

# MECHANICAL, MATERIALS, AND AEROSPACE ENGINEERING

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## Chair

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For information regarding faculty visit the Department of Mechanical, Materials, and Aerospace Engineering website .

The Department of Mechanical, Materials, and Aerospace Engineering offers the Bachelor of Science degree in Aerospace Engineering (AE), Materials Science and Engineering (MSE), and Mechanical Engineering (ME). These degree programs are accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (ABET).

The educational objectives of the (AE/ME/MSE) undergraduate program are the following:

- Graduates will meet the expectations of employers of AE/ME/MSE engineers.
- Qualified graduates will pursue advanced study if they so desire.
- Graduates will assume/undertake leadership roles in their community and/or profession.

The educational outcomes of the (AE/ME/MSE) program are to develop in graduates:

- An ability to apply knowledge of mathematics, science, and engineering.
- An ability to design and conduct experiments, as well as to analyze and interpret data.
- An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.
- An ability to function on multidisciplinary teams.
- An ability to identify, formulate, and solve engineering problems.
- An understanding of professional and ethical responsibility.
- An ability to communicate effectively.
- The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.
- A recognition of the need for, and an ability to engage in, life-long learning.
- A knowledge of contemporary issues.
- An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

## Mechanical, Materials, and Aerospace Engineering

Students are introduced to the scope of the engineering profession in the first-semester course "Introduction to the Profession", and to the ethical, economical, safety, environmental, and other responsibilities of being a professional engineer. Strong emphasis is placed on development of oral and written communication skills. Accompanying courses in mathematics and the basic sciences provide the foundation for later studies of engineering sciences relevant to the students' major fields of study. These areas include: energy, structures, and motion for the ME major; materials, structure-property relations, materials processing, service behavior, and design for the MSE major; and structures and materials, propulsion, and aerodynamics for the AE major. Regardless of the students' intended major, all MMAE students have a common curriculum for the first two semesters.

The second year emphasizes building a foundation for the eventual study of engineering design. The engineering sciences offer a rational approach to solving detailed problems encountered in major-specific courses, including the IPROs and capstone design courses of the third and fourth years.

In the third year, students begin the transition to professional practice and learn to develop sound engineering judgment by studying open-ended problems and realistic constraints. Students build further on the engineering sciences, and approximately one-third of major-specific coursework is devoted to the introduction of tangible engineering design. The student's professional experience is developed by participation in a minimum of two Interprofessional Projects (IPROs) in the third and fourth years.

The process continues into the fourth year where the three programs culminate in senior-year projects. Mechanical engineering projects involve design of thermal and mechanical systems; materials science and engineering students develop new or optimized materials, processing routes, or selection schemes; and aerospace engineering students produce conceptual designs of aircraft and spacecraft missions.

## Advising

The MMAE department considers the advising of students an important obligation. Each student must meet with a faculty adviser during the advising period each semester. Students must closely adhere to course prerequisites to maximize academic performance and satisfy requirements for ABET accreditation. Students' academic advisers can be found on their MyIIT portal account.

Program requirements may not be waived, nor will substitutions be permitted, without the approval of the departmental undergraduate studies committee.

## Degree Programs

- Bachelor of Science in Aerospace Engineering
- Bachelor of Science in Materials Science and Engineering
- Bachelor of Science in Mechanical Engineering

## Co-Terminal Options

The Department of Mechanical, Materials, and Aerospace Engineering also offers the following co-terminal degrees, which enables a student to simultaneously complete both an undergraduate and graduate degree in as few as five years:

- Bachelor of Science in Aerospace Engineering/Master of Engineering in Materials Science and Engineering
- Bachelor of Science in Aerospace Engineering/Master of Engineering in Mechanical and Aerospace Engineering
- Bachelor of Science in Mechanical Engineering/Master of Engineering in Materials Science and Engineering
- Bachelor of Science in Mechanical Engineering/Master of Engineering in Mechanical and Aerospace Engineering

These co-terminal degrees allow students to gain greater knowledge in specialized areas while, in most cases, completing a smaller number of credit hours with increased scheduling flexibility. For more information, please visit the Department of Mechanical, Materials, and Aerospace Engineering website ([engineering.iit.edu/mmae](http://engineering.iit.edu/mmae)).

## Minors

Minors available to students who wish to broaden their knowledge can be found in the Minors section. In all programs, two of the required minor courses substitute for two free or technical electives. Minors other than those listed below may be undertaken with the approval of the student's faculty adviser and the MMAE undergraduate studies committee. In the event that a required course for a minor is also required for the major, an approved substitution must be made. Application to take a minor is typically made in the student's third or fourth semester. Minors require completion of additional courses.

Among the minors that are available to ME, MSE, and AE students are:

- Aerospace Engineering (for ME students only)
- Air Force Aerospace Studies
- Artificial Intelligence
- Business
- Construction Management
- Electromechanical Design and Manufacturing (for ME and AE students only)
- Energy/Environment/Economics (E3)
- Environmental Engineering
- Materials Engineering (for ME or AE students only)
- Mechanical Engineering (for AE students only)
- Military Science
- Naval Science
- Polymer Science and Engineering
- Premedical Studies
- Software Engineering

## Course Descriptions

### MMAE 100

#### Introduction to the Profession

Introduces the student to the scope of the engineering profession and its role in society, develops a sense of professionalism in the student, confirms and reinforces the student's career choices, and provides a mechanism for regular academic advising. Provides integration with other first-year courses. Applications of mathematics to engineering. Emphasis is placed on the development of professional communications and teamwork skills.

**Lecture: 2 Lab: 1 Credits: 3**

**Satisfies:** Communications (C)

### MMAE 200

#### Introduction to Mechanics

Equilibrium concepts. Free body diagrams. Statics of particles and rigid bodies. Distributed forces, centroids, center of gravity, and moments of inertia. Friction. Internal loads in bars, shafts, cables, and beams.

**Prerequisite(s):** [(MATH 152\* and PHYS 123)]An asterisk (\*) designates a course which may be taken concurrently.

**Lecture: 3 Lab: 0 Credits: 3**

### MMAE 202

#### Mechanics of Solids

Stress and strain relations, mechanical properties. Axially loaded members. Torsion of circular shafts. Plane stress and strain, Mohr's circle, stress transformation. Elementary bending theory, normal and shear stresses in beams, beam deflection. Combined loading.

**Prerequisite(s):** [(MMAE 200)]

**Lecture: 3 Lab: 0 Credits: 3**

### MMAE 232

#### Design for Innovation

Design and development of mechanical systems. The design process, isometric sketching, engineering drawings, CAD, sustainable design, whole-system design and lifecycle thinking, design for product lifetime, lightweighting, technical writing, bio-inspired design process, bio-inspired design for locomotion, mechanism and linkage design, actuators, triggers, engineering and ethics, and engineering and law. Team-based design and build projects focusing on sustainable design techniques, bio-inspired locomotion, and mechatronics.

**Prerequisite(s):** [(CS 104 and MMAE 200\*)]An asterisk (\*) designates a course which may be taken concurrently.

**Lecture: 1 Lab: 3 Credits: 3**

**Satisfies:** Communications (C)

### MMAE 302

#### Advanced Mechanics of Solids

Analysis of stress and strain. Torsional and bending structural elements. Energy methods and Castigliano's theorems. Curved beams and springs. Thick-walled cylinders and spinning disks. Pressure vessels. Contact stresses. Stability of columns. Stress concentration and stress intensity factors. Theories of failure, yield, and fracture. Fatigue.

**Prerequisite(s):** [(MATH 251, MATH 252, and MMAE 202)]

**Lecture: 3 Lab: 0 Credits: 3**

### MMAE 304

#### Mechanics of Aerostructures

Loads on aircraft, and flight envelope. Stress, strain and constitutive relations. Torsion of open, closed and multi-cell tubes. Energy methods. Castigliano's theorems. Structural instability.

**Prerequisite(s):** [(MATH 251, MATH 252, and MMAE 202)]

**Lecture: 3 Lab: 0 Credits: 3**

### MMAE 305

#### Dynamics

Kinematics of particles. Kinetics of particles. Newton's laws of motion, energy; momentum. Systems of particles. Kinematics of rigid bodies. Plane motion of rigid bodies: forces and accelerations, energy, momentum.

**Prerequisite(s):** [(CAE 286) OR (MMAE 200)]AND[(MATH 252\*)]An asterisk (\*) designates a course which may be taken concurrently.

**Lecture: 3 Lab: 0 Credits: 3**

### MMAE 311

#### Compressible Flow

Regimes of compressible perfect-gas flow. Steady, quasi one-dimensional flow in passages. Effects of heat addition and friction in ducts. Design of nozzles, diffusers and wind tunnels. Simple waves and shocks in unsteady duct flow. Steady two-dimensional supersonic flow including oblique shocks and Prandtl-Meyer expansions.

**Prerequisite(s):** [(MMAE 313 and MMAE 320)]

**Lecture: 3 Lab: 0 Credits: 3**

### MMAE 312

#### Aerodynamics of Aerospace Vehicles

Analysis of aerodynamic lift and drag forces on bodies. Potential flow calculation of lift on two-dimensional bodies; numerical solutions; source and vortex panels. Boundary layers and drag calculations. Aerodynamic characteristics of airfoils; the finite wing.

**Prerequisite(s):** [(MMAE 311\*, MMAE 313, and MMAE 320)]An asterisk (\*) designates a course which may be taken concurrently.

**Lecture: 3 Lab: 0 Credits: 3**

### MMAE 313

#### Fluid Mechanics

Basic properties of fluids in motion. Lagrangian and Eulerian viewpoints, materials derivative, streamlines, etc. Continuity, energy, and linear and angular momentum equations in integral and differential forms. Integration of equations for one-dimensional forms and application to problems. Incompressible viscous flow; Navier-Stokes equations, parallel flow, pipe flow, and the Moody diagram. Introduction to laminar and turbulent boundary layers and free surface flows.

**Prerequisite(s):** [(MATH 251, MATH 252\*, MMAE 200, and MMAE 320\*)]An asterisk (\*) designates a course which may be taken concurrently.

**Lecture: 3 Lab: 0 Credits: 3**

**MMAE 315****Aerospace Laboratory I**

Basic skills for engineering research are taught, which include: analog electronic circuit analysis, fundamentals of digital data acquisition, measurements of pressure, temperature, flow rate, heat transfer, and static forces and moments; statistical data analysis.

**Prerequisite(s):** [(MMAE 311\*, MMAE 313, and PHYS 221)]An asterisk (\*) designates a course which may be taken concurrently.

**Lecture: 2 Lab: 3 Credits: 4**

**Satisfies:** Communications (C)

**MMAE 319****Mechanical Laboratory I**

Basic skills for engineering research are taught, which include: analog electronic circuit analysis; fundamentals of digital data acquisition; measurements of pressure, temperature, flow rate, heat transfer, and static forces and moments; and statistical data analysis.

**Prerequisite(s):** [(MMAE 313 and PHYS 221)]

**Lecture: 3 Lab: 3 Credits: 4**

**Satisfies:** Communications (C)

**MMAE 320****Thermodynamics**

Introduction to thermodynamics including properties of matter; First Law of Thermodynamics and its use in analyzing open and closed systems; limitations of the Second Law of Thermodynamics; entropy.

**Prerequisite(s):** [(MATH 251)]

**Lecture: 3 Lab: 0 Credits: 3**

**MMAE 321****Applied Thermodynamics**

Analysis of thermodynamic systems including energy analysis; analysis and design of power and refrigeration cycles; gas mixtures and chemically reacting systems; chemical equilibrium; combustion and fuel cells.

**Prerequisite(s):** [(MMAE 313\* and MMAE 320)]An asterisk (\*) designates a course which may be taken concurrently.

**Lecture: 3 Lab: 0 Credits: 3**

**MMAE 323****Heat and Mass Transfer**

Basic laws of transport phenomena, including: steady-state heat conduction; multi-dimensional and transient conduction; forced internal and external convection; natural convection; heat exchanger design and analysis; fundamental concepts of radiation; shape factors and network analysis; diffusive and convective mass transfer; phase change, condensation and boiling.

**Prerequisite(s):** [(MMAE 313 and MMAE 320)]

**Lecture: 3 Lab: 0 Credits: 3**

**MMAE 332****Design of Machine Elements**

Students will gain an understanding of the basic elements used in machine design. These include the characteristics of gears, bearings, shafts, keys, couplings, fasteners, springs, electric motors, brakes and clutches, and flexible elements. Students will also learn mechanism types, linkage analysis, and kinematic synthesis.

**Prerequisite(s):** [(MMAE 232\*)]AND[(MMAE 302) OR (MMAE 304)]AND[(MS 201)]An asterisk (\*) designates a course which may be taken concurrently.

**Lecture: 3 Lab: 0 Credits: 3**

**MMAE 350****Computational Mechanics**

Explores the use of numerical methods to solve engineering problems in solid mechanics, fluid mechanics and heat transfer. Topics include matrix algebra, nonlinear equations of one variable, systems of linear algebraic equations, nonlinear equations of several variables, classification of partial differential equations in engineering, the finite difference method, and the finite element method. Same as MATH 350.

**Prerequisite(s):** [(CS 104-201, MATH 251, MATH 252\*, and MMAE 202\*)]An asterisk (\*) designates a course which may be taken concurrently.

**Lecture: 3 Lab: 0 Credits: 3**

**MMAE 361****Fundamentals of Crystalline Solids**

Imperfections in metals and ceramics. Dislocations and plastic deformation. The thermodynamic and kinetic principles of binary phase diagrams. Diffusion. Solidification.

**Prerequisite(s):** [(MMAE 371 and MS 201)]

**Lecture: 3 Lab: 0 Credits: 3**

**MMAE 362****Physics of Solids**

Introduction of crystallography, crystal structure, crystal systems, symmetry, stereographic representation. Crystal structures in materials. X-ray diffraction; character of X-rays and their interaction with crystals; diffraction methods. Structure of the atom and the behavior of electrons in solids. Band theory of solids. Electrical, thermal and magnetic behavior. Theory of phase stability in alloys. Equivalent to PHYS 437.

**Prerequisite(s):** [(MS 201)]

**Lecture: 3 Lab: 0 Credits: 3**

**Satisfies:** Communications (C)

**MMAE 365****Structure and Properties of Materials I**

Crystal structures and structure determination. Crystal defects, intrinsic and extrinsic properties, diffusion, kinetics of transformations, evolution and classification of microstructures.

**Prerequisite(s):** [(MMAE 320\* and MS 201)]An asterisk (\*) designates a course which may be taken concurrently.

**Lecture: 3 Lab: 0 Credits: 3**

**MMAE 370****Materials Laboratory I**

Introduction to materials characterization techniques including specimen preparation, metallography, optical and scanning electron microscopy, temperature measurement, data acquisition analysis and presentation.

**Prerequisite(s):** [(MMAE 365\*) OR (MMAE 371\*)]An asterisk (\*) designates a course which may be taken concurrently.

**Lecture: 1 Lab: 6 Credits: 3**

**Satisfies:** Communications (C)

**MMAE 372****Aerospace Materials Lab**

Mechanical behavior and microstructural characterization of aerospace materials including advanced metal alloys, polymers, ceramics, and composites. Introduction to mechanical testing techniques for assessing the properties and performance of aerospace materials. Evaluation of structural performance in terms of materials selection, processing, service conditions, and design.

**Prerequisite(s):** [(MMAE 202 and MS 201)]

**Lecture: 3 Lab: 3 Credits: 3**

**Satisfies:** Communications (C)

**MMAE 373****Instrumentation and Measurements Laboratory**

Basic skills for engineering research are taught, which include: analog electronic circuit analysis, fundamentals of digital data acquisition and statistical data analysis. Laboratory testing methods including solid mechanics: tension, torsion, hardness, impact, toughness, fatigue and creep. Design of experiments.

**Prerequisite(s):** [(PHYS 221)]

**Lecture: 2 Lab: 3 Credits: 4**

**Satisfies:** Communications (C)

**MMAE 406****Mechanical Vibrations**

Study of free, forced and damped vibrations of single degree of freedom mechanical systems: resonance, critical damping, and vibration isolation. Two degree of freedom systems: natural frequencies, normal modes, resonances and vibration absorbers. Introduction to vibrations of multiple degree of freedom.

**Prerequisite(s):** [(MMAE 305 and MMAE 350)]

**Lecture: 3 Lab: 0 Credits: 3**

**Satisfies:** Communications (C)

**MMAE 407****Biomechanics: Solids**

Properties of mathematical models for bone, soft tissues, tendons, ligaments, cartilage, and muscles. Human body structure, posture movement, and locomotion. Spine mechanics and joint mechanics. Mechanics of occlusion and mastication. Exoprosthetics and endoprosthetics. Implants and biomechanical compatibility.

**Prerequisite(s):** [(MMAE 302) OR (MMAE 304)]AND[(MMAE 430\*)]An asterisk (\*) designates a course which may be taken concurrently.

**Lecture: 3 Lab: 0 Credits: 3**

**Satisfies:** Communications (C)

**MMAE 410****Aircraft Flight Mechanics**

Airplane performance: takeoff, rate of climb, time to climb, ceilings, range and endurance, operating limitations, descent and landing. Helicopters and V/STOL aircraft. Airplane static stability and control: longitudinal stability, directional stability, and roll stability. Airplane equations of motion: kinematics and dynamics of airplanes, and stability derivatives. Dynamic response: longitudinal modes of motion, lateral modes of motion. Introduction to aircraft control.

**Prerequisite(s):** [(MMAE 312 and MMAE 443\*)]An asterisk (\*) designates a course which may be taken concurrently.

**Lecture: 3 Lab: 0 Credits: 3**

**MMAE 411****Spacecraft Dynamics**

Orbital mechanics: two-body problem, Kepler's equation, classical orbital elements, and introduction to orbit perturbations. Spacecraft mission analysis: orbital maneuvers and station keeping, earth orbiting, lunar, and interplanetary missions, introduction to orbit determination. Spacecraft attitude dynamics: three-dimensional kinematics and dynamics of spacecraft, rotating reference frames and orientation angles, and spacecraft equations of motion. Spacecraft attitude stability and control: dual-spin platforms, momentum wheels, control-moment gyros, gravity gradient stabilization, introduction to spacecraft attitude determination and control.

**Prerequisite(s):** [(MATH 252, MMAE 200, MMAE 305, and MMAE 443\*)]An asterisk (\*) designates a course which may be taken concurrently.

**Lecture: 3 Lab: 0 Credits: 3**

**MMAE 412****Spacecraft Design I**

Launch vehicle design including a system engineering, payload mission definition, propulsion and staging, structural design, trajectory analysis and guidance, launch window considerations, navigation and attitude determination, booster re-entry, range safety, and reliability. Semester-long project is focused on the integration of multiple systems into a coherent launch vehicle design to achieve specific mission requirements.

**Prerequisite(s):** [(MMAE 302) OR (MMAE 304)]AND[(MMAE 411\*)]AND[(MMAE 452)]An asterisk (\*) designates a course which may be taken concurrently.

**Lecture: 2 Lab: 1 Credits: 3**

**Satisfies:** Communications (C)

**MMAE 413****Spacecraft Design II**

Spacecraft systems design including real world mission analysis and orbit design, launch vehicle requirements, attitude determination and control, propulsion, structural design, power systems thermal management, and telecommunications. Semester-long project is focused on the integration of multiple systems into a coherent spacecraft design to achieve specific mission requirements.

**Prerequisite(s):** [(MMAE 411 and MMAE 412)]

**Lecture: 2 Lab: 1 Credits: 3**

**MMAE 414****Aircraft Design I**

Aircraft design including aerodynamic, structural, and power plant characteristics to achieve performance goals. Focus on applications ranging from commercial to military and from manpowered to high-speed to long-duration aircraft. Semester project is a collaborative effort in which small design groups complete the preliminary design cycle of an aircraft to achieve specific design requirements.

**Prerequisite(s):** [(MMAE 302) OR (MMAE 304)]AND[(MMAE 312)]AND[(MMAE 410\*)]AND[(MMAE 452)]An asterisk (\*) designates a course which may be taken concurrently.

**Lecture: 2 Lab: 1 Credits: 3**

**Satisfies:** Communications (C)

**MMAE 415****Aerospace Laboratory II**

Advanced skills for engineering research are taught, which include experiments with digital electronic circuit analysis, dynamic data acquisition techniques, fundamentals of fluid power system design, GPS and inertial guidance systems, air-breathing propulsion, and fly-by-wire control.

**Prerequisite(s):** [(MMAE 315) OR (MMAE 319)]AND[(MMAE 443\*)]An asterisk (\*) designates a course which may be taken concurrently.

**Lecture: 2 Lab: 3 Credits: 4**

**Satisfies:** Communications (C)

**MMAE 416****Aircraft Design II**

Team project that includes conceptual design, detail design, prototyping, and testing (or simulation) of an aircraft model or aircraft subsystem to meet performance specifications.

**Prerequisite(s):** [(MMAE 410 and MMAE 414)]

**Lecture: 3 Lab: 3 Credits: 3**

**MMAE 417****Advanced Aerodynamics**

Unsteady aerodynamics, nonlinear flight regimes at high angle of attack, missile aerodynamics, hypersonic flight, and other topics relevant to the aerospace industry.

**Prerequisite(s):** [(MMAE 410\*)]An asterisk (\*) designates a course which may be taken concurrently.

**Lecture: 3 Lab: 0 Credits: 3**

**MMAE 418****Fluid Power for Aerospace Applications**

Basic principles and concepts needed for the design and troubleshooting of fluid power systems. An emphasis is placed on flight control and simulation of hydraulic systems and is extended to mobile and industrial applications.

**Prerequisite(s):** [(MMAE 313 and MMAE 443\*)]An asterisk (\*) designates a course which may be taken concurrently.

**Lecture: 2 Lab: 3 Credits: 3**

**MMAE 419****Mechanical Laboratory II**

Laboratory testing methods including solid mechanics: tension, torsion, hardness, impact, toughness, fatigue and creep; heat and mass transfer: conduction, fins, convection, radiation, diffusion; vibrations and control. Design of experiments.

**Prerequisite(s):** [(MMAE 302\*) OR (MMAE 304\*)]AND[(MMAE 315) OR (MMAE 319)]AND[(MMAE 323)]AND[(MMAE 443\*)]An asterisk (\*) designates a course which may be taken concurrently.

**Lecture: 3 Lab: 3 Credits: 4**

**Satisfies:** Communications (C)

**MMAE 425****Direct Energy Conversion**

A study of various methods available for direct conversion of thermal energy into electrical energy. Introduction to the principles of operation of magneto-hydrodynamic generators, thermoelectric devices, thermionic converters, fuel cells and solar cells.

**Prerequisite(s):** [(MMAE 321 and PHYS 224)]

**Lecture: 3 Lab: 0 Credits: 3**

**MMAE 426****Nuclear, Fossil-Fuel, and Sustainable Energy Systems**

Principles, technology, and hardware used for conversion of nuclear, fossil-fuel, and sustainable energy into electric power will be discussed. Thermodynamic analysis – Rankine cycle. Design and key components of fossil-fuel power plants. Nuclear fuel, reactions, materials. Pressurized water reactors (PWR). Boiling water reactors (BWR). Canadian heavy water (CANDU) power plants. Heat transfer from the nuclear fuel elements. Introduction to two phase flow: flow regimes; models. Critical heat flux. Environmental effects of coal and nuclear power. Design of solar collectors. Direct conversion of solar energy into electricity. Wind power. Geothermal energy. Energy conservation and sustainable buildings. Enrichment of nuclear fuel. Nuclear weapons and effects of the explosions.

**Prerequisite(s):** [(CHE 302) OR (MMAE 323)]

**Lecture: 3 Lab: 0 Credits: 3**

**MMAE 432****Design of Mechanical Systems**

Small-group design projects drawn from industry.

**Prerequisite(s):** [(MMAE 304) OR (MMAE 332\*)]An asterisk (\*) designates a course which may be taken concurrently.

**Lecture: 1 Lab: 3 Credits: 3**

**Satisfies:** Communications (C)

**MMAE 433****Design of Thermal Systems**

Application of principles of fluid mechanics, heat transfer, and thermodynamics to design of components of engineering systems. Examples are drawn from power generation, environmental control, air and ground transportation, and industrial processes, as well as other industries. Groups of students work on projects for integration of these components and design of thermal systems.

**Prerequisite(s):** [(MMAE 321)]AND[(MMAE 323)]

**Lecture: 3 Lab: 0 Credits: 3**

**Satisfies:** Communications (C)



**MMAE 434****Design for Mechanical Reliability**

Reliability and hazard functions; statics and dynamic reliability models for series, parallel and complex systems; reliability allocation. Probabilistic design; stress and strength distributions; safety factors; loading random variables; geometric tolerances, linear and nonlinear dimensional combinations; stress as random variable; material properties as random variables; failure theories; significant stress-strength models; reliability confidence intervals.

**Prerequisite(s):** [(MMAE 332)]

**Lecture: 3 Lab: 0 Credits: 3**

**MMAE 435****Design for Safety in Machines**

A critical study of the interface between law and safety engineering, which embraces not only statutory law, such as OSHA and the Consumer Products Safety Act, but also case law arising from product liability suits. Detailed analysis of actual industrial and consumer accidents from the investigative stages through their litigation. Formulation of general safety design techniques for mechanical engineering systems and the development of courtroom communication skills for expert witnesses.

**Lecture: 3 Lab: 0 Credits: 3**

**MMAE 440****Introduction to Robotics**

Classification of robots; kinematics and inverse kinematics of manipulators; trajectory planning; robot dynamics and equations of motion; position control.

**Prerequisite(s):** [(MMAE 305)]AND[(MMAE 315) OR (MMAE 319)]

**Lecture: 3 Lab: 0 Credits: 3**

**MMAE 443****Systems Analysis and Control**

Mathematical modeling of dynamic systems; linearization. Laplace transform; transfer functions; transient and steady-state response. Feedback control of single-input, single-output systems. Routh stability criterion. Root-locus method for control system design. Frequency-response methods; Bode plots; Nyquist stability criterion.

**Prerequisite(s):** [(MATH 252)]AND[(MMAE 305)]

**Lecture: 3 Lab: 0 Credits: 3**

**MMAE 444****Design for Manufacture**

The materials/design/manufacturing interface in the production of industrial and consumer goods. Material and process selection; process capabilities; modern trends in manufacturing. Life cycle engineering; competitive aspects of manufacturing; quality, cost, and environmental considerations.

**Prerequisite(s):** [(MMAE 485)]

**Lecture: 3 Lab: 0 Credits: 3**

**MMAE 445****Computer-Aided Design**

Principles of geometric modeling, finite element analysis and design optimization. Curve, surface, and solid modeling. Mesh generation, Galerkin method, and Isoparametric elements. Optimum design concepts. Numerical methods for constrained and unconstrained optimization. Applications of CAD/CAE software for mechanical design problems.

**Prerequisite(s):** [(MMAE 304) OR (MMAE 332)]AND[(MMAE 350)]

**Lecture: 3 Lab: 0 Credits: 3**

**MMAE 450****Computational Mechanics II**

Explores the use of numerical methods to solve engineering problems in continuum mechanics, fluid mechanics, and heat transfer. Topics include partial differential equations and differential and integral eigenvalue problems. As tools for the solution of such equations, we discuss methods of linear algebra, finite difference and finite volume methods, spectral methods, and finite element methods. The course contains an introduction to the use of a commercial finite element package for the solution of complex partial differential equations.

**Prerequisite(s):** [(MATH 350) OR (MMAE 350)]

**Lecture: 3 Lab: 0 Credits: 3**

**MMAE 451****Finite Element Methods in Engineering**

Principles of minimum potential energy of structures--stiffness matrices, stress matrices and assembly process of global matrices. The finite element method for two-dimensional problems: interpolation functions, area coordinates, isoperimetric elements, and problems of stress concentration. General finite element codes: data generation and checks, ill-conditioned problems, and node numbering.

**Prerequisite(s):** [(MATH 252, MMAE 202, and MMAE 350)]

**Lecture: 3 Lab: 0 Credits: 3**

**MMAE 452****Aerospace Propulsion**

Analysis and performance of various jet and rocket propulsive devices. Foundations of propulsion theory. Design and analysis of inlets, compressors, combustion chambers, and other elements of propulsive devices. Emphasis is placed on mobile power plants for aerospace applications.

**Prerequisite(s):** [(MMAE 311)]

**Lecture: 3 Lab: 0 Credits: 3**

**MMAE 453****Advanced Automotive Powertrains**

This course provides insight into the various methods of propulsion available for automobiles. Students will receive the tools and practical understanding required to analyze a variety of vehicle powertrain architectures and predict the energy consumptions and vehicle performance of the current automotive powertrains. This course will provide students with an understanding of the working principles of internal combustion engines, hybrid powertrains, and electric vehicles; the ability to predict the energy requirements of these powertrains; experience in analyzing system and component efficiency based on vehicle test data; and a comprehensive view of the current challenges in the automotive transportation sector. Students will apply the analytical tools presented in the course to examine topics such as vehicle loads and losses, emissions control, vehicle efficiency, and the impact of vehicle hybridization and electrification.

**Prerequisite(s):** [(MMAE 321)]

**Lecture: 3 Lab: 0 Credits: 3**

**MMAE 455****Cardiovascular Fluid Mechanics**

Anatomy of the cardiovascular system. Scaling principles. Lumped parameter, one-dimensional linear and nonlinear wave propagation, and three-dimensional modeling techniques applied to simulate blood flow in the cardiovascular system. Steady and pulsatile flow in rigid and elastic tubes. Form and function of blood, blood vessels, and the heart from an engineering perspective. Sensing, feedback, and control of the circulation. Possible project using custom software to run blood flow simulations. Same as BME 455.

**Prerequisite(s):** [(BME 301) OR (MMAE 313)]

**Lecture: 3 Lab: 0 Credits: 3**

**MMAE 461****Failure Analysis**

This course provides comprehensive coverage of both the "how" and "why" of metal and ceramic failures and gives students the intellectual tools and practical understanding needed to analyze failures from a structural point of view. Its proven methods of examination and analysis enable students to reach correct, fact-based conclusions on the causes of metal failures, present and defend these conclusions before highly critical bodies, and suggest design improvements that may prevent future failures. Analytical methods presented in the course include stress analysis, fracture mechanics, fatigue analysis, corrosion science, and nondestructive testing. Numerous case studies illustrate the application of basic principles of metallurgy and failure analysis to a wide variety of real-world situations.

**Prerequisite(s):** [(MS 201)]

**Lecture: 3 Lab: 0 Credits: 3**

**MMAE 463****Structure and Properties of Materials II**

Continuation of MMAE 365. Solidification structures, diffusional and diffusionless transformations. Structure-property relationships in commercial materials.

**Prerequisite(s):** [(MMAE 365)]

**Lecture: 3 Lab: 0 Credits: 3**

**MMAE 464****Physical Metallurgy**

Principles of microstructure evolution with emphasis on phase transformations in metals and alloys. Processing-microstructure-property relationships. Fundamentals of alloy design for commercial applications.

**Prerequisite(s):** [(MMAE 361) OR (MMAE 365)]

**Lecture: 3 Lab: 0 Credits: 3**

**MMAE 465****Electrical, Magnetic, and Optical Properties of Materials**

Electronic structure of solids, semiconductor devices and their fabrication. Ferroelectric and piezoelectric materials. Magnetic properties, magnetocrystalline anisotropy, magnetic materials and devices. Optical properties and their applications, generation and use of polarized light. Same as PHYS 465.

**Prerequisite(s):** [(MMAE 365) OR (PHYS 348)]

**Lecture: 3 Lab: 0 Credits: 3**

**Satisfies:** Communications (C)

**MMAE 466****Microstructural Characterization of Materials**

Advanced optical microscopy. Scanning and transmission electron microscopes. X-ray microanalysis. Surface characterization. Quantitative microscopy.

**Prerequisite(s):** [(MMAE 370)]

**Lecture: 2 Lab: 3 Credits: 3**

**Satisfies:** Communications (C)

**MMAE 468****Introduction to Ceramic Materials**

The structure and structure/properties relationships of ceramic materials. Topics include: crystal structure types; crystal defects; structure of glass; phase equilibria and how these affect applications for mechanical properties; electrical properties; and magnetic properties. Sintering and ceramic reactions are related to microstructure and resultant properties.

**Prerequisite(s):** [(MS 201)]

**Lecture: 3 Lab: 0 Credits: 3**

**MMAE 470****Introduction to Polymer Science**

An introduction to the basic principles that govern the synthesis, processing and properties of polymeric materials. Topics include classifications, synthesis methods, physical and chemical behavior, characterization methods, processing technologies and applications. Credit will only be granted for CHE 470, CHEM 470, MMAE 470.

**Prerequisite(s):** [(CHEM 124, MATH 251, and PHYS 221)]

**Lecture: 3 Lab: 0 Credits: 3**

**Satisfies:** Communications (C)

**MMAE 472****Advanced Aerospace Materials**

Principles of materials and process selection for minimum weight design in aerospace applications. Advanced structural materials for aircraft fuselage and propulsion applications. Materials for space vehicles and satellites. Environmental degradation in aerospace materials.

**Prerequisite(s):** [(MMAE 372)]

**Lecture: 3 Lab: 0 Credits: 3**



**MMAE 473****Corrosion: Materials Reliability and Protective Measures**

This course covers the basics of corrosion science (fundamentals and mechanisms) and corrosion engineering (protection and control). The various forms of corrosion (uniform, pitting, crevice, stress corrosion cracking, etc.) are illustrated along with practical protective measures (coatings, inhibitors, electrochemical protection, materials upgrade, etc.). The course highlights the concepts of alloys design to minimize corrosion, the properties of steels, stainless steels, and high-performance alloys along with case studies of corrosion failures and lessons learned.

**Prerequisite(s):** [(MMAE 365)]

**Lecture: 2 Lab: 0 Credits: 2**

**MMAE 476****Materials Laboratory II**

Team design projects focused on the processing and/or characterization of metallic, non-metallic, and composite materials. Students will work on a capstone design problem with realistic constraints, perform experimental investigations to establish relationships between materials structures, processing routes and properties, and utilize statistical or computational methods for data analysis.

**Prerequisite(s):** [(MMAE 370)]

**Lecture: 1 Lab: 6 Credits: 3**

**MMAE 482****Composites**

This course focuses on metal, ceramic and carbon matrix composites. Types of composite. Synthesis of precursors. Fabrication of composites. Design of composites. Mechanical properties and environmental effects. Applications.

**Prerequisite(s):** [(MS 201)]

**Lecture: 3 Lab: 0 Credits: 3**

**MMAE 484****Materials and Process Selection**

Decision analysis. Demand, materials and processing profiles. Design criteria. Selection schemes. Value and performance oriented selection. Case studies.

**Lecture: 3 Lab: 0 Credits: 3**

**Satisfies:** Communications (C)

**MMAE 485****Manufacturing Processes**

Principles of material forming and removal processes and equipment. Force and power requirements, surface integrity, final properties and dimensional accuracy as influenced by material properties and process variables. Design for manufacturing. Factors influencing choice of manufacturing process.

**Prerequisite(s):** [(MMAE 332) OR (MMAE 372)]

**Lecture: 3 Lab: 0 Credits: 3**

**MMAE 490****Crystallography and Crystal Defect**

Geometrical crystallography - formal definitions of lattices, systems, point groups, etc. Mathematical methods of crystallographic analysis. Diffraction techniques: X-ray, electron and neutron diffraction. Crystal defects and their influence on crystal growth and crystal properties.

**Lecture: 3 Lab: 0 Credits: 3**

**MMAE 491****Undergraduate Research**

Student undertakes an independent research project under the guidance of an MMAE faculty member. Requires the approval of the MMAE Department Undergraduate Studies Committee.

**Credit:** Variable

**MMAE 494****Undergraduate Design Project**

Student undertakes an independent design project under the guidance of an MMAE faculty member. Requires the approval of the MMAE Department Undergraduate Studies Committee.

**Credit:** Variable

**MMAE 497****Undergraduate Special Topics**

Special individual design project, study, or report as defined by a faculty member of the department. Requires junior or senior standing and written consent of both academic advisor and course instructor.

**Credit:** Variable

**MS 201****Materials Science**

The scientific principles determining the structure of metallic, polymeric, ceramic, semiconductor and composite materials; electronic structure, atomic bonding, atomic structure, microstructure and macrostructure. The basic principles of structure-property relationships in the context of chemical, mechanical and physical properties of materials.

**Prerequisite(s):** [(CHEM 122) OR (CHEM 124)]

**Lecture: 3 Lab: 0 Credits: 3**