

# Mechanical and Aerospace Engineering (MAE)

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## COURSES

### **MAE 1104. INTRODUCTION TO ENGINEERING. 1 Hour.**

Introduction to basic engineering concepts. Students will become familiar with engineering and its many sub-fields, ethical responsibilities, creativity, and design.

### **MAE 1105. INTRODUCTION TO MECHANICAL AND AEROSPACE ENGINEERING. 1 Hour.**

Introduction to basic engineering concepts. Opportunities are provided to develop skills in oral and written communication and department specific material. Case studies are presented and analyzed. Prerequisite: C or better in ENGR 1250 (or concurrent enrollment), or C or better in ENGR 1300 or MAE 1104.

### **MAE 1106. INTRODUCTION TO AEROSPACE ENGINEERING. 1 Hour.**

An introduction to human flight and to the field of aerospace engineering through a combined theoretical and hands-on approach. Topics covered include history of flight and aerospace engineering and introductions to aerostatics and aerodynamics, aerospace structures, stability and control, and propulsion. Some College of Engineering requirements are satisfied by the content of this course. Prerequisite: C or better in MATH 1426 (or concurrent enrollment) or MATH 1426 qualifying score in Math Placement Test; or student group.

### **MAE 1107. INTRODUCTION TO MECHANICAL ENGINEERING. 1 Hour.**

Introduction to basic engineering concepts. Opportunities are provided to develop skills in oral and written communication, in engineering design teamwork, as well as in department-specific material. Some College of Engineering requirements are satisfied by the content of this course. Prerequisite: C or better in MATH 1426 (or concurrent enrollment) or MATH 1426 qualifying score in Math Placement Test; or student group.

### **MAE 1140. PROBLEMS IN MECHANICAL AND AEROSPACE ENGINEERING. 1 Hour.**

This course introduces students to units, 2D and 3D coordinate geometry, vector algebra and scientific problem solving, in preparation for higher level courses. Prerequisite: C or better in MATH 1426 (or concurrent enrollment); or student group.

### **MAE 1312. ENGINEERING STATICS. 3 Hours. (TCCN = ENGR 2301)**

A study of forces and force systems, resultants and components of force systems, forces due to friction, conditions of equilibrium, forces acting on members of trusses and frame structures, centroids and moments of inertia. Vector and index notation introduced. Prerequisite: C or better in each of the following, MAE 1140 (or ENGR 1250 or REE 1301), MATH 1426 (or HONR-SC 1426), and PHYS 1443; or student group.

### **MAE 1351. INTRODUCTION TO ENGINEERING DESIGN. 3 Hours.**

Foundational course in product design and manufacturing using computer-based methodologies. 3D parametric solid modeling of parts and assemblies. Technical sketching, and ASME Y14 engineering drawing standards. Industrial practices for product design and fabrication. Introduction to 3D product analysis tools. Prerequisite: C or better in MATH 1426 (or concurrent enrollment) or HONR-SC 1426 (or concurrent enrollment) or MATH 1426 qualifying score in Math Placement Test; or student group.

### **MAE 2000. UNDERGRADUATE RESEARCH. 0 Hours.**

Sophomore level undergraduate research. Prerequisite: Departmental good standing and permission of instructor. May be taken a maximum of 3 times.

### **MAE 2010. AUTOMOTIVE ENGINEERING PRACTICUM I. 0 Hours.**

Practical design experience as full team member of automotive design competition team. Prerequisite: Permission of Director of the Arnold E. Petsche Center for Automotive Engineering.

### **MAE 2312. SOLID MECHANICS. 3 Hours.**

The relationship between stresses and strains in elastic bodies and the tension, compression, shear, bending, torsion, and combined loadings which produce them. Deflections and elastic curves, shear and bending moment diagrams for beams, and column theory. Prerequisite: C or better in each of the following, MAE 1140 (or ENGR 1250 or REE 1301) and MAE 1312; or student group.

### **MAE 2315. FLUID DYNAMICS. 3 Hours.**

Introduction to Fluid Dynamics and low speed aerodynamics; fluid properties; dimensional analysis; conservation equations in integral and differential form; potential flow theory and viscous flow. Prerequisites: C or better in each of the following, MAE 1106, MAE 2323 (or concurrent enrollment), MAE 3309 (or concurrent enrollment) or MAE 3310 (or concurrent enrollment), and MAE 3360 (or concurrent enrollment); or student group.

### **MAE 2323. DYNAMICS. 3 Hours. (TCCN = ENGR 2302)**

The relation between forces acting on particles, systems of particles and rigid bodies, and the changes in motion produced. Review of kinematics and vector analysis, Newton's Laws, energy methods, methods of momentum, inertia tensor and Euler's equations of motion. Prerequisite: C or better in each of the following, MAE 1140 (or ENGR 1250 or REE 1301), MAE 1312 and MATH 2425 (or HONR-SC 2425); or student group.

### **MAE 2360. NUMERICAL ANALYSIS & PROGRAMMING. 3 Hours.**

Utilization of digital computers in mechanical and aerospace engineering. Computational algorithms and their representation in FORTRAN, C, and Matlab. Introduction to linear algebra and numerical methods. Prerequisite: C or better in MATH 1426; or student group.

### **MAE 2381. EXPERIMENTAL METHODS AND MEASUREMENTS. 3 Hours.**

Introduction to data analysis, incorporating statistics and probability, design and planning of engineering experiments for error prediction and control. Measurement and instrumentation, basic instruments, their calibration and use. Prerequisite: C or better in each of the following, MAE 1351 and MATH 2425 (or HONR-SC 2425) and PHYS 1443 (or HONR-SC 1443); or student group.

**MAE 2391. SPECIAL PROBLEMS IN MECHANICAL AND AEROSPACE ENGINEERING. 3 Hours.**

Special problems in mechanical and aerospace engineering for preprofessional students in mechanical or aerospace engineering. Prerequisite: Instructor permission.

**MAE 3000. UNDERGRADUATE RESEARCH. 0 Hours.**

Junior level undergraduate research. Prerequisite: Departmental good academic standing and permission of instructor. May be taken a maximum of 3 times.

**MAE 3181. MATERIALS AND STRUCTURES LAB. 1 Hour.**

Experiments to study materials behavior and deformation of structural elements. Prerequisite: Must be in the professional ME or AE program and C or better in MAE 2381 and C or better in MAE 3315 (or concurrent enrollment) or MAE 3242 (or concurrent enrollment); or student group.

**MAE 3182. AERODYNAMICS AND FLUIDS LAB. 1 Hour.**

Wind tunnel experiments to study flow phenomena of aerodynamics interest, including scale testing of airfoils, wings, and aircraft. Prerequisite: C or better in each of the following, MAE 2381, MAE 3302 (or concurrent enrollment), and MAE 3303 (or concurrent enrollment); or student group.

**MAE 3183. MEASUREMENTS LABORATORY II. 1 Hour.**

Fundamental measurement techniques and experimental data analysis in mechanical engineering in the fields of thermal, fluid, structures, design, and dynamic systems. Introduction to sensor calibration, digital data acquisition, uncertainty analysis, and report writing. Prerequisite: Must be in the professional ME program and C or better in each of the following, MAE 2381, MAE 3314, and MAE 3319; or student group.

**MAE 3185. INTRODUCTION TO MECHATRONICS. 1 Hour.**

Project based introduction to the application of software and hardware required to build functioning electromechanical systems. Integrates the theory of electrical circuits, electromechanics, electronics, mechanics, and mechanical devices, along with computer and microprocessor programming and the software-hardware interface, for practical applications. Prerequisite: Professional AE or ME program and C or better in each of MAE 2360, MAE 2381, MAE 3360 and EE 2320; or student group.

**MAE 3242. MECHANICAL DESIGN I. 2 Hours.**

The overall nature of design as a process is presented along with various models, methods, techniques, and tools for the various phases of the process provide the student with an excellent understanding of how to design. Students learn to design mechanical components based on stress/deflection and the associated failure theories. Prerequisite: Must be in the professional ME or AE program and C or better in each of the following, MAE 2312, MAE 2323, and MAE 3324; or student group.

**MAE 3302. INCOMPRESSIBLE AERODYNAMICS. 3 Hours.**

Introduction to and application of the methods used to determine the low speed aerodynamic forces on aerodynamic components such as wings and airfoils. Topics include potential flow theory for lifting flows; airfoil and finite wing theory; panel and vortex-lattice methods. Prerequisite: Must be in the professional ME or AE program and C or better in each of the following, MAE 2315, MAE 2323, MAE 3309 (or MAE 3310), and MAE 3360; or student group.

**MAE 3303. COMPRESSIBLE FLOW. 3 Hours.**

Fundamental thermodynamic concepts of compressible flow, isentropic flow, normal and oblique shock waves; expansion waves; quasi-one dimensional flows within nozzles and diffusers, linearized compressible flow theory, the method of characteristics and supersonic nozzle design. Prerequisite: Must be in the professional ME or AE program and C or better in each of the following MAE 2315, MAE 2323, MAE 3309 (or MAE 3310), and MAE 3360; or student group.

**MAE 3304. ASTRONAUTICS I. 3 Hours.**

Introduction to astronautics, the solar system, and the two-body problem. Orbit shaping and orbit transfers. Patched conic approximations for interplanetary transfers. Introduction to the three-body problem and relative motion. Rigid spacecraft equation of motion. Active and passive attitude stabilization techniques for spacecraft. Prerequisite: Must be in the professional ME or AE program and C or better in each of the following: MAE 2323, MAE 2360, and MAE 3360; or student group.

**MAE 3306. FLIGHT PERFORMANCE, STABILITY & CONTROL. 3 Hours.**

Review of aerodynamics. Introduction to aircraft performance and the assessment of aircraft static stability and control characteristics. Performance topics covered include cruise, climb, gliding flight, turns, range and endurance. Static stability and control topics covered include longitudinal, lateral and directional stability and control power calculations. Prerequisite: Must be in the professional ME or AE program and C or better in each of the following: MAE 3302 and MAE 3303.

**MAE 3309. THERMAL ENGINEERING. 3 Hours.**

Basic concepts and definitions, properties of pure substances, work and heat, first law of thermodynamics, second law of thermodynamics, entropy, and introduction to conductive, convective, and radiative transfer. Prerequisite: Must be in an EE or MAE department degree program and C or better in each of the following, CHEM 1465 or both CHEM 1441 and CHEM 1442; MATH 2425 (or HONR-SC 2425) and PHYS 1444; or student group.

**MAE 3310. THERMODYNAMICS I. 3 Hours.**

Basic concepts and definitions, properties of pure substances, work and heat, first law of thermodynamics, second law of thermodynamics, entropy, thermodynamics of gases, vapors, and liquids in various nonflow and flow processes, and irreversibility and availability. Prerequisite: Must be in an MAE department degree plan and C or better in each of the following, CHEM 1465 or both CHEM 1441 and CHEM 1442; MATH 2425 (or HONR-SC 2425), and PHYS 1444; or student group.

**MAE 3311. THERMODYNAMICS II. 3 Hours.**

Availability, power, refrigeration and heat pump cycles (both gas and vapor), property relations and equations of state, ideal gas mixtures, mixtures of gases and vapors, psychrometrics, adiabatic flame temperature, thermochemical equilibrium, and compressible flow. Emphasis is on applying these topics to thermal systems design. Prerequisite: Must be in the professional ME or AE program and C or better in each of the following, MAE 3313 (or concurrent enrollment) and MAE 3310; or student group.

**MAE 3313. FLUID MECHANICS. 3 Hours.**

Fundamental concepts of fluid mechanics leading to the development of both the integral and differential forms of the basic conservation equations. Application of the integral conservation equations to engineering problems in fluid dynamics including buoyancy and other hydrostatics problems. Dimensional analysis and similitude are also discussed. Prerequisite: Must be in the professional ME program and C or better in each of the following, MAE 2323, MAE 2360, MAE 3360, and MAE 3310 (or concurrent enrollment); or student group.

**MAE 3314. HEAT TRANSFER. 3 Hours.**

Topics cover the fundamental laws of heat and mass transfer, including steady and unsteady conduction, forced and free convection, and radiation as well as heat transfer in phase change. Applications of heat transfer to thermal systems design are included. Prerequisite: Must be in the professional ME or AE program and C or better in MAE 3313 or C or better in MAE 3302.

**MAE 3315. AEROSPACE STRUCTURAL STATICS. 3 Hours.**

Overview of aircraft basic structural elements and materials; introduction to elasticity; equations of equilibrium; constitutive equations of isotropic solids; bending and torsion analysis of thin-walled beams; flexure shear of thin-walled beams with stringer reinforcement; introduction to fatigue and fracture analysis; failure criteria; energy method to find strain energy release rate; elastic column buckling. Prerequisite: Must be in the professional ME or AE program and C or better in MAE 2312; or student group.

**MAE 3316. AEROSPACE STRUCTURAL DYNAMICS. 3 Hours.**

Harmonic and periodic motion including both damped and undamped free and forced vibration. Single- and multi-degree-of-freedom discrete systems. Vibration of continuous systems. Introduction of finite element method for structural dynamics. Prerequisite: Must be in the professional ME or AE program and C or better in each of the following, MAE 2312, MAE 2323, MAE 3360, and MATH 3330; or student group.

**MAE 3318. KINEMATICS AND DYNAMICS OF MACHINES. 3 Hours.**

The motion and interaction of linkage and mechanisms. Fundamental concepts of kinematics and dynamics applied to the determination of degree of freedom mechanisms and forces acting on joints of mechanisms. Specific mechanisms and applications such as multi-body mechanisms, linkage synthesis, cam design, and balancing. Prerequisite: Must be in the professional ME or AE program and C or better in MAE 2323, or student group.

**MAE 3319. DYNAMIC SYSTEMS MODELING AND SIMULATION. 3 Hours.**

Introduction to modeling and prediction of behavior of engineering systems. Analytic and numerical simulation, state-space differential equations, and Laplace transform methods. Effects of physical characteristics of system elements on system design and dynamic performance. Prerequisite: Must be in the professional ME or AE program and C or better in each of the following, MAE 3314 (or concurrent enrollment), EE 2320, and MATH 3330; or student group.

**MAE 3324. STRUCTURE & MECHANICAL BEHAVIOR OF MATERIALS. 3 Hours.**

Crystal structure and defects in materials. Diffusion, phase diagrams and phase transformations in metallic systems. The inter relationships between processing, structure, and properties of engineering materials with emphasis on the mechanical behavior of metals, polymers, and composite materials. Prerequisites: Must be in an MAE department degree program and C or better in each of the following, CHEM 1465 (or CHEM 1441 and CHEM 1442), MAE 2312 (or concurrent enrollment), and PHYS 1444; or student group.

**MAE 3344. INTRODUCTION TO MANUFACTURING ENGINEERING. 3 Hours.**

Introduction to casting, forming, machining, and joining processes for metals and nonmetals. Prerequisite: Must be in the professional ME program and C or better in each of the following, MAE 2312 and MAE 3324; or student group.

**MAE 3360. ENGINEERING ANALYSIS. 3 Hours.**

Mathematical analysis with emphasis on solution techniques and engineering applications. Topics include: ordinary differential equations (ODE), Laplace Transform, numerical solutions of ODE, boundary value problems, Fourier series, Sturm-Liouville problem and vector calculus. Prerequisite: Must be in an MAE department degree program and C or better in each of the following, MATH 2326 and MAE 2360 (or concurrent enrollment); or student group.

**MAE 3405. FLIGHT DYNAMICS. 4 Hours.**

Derivation of equation of motion (EOM) of a flight vehicle. Trimmed flight condition analysis based on the nonlinear EOM. Linearization of EOM for a given trimmed flight condition. State-space and transfer-function representations of the linear EOM. Aircraft stability and dynamic performance analysis based on the linear EOM. Prerequisite: Must be in the professional ME or AE program and C or better in each of the following, MAE 3406 (or concurrent enrollment) or MAE 3306 (or concurrent enrollment) and MATH 3330; or student group.

**MAE 3406. FLIGHT PERFORMANCE & STABILITY. 4 Hours.**

Classical Aerodynamics including potential flow theory for lifting flows; airfoil and finite wing theory; panel and vortex-lattice methods. Lift and drag buildup for aircraft. Aircraft performance analysis including cruise, climbing, gliding and turning flight, range and endurance. Aircraft longitudinal, lateral and roll stability and control. Prerequisite: Must be in the professional ME or AE program and C or better in MAE 3303 (or concurrent enrollment).

**MAE 4000. UNDERGRADUATE RESEARCH. 0 Hours.**

Senior level undergraduate research. Prerequisite: Departmental good academic standing and permission of instructor. May be taken a maximum of 3 times.

**MAE 4010. AUTOMOTIVE ENGINEERING PRACTICUM II. 0 Hours.**

Practical design experience as full team member of automotive design competition team. Prerequisite: Permission of Director of the Arnold E. Petsche Center for Automotive Engineering.

**MAE 4151. AEROSPACE VEHICLE DESIGN II. 1 Hour.**

Analysis and design of an aerospace system such as a complete flight vehicle, a propulsion system, a structural system, or a control system; market analysis, operating studies, mission specification, civil and military certification requirements; design process, methods and tools; configuration concept selection, harmonization of individual design disciplines (aerodynamics, performance, flight mechanics, structures, cost, systems, etc.). Prerequisite: Must be in the professional ME or AE program and C or better in MAE 4350.

**MAE 4188. DESIGN PROJECT LABORATORY II. 1 Hour.**

The design project from MAE 4287 continued. The design is finalized, a physical model (prototype) is manufactured and tested. Redesign and retest is accomplished as desired. The final design is documented by written report and oral presentation. Exit survey forms and exit essays must be submitted to complete the requirements of this course. Prerequisite: Must be in the professional ME program and C or better in MAE 4287.

**MAE 4191. SPECIAL PROBLEMS IN MECHANICAL AND AEROSPACE ENGINEERING. 1 Hour.**

Special problems in mechanical and aerospace engineering for students of professional program standing. Prerequisite: Must be in the professional ME or AE program.

**MAE 4287. DESIGN PROJECT I. 2 Hours.**

Team engineering approach to a design project that integrates engineering knowledge from several courses. Problem definition and creative synthesis of prospective design solutions. Engineering proposals, feasibility studies, trade-off studies, systems models and analysis, decision making, and engineering reports and presentations. Professionalism, ethics, and societal impact issues. Prerequisite: Must be in the professional ME program and C or better in MAE 4344 (or concurrent enrollment) and must be within two calendar semesters of graduation (possibly including an 11-week summer session). MAE 4287 and MAE 4188 must be taken in consecutive semesters.

**MAE 4291. SPECIAL PROBLEMS IN MECHANICAL AND AEROSPACE ENGINEERING. 2 Hours.**

Special problems in mechanical and aerospace engineering for students of professional program standing. Prerequisite: Must be in the professional ME or AE program.

**MAE 4301. SPECIAL TOPICS IN MECHANICAL AND AEROSPACE ENGINEERING. 3 Hours.**

Topics will vary from semester to semester depending on student interest and the availability of faculty. May be repeated, provided topics are different. Prior approval by the student's advisor required. Prerequisite: Must be in the professional ME or AE program and others that vary by topic.

**MAE 4302. INTRODUCTION TO BEARING DESIGN AND LUBRICATION. 3 Hours.**

The course introduces 1) selection principles and design guidelines for various rolling element bearings, 2) theory of liquid and gas lubrication, 3) various novel fluid film bearings used in modern high speed turbomachinery and energy systems, and 4) fundamental principles of rotordynamics. Prerequisite: Must be in the professional ME or AE program and C or better in MAE 3313.

**MAE 4304. ASTRONAUTICS II. 3 Hours.**

The restricted three-body problem, the n-body problem, and approximations. Interplanetary transfers. Design considerations for both manned and unmanned interplanetary vehicles. Prerequisite: Must be in the professional ME or AE program and C or better in MAE 3304.

**MAE 4305. FUNDAMENTALS OF ELECTRONIC PACKAGING. 3 Hours.**

An introductory treatment of electronic packaging, from single chip to multichip, including materials, electrical design, thermal design, mechanical design, package modeling and simulation, processing considerations, reliability, and testing. Prerequisite: Must be in the professional ME or AE program and C or better in MAE 3314 or MAE 3309; or student group.

**MAE 4306. COMPUTATIONAL TECHNIQUES FOR ELECTRONIC PACKAGING. 3 Hours.**

Characterization of the thermo/mechanical reliability of microelectronics devices using commercial computational heat transfer codes (Icepak, Flotherm, and ANSYS). Industry related problems ranging from first level packages through system level packages analyzed. Formulate and model contemporary problems using commercial CFD codes. Prerequisite: Must be in the professional ME or AE program and C or better in MAE 3314 or MAE 3309; or student group.

**MAE 4307. FINITE ELEMENT METHODS. 3 Hours.**

Static response of complex structures and continua; application to field problems; mesh generation; error estimation and adaptive refinement. Prerequisite: Must be in the professional ME or AE program and C or better in MAE 3242.

**MAE 4310. INTRODUCTION TO AUTOMATIC CONTROL. 3 Hours.**

Block diagram algebra, transfer functions, and stability criteria. The use of transient response, frequency response, and root locus techniques in the performance analysis, evaluation, and design of dynamic systems. Prerequisite: Must be in the professional ME or AE program and C or better in each of the following, (MAE 3314 and MAE 3319) or (MAE 3405 and EE 2320); or student group.

**MAE 4312. CONTROL SYSTEMS COMPONENTS. 3 Hours.**

The components used in mechanical, electronic, and fluid power control systems are studied. Modeling and performance analysis are used to help in the understanding of system behavior. Prerequisite: Must be in the professional ME or AE program and C or better in MAE 4310.

**MAE 4314. MECHANICAL VIBRATIONS. 3 Hours.**

Harmonic and periodic motion including both damped and undamped free and forced vibration. Single and multi-degree-of-freedom discrete systems. Vibration of continuous systems. Introduction of finite element method for structural dynamics. Prerequisite: Must be in the professional ME or AE program and C or better in each of the following, MAE 2312, MAE 2323, MAE 3360, and MATH 3330; or student group.

**MAE 4315. INTRODUCTION TO COMPOSITES. 3 Hours.**

Composite classification, laminate coding, fiber and weight fractions of composite lamina; lamina constitutive equations; structural characteristics of [A], [B], [D] matrices; lamination theory; thermal and moisture induced load and moment; lamina stress analysis and failure prediction; issues in composite structural design. Prerequisite: Must be in the professional ME or AE program and C or better in MAE 2312 (or CE 2313); or student group.

**MAE 4320. HYDRAULIC AND PNEUMATIC SYSTEMS. 3 Hours.**

The fundamentals of fluid mechanics as applied to hydraulic and pneumatic hardware. Mathematical models of pumps, motors, pistons, accumulators, valves, and transmission lines. Design and analysis procedures for implementing total fluid power systems with high operating efficiencies and adequate dynamic response characteristics. Theory is supported by laboratory demonstrations. Prerequisite: Must be in the professional ME or AE program and C or better in each of the following, MAE 3313, MAE 4310, and MAE 3310; or student group.

**MAE 4321. AEROSPACE PROPULSION. 3 Hours.**

Introduction to rocket and air-breathing propulsion systems. Development of thrust and efficiency relations, mission requirements, rocket and gas turbine engine cycle analysis, off-design performance, component design and performance analysis, advanced propulsion system concepts. Prerequisite: Must be in the professional ME or AE program and C or better in MAE 3303 or C or better in each of MAE 3313 and MAE 3311.

**MAE 4322. ROCKET PROPULSION. 3 Hours.**

Examines chemical, nuclear, and electrical propulsion concepts. Development of design and performance analysis methods. Flight performance of rocket powered vehicles. Prerequisite: Must be in the professional ME or AE program and C or better in MAE 3303 (or MAE 3311).

**MAE 4323. ENERGY CONVERSION. 3 Hours.**

Thermodynamics as applied to thermo-mechanical systems such as power cycles, engines, turbines, refrigeration, and air-conditioning systems. Prerequisite: Must be in the professional ME or AE program and C or better in each of the following, MAE 3311 and MAE 3314.

**MAE 4324. POWER PLANT ENGINEERING. 3 Hours.**

Fundamental thermodynamics and heat transfer principles behind design and optimization of power generation systems with significant emphasis on component and system design. This class will cover a number of power plant types, including coal/gas fired, hydroelectric, nuclear, and solar. Concepts learnt in this class prepare students for an engineering career in power plants, oil, gas and related industries. Prerequisite: Must be in the professional ME or AE program and C or better in MAE 3310 (or MAE 3309); or student group.

**MAE 4325. COMBUSTION. 3 Hours.**

Fundamental treatment of problems involving simultaneous occurrence of chemical reaction and transfer of heat, mass and momentum. Topics include kinetically controlled combustion phenomena; diffusion flames in liquid fuel combustion; combustion of solids; combustion of gaseous fuel jets; flames in premixed gasses. Prerequisite: Must be in the professional ME or AE program and C or better in MAE 3311 or MAE 3303.

**MAE 4326. COMPUTATIONAL AERODYNAMICS I. 3 Hours.**

Solution of engineering problems by finite-difference methods, emphasis on aerodynamic problems characterized by single linear and non-linear equations, introduction to and application of major algorithms used in solving aerodynamics problems by computational methods. Prerequisite: Must be in the professional ME or AE program and C or better in MAE 3314 or MAE 3303.

**MAE 4327. HEATING, VENTILATION, AND AIR CONDITIONING. 3 Hours.**

Application of engineering sciences to design of heating, venting, and air conditioning (HVAC) systems. Humidification and dehumidification, psychrometric charts, heat load, cooling load, degree-days, comfort zones, and air distribution systems. Prerequisite: Must be in the professional ME or AE program and C or better in each of the following, MAE 3311 and MAE 3314.

**MAE 4328. METAL ADDITIVE MANUFACTURING. 3 Hours.**

This course will provide students with essential knowledge and technical skills for metal additive manufacturing (AM), providing a solid foundation for a future career in the field. Primary areas of focus include: metal AM processes and their capabilities, process fundamentals, part design and analysis, build preparation and machine set-up, fabrication and post-processing, inspection and monitoring, microstructure analysis and mechanical testing, and process optimization. Prerequisite: Must be in the professional ME or AE program.

**MAE 4329. ADDITIVE MANUFACTURING. 3 Hours.**

The range of technologies and processes, both physical and digital, used to translate virtual solid model data into physical models using additive layering methods. Emphasis is given to application of these technologies to manufacture end use components and assemblies but rapid prototyping is also discussed. Metal, polymer, ceramic, and composite material applications of additive manufacturing (AM) are included. Discussion includes advantages and limitations of additive methods with respect to subtractive methods and to each other. Principles of design for AM are covered along with discussion of applications. Students complete a project to design and build an engineering component or assembly for additive manufacture. Prerequisite: Must be in the professional ME or AE program and C or better in each of the following, MAE 1351 and MAE 3324; or student group.

**MAE 4331. DESIGN FOR MANUFACTURING. 3 Hours.**

The interaction between design and manufacturing stressed in terms of the design process, customer-focused quality, design specifications versus process capability and tolerances, and redesign for producibility. Topics include material and manufacturing process selection, tolerancing, quality function deployment (QFD), design for assembly (DFA), quality control techniques, reliability, and robust design. Prerequisite: Must be in the professional ME or AE program and C or better in each of the following, MAE 3242 and MAE 3344.

**MAE 4335. ANALYTICAL & COMPUTATIONAL DYNAMICS. 3 Hours.**

The course focuses on developing the equations of motion for dynamic systems composed of multiple, connected and unconnected, rigid bodies using Kane's method and the Lagrangian approach. The resulting model is used to simulate and visualize the predicted motion. Topics include: kinematics, Euler parameters, kinematic constraints, virtual work, the calculus of variations, energy, momentum, contact, impact, and checking functions. Prerequisite: Must be in the professional ME or AE program and C or better in MAE 3318.

**MAE 4336. ADVANCED MECHANICAL BEHAVIOR OF MATERIALS. 3 Hours.**

Concept of stress and strain; elementary dislocation theory. Deformation of single crystals; strengthening mechanisms including solid solution strengthening, and precipitation hardening. Fracture mechanics; microscopic aspects of fracture, fatigue, and creep of materials; design and processing of materials for improved mechanical properties. Prerequisite: Must be in the professional ME or AE program and C or better in each of the following, MAE 2312 and MAE 3324; or student group.

**MAE 4338. FAILURE ANALYSIS. 3 Hours.**

Theory and practice of techniques for determining modes of failure and fracture of engineering materials. Prerequisite: Must be in the professional ME or AE program and C or better in each of the following, MAE 2312 and MAE 3324; or student group.

**MAE 4339. FRACTURE MECHANICS. 3 Hours.**

Theory and applications of fracture mechanics. Stress analysis of cracks, crack-tip plasticity, fatigue crack growth, and stress corrosion cracking. Applicability to materials selection, structural design, failure analysis, and structural reliability. Prerequisite: Must be in the professional ME or AE program and C or better in MAE 3242.

**MAE 4342. MECHANICAL DESIGN II. 3 Hours.**

Analysis for the design and manufacture of basic mechanical elements, and their role in the design of machines. A brief review of relevant topics including stress/deflection, failure theories, and contact stress is initially conducted. It is then extended to the design of fundamental mechanical components including shafts, gears, springs, bearings, fasteners, and clutches/brakes. Prerequisite: Must be in the professional ME or AE program and C or better in each of the following, MAE 3242 and MAE 3318 (or concurrent enrollment).

**MAE 4344. COMPUTER-AIDED ENGINEERING. 3 Hours.**

A study of the principles of computer-aided engineering in mechanical and aerospace engineering. Applications in mechanical, structural, and thermal systems. Prerequisite: Must be in the professional ME or AE program and C or better in each of the following, MAE 3242, MAE 3314 (or concurrent enrollment), and MAE 3318.

**MAE 4345. INTRODUCTION TO ROBOTICS. 3 Hours.**

Overview of industrial robots. Study of principles of kinematics, dynamics, and control as applied to industrial robotic systems; robotic sensors and actuators; path planning; guidelines to robot arm design and selection; introduction to mechatronics; laboratory exercise in designing, building, and controlling a 3D-printed robotic manipulator. Prerequisite: Must be in the professional ME or AE program.

**MAE 4347. HEAT EXCHANGER DESIGN. 3 Hours.**

Design procedure system evaluation; design parameters in heat exchangers. The course considers various heat exchanger configurations and includes student design projects. Prerequisite: Must be in the professional ME or AE program and C or better in MAE 3314.

**MAE 4348. COOLING OF ELECTRONIC PACKAGES. 3 Hours.**

The calculation of heat loads and temperature fields using different cooling techniques. Includes parameter evaluation and design studies. Prerequisite: Must be in the professional ME or AE program and C or better in, MAE 3314 (or MAE 3309); or student group.

**MAE 4350. AEROSPACE VEHICLE DESIGN I. 3 Hours.**

Analysis and design of an aerospace system such as a complete flight vehicle, a propulsion system, a structural system, or a control system; market analysis, operating studies, mission specification, civil and military certification requirements; design process, methods and tools; configuration concept selection, integration of design disciplines (aerodynamics, performance, flight mechanics, structures, cost, systems, etc.). Prerequisite: Must be in the professional ME or AE program and C or better in each of the following: MAE 3306 or MAE 3406 and MAE 3405.

**MAE 4351. AEROSPACE VEHICLE DESIGN II. 3 Hours.**

Analysis, design, and synthesis of an aerospace system such as a complete flight vehicle, a propulsion system, a structural system, or a control system; market analysis, operating studies, mission specification, civil and military certification requirements; design process, methods and tools; configuration concept selection, integration of individual design disciplines (aerodynamics, performance, flight mechanics, structures, cost, systems, etc.). Also included will be economic, environmental, sustainability, manufacturability, safety, social and political considerations. Formal written and oral reports are required. Exit survey forms and exit essays must be submitted to complete the requirements of this course. Prerequisite: Must be in the professional AE program and C or better in MAE 4350.

**MAE 4352. SPACE VEHICLE AND MISSION DESIGN. 3 Hours.**

Space vehicle design; influence of space environment, astrodynamics, and atmospheric reentry. Space vehicle sub system design; propulsion, attitude determination and control, structural design, thermal control, power and telecommunications. Investigation into mission design concepts and considerations. Prerequisite: Must be in the professional ME or AE program and C or better in each of the following, MAE 2323 and MATH 2326; or student group.

**MAE 4357. AUTOMOTIVE ENGINEERING. 3 Hours.**

Introduction to automotive engine types and performance, drive train modeling and vehicle loading characteristics, fueling requirements, fuel injection systems, tire characteristics and modeling, suspension characteristics and handling, braking systems and requirements. Course taught through lecture, student presentations and student design projects. Prerequisite: Must be in the professional ME, AE or EE program and C or better in each of the following, MAE 3360 (or MATH 3319) and MAE 2312 (or EE 3446); or student group.

**MAE 4358. RACECAR ENGINEERING. 3 Hours.**

This course is intended for Formula SAE team members and other interested students to develop new systems or analyze concepts for the Formula SAE or Formula Electric racecar and related equipment. The students will form teams and perform research and development on projects related to automotive or racecar engineering. Prerequisites: Must be in the professional ME, AE or EE program and C or better in each of the following, MAE 3360 (or Math 3319) and MAE 2312 (or EE 3446); or student group.

**MAE 4362. INTRODUCTION TO MICRO AND NANOFUIDICS. 3 Hours.**

As going down to micro scales, the basic hypothesis in the macro scale fluid mechanics may not be applicable in such scales. The objectives of this course are: to identify dominant forces and their effects in micro scale fluid systems that are different from those in the macro scales; to understand the fundamentals of micro fluidic phenomena; to discuss various microfluidic applications in research and commercial levels; and to explore new possible microfluidic applications in the emerging fields. Topics include overview of microfluidics, scaling laws, violation limit of the Navier-Stokes equations, surface force, surface tension, electrowetting, electrokinetics, dielectrophoresis, and soft lithography. Prerequisite: Must be in the professional ME or AE program and C or better in MAE 3313 and MAE 3310; or student group.

**MAE 4363. INTRODUCTION TO ROTORCRAFT ANALYSIS. 3 Hours.**

History of rotorcraft. Behavior of the rotor blade in hover and forward flight. Rotor configurations, dynamic coupling with the fuselage, elastic and aeroelastic effects.

**MAE 4378. INTRODUCTION TO UNMANNED VEHICLE SYSTEMS. 3 Hours.**

Introduction to UVS (Unmanned Vehicle Systems) such as UAS (Unmanned Aircraft Systems), UGS (Unmanned Ground System) and UMS (Unmanned Maritime System), their history, missions, capabilities, types, configurations, subsystems, and the disciplines needed for UVS development and operation. UVS missions could include student competitions sponsored by various technical organizations. This course is team-taught by engineering faculty. Prerequisite: Admission to a professional engineering or science program.

**MAE 4379. UNMANNED VEHICLE SYSTEM DEVELOPMENT. 3 Hours.**

Introduction to the technologies needed to create an UVS (Unmanned Vehicle System). Integration of these technologies (embodied as a set of sensors, actuators, computing and mobility platform sub-systems) into a functioning UVS through team work. UVS could be designed to compete in a student competition sponsored by various technical organizations or to support a specific mission or function defined by the instructors. This course is team-taught by engineering faculty. Prerequisite: B or better in MAE 4378 and admission to the UVS certificate program.

**MAE 4382. RESEARCH TRENDS IN RENEWABLE ENERGY TECHNOLOGIES. 3 Hours.**

This course is offered to graduate and senior level undergraduate students with engineering and science background to introduce them to micro/nano research and development for energy conversion and storage. This course will include: Scaling laws, MEMS fabrication, Nanomaterial synthesis, Electrochemical energy storage/conversion (Batteries, Fuel Cells & Supercapacitors), Solar energy (photovoltaics and solar thermal energy), Energy harvesting and Solar water splitting and electrocatalysis. Prerequisite: Must be in the professional ME or AE program.

**MAE 4386. WIND & OCEAN CURRENT ENERGY HARVESTING FUNDAMENTALS. 3 Hours.**

A broad senior/graduate first course in wind/wave/ocean current energy harvesting systems, focused on fundamentals, and serving as the basis for subsequent MAE specialized follow-on graduate course offerings focused on structures (conventional and composite), aero/hydro-mechanical response and control, and tailoring and smart material actuation, respectively, as well as for non-MAE, specialized graduate courses. Prerequisite: Must be in the professional ME or AE program and C or better in EE 2320 and C or better in either MAE 3313 or MAE 2315, or student group.

**MAE 4391. SPECIAL PROBLEMS IN MECHANICAL AND AEROSPACE ENGINEERING. 3 Hours.**

Special problems in mechanical and aerospace engineering for students of professional program standing. Prerequisite: Must be in the professional ME or AE program.