine processes.

Prerequisite: MAE 302 and (MAE 308 or MAE 252)
*Typically offered in Fall only*

**MAE 408 Internal Combustion Engine Fundamentals** (3 credit hours)
Fundamentals common to internal combustion engine cycles of operation. Otto engine: carburetion, combustion, knock, exhaust emissions and engine characteristics. Diesel engine: fuel metering, combustion, knock, and performance. Conventional and alternative fuels used in internal combustion engines.

Prerequisite: MAE 302
*Typically offered in Fall only*

**MAE 410 Modern Manufacturing Processes** (3 credit hours)
Introduction to modern manufacturing processes and technologies. Topics to be covered include traditional machining, laser and electrochemical machining, electro-discharge machining, geometric dimensioning & tolerancing, tolerance chart, statistical process control, metal forming, metal casting, rapid prototyping, welding, micro-fabrication, hybrid processes, and computer aided manufacturing. To relate theory taught in class with practice, the course includes mini projects on machining, rapid prototyping, and material testing.

Prerequisite: MAE 316 or MAE 371
*Typically offered in Fall and Spring*

**MAE 412 Design of Thermal System** (3 credit hours)
Applications of thermodynamics, fluid mechanics, and heat transfer to thermal systems with an emphasis on system design and optimization. Design of heat exchangers. Analysis of engineering economics, including time value of money, present and future worth, payback period, internal rates of return, and cost benefit analysis. Review of component model for pipes, pumps, fans, compressors, turbines, evaporators, condensers and refrigerators. Simulation methods for finding the operating point for thermal systems. Design of thermal systems through methods of optimization.

Prerequisite: MAE 302, MAE 308, MAE 310
*Typically offered in Fall and Spring*

**MAE 413 Design of Mechanical Systems** (3 credit hours)
Integration of the physical sciences, mathematics, and engineering to solve real-world mechanical engineering design problems. Design of mechanical elements including: fasteners, welds, springs, bearings, gears, belts, brakes, clutches, flywheels, shafts. Emphasis on open-ended problems which contain superfluous information and/or insufficient data. Solution techniques focus on problem definition,reduction to a solvable system, and development of a design response. Team based projects. Formal written communication of results.

Prerequisite: MAE 315 and MAE 316
*Typically offered in Fall only*

**MAE 415 Mechanical Engineering Design I** (3 credit hours)
The first course in the sequence of a two-semester capstone senior design project. Teamwork, independent learning and communication skills are emphasized. Team of students practice engineering design process through: problem definition, research, brainstorming, optimization, critical review and analysis. Lectures focus on conceptual design, embodiment design, and quality. Communication skills are developed through reports and presentations.

Prerequisite: MAE 315, MAE 316, MAE 302, MAE 308 and MAE 310
*Typically offered in Fall only*

**MAE 416 Mechanical Engineering Design II** (4 credit hours)
The second course in the sequence of a two-semester capstone senior design project. Teamwork, independent learning and communication skills are emphasized. Building on the experience and knowledge from Mechanical Engineering Design I, teams of students extend engineering design process through: investigation, critical review, analysis, and prototype construction and testing. Communication skills are developed through reports and presentations.

Prerequisite: MAE 415
*Typically offered in Spring only*

**MAE 420/MAE 520 Dynamic Analysis of Human Movement** (3 credit hours)
Topics in movement biomechanics and computational analyses of movement, including muscle physiology and mechanics, advanced muscle modeling, neural control of muscle and motor control theories, and dynamic simulation and optimization. Discussion of fundamental research underpinnings and clinical and sports applications.

P: MAE208 or equivalent
*Typically offered in Spring only*

**MAE 421 Design of Solar Thermal Systems** (3 credit hours)
Analysis and design of active and passive solar thermal systems for residential and small commercial buildings. Solar insulation, flat plate collectors, thermal storage, heat exchanges, controls, design, performance calculations, economics. Site evaluation, shading, suncharts, types of passive systems. Heating load analysis. Overview of photovoltaics. On-site evaluation of NCSU Solar House.

Prerequisite: MAE 302, MAE 310
*Typically offered in Spring only*

**MAE 426/MAE 526 Fundamentals of Product Design** (3 credit hours)
Many think of design as more of an art than a science. However, the growing body of research in the engineering design community teaches us ways to navigate the design of consumer products using interdisciplinary design tools and rational decision making. This course introduces students to scientific design techniques that are more effective than "ad hoc" tactics. By exploring how engineering principles integrate with "real world" design challenges, students will learn to solve product design problems that encompass heterogeneous markets, multiple disciplines, and large-scale complex systems.

Prerequisite: MA 241
*Typically offered in Spring only*

**MAE 430 Applied Finite Element Analysis** (3 credit hours)
Finite element modeling techniques for solving real-world engineering problems are discussed. Theory of finite element discretization is highlighted follow by software implementation, emphasis is given on accurate prescription of boundary conditions that represent actual physical systems, modeling exercises and projects include solid structural problems, heat transfer, structural vibrations, fluid dynamics and contact problems, modeling is carried out using commercial software packages.

Prerequisite: MAE 201 and (MAE 316 or MAE 371)
*Typically offered in Fall and Spring*

**MAE 435 Principles of Automatic Control** (3 credit hours)
Study of linear feedback control systems using transfer functions. Transient and steady state responses. Stability and dynamic analyses using time response and frequency response techniques. Compensation methods. Classical control theory techniquesfor determination and modification of the dynamic response of a system. Synthesis and design applications to typical mechanical engineering control systems. Introduction to modern control theory.

Prerequisites: MAE 315 or MAE 361
*Typically offered in Fall, Spring, and Summer*

**MAE 440 Non-Destructive Testing and Evaluation** (3 credit hours)
NDT/NDE is a 3-credit elective course covering the general defect and damage types in materials and structures, principles of NDT/NDE techniques, and NDT/NDE applications. Associated lab modules (3 weeks) provide hands-on opportunities to students on often used NDT/NDE methods including magnetic particle, ultrasonics, and eddy current methods. A final project team will work on research and industrial NDT/NDE solutions.

Junior or Senior standing in the College of Engineering
*Typically offered in Fall only*

**MAE 451 Experimental Aerodynamics III** (1 credit hours)
Laboratory experiments in internal compressible flow and boundary layers in conjunction with MAE 458 or MAE 459. Topics include nozzle flows, constant area duct flows, component/overall performance of a gas turbine, and boundary layer analysis.

Prerequisite: MAE 352, Corequisite: MAE 458 or MAE 459
*Typically offered in Fall only*

**MAE 452 Aerodynamics of V/STOL Vehicles** (3 credit hours)
Introduction to the aerodynamics and performance of vertical and short take-off and landing vehicles. Aerodynamics of propellers and rotors. High lift devices.

*Typically offered in Fall only*

**MAE 455 Boundary Layer Theory** (3 credit hours)
Introduction to the Navier-Stokes Equations and boundary layer approximations for incompressible flow. Calculation techniques for laminar and turbulent boundary layer parameters which affect lift, drag, and heat transfer on aerospace vehicles. Discussions of compressible flows.

Prerequisite: MAE 252 or MAE 308
*Typically offered in Fall only*

**MAE 456 Computational Methods in Aerodynamics** (3 credit hours)
Introduction to computational methods for solving exact fluid equations. Emphasis on development of the fundamentals of finite difference methods and their application to viscous and inviscid flows.

Prerequisite: MAE 252
*Typically offered in Spring only*

**MAE 457 Flight Vehicle Stability and Control** (3 credit hours)
Longitudinal, directional and lateral static stability and control of aerospace vehicles. Lineralized dynamic analysis of the motion of a six degree-of-freedom flight vehicle in response to control inputs and disturbance through use of the transfer function concept. Control of static and dynamic behavior by vehicle design (stability derivatives) and/or flight control systems.

Prerequisite: MAE 252 and (MAE 361 or MAE 315)
*Typically offered in Spring only*

**MAE 458 Propulsion** (3 credit hours)
One-dimensional, internal, compressible flow including: isentropic flow, normal shocks, flow with friction and simple heat addition. Applications to air-breathing aircraft propulsion systems. Performance, analysis and design of components and overall performance of air-breathing engines.

Prerequisite: MAE 351
*Typically offered in Fall only*

**MAE 459 Rocket Propulsion** (3 credit hours)
Study of chemical rockets. This includes nozzle theory, flight performance, thermochemical calculations, and component and system analysis and design.

Prerequisite: MAE 351or MAE 302
*Typically offered in Fall only*

**MAE 467 Introduction to Space Flight** (3 credit hours)
Fundamental aspects of space flight including launch vehicle performance and design, spacecraft characteristics, two-body orbital mechanics, earth satellites, interplanetary trajectories, atmospheric entry, and atmospheric heating.

Prerequisites: MAE 361 or MAE 315
*Typically offered in Spring only*

**MAE 470/MAE 570 Space Exploration Systems** (3 credit hours)
This course will cover topics related to space exploration systems. In particular, the basic concepts of orbital mechanics needed for space mission planning will be covered, along with the essential subsystems found on a typical spacecraft.

Prerequisite: MAE 467 Introduction to Space Flight or Graduate Standing and Consent of Instructor
*Typically offered in Fall only*

**MAE 472 Aerospace Structures II** (3 credit hours)
A continuation of MAE 371; deflection of structures, indeterminate structures, minimum weight design fatigue analysis and use of matrix methods in structural analysis. Selection of materials for aircraft construction based on mechanical, physical, and chemical properties.

Prerequisite: MAE 371
*Typically offered in Spring only*

**MAE 480 Aerospace Vehicle Design I** (3 credit hours)
A synthesis of previously acquired theoretical and empirical knowledge and application to the design of practical aerospace vehicle systems.

Prerequisites: (MAE 457 or MAE 467) and MAE 252 and MAE 371; Restrictions: Senior standing and Aerospace Engineering Majors
*Typically offered in Fall only*

**MAE 481 Aerospace Vehicle Design II** (3 credit hours)
A continuation of MAE 480. Designs are refined and vehicles constructed and instrumented by students. A flight test program is designed and carried out in cooperation with MAE 525 students.

Prerequisite: MAE 480
*Typically offered in Spring only*

**MAE 482/ECE 482 Engineering Entrepreneurship and New Product Development I** (3 credit hours)
Applications of engineering, mathematics, basic sciences, finance, and business to the design and development of prototype engineering products. This course requires a complete written report and an end-of-course presentation. This is the first course in a two semester sequence. Students taking this course will implement their designed prototype in ECE 483: Senior Design Project in Electrical Engineering and Computer Engineering II-Engineering Entrepreneurs. Departmental approval required.

*Typically offered in Fall only*

**MAE 483/ECE 483 Engineering Entrepreneurship and New Product Development II** (3 credit hours)
Applications of engineering, science, management and entrepreneurship to the design, development and prototyping of new product ideas. Based on their own new product ideas, or those of others, students form and lead entrepreneurship teams (eTeams) to prototype these ideas. The students run their eTeams as 'virtual' startup companies where the seniors take on the executive roles. Joining them are students from other grade levels and disciplines throughout the university that agree to participate as eTeam members. Departmental approval required.

Prerequisite: ECE 482
*Typically offered in Fall and Spring*

**MAE 484 Engineering Entrepreneurship Senior Design Lab** (1 credit hours)
This is the lab for MAE 483. Applications of engineering, science, management, and entrepreneurship to the design, development, and prototyping of new product ideas. Based on their own product ideas, or those of others, students form and lead entrepreneurship teams (eTeams) to prototype these ideas. The students run their eTeams as 'virtual' startup companies where the seniors take on the executive roles. Joining them are students from other grade levels and disciplines throughout the University that agree to participate as eTeam members. Departmental approval required.

Prerequisite: MAE/ECE 482; C: MAE/ECE 483
*Typically offered in Spring only*

**MAE 495 Special Topics in Mechanical and Aerospace Engineering** (1-3 credit hours)
Offered as needed to present new or special MAE subject matter.

**MAE 496 Undergraduate Project Work in Mechanical and Aerospace Engineering** (1-6 credit hours)
Individual or small group project in engineering, comprising the design of an equipment or system stemming from a mutual student-faculty interest; a substantial final report (project) containing calculations, drawings and specifications must be produced. Alternatively, individual or small group undergraduate research evolving from a mutual student-faculty interest; a conference or scientific journal paper must be submitted for publication. Departmental approval required

Prerequisite: Completion of all required MAE-300 level courses, Corequisite: MAE 415 or MAE 478
*Typically offered in Fall, Spring, and Summer*

**MAE 501 Advanced Engineering Thermodynamics** (3 credit hours)
Classical thermodynamics of a general reactive system; conservation of energy and principles of increase of entropy; fundamental relation of thermodynamics; Legendre transformations; phase transitions and critical phenomena; equilibrium and stability criteria in different representation; irreversible thermodynamics. Introduction to statistical thermodynamics.

Prerequisite: MAE 302; MA 401 or MA 511
*Typically offered in Spring only*

**MAE 504 Fluid Dynamics Of Combustion I** (3 credit hours)
Gas-phase thermochemistry including chemical equilibrium and introductory chemical kinetics. Homogeneous reaction phenomena. Subsonic and supersonic combustion waves in premixed reactants (deflagration and detonation). Effects of turbulence. Introduction to diffusion flame theory.

Prerequisite: MAE 201 or MAE 252 or MAE 308
*Typically offered in Fall only*

**MAE 505 Heat Transfer Theory and Applications** (3 credit hours)
Development of basic equations for steady and transient heat and mass transfer processes. Emphasis on application of basic equations to engineering problems in areas of conduction, convection, mass transfer and thermal radiation.

Prerequisite: MAE 310
*Typically offered in Fall only*

**MAE 508 Automotive Power Systems** (3 credit hours)
This course will cover topics related to automotive power systems. In particular, this course provides fundamental concepts and knowledge on different power station options for automotive applications including internal combustion engines, battery electrical vehicles, engine/battery hybrid vehicles, and fuel cell powered vehicles.

P: Graduate Standing
*Typically offered in Spring only*

**MAE 511 Advanced Dynamics with Applications to Aerospace Systems** (3 credit hours)
Basic topics in advanced dynamics and with applications to aerospace systems. Rotating coordinate systems, Euler angles, three-dimensional kinematics and kinetics, angular momentum methods and an introduction to analytical mechanics. Examples are concentrated in the area of aerospace vehicles, but the methods learned will be applicable to land-based vehicles and any engineering system undergoing rigid body rotation, e.g. wind turbines, biomechanical systems, machine tools, robotic systems, etc.

Prerequisite: (MAE 208 or PY 205) and MA 242 and (MA 301 or MA 341)
*Typically offered in Fall and Summer*

**MAE 513 Principles of Structural Vibration** (3 credit hours)
Principles of structural vibration beginning from single and multi-degree of freedom systems and extending to distributed systems. Forced system response, vibration of strings, bars, shafts and beams and an introduction to approximate methods.

Prerequisite: MAE 315
*Typically offered in Fall only*

**MAE 515 Advanced Automotive Vehicle Dynamics** (3 credit hours)
This course covers advanced materials related to mathematical models and designs in automotive vehicles as multiple degrees of freedom systems for dynamic behaviors in acceleration, braking, rollover, aerodynamics, suspections, tire, and drive train.

Prerequisite: MAE 208 or MAE 315 or MAE 472 or equivalent; or consent of the instructor
*Typically offered in Spring only*

**MAE 517 Advanced Precision Manufacturing for Products, Systems and Processes** (3 credit hours)
This is a graduate level course designed for graduate students and undergraduate seniors. This course examines precision issues for products, manufacturing machines, processes, and instruments. Modern manufacturing technologies are distinct in their multifarious nature in product sizes, materials, energy forms, theories, and information types; however, the key to their success relies on the management of precision. This course discusses issues critical to both existing precision manufacturing and future sub-micron/nano technology. Important topics include fundamental mechanical accuracies; manufacturing systems and processes; geometric dimensioning and tolerancing; process planning, tolerance charts, and statistical process control; principles of accuracy, repeatability, and resolution; error assessment and calibration; error budget; reversal principles; joint design and stiffness consideration; precision sensing and control; precision laser material processing.

Prerequisite: MAE 496 or MAE 415 or equivalent or instructor permission
*Typically offered in Fall only*

**MAE 518 Acoustic Radiation I** (3 credit hours)
Introduction to principles of acoustic radiation from vibrating bodies and their related fields. The radiation of simple sources, propagation of sound waves in confined spaces and transmission through different media.

Prerequisite: MA 301 and MAE 308 or MAE 356
*Typically offered in Fall and Spring*

**MAE 520/MAE 420 Dynamic Analysis of Human Movement** (3 credit hours)
Topics in movement biomechanics and computational analyses of movement, including muscle physiology and mechanics, advanced muscle modeling, neural control of muscle and motor control theories, and dynamic simulation and optimization. Discussion of fundamental research underpinnings and clinical and sports applications.

P: MAE208 or equivalent
*Typically offered in Spring only*

**MAE 521 Linear Control and Design For Mimo Systems** (3 credit hours)
Linear Multivariable control and design for multibody engineering systems (robotics) and aircraft controls and navigation. Emphasis on multi-input and multi-output (MIMO) system analysis and design using frequency-based approach. Controllability andobservability, transmission zeroes and pole-zero cancellation, eigenstructures, singular value decomposition in frequency domain, stability and performance robustness of MIMO systems.

Prerequisite: MAE 435, MA 341
*Typically offered in Spring only*

**MAE 522 Non Linear System Analysis and Control** (3 credit hours)
Nonlinear system analysis, Lyapunov stability theory, absolute stability, feedback linearization, sliding mode control, backstepping control technique, as well as various advanced nonlinear control methods.

Prerequisite: MAE 521 or equivalent

**MAE 525 Advanced Flight Vehicle Stability and Control** (3 credit hours)
Preliminary analysis and design of flight control systems to include autopilots and stability augmentation systems. Study of effects of inertial cross-coupling and nonrigid bodies on vehicle dynamics.

Prerequisite: MAE 457
*Typically offered in Fall only*

**MAE 526/MAE 426 Fundamentals of Product Design** (3 credit hours)
Many think of design as more of an art than a science. However, the growing body of research in the engineering design community teaches us ways to navigate the design of consumer products using interdisciplinary design tools and rational decision making. This course introduces students to scientific design techniques that are more effective than "ad hoc" tactics. By exploring how engineering principles integrate with "real world" design challenges, students will learn to solve product design problems that encompass heterogeneous markets, multiple disciplines, and large-scale complex systems.

Prerequisite: MA 241
*Typically offered in Spring and Summer*

**MAE 528 Experimental Flight Testing** (3 credit hours)
Application of engineering methods to experimental flight testing of fixed-wing aircraft for determination of performance and handling qualities of air vehicles. Risk minimization techniques are included in the formulation of a flight test plan. Collected flight test data is corrected for standard day and analyzed.

Prerequisite: Graduate standing, Aerospace Engineering Majors, MAE 525
*Typically offered in Spring only*

**MAE 531 Engineering Design Optimization** (3 credit hours)
Nonlinear optimization techniques with applications in various aspects of engineering design. Terminology, problem formulation, single and multiple design variables, constraints, classical and heuristic approaches, single and multiobjective problems, response surface modeling, and tradeoffs in complex engineering systems. Numerical optimization algorithms and implementation of these optimization techniques. Graduate standing in engineering recommended.

Prerequisite: Graduate standing in Engineering is recommended.
*Typically offered in Fall only*

**MAE 532 Smart Structures and Micro-Transducers** (3 credit hours)
This course is designed for graduate students who wish to learn fundamentals and applications of smart structures and micro transducers. The course focuses on materials, structures, design, fabrication, and characterization of micro transducers. It also covers the recent progress in applications of micro transducers in aerospace, biomedical, civil, electrical and mechanical engineering.

Prerequisite: MAE 314, MAE 315, or equivalent.
*Typically offered in Fall only*

**MAE 533 Finite Element Analysis I** (3 credit hours)
Fundamental concepts of the finite element method for linear stress and deformation analysis of mechanical components. Development of truss, beam, frame, plane stress, plane strain, axisymmetric and solid elements. Isoparametric formulations. Introduction to structural dynamics. Practical modeling techniques and use of general-purpose codes for solving practical stress analysis problems.

Prerequisite: MAE 316 or MAE 472
*Typically offered in Fall only*

**MAE 534 Mechatronics Design** (3 credit hours)
Principles of Mechatronics Design, review of logic gates, microprocessor architecture, sensors and actuators, A/D and D/A conversion techniques, real-time multi-tasking programming concepts, direct digital control implementation. "Hands-on" experience through several laboratory assignments and final team project.

Prerequisite: Structured Programming Experience, Senior/Graduate Standing in WPS/MAE.
*Typically offered in Spring only*

**MAE 535/ECE 535 Design of Electromechanical Systems** (3 credit hours)
A practical introduction to electromechanical systems with emphasis on modeling, analysis, design, and control techniques. Provides theory and practical tools for the design of electric machines (standard motors, linear actuators, magnetic bearings, etc). Involves some self-directed laboratory work and culuminates in an industrial design project. Topics include Maxwell's equations, electromechanical energy conversion, finite element analysis, design and control techniques.

Prerequisite: MA 341
*Typically offered in Spring and Summer*

**MAE 536 Micro/Nano Electromechanical Systems** (3 credit hours)
Fundamentals and applications of micro/nano sensors and actuators. Emphasis upon MEMS/NEMS design, microfabrication techniques, and case studies of MEMS devices. Nanomaterials and NEMS devices also covered. Students have opportunity to learn commercial software packages on design and simulation of MEMS and hear from experts from leading MEMS companies through guest lectures. Previous knowledge of MEMS and nanotechnology is not required. The course is restricted to advanced undergrads and graduate students in engineering, materials science, physics and biomedical fields.

*Typically offered in Fall only*

**MAE 537 Mechanics Of Composite Structures** (3 credit hours)
Manufacturing techniques with emphasis on selection of those producing most favorable end result. Classical plate theory, materials properties and failure theories. Micromechanics, repair, plate solutions and elasticity solutions covered as requiredto meet special interests of students.

Prerequisite: MAE 316 or MAE 472
*Typically offered in Spring only*

**MAE 538 Smart Structures and Materials** (3 credit hours)
An application-oriented introduction to smart structures and materials with examples from mechanical, aerospace and biomedical engineering. Experimentally observed phenomena, micromechanisms, and models for material behavior. Team work developing simulation tools for typical applications. Validating results experimentally using PC-based data acquisition systems.

Prerequisite: MAE 415 or MAE 472
*Typically offered in Spring only*

**MAE 539/MSE 539 Advanced Materials** (3 credit hours)
Introduces production/structure/property/function relation and application of a number of materials mainly for biomedical, mechanical and aerospace applications. Topics include ultra light materials (production, processing and applications of cellular solids), biomaterials (classes and application of materials in medicine and dentistry), composites (classes and application), refractory materials and coatings for high temperature applications, thin film shape memory alloys for micro-electro mechanical systems (MEMS).

Prerequisite: MSE 201 and MAE 314
*Typically offered in Fall only*

**MAE 540 Advanced Air Conditioning Design** (3 credit hours)
Psychrometric process representations. Heating and cooling coil design. Heat pump design. Air washer design. Direct contact heat and mass transfer systems. Ventilation requirements, air dilution calculations. Cooling load calculations; CLTD, CLF andtransfer functions methods. Room air distribution.

Prerequisite: MAE 403, 404
*Typically offered in Spring only*

**MAE 541 Advanced Solid Mechanics I** (3 credit hours)
Development of principles of advanced strength of materials and elasticity theory leading to solution of practical engineering problems concerned with stress and deformation analysis. Tensor analysis, coordinate transformations, alternative measures of strain, elastic constitutive equations, stress measures, formulation and solution of two and three dimensional elasticity problems. Examples include advanced beam theory for shear deformation and large deformation, contact mechanics, stress concentration, pressure vessels and compound cylinders, thermal stress analysis, and stresses in layered microelectronic devices.

Prerequisite: MAE 316
*Typically offered in Fall only*

**MAE 543 Fracture Mechanics** (3 credit hours)
Concept of elastic stress intensity factor, Griffith energy balance, determination of the elastic field at a sharp crack tip via eigenfunction expansion methods, J integrals analysis, experimental determination of fracture toughness, fatigue crack growth, elastic-plastic crack tip fields. Emphasis on modern numerical methods for determination of stress intensity factors, critical crack sizes and fatigue crack propagation rate predictions.

Prerequisite: MAE 316
*Typically offered in Spring and Summer*

**MAE 544 Real Time Robotics** (3 credit hours)
Real-time programming for servo control using an embedded controller. Software and hardware interfacing for control of a D.C. servo device. Introduction of multi-tasking to establish concurrent control of several processes, transforming servo loop into a process executing concurrently on single board computer. Provision for hands-on development systems and software emulators.

Prerequisite: Pascal, C, FORTRAN or Assembly language experience

**MAE 545 Metrology For Precision Manufacturing** (3 credit hours)
Foundations of dimensional metrology and error analysis as applied to accuracy and repeatability in machine design. Plane, length, angle, and roundness metrology. Design of precision systems, Abbe' principle, error analysis, measurement, and compensation. Precision instruments and operating principles. Hands-on experience with measurement instruments and techniques.

Prerequisite: Senior standing in MAE or BS in other curriculum
*Typically offered in Spring only*

**MAE 546 Photonic Sensor Applications in Structure** (3 credit hours)
Use of optical fiber and other photonic device based sensors to measure strain, temperature and other measurands in aerospace, mechanical, civil and biomedical applications. An introduction to optical waveguide analysis will be provided at the beginning of the course.

Prerequisite: MAE 371 or MAE 316
*Typically offered in Fall only*

**MAE 550 Foundations Of Fluid Dynamics** (3 credit hours)
Review of basic thermodynamics pertinent to gas dynamics. Detailed development of general equations governing fluid motion in both differential and integral forms. Simplification of the equations to those for specialized flow regimes. Similarity parameters. Applications to simple problems in various flow regimes.

Prerequisite: MAE 201 or MAE 252 or MAE 308
*Typically offered in Fall and Summer*

**MAE 551 Airfoil Theory** (3 credit hours)
Development of fundamental aerodynamic theory. Emphasis upon mathematical analysis and derivation of equations of motion, airfoil theory and comparison with experimental results. Introduction to super sonic flow theory.

Prerequisite: MAE 252

**MAE 552 Introduction to Experimental Fluid Dynamics and Measurement Systems** (3 credit hours)
This course educates graduate students in the design of experiments and basis for model testing and scaling laws; uncertainty and error analysis in selecting measurement systems for experiments; qualitative and quantitative technologies for obtaining measurements; analysis, post-processing and visualization techniques of data.

Prerequisite: MAE 308 and MAE 451 or equivalent
*Typically offered in Spring only*

**MAE 553 Compressible Fluid Flow** (3 credit hours)
Equations of motion in supersonic flow; unsteady wave motion, velocity potential equation; linearized flow; conical flow. Slender body theory. Methods of characteristics. Shockwave/ boundary layer interactions.

Prerequisite: MAE 351 or MAE 550
*Typically offered in Spring only*

**MAE 554 Hypersonic Aerodynamics** (3 credit hours)
Fundamentals of inviscid and viscous hypersonic flowfields. Classical and modern techniques for calculating shock wave shapes, expansions, surface pressures, heat transfer and skin friction. Applications to high speed aircraft, rockets and spacecraft.

Prerequisite: MAE 553

**MAE 555 Applications of Acoustic and Elastic Wave Propagation** (3 credit hours)
This course covers the principles for acoustic and elastic propagation in fluids and solids. Diffraction theory is developed for finite sources. The notions of wavepacket, dispersion and waveguiding are reviewed. The fundamentals of the theory of elasticity and elastic propagation in solids are introduced, based on tensor analysis. Time reversal of acoustic waves is presented, as well as applications to underwater acoustics, medical imaging and therapy, nondestructive testing, elasticity imaging.

*Typically offered in Spring only*

**MAE 558 Microfluidics and Nanofluidics** (3 credit hours)
Macroscale fluid mechanics, heat and mass transfer. Theories of microfluidics and nanofluidics. Applications in mechanical, biomedical, and chemical engineering. Discussions of journal articles and modern fluid dynamics projects. Expert guest lectures on advanced micro/ nanotechnology topics.

Prerequisite: MAE 310 and MA 427
*Typically offered in Spring only*

**MAE 560 Computational Fluid Mechanics and Heat Transfer** (3 credit hours)
Introduction to integration of the governing partial differential equations of fluid flow and heat transfer by numerical finite difference and finite volume means. Methods for parabolic, hyper-bolic and elliptical equations and application to model equations. Error analysis and physical considerations.

Prerequisite: MA 501 or MA 512, MAE 550 or MAE 557, proficiency in the FORTRAN programming language is required
*Typically offered in Fall only*

**MAE 561 Wing Theory** (3 credit hours)
Discussion of inviscid flow fields over wings in subsonic flow. Vortex lattice methods, lifting surface theories and panel methods developed for wings with attached flow and leading-edge separation. Calculation of aerodynamic characteristics and determination of effects of planform and airfoil shapes.

Prerequisite: MAE 551
*Typically offered in Spring only*

**MAE 562 Physical Gas Dynamics** (3 credit hours)
Introduction to kinetic theory, statistical mechanics and chemical thermodynamics. Law of Action. Vibrational and chemical rate processes. Application to equilibrium and nonequilibrium flows.

Prerequisite: MAE 550
*Typically offered in Fall only*

**MAE 570/MAE 470 Space Exploration Systems** (3 credit hours)
This course will cover topics related to space exploration systems. In particular, the basic concepts of orbital mechanics needed for space mission planning will be covered, along with the essential subsystems found on a typical spacecraft.

Prerequisite: MAE 467 Introduction to Space Flight or Graduate Standing and Consent of Instructor
*Typically offered in Fall only*

**MAE 573 Hydrodynamic Stability and Transition** (3 credit hours)
Conceptual framework and development of hydrodynamic stability theory. Application of the theory to two-dimensional incompressible and compressible subsonic, transonic, supersonic and hypersonic flows. Results for three-dimensional flows. Introduction of mechanisms of transition and discussion of transition models in numerical methods.

Prerequisite: MAE 550
*Typically offered in Spring only*

**MAE 575 Advanced Propulsion Systems** (3 credit hours)
The course will focus on non-turbomachinery, air-breathing hypersonic aeropropulsion applications. Specific propulsion systems to be covered include ramjets and scramjets, pulsed detonation engines, and combined cycle engines, with historical perspective.

Prerequisite: Both MAE 458 and MAE 459 or both MAE 302 and MAE 308

**MAE 577/NE 577 Multiscale Two-phase Flow Simulations** (3 credit hours)
Modeling and simulation of two-phase flows using interface tracking approach and ensemble averaging approaches. Model validation and verification based on interface-tracking data, boiling models. Nuclear reactor applications. The course focuses on interface tracking methods understanding as applied to bubbly flow simulations. Students will develop a simplified solver to track 2D bubbles/droplets throughout the course homework assignments and will learn how to apply this approach for better understanding of multi-phase flow as part of the course project.

*Typically offered in Spring only*

**MAE 586 Project Work In Mechanical Engineering** (1-6 credit hours)
Individual or small group investigation of a problem stemming from a mutual student-faculty interest. Emphasis on providing a situation for exploiting student curiosity.

*Typically offered in Fall, Spring, and Summer*

**MAE 589 Special Topics In Mechanical Engineering** (1-6 credit hours)
Faculty and student discussions of special topics in mechanical engineering.

Prerequisite: Advanced Undergraduate standing or Graduate standing
*Typically offered in Fall and Spring*

**MAE 685 Master's Supervised Teaching** (1-3 credit hours)
Teaching experience under the mentorship of faculty who assist the student in planning for the teaching assignment, observe and provide feedback to the student during the teaching assignment, and evaluate the student upon completion of the assignment.

Prerequisite: Master's student
*Typically offered in Fall, Spring, and Summer*

**MAE 688 Non-Thesis Masters Continuous Registration - Half Time Registration** (1 credit hours)
For students in non-thesis master's programs who have completed all credit hour requirements for their degree but need to maintain half-time continuous registration to complete incomplete grades, projects, final master's exam, etc.

Prerequisite: Master's student
*Typically offered in Summer only*

**MAE 689 Non-Thesis Master Continuous Registration - Full Time Registration** (3 credit hours)
For students in non-thesis master's programs who have completed all credit hour requirements for their degree but need to maintain full-time continuous registration to complete incomplete grades, projects, final master's exam, etc. Students may register for this course a maximum of one semester.

Prerequisite: Master's student
*Typically offered in Fall, Spring, and Summer*

**MAE 690 Master's Examination** (1-9 credit hours)
For students in non thesis master's programs who have completed all other requirements of the degree except preparing for and taking the final master's exam.

Prerequisite: Master's student
*Typically offered in Fall and Spring*

**MAE 693 Master's Supervised Research** (1-9 credit hours)
Instruction in research and research under the mentorship of a member of the Graduate Faculty.

Prerequisite: Master's student
*Typically offered in Fall and Spring*

**MAE 695 Master's Thesis Research** (1-9 credit hours)
Thesis Research

Prerequisite: Master's student
*Typically offered in Fall, Spring, and Summer*

**MAE 696 Summer Thesis Research** (1 credit hours)
For graduate students whose programs of work specify no formal course work during a summer session and who will be devoting full time to thesis research.

Prerequisite: Master's student
*Typically offered in Summer only*

**MAE 699 Master's Thesis Preparation** (1-9 credit hours)
Individual research in the field of mechanical engineering.

Prerequisite: Graduate standing in Mechanical Engineering, Consent of Adviser
*Typically offered in Fall, Spring, and Summer*

**MAE 702 Statistical Thermodynamics** (3 credit hours)
Analysis and establishment of conclusions of classical thermodynamics from the microscopic viewpoint. Topics include: ensemble methods, partition functions, translational, rotational and vibrational energy modes of an ideal gas, chemical equilibrium, imperfect gases, dense fluids, critical-point theories, mean free path concepts, Boltzmann equation, hydrodynamic equations from kinetic theory and properties of disordered composite media.

Prerequisite: MAE 501
*Typically offered in Spring only*

**MAE 703 Direct Energy Conversion** (3 credit hours)
The course is intended to be an introduction to fundamentals of energy transport and energy conversion concepts from nano to macro scales. The course will cover the state of energy carriers (photons, electrons, and phonons) and their transport characteristics. A focus will be on material properties that dictate energy related processes. The foundational concepts will then be applied to direct energy conversion devices including thermoelectrics and photovoltaics. Finally, the course will cover system analysis of solid-state energy conversion applications.

*Typically offered in Spring only*

**MAE 704 Fluid Dynamics of Combustion II** (3 credit hours)
Advanced theory of detonation and deflagration. Ignition criteria. Direct initiation of detonation including blast-wave theory. Transition from deflagration to detonation. Combustion wave structure and stability. Liquid droplet and solid particle combustion.

Prerequisite: MAE 504
*Typically offered in Spring only*

**MAE 707 Advanced Conductive Heat Transfer** (3 credit hours)
Comprehensive, unified treatment of methodologies for solving multidimensional transient and steady heat conduction. Approximate and exact methods of solving nonlinear problems, including phase and temperature-dependent thermal properties, nonlinearboundary conditions. Heat conduction in composite media and anisotropic solids. Use of finite integral transform and Green's function techniques.

Prerequisite: MAE 505 or MA 501
*Typically offered in Spring only*

**MAE 708 Advanced Convective Heat Transfer** (3 credit hours)
Advanced topics in steady and transient, natural and forced convective heat transfer for laminar and turbulent flow through conduits and over surfaces. Mass transfer in laminar and turbulent flow. Inclusion of topics on compressible flow with heat and mass transfer.

Prerequisite: MAE 550
*Typically offered in Spring only*

**MAE 709 Advanced Radiative Heat Transfer** (3 credit hours)
Comprehensive and unified treatment of basic theories; exact and approximate methods of solution of radiative heat transfer and the interaction of radiation with conductive and convective modes of heat transfer in participating and non-participatingmedia.

Prerequisite: MAE 505
*Typically offered in Fall only*

**MAE 718 Acoustic Radiation II** (3 credit hours)
Advanced treatment of the theory of sound generation and transmission. Topics include: techniques for solution of the wave equation, radiation from spheres, cylinders and plates, sound propagation in ducts, scattering.

Prerequisite: MAE 518
*Typically offered in Spring only*

**MAE 721 Robust Control with Convex Methods** (3 credit hours)
This course emphasizes on control design techniques which result in closed-loop systems that are insensitive to modeling errors and which achieve a prespecified level of performance. Robustness margins against model uncertainty. Robust control design techniques based on linear matrix inequalities. Topics include uncertainty modeling, robust stability and performance, H_inf control, convex optimization technique (LMI), mu-analysis and synthesis, computer-aided analysis and control design.

Prerequisite: Graduate standing in Engineering and Applied Mathematics, MAE 521 or ECE 716
*Typically offered in Spring only*

**MAE 725 Geophysical Fluid Mechanics** (3 credit hours)
The principles of fluid mechanics applied to geophysical systems. Special emphasis placed on those features of these systems, such as almost rigid rotation and stable stratification, which produce unique and important effects. The effects of almost rigid rotations on homogeneous and stratified flows examined in detail.

Prerequisite: MAE 501
*Typically offered in Fall only*

**MAE 726 Advanced Geophysical Fluid Mechanics** (3 credit hours)
Principles of fluid mechanics applied to geophysical systems. Special emphasis on role of stable stratification on the flows in these systems. Detailed study of generation, interaction, propagation and dissipation of internal gravity waves. Studyof other geophysically important flows.

Prerequisite: MAE 725 or equivalent
*Typically offered in Spring only*

**MAE 730 Modem Plasticity** (3 credit hours)
Classical theories of plasticity and solutions pertaining to rate-independent and -dependent deformations modes in metals, geomaterials and concrete. Ductile failure modes, i.e., shear-strain localization and other failure modes associated with large deformation modes. Inelastic wave propagation, crystalline constitutive formulations and computational aspects of quasi-static and dynamic plasticity.

Prerequisite: Grad. course in elasticity or strength of materials
*Typically offered in Fall only*

**MAE 731/MSE 731 Materials Processing by Deformation** (3 credit hours)
Presentation of mechanical and metallurgical fundamentals of materials processing by deformation. Principles of metal working, friction, forging, rolling, extrusion, drawing, high energy rate forming, chipless forming techniques, manufacturing system concept in production.

Prerequisite: Six hrs. of solid mechanics and/or materials
*Typically offered in Fall only*

**MAE 734 Finite Element Analysis II** (3 credit hours)
Advanced treatment of finite element analysis for non-linear mechanics problems, including most recent developments in efficient solution procedures. Plate bending and shell elements, computational plasticity and viscoplastic materials, large deformation formulations, initial stability and buckling, structural vibrations, incompressible elasticity, contact problems, flow in incompressible media, weighted residuals and field problems. Development of efficient algorithms for practical application.

Prerequisite: MAE 533
*Typically offered in Spring only*

**MAE 742 Mechanical Design for Automated Assembly** (3 credit hours)
Mechanical design principles important in high volume production using modern automated assembly technology. Production and component design for ease of assembly as dictated by part handling, feeding, orientation, insertion and fastening requirements. Existing product evaluation and redesign for improved assemblage.

Prerequisite: Graduate standing or PBS status in Engineering
*Typically offered in Fall only*

**MAE 766 Computational Fluid Dynamics** (3 credit hours)
Advanced computational methods for integrating, by use of finite differences, and finite volume discretizations, non-linear governing equations of fluid flow; the Euler equations and the Navier-Stokes equations. Topics from current literature.

Prerequisite: MAE 560; proficiency in the FORTRAN programming language is required
*Typically offered in Spring only*

**MAE 770 Computation of Reacting Flows** (3 credit hours)
Development of governing equations for chemically and thermally nonequilibrium flows. Numerical formulation with application to planetary entry flows and supersonic combustion. Numerical examples. Computational problems.

Prerequisite: MAE 560, MAE 766
*Typically offered in Spring only*

**MAE 776 Turbulence** (3 credit hours)
Development of basic concepts and governing equations for turbulence and turbulent field motion. Formulations of various correlation tensors and energy spectra for isotropic and nonisotropic turbulence. Introduction to turbulent transport processes,free turbulence, and wall turbulence.

Prerequisite: MAE 550
*Typically offered in Spring only*

**MAE 787 Structural Health Monitoring** (3 credit hours)
The course will provide the students with in-depth knowledge of technologies in structural health monitoring using smart materials as sensing and actuating elements to interrogate the structures. Damage detection techniques such as wave, impedance, and vibration-based damage detection techniques will be discussed and applied to different types of structures. Advanced signal processing techniques such as wavelet, neural network, principal component analysis will be used to make the damage more quantifiable.

Prerequisite: MAE 541 or MAE 513 or equivalent
*Typically offered in Spring only*

**MAE 789 Advanced Topics In Mechanical Engineering** (1-3 credit hours)
Faculty and graduate student discussions of advanced topics in contemporary mechanical engineering.

Prerequisite: Graduate standing
*Typically offered in Fall and Spring*

**MAE 801 Mechanical Engineering Seminar** (1 credit hours)
Faculty and graduate student discussions centered around current research problems and advanced engineering theories.

*Typically offered in Fall and Spring*

**MAE 830 Doctoral Independent Study** (1-3 credit hours)
Individual investigation of advanced topics under the direction of member(s) of the graduate faculty.

*Typically offered in Spring only*

**MAE 885 Doctoral Supervised Teaching** (1-3 credit hours)
Teaching experience under the mentorship of faculty who assist the student in planning for the teaching assignment, observe and provide feedback to the student during the teaching assignment, and evaluate the student upon completion of the assignment.

Prerequisite: Doctoral student
*Typically offered in Fall and Spring*

**MAE 890 Doctoral Preliminary Examination** (1-9 credit hours)
For students who are preparing for and taking written and/or oral preliminary exams.

Prerequisite: Doctoral student
*Typically offered in Fall and Spring*

**MAE 893 Doctoral Supervised Research** (1-9 credit hours)
Instruction in research and research under the mentorship of a member of the Graduate Faculty.

Prerequisite: Doctoral student
*Typically offered in Fall and Spring*

**MAE 895 Doctoral Dissertation Research** (1-9 credit hours)
Dissertation Research

Prerequisite: Doctoral student
*Typically offered in Fall, Spring, and Summer*

**MAE 896 Summer Dissertation Research** (1 credit hours)
For graduate students whose programs of work specify no formal course work during a summer session and who will be devoting full time to thesis research.

Prerequisite: Doctoral student
*Typically offered in Summer only*

**MAE 899 Doctoral Dissertation Preparation** (1-9 credit hours)
For students who have completed all credit hour, full-time enrollment, preliminary examination, and residency requirements for the doctoral degree, and are writing and defending their dissertations.

*Typically offered in Fall, Spring, and Summer*