MECHANICAL, MATERIALS, AND AEROSPACE ENGINEERING

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Faculty with Research Interests
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 (my.iit.edu) account.

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

Taking a Course for Pass/Fail

Students majoring in Aerospace Engineering, Materials Science and Engineering, or Mechanical Engineering cannot take any required course for their major as Pass/Fail except for free elective courses. Any courses taken above and beyond the student's program requirements can also be taken as Pass/Fail.

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 Materials Science and Engineering/Master of Engineering in Materials Science and 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)**.**

Minors

Minors available to students who wish to broaden their knowledge can be found in the Minors section. In all programs, required minor courses may substitute for free electives. In addition, required minor courses may also substitute for technical electives provided that the minor courses are approved technical elective courses. 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 Science (for ME and MSE 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 Science (for ME and AE students only)
- Military Science
- Naval Science

- Polymer Science and Engineering
- Premedical Studies
- Software Engineering

MMAE Minors

- Minor in Aerospace Science
- Minor in Applied Mechanics
- Minor in Electromechanical Design and Manufacturing
- Minor in Materials Science

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
Statics
Equilibrium concepts. Free body diagrams. Statics of particles and rigid bodies. Distributed forces, centroids, center of gravity, hydrostatic loads, and moments of inertia. Analysis of trusses and frames. Friction including wedges, screws, and belts. Internal loads in beams.
Prerequisite(s): (CS 104* or CS 105* or CS 115*) and 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. Elementary bending theory, unsymmetric bending, normal and shear stresses in beams, beam deflection. Combined loading. Plane stress and strain, Mohr's circle, stress transformation.
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, mechanism and linkage design, actuators, and engineering and law. Team-based design and build projects focusing on sustainable design techniques, bio-inspired locomotion, and mechatronics.
Prerequisite(s): (CS 104 or CS 105 or CS 115) and MMAE 200*, An asterisk (*) designates a course which may be taken concurrently.
Lecture: 1 **Lab:** 3 **Credits:** 3

MMAE 302
Advanced Mechanics of Solids
Analysis of stress and strain. Singularity functions. Plasticity under torsional and bending loads. Energy methods and Castigliano's theorems. Curved beams and springs. Pressure vessels. Stability of columns. Stress concentration and stress intensity factors. Theories of failure, yield, and fracture. Fatigue.
Prerequisite(s): MMAE 202 and MATH 252 and MATH 251
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): MMAE 202 and MATH 252 and MATH 251
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): MATH 252* and (MMAE 200 or CAE 286), 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 320 and MMAE 313
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 320 and MMAE 313 and MMAE 311*, 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. Langrangian 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): MMAE 200 and MATH 252* and MATH 251 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): PHYS 221 and MMAE 350* and MMAE 311* and MMAE 313, 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 date analysis.
Corequisite(s): MMAE 323
Prerequisite(s): MMAE 313 and MMAE 323* and PHYS 221, An asterisk (*) designates a course which may be taken concurrently.
Lecture: 3 **Lab:** 3 **Credits:** 4

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 320 and MMAE 313*, 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 320 and MMAE 313
Lecture: 3 **Lab:** 0 **Credits:** 3

MMAE 332
Design of Machine Elements
Students will gain an understanding of the analysis of basic elements used in machine design. These include the characteristics of gears, gear trains, bearings, shafts, keys, mechanical springs, brakes and clutches, and flexible elements.
Prerequisite(s): (MMAE 302 or MMAE 304) and MMAE 232*, 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 a MATH 350.
Prerequisite(s): MATH 251 and CS 104-201 and MMAE 202* and MATH 252*, An asterisk (*) designates a course which may be taken concurrently.
Lecture: 3 **Lab:** 0 **Credits:** 3

MMAE 352
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 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

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

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 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 443* and MMAE 312, 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): MMAE 443* and MMAE 305 and MMAE 200 and MATH 252, 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 352, An asterisk (*) designates a course which may be taken concurrently.
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 352, 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 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 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): MMAE 323 or CHE 302
Lecture: 3 **Lab:** 0 **Credits:** 3

MMAE 432
Design of Mechanical Systems
Capstone design courses taken during the senior year. At the end of this course, students should have a good grasp of the design process and how to integrate design with the analysis taught in previous courses. The course serves as a guide to transferring the skills that the students learned in the classroom into becoming an engineer in industry or a graduate student in the field. The focus of the class will be a team-based project conceptualized and developed by the students.
Prerequisite(s): MMAE 332
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 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 441
Spacecraft and Aircraft Dynamics
Kinematics and dynamics of particles, systems of particles, and rigid bodies; translating and rotating reference frames; Euler angles. Aircraft longitudinal and lateral static stability; aircraft equations of motion. Spacecraft orbital dynamics; two-body problem classical orbital elements; orbital maneuvers.
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): MMAE 305 and MATH 252
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 350 and (MMAE 304 or MMAE 332)
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): MMAE 350 or MATH 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): MMAE 202 and MATH 252 and MMAE 350
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 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 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

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 and MATH 251 and PHYS 221
Lecture: 3 **Lab:** 0 **Credits:** 3

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

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 124 or CHEM 122
Lecture: 3 **Lab:** 0 **Credits:** 3