Aerospace Engineering

Department of Mechanical and Aerospace Engineering

School of Engineering and Applied Sciences
309 Furnas Hall
North Campus
Buffalo, NY 14260-4400

PH: 716.645.2593
Fax: 716.645.2883
Web: www.mae.buffalo.edu

Overview

The four-year undergraduate program leading to the BS degree in aerospace engineering prepares students for careers in aerospace and related technologies. This includes the traditional aeronautics and astronautics applications (e.g., subsonic and supersonic aircraft, satellites, space shuttle, space station), as well as aerospace-related component development (design of structures, devices, and instruments) and vehicle and propulsion system design.

The educational objectives for our graduates are: 1) Holds position in engineering or other professional career or is engaged in advanced study; 2) Functions effectively in multidisciplinary teams, is able to communicate effectively and use scientific and technological tools; and 3) Engages in service activities such as participation in professional societies or community groups and always recognizes the environmental, societal, and ethical contexts of his/her work.

During the first and second years, students will be provided with broad knowledge in applied mathematics, physics, and the engineering sciences. During the third and fourth years, students build upon this foundation by learning the specialized topics of aerodynamics, propulsion, structures, vehicle design, and stability and control.

About our Degrees

See School of Engineering and Applied Sciences for Acceptance Information

Acceptance Information

Admission into Aerospace Engineering for freshmen or current UB students is described in the Acceptance Information section of the School of Engineering and Applied Sciences. For admission of transfer students into Aerospace Engineering, see the Transfer Policy of the School of Engineering and Applied Sciences.

Degree Requirements

Please see Degrees and Policies.

About our Courses

The typical class size for:

Freshman/introductory courses is: 100-300
Sophomore/intermediate courses is: 100-300
Upper level/advanced courses is: 30-100

In the Department of Mechanical and Aerospace Engineering, what do teaching assistants (TAs) do?

Nearly all of our courses are taught by regular full-time faculty members and, in some cases, by practicing professionals from industry. Normally, graduate student teaching assistants grade homework and conduct laboratory and recitation sections of courses.

For course descriptions, please see Courses.

About our Faculty

The faculty members in Mechanical and Aerospace Engineering are widely recognized for their technical skills. They have received recognition

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for both teaching and research accomplishments, with over 40 awards from national and international organizations. Research awards have come from the National Science Foundation, the National Institutes of Health, and the Office of Naval Research, and international study awards have come from the J. William Fulbright and the Alexander von Humboldt Foundations.

See a list of our Undergraduate Faculty.

Transfer Policy

Transfer students must first apply to the university and meet the university transfer admission requirements. See the School of Engineering and Applied Sciences for transfer information.

Extracurricular Activities

American Institute of Aeronautics and Astronautics (AIAA):

The AIAA is a national organization whose goal is to serve the technical needs and to promote the professional development of engineers in the aerospace field. The student chapter at UB serves the interests of both undergraduate and graduate students of aerospace engineering. The student section runs a variety of activities including field trips, guest speakers, and design projects.

American Society of Mechanical Engineering (ASME):

ASME organizes meetings of researchers and practitioners throughout the country and publishes numerous reports, conference proceedings, and journals, as well as the monthly magazine, Mechanical Engineering, which is received by members. Here at UB, the student chapter coordinates, plans and runs a variety of student activities, including invitation of guest speakers, organization of field trips, a departmental open house for the Buffalo community, student paper contests, an annual picnic and banquet, and participation in the Mid-Atlantic Regional Student Conference. Membership provides students with the privileges of the parent society.

Biomedical Engineering Society (BMES):

BMES is a national organization with 2,000 members, approximately half of whom are students. Members include engineers as well as physiologists and other health scientists with interests in Biomedical Engineering. The annual BMES Fall Meeting features awards to undergraduate and graduate students. The Buffalo student section program includes guest lecturers, and field trips to research and manufacturing facilities.

Pi Tau Sigma:

Pi Tau Sigma is the National Honorary Society for Mechanical Engineering in the United States. This organization was established to recognize and honor those men and women in the field of Mechanical Engineering who have, through scholarship, integrity, and outstanding achievement, been a credit to their profession. Outstanding students may be nominated from among the juniors and seniors in the Mechanical Engineering Program.

Sigma Gamma Tau:

Sigma Gamma Tau is the National Honorary Society for Aeronautics, Astronautics, and Aerospace Engineering in the United States. Outstanding students are selected from among the juniors and seniors in the Aerospace Engineering program. A formal initiation coupled with a dinner takes place every spring.

Society of Automotive Engineers (SAE):

The SAE student chapter is organized primarily to train students in hands-on engineering and design skills. To accomplish this, teams are formed to work on projects that will subsequently be entered in national competitions. Typical projects include: Mini-Baja, Formula Car, and Go-Karts (an introductory experience to involve underclassmen). The UB SAE student chapter is large and well-motivated, and has performed well in recent competitions. The SAE has been named the UB Student Association's 'Club-of-the-Year' - a rare honor for a technically oriented club.

Society of Women Engineers (SWE):

SWE provides a means of increasing awareness of issues associated with being part of a minority body within the field of engineering. SWE encourages participation of all students in several extra-curricular activities, including seminars, workshops, and regional meetings. UB has

been selected as the site for regional meetings of the SWE, with participation of hundreds of students.

Students for the Exploration and Development of Space (SEDS):

Students for the Exploration and Development of Space is a completely student-run organization promoting space and its related activities. The organization is continually growing and adding new projects. Current projects include rocketry, propulsion, educational outreach, and astronomy. Students also attend conferences, discuss current space activities, host speakers, and much more.

Tau Beta Pi (TBP):

Tau Beta Pi is the National Honorary Society for Engineering in the United States. This organization was established to recognize and honor those men and women in all fields of engineering who have, through scholarship, integrity, and outstanding achievement, been a credit to their profession. Outstanding students are selected from among the juniors and seniors in the engineering programs. A formal initiation coupled with a dinner takes place every spring.

See the UB Student Association.

Practical Experience and Special Academic Opportunities

Independent study, internships, and co-op experiences are all available in the Department of Mechanical and Aerospace Engineering.

Opportunities for Undergraduate Research and Practical Experience
Students are encouraged to participate in work experience classes and research opportunities as part of their undergraduate education.

Work experience is available through the Engineering Career Institute program in the School of Engineering and Applied Sciences, as well as departmental co-op and internship classes. The Engineering Career Institute (EAS 396, 1 academic credit) provides career-effectiveness skills and co-op placement assistance during the junior year. This may be followed by one to three co-op work experiences (EAS 496, 2 academic credit hours). Descriptions of co-op courses may be found at http://undergrad-catalog.buffalo.edu/academicprograms/eas_courses.shtml.

Undergraduate research experiences are available for course credit (Undergraduate Research and Creative Activity or Independent Study) or as an assistant in the research laboratory of a faculty member. The Center for Undergraduate Research and Creative Activity serves as a clearing house for information regarding undergraduate research opportunities.

Career Information and Further Study

At the University at Buffalo, the four-year undergraduate program leading to the BS degree in aerospace engineering prepares students for a career in the aerospace engineering profession and the aerospace industry. This preparation includes traditional aeronautics and astronautics applications (such as subsonic and supersonic aircraft, satellites, space shuttle, and the space station) as well as aerospace-related component development (such as design of structures, and devices and instruments) and vehicle and propulsion system design. Because of the rapid pace of development and extreme diversity of the aerospace field, the undergraduate aerospace engineering program stresses knowledge of the fundamentals of the profession so as to provide a meaningful multidisciplinary foundation for the student's entire career span. While many students enter industry directly after completing the B.S. program, about 50 percent of our aerospace graduates elect to pursue graduate work in engineering or other fields.

The future for the aerospace engineer is extremely exciting. Aerospace engineers find themselves on the leading edge of technology, solving problems existing high in the clouds or in the vast reaches of space just as often they consider problems closer to home.

A variety of industries require the talents of aerospace engineers. The automotive industry, for example, has recently seen increased interest in aerospace technologies such as aerodynamics, feedback control, propulsion, system dynamics, and lightweight structures. The aerospace engineering program is also intended to prepare students for service in aerospace-related government agencies, such as NASA; FAA; and the U.S. Air Force, Navy, or Marine flying services.

Salaries range greatly from one occupation, position, and work setting to another. However, according to Bureau of Labor Statistics, the 2011 starting salary for graduates with a bachelor's degree in aerospace engineering is $56,311.

Additional Resources

The American Institute of Aeronautics and Astronautics

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Degrees Offered

Undergraduate: BS
Graduate: MS, PhD

Links to Further Information About this Program

- Undergraduate Catalog
- Undergraduate Admissions
- Graduate Admissions
- Department of Mechanical and Aerospace Engineering
- School of Engineering and Applied Sciences

Aerospace Engineering - B.S.

Acceptance Criteria

See School of Engineering and Applied Sciences for Acceptance Information. Students may apply for admission to Aerospace Engineering when they enter the University as freshmen, as transfer students, or later in their academic careers. To remain in Aerospace Engineering and to be permitted to take upper-level (300/400 level) Aerospace Engineering Courses, students must satisfy the following requirements:

1) Successful completion of the following five courses with at least a 2.2 GPA: MTH 141, MTH 142, PHY 107, MAE 204, EAS 207. If a course is repeated, the grade that is counted is the grade earned the second time, even if this grade is lower than the grade earned the first time.

2) Minimum overall and UB GPA of 2.0 to be considered in academic good standing with the University.

Advising Notes

Students must meet minimum GPA and residency requirements in engineering as specified by the Dean of Engineering to graduate from the program. See the Academic Requirements section of the School of Engineering and Applied Sciences for additional information.

Required Courses

CHE 107 General Chemistry for Engineers
EAS 140 Engineering Solutions
EAS 202 Engineering Impact On Society
EAS 207 Statics
EAS 208 Dynamics
EAS 209 Mechanics of Solids
EAS 230 Engineering Computations
EE 200 EE Concepts/Non-majors
MAE 177 Introduction to Engineering Drawing and CAD
MAE 204 Thermodynamics
MAE 278 Introduction to Aerospace Engineering Practice
MAE 315 Analysis of Structures
MAE 316 Aerospace Structures
MAE 334 Mechanical and Aerospace Engineering Lab I
MAE 335 Fluid Mechanics
MAE 336 Heat Transfer
MAE 338 Mechanical and Aerospace Engineering Lab 2
MAE 340 Dynamic Systems
MAE 376 Applied Math for MAE
MAE 377 Product Design in a CAD Environment
MAE 381 Engineering Materials
MAE 385 Engineering Materials Laboratory
MAE 422 Gas Dynamics
MAE 423 Introduction to Propulsion
MAE 424 Aerodynamics
MAE 425 Spacecraft Dynamics and Control
MAE 434 Aircraft Design
MAE 436 Flight Dynamics
MAE 451 Design Process and Methods
MTH 141 College Calculus I

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MTH 142 College Calculus II
MTH 241 College Calculus III
MTH 306 Introduction to Differential Equations
PHY 107 General Physics I
PHY 108/PHY 158 General Physics II/Lab
One technical elective

Summary
Total credit hours required for the major: 130

See Baccalaureate Degree Requirements for general education and remaining university requirements.

Recommended Sequence of Program Requirements

FIRST YEAR
Fall CHE 107, EAS 140, MTH 141, ENG 101, Gen Ed 1
Spring EAS 202, EAS 230, MAE 177, MTH 142, PHY 107, ENG 201, Library Skills

SECOND YEAR
Fall EAS 207, MAE 204, MAE 278, MTH 241, PHY 108/PHY 158
Spring EAS 208, EAS 209, EE 200, MTH 306, Gen Ed 2

THIRD YEAR
Fall MAE 315, MAE 335, MAE 340, MAE 376, MAE 381
Spring MAE 316, MAE 334, MAE 336, MAE 385, MAE 424, Gen Ed 3

FOURTH YEAR
Fall MAE 338, MAE 377, MAE 422, MAE 436, MAE 451, Gen Ed 4
Spring MAE 423, MAE 425, MAE 434, one technical elective, Gen Ed 5

Electives and Course Groupings

Technical Electives (TE)

Technical Electives are engineering, mathematics, or science courses at the 300/400 level that are not required courses. Any course that substantially duplicates the material presented in another course that is being counted toward the degree cannot be used to satisfy the TE requirement.

Mechanical And Aerospace Engineering (Double Major) - B.S.

Acceptance Criteria

See School of Engineering and Applied Sciences for acceptance information. Students may apply for admission to the double major in aerospace and mechanical engineering when they enter the university as freshmen, as transfer students, or later in their academic careers. To remain in aerospace and mechanical engineering and to be permitted to take upper-level (300/400 level) aerospace and mechanical engineering Courses, students must satisfy the following requirements:

1) Successful completion of the following five courses with at least a 2.2 GPA: MTH 141, MTH 142, PHY 107, MAE 204, EAS 207. If a course is repeated, the grade that is counted is the grade earned the second time, even if this grade is lower than the grade earned the first time.

2) Minimum overall and UB GPA of 2.0 to be considered in academic good standing with the University.

Required Courses

CHE 107 General Chemistry for Engineers
EAS 140 Engineering Principles
EAS 202 Engineering Impact On Society
EAS 207 Statics
EAS 208 Dynamics
EAS 209 Mechanics of Solids
EAS 230 Engineering Computations
EE 200 EE Concepts/Non-majors
MAE 177 Introduction to Engineering Drawing and CAD
MAE 204 Thermodynamics

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MAE 277 Introduction to Mechanical Engineering Practice or MAE 278 Introduction to Aerospace Engineering Practice
MAE 311 Machines and Mechanisms
MAE 315 Analysis of Structures
MAE 316 Aerospace Structures
MAE 334 MAE Laboratory I
MAE 335 Fluid Mechanics
MAE 336 Heat Transfer
MAE 338 MAE Laboratory II
MAE 340 Dynamic Systems
MAE 364 Manufacturing Processes
MAE 376 Applied Math for MAE
MAE 377 Product Design in a CAE Environment
MAE 381 Engineering Materials
MAE 385 Engineering Materials Laboratory
MAE 422 Gas Dynamics
MAE 423 Introduction to Propulsion
MAE 424 Aerodynamics
MAE 425 Spacecraft Dynamics and Control
MAE 434 Aircraft Design
MAE 436 Flight Dynamics
MAE 451 Design Process and Methods
MAE 494 Design Project
MTH 141 College Calculus I
MTH 142 College Calculus II
MTH 241 College Calculus III
MTH 306 Introduction to Differential Equations
PHY 107 General Physics I
PHY 108/PHY 158 General Physics II/Lab
One professional practice course

Summary
Total credit hours required for the major...118

See Baccalaureate Degree Requirements for general education and remaining university requirements.

Recommended Sequence of Program Requirements

FIRST YEAR
Fall CHE 107, EAS 140, MTH 141, ENG 101, Gen Ed 1
Spring EAS 202, EAS 230, MAE 177, MTH 142, PHY 107, ENG 201, Library Skills

SECOND YEAR
Fall EAS 207, MAE 204, MAE 277 or MAE 278, MTH 241, PHY 108/PHY 158
Spring EAS 208, EAS 209, EE 200, MTH 306, Gen Ed 2

THIRD YEAR
Fall MAE 315, MAE 335, MAE 340, MAE 376, MAE 381
Spring MAE 316, MAE 334, MAE 336, MAE 385, MAE 424

FOURTH YEAR
Fall MAE 338, MAE 377, MAE 422, MAE 436, MAE 451, Gen Ed 3
Spring MAE 364, MAE 423, MAE 425, MAE 434, Gen Ed 4

FIFTH YEAR
Fall MAE 311, MAE 494, one professional practice course, Gen Ed 5

Electives and Course Groupings

Professional Practice Course

CIE 303 Geodesy, GPS, and GIS
CIE 340 Environmental Engineering
COM 317* Business/Professional Communication
EAS 396 / EAS 496 Engineering Career Institute / Engineering Co-op
ECO 405 Microeconomic Theory
ECO 469 Industrial Organization
ECO 470 Economics of Regulation
GEO 333 Bases of World Commerce
GEO 334 International Environments and Commercial Problems

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IE 320 Engineering Economy
IE 326 Planning for Production
MAE 496 Engineering Internship

MAE 177: Introduction to Engineering Drawing and CAD

Credits: 2
Semester(s): Spring
Type: LEC/LAB

Provides a first exposure to mechanical design for engineers. Includes the nature and visual representation of mechanical components and principles of engineering drawing and sketching for mechanical design. Utilizes up-to-date computer-aided design software (such as AutoCAD) for mechanical drawings and mechanical designs.

MAE 204: Thermodynamics I

Credits: 3
Pre-requisites: MTH 142
Approved Engineering Majors Only
Type: LEC/REC

Covers conservation of mass, first and second laws of thermodynamics, thermodynamic properties, equilibrium, and their application to physical and chemical systems.

MAE 277: Introduction to Mechanical and Aerospace Engineering Practice

Credits: 3
Semester(s): Fall
Type: LEC

An overview of engineering in industry; introduces engineering design concepts, reverse engineering, case studies including a hands-on product dissection project, basics of manufacturing processes, elementary modeling of engineering systems, and technical communications. Students who have completed MAE 311, MAE 364, or MAE 377 should see the Director of Undergraduate Studies to select an alternative course.

MAE 278: Introduction to Aerospace Engineering Practice

Credits: 3
Type: LEC

An overview of aerospace engineering; introduces aerospace history, airplane and rocket anatomy, flow and fluid properties, earth atmosphere, wind tunnels, aerodynamic drag, aircraft performance, aircraft structures and materials, supersonic and hypersonic flight, propulsion, orbital mechanics, and future of air and space transportation.

MAE 311: Machines and Mechanisms I

Credits: 3
Semester(s): Spring
Pre-requisites: EAS 209
Co-requisites: MAE 381
Mechanical or Aerospace Engineering Majors Only; refer to MAE Progression Criteria in your academic advising report for additional requirements.
Type: LEC

Examines analysis and design of machine elements, including theories of failure, fatigue strength, and endurance limits; fluctuating stresses; Goodman diagram; and fatigue design under torsional and combined stresses. Also covers design of bolted connections, fasteners, welds, springs, ball and roller bearings, journal bearings, gears, clutches, and brakes.

MAE 315: Analysis of Structures

Credits: 3
Pre-requisites: EAS 209
Co-requisites: MAE 376
Approved ASE and ME majors only; refer to MAE Progression Criteria in your academic advising report for additional requirements.
Type: LEC

Examines the theory of elastic structural components including elastic stress analysis; equilibrium, strain displacement and compatibility; yield criteria; energy methods; finite element analysis and numerical methods.

MAE 316: Aerospace Structures

Credits: 3
Pre-requisites: MAE 315
Mechanical or Aerospace Engineering Majors Only; refer to MAE Progression Criteria in your academic advising report for additional requirements.
Type: LEC

Explores the theory of light structures including beam bending, shear stress, shear center, and composite beams; shear flow, warping stresses, and secondary warping; torsion of thin-walled single and multi-cell tubes; deformation of struts, plates, frames, and trusses; stress analysis of connections; composite structures and sandwich construction. Also covers computer implementation with applications to aircraft and aerospace structures.

MAE 334: Mechanical and Aerospace Engineering Lab I

Credits: 2
Semester(s): Fall
Pre-requisites: MAE 340 And EAS 209 And EE 200 Or EE 202
Mechanical Or Aerospace Engineering Majors Only; refer to MAE Progression Criteria in your academic advising report for additional requirements.
Type: LEC/LAB

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Introduces digital data acquisition systems. A/D convertors, and amplifiers. Error analysis. Transducers for mechanical and electrical measurements. Static and dynamic response of electrical and mechanical elements and systems. Modifying dynamic response using feedback control. One lecture and one three-hour laboratory weekly.

MAE 335: Fluid Mechanics

Credits: 3
Semester(s): Fall
Pre-requisites: EAS 209; refer to MAE Progression Criteria in your academic advising report for additional requirements.
Type: LEC/REC

Fluid statics; substantial derivatives; Reynolds transport equation; control volume approach for conservation of mass, linear momentum, moment of momentum, and the first law of thermodynamics; dimensional analysis and similitude; laminar and turbulent pipe flow of liquids; boundary-layer theory; one-dimensional, compressible flow; potential flow.

MAE 336: Heat Transfer

Credits: 3
Semester(s): Spring
Pre-requisites: MAE 204
Mechanical Or Aerospace Engineering Majors Only; refer to MAE Progression Criteria in your academic advising report for additional requirements.
Type: LEC

Introduces the transport of heat by conduction, convection, and radiation. Topics include transient and steady-state, one- and multidimensional heat conduction (treated both analytically and numerically); single-phase, laminar and turbulent, and forced and natural convection both within ducts and on external surfaces (dimensional analysis and empirical correlations); two-phase transport (boiling and condensation); radiative properties of materials and analysis of radiative heat transfer in enclosures; and analysis of heat exchangers.

MAE 338: MAE Lab II

Credits: 2
Semester(s): Fall
Pre-requisites: MAE 335 and MAE 336; refer to MAE Progression Criteria in your academic advising report for additional requirements.
Type: LAB

Testing the behavior and response of fluid and thermal systems; dimensionless groups, flow metering; measurement of properties such as viscosity, friction losses, thermal conductivity; heat exchangers, thermodynamic cycles. One lecture and one three-hour laboratory weekly.

MAE 340: Dynamic Systems

Credits: 3
Semester(s): Spring
Pre-requisites: EAS 208, Mecahnical or Aerospace Engineering Majors Only
Co-requisites: MAE 376
Refer to MAE Progression Criteria in your academic advising report for additional requirements.
Type: LEC

Modeling and analysis of lumped physical systems; static and dynamic response of electrical, mechanical, thermal and hydraulic elements, systems and transducers; Laplace transforms, transfer functions, frequency response; mixed systems; use of state space and matrix methods in systems modeling and analysis; introduction to feedback control. Three credit-hours of lecture per week.

MAE 364: Manufacturing Processes

Credits: 3
Semester(s): Spring
Type: LEC

Examines manufacturing processes including casting, forming, cutting, joining, and molding of various engineering materials (metals and non-metals). Also studies manufacturing considerations in design including material and process selection, tooling, product quality, and properties/processing tradeoffs. Includes quality control and automation issues.

MAE 376: Applied Mathematics for MAE

Credits: 3
Semester(s): Fall
Pre-requisites: EAS 230 and MTH 306 or MTH 242; refer to MAE Progression Criteria in your academic advising report for additional requirements.
Type: LEC/REC

Considers the solution of engineering problems using computational methods. Topics include linear algebra, sets of linear and nonlinear equations, ordinary differential equations, and matrix eigen values. Also covers topics in statistics (particularly with normal distributions) and engineering applications involving error analysis. Considers interpolation, splines, and nonlinear curve fitting as time permits. Programming will be required and will build on the basis of earlier Matlab or equivalent language instruction

MAE 377: Product Design in a CAE Environment

Credits: 3
Semester(s): Fall, Spring
Type: LEC/LAB

Examines mechanical design of functional, pragmatic products from inception through implementation, including topics in computer-aided-design (CAD). Discusses the design process in the context of product redesign assignments using CAD. Includes a final design project with professional documentation including sketches, detailed and assembly CAD drawings, a comprehensive written design analysis, and cost breakdown.

MAE 381: Engineering Materials

Credits: 3
Semester(s): Fall
Pre-requisites: CHE 101 or CHE 105 or CHE 107; refer to MAE Progression Criteria in your academic advising report for additional requirements.
Type: LEC

Introduces the physics and chemistry of engineering materials

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including metals, ceramics, polymers, and composites. Covers the relationships among the processing, internal structure, material properties, and applications. Internal structure includes crystal structure, imperfections, and phases. Processing includes annealing, precipitation hardening, and heat treatment of steel. Properties include mechanical properties and corrosion behavior. Also considers current industrial needs.

MAE 385: Engineering Materials Laboratory

Credits: 1
Semester(s): Spring
Pre-requisites: MAE 381
Mechanical Or Aerospace Engineering Majors Only; refer to MAE Progression Criteria in your academic advising report for additional requirements.
Type: LAB

Involves experiments designed to illustrate the relationships among the processing, internal structure and properties of engineering materials, emphasizing metals and their heat treatment, microstructure and mechanical properties. Provides hands-on experience in metallography, heat treatment and mechanical testing. Includes laboratory report writing and work in groups.

MAE 412: Machines and Mechanisms II

Credits: 3
Semester(s): Fall
Pre-requisites: MAE 376; refer to MAE Progression Criteria in your academic advising report for additional requirements.
Type: LEC/REC

Studies kinematics and dynamics of machinery including linkages, geometry of motion, mobility, cam design, gear trains, and computing mechanisms. Also covers velocity and acceleration analysis by graphical, analytical, and numerical techniques; static and dynamic force analysis in machinery; engine analysis; flywheels; and balancing.

MAE 417: Applied Orthopedic Biomechanics

Credits: 3
Semester(s): Spring
Pre-requisites: EAS 209
Mechanical Or Aerospace Engineering Majors Only; refer to MAE Progression Criteria in your academic advising report for additional requirements.
Type: LEC

Studies the design of implants and prosthetics in relation to the biomechanics of the musculoskeletal system. Topics include bone physiology, testing methods (tension, compression, bending, torsion, shear, and fatigue, including nondestructive testing), strain gage application, composite theory of bone, stress fractures and fatigue properties in the musculoskeletal system, fracture healing, external/internal fixation (Ilizarov, etc.), aging and osteoporosis, pathology of osteoarthritis, joint replacement and arthroplasty, and spin biomechanics.

MAE 420: Biomechanics of the Musculoskeletal System

Credits: 3
Semester(s): Fall
Pre-requisites: EAS 209; refer to MAE Progression Criteria in your academic advising report for additional requirements.
Type: LEC/SEM

Reviews basic aspects of anatomy including forces transmitted in the body, bones as structural members, and joint and muscle forces. Also considers kinematics of body motions, instantaneous centers of joint motions, behavior of normal and abnormal joints, remodeling, biomaterials, and ligaments and tendons. Also studies functions of orthotics and prostheses, including design considerations. Involves a weekly seminar and one or two laboratory sessions.

MAE 422: Gas Dynamics

Credits: 3
Semester(s): Spring
Pre-requisites: MAE 335
Mechanical Or Aerospace Engineering Majors Only; refer to MAE Progression Criteria in your academic advising report for additional requirements.
Type: LEC

Explores fundamentals of gas dynamics and compressible aerodynamics including one-dimensional isentropic flow; one-dimensional flow with friction and with heating or cooling; normal shock relations; oblique shocks and expansion waves; the method of characteristics; quasi-one-dimensional flow; nozzles and diffusers; shock tubes; and small perturbation theory.

MAE 423: Introduction to Propulsion

Credits: 3
Semester(s): Fall
Pre-requisites: MAE 335; refer to MAE Progression Criteria in your academic advising report for additional requirements.
Type: LEC

Reviews combustion thermodynamics; flow in nozzle, diffuser, and constant area duct with shock; analysis and performance of air breathing and chemical rocket propulsion systems; performance of single and multi-staged rocket vehicles; and space missions.

MAE 424: Aerodynamics

Credits: 4
Semester(s): Fall
Pre-requisites: MAE 335
Mechanical Or Aerospace Engineering Majors Only; refer to MAE Progression Criteria in your academic advising report for additional requirements.
Type: LEC/LAB

Explores flow over airfoils and wings; ideal flow theory; singularity solutions; superposition; source; and vortex panel methods; method of source panels; 2-D airfoil theory; pressure distributions and lift; effects of compressibility; Prandtl's lifting-line theory; boundary-layer theory; and friction drag. Includes an aerodynamics laboratory experience, considering airfoil characteristics, and boundary-layer measurements.

MAE 425: Spacecraft Dynamics and Control

Credits: 3
Pre-requisites: MAE 376
Mechanical Or Aerospace Engineering Majors Only; refer to MAE

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Progression Criteria in your academic advising report for additional requirements.
Type: LEC

Introduces the concepts of spacecraft orbital mechanics and attitude dynamics. Orbital mechanics is the study of the positional motion, while attitude dynamics describes the orientation of the spacecraft. Topics include: review of rotational kinematics and dynamics, orbital mechanics, gravity turn and trajectory optimization, orbit lifetimes, three-body problem, orbit perturbations, orbit determination, spacecraft dynamics, spinning and three-axis stabilized spacecraft, and attitude determination.

MAE 428: Analytical Methods

Credits: 3
Semester(s): Spring
Pre-requisites: MAE 376; refer to MAE Progression Criteria in your academic advising report for additional requirements.
Type: LEC

Covers solution methods for practical problems in mechanical and aerospace engineering, involving partial differential equations. Explores Fourier series, orthogonal functions, Laplace transforms, examples of partial differential equations (e.g. waves and heat conduction equations), method of separation of variables, and Bessel functions. Also involves an introduction to complex variable theory, and application to potential flow.

MAE 431: Energy Systems

Credits: 3
Semester(s): Fall
Pre-requisites: MAE 204; refer to MAE Progression Criteria in your academic advising report for additional requirements.
Type: LEC

Continuation of thermodynamics. Studies availability, psychrometrics, real gases, combustion thermochemistry, phase and chemical equilibrium, fuel cells, flow through nozzles, and blade passages.

MAE 434: Aircraft Design

Credits: 3
Semester(s): Spring
Pre-requisites: MAE 436
Mechanical Or Aerospace Engineering Majors Only; refer to MAE Progression Criteria in your academic advising report for additional requirements.
Type: LEC

Involves practice predicting performance of existing designs with comparison to actual performance; and analyzes performance of new, student-designed aircraft. Conceptual aircraft design for specific mission profiles is facilitated by course-licensed software.

MAE 436: Flight Dynamics

Credits: 3
Semester(s): Fall
Pre-requisites: MAE 376
Co-requisites: MAE 424
Refer to MAE Progression Criteria in your academic advising report for additional requirements.
Type: LEC/REC

Reviews practical aerodynamics of wings and bodies, as well as performance of aircraft and missiles in the atmosphere. Topics include longitudinal, lateral, and directional static stability; control effectiveness; control forces; basic equations of motion of flight vehicles; aerodynamics, thrust and gravity forces; and stability derivatives. Analyzes aircraft and missile dynamic stability, as well as typical model responses to control inputs. Further studies autopilots, stability augmentation, and analysis of the pilot as a control-system element.

MAE 438: Smart Materials

Credits: 3
Pre-requisites: MAE 381
Mechanical Or Aerospace Engineering Majors Only; refer to MAE Progression Criteria in your academic advising report for additional requirements.
Type: LEC

Introduces concepts and applications of smart materials, which refer to materials that can sense a certain stimulus and, in some cases, even react to the stimulus in a positive way so as to counteract negative effects of the stimulus. Strain/stress sensors and actuators are emphasized. Topics include intrinsically smart structural materials, piezoelectric and electrostrictive materials, magnetostrictive materials, electrorheological and magnetorheological fluids, shape memory materials and optical fibers.

MAE 439: Heating, Ventilation, and Air Conditioning

Credits: 3
Semester(s): Spring
Pre-requisites: MAE 336
Mechanical Or Aerospace Engineering Majors Only; refer to MAE Progression Criteria in your academic advising report for additional requirements.
Type: LEC

Reviews psychrometrics, physiological factors, heating and cooling load calculations, refrigeration methods and applications to air conditioning, cryogenic methods, fan and duct analyses, and solar energy.

MAE 442: Computer-Aided Analysis in Fluid and Thermal Sciences

Credits: 3
Semester(s): Spring
Pre-requisites: MAE 335 and MAE 336 and MAE 376; refer to MAE Progression Criteria in your academic advising report for additional requirements; Approved ASE and ME majors only.
Type: LEC

For seniors and beginning graduate students interested in computer-based analysis of engineering problems in fluid mechanics and heat transfer. Emphasizes applications of computer analysis to engineering design of fluid/thermal systems. Surveys the general governing equations and methods to solve them, including finite-difference, finite-volume, panel methods, and finite element methods. Introduces state-of-the-art computer tools for analysis and graphical representation of results. Gives students a broad view of computational fluid mechanics for engineering applications in the fluid/thermal sciences.

Aerospace Engineering

MAE 443: Continuous Control System

Credits: 3
Semester(s): Fall
Pre-requisites: MAE 340; refer to MAE Progression Criteria in your academic advising report for additional requirements; Approved ASE and ME majors only.
Type: LEC

Examines system modeling and identification of plants to be controlled; use of feedback control systems; design of feedback control laws including P, I, D; block diagrams, transfer functions, and frequency response functions; control system design and analysis in the time domain and frequency domain; computer simulation of control systems; stability analysis using Routh-Hurwitz criterion; design for stability, speed of response, and accuracy; root locus, Bode, and Nyquist plots; compensation strategies.

MAE 444: Digital Control Systems

Credits: 3
Semester(s): Spring
Pre-requisites: MAE 443; refer to MAE Progression Criteria in your academic advising report for additional requirements.
Type: LEC/LAB

Characterization of discrete time systems; analysis of discrete control systems by time-domain and transform techniques; stability analysis (Jury test, bilinear transformation, Routh stability test); deadbeat controller design; root-locus based controller design; discrete state variable techniques; synthesis of discrete time controllers; engineering consideration of computer controlled systems.

MAE 448: Issues in Concurrent Design

Credits: 3
Type: LEC

Current interest in incorporating quality and manufacturing concerns in the early stages of the design process has resulted in such concepts as concurrent engineering, total quality management, quality function deployment, robust design, Taguchi's quality functions, teaming approaches for complex design, and many others. The course addresses these concepts, particularly as they pertain to complex engineering design. Investigates industrial case studies and design projects incorporating some or all of the above concepts, provides first-hand experience.

MAE 449: Design of Complex Engineering Systems

Credits: 3
Semester(s): Spring
Type: LEC

Applies domain-independent design methods and decision-support theories and tools to the design of large-scale, complex systems. Covers the role of design, decision-making, and open engineering systems in a globally competitive society. Topics include descriptive and prescriptive models of design, decision theory, utility theory, game theory, design of experiments, approximation, and stochastic and deterministic processes.

MAE 451: Design Process and Methods

Credits: 3
Semester(s): Fall
Type: LEC

Discusses the fundamental concepts and activities of design processes. Investigates domain-independent topics of design processes. These topics include idea conception, teamwork, quality, experimental design, optimization, and technical communication. In addition, discusses fundamental methods of design, including decision making, conceptual design, cost evaluation, ethics issues, and intellectual property issues, which are investigated through interactive lectures and individual and group exercises.

MAE 454: Road Vehicle Dynamics

Credits: 3
Pre-requisites: MAE 340; refer to MAE Progression Criteria in your academic advising report for additional requirements; Approved ASE and ME majors only
Type: LEC

Covers the forces and torques generated by tires (under both traction and braking) and by the relative wind; two-wheel and four-wheel models of a vehicle; simplified stability and control of transients; steady-state response to external disturbances; effects of the roll degree of freedom; equations of motion in body-fixed coordinates; lateral load transfer; force-moment analysis; and applications of feedback-control theory to the design of subsystems for improved performance.

MAE 457: Fire Science and Safety Engineering

Credits: 3
Pre-requisites: MAE 335 and MAE 336; refer to MAE Progression Criteria in your academic advising report for additional requirements.
Type: LEC

Considers the building blocks of a fire, including a basic understanding of chemically reactive flows, fire plume dynamics, and flame spread rates across liquid and solid surfaces. Larger compartment fires will then be examined and the origin of flashover and backdraft discussed leading up to a fully developed fire. Explores fire protection engineering and introduces advanced simulation and modeling tools that are used by professionals to aid in the design of a fire protection system.

MAE 458: Tribology

Credits: 3
Semester(s): Fall
Type: LEC

Explores friction, lubrication, and wear; contact of real surfaces; mechanics of friction; surface failures; boundary lubrication; fluid properties; thin-film lubrication; thick-film lubrication; and bearing and lubricant selection.

MAE 464: Manufacturing Automation

Credits: 3
Semester(s): Fall

Aerospace Engineering

Pre-requisites: MAE 364; refer to MAE Progression Criteria in your academic advising report for additional requirements; Approved ASE and ME majors only
Type: LEC/LAB

Introduces the theory of automation as related to manufacturing and design integration, including hardware, software, and algorithm issues involved in fast and flexible product development cycles. Studies strategies of automated manufacturing systems; CAD-CAM; and integration, programming, and simulation. Additional topics include Robotics (e.g. applications in welding, material handling, and human intensive processes), Reverse Engineering (e.g. modeling product from laser and CMM data of parts), Virtual Environments (e.g. industrial applications of virtual reality and prototyping), Intelligent Diagnostics (e.g. sensor fusion for machine tool monitoring), Automated Inspection (e.g. computer vision and methods of automated quality control), and Design for Manufacturing (e.g. issues involved in concurrent product development).

MAE 467: Vibration and Shock

Credits: 3
Semester(s): Spring
Pre-requisites: MAE 340
Mechanical Or Aerospace Engineering Majors Only; refer to MAE Progression Criteria in your academic advising report for additional requirements.
Type: LEC

Examines mechanical vibration and shock including free and forced, periodic, and aperiodic vibration of single-degree and multi-degree of freedom systems.

MAE 473: Graphics in Computer-Aided Design

Credits: 3
Semester(s): Fall
Type: LEC

Examines basic programming concepts in computer-aided design (CAD) for mechanical engineers, including interactive computing in design; the role of graphics in CAD; 2-D graphics; computer graphic operations, including curve generation and splines; and 3-D graphics, including data structures, rotation, translation, reflection, isometric and perspective projection, hidden line removal, shading, surface generation, solid modeling concepts, and object-oriented programming. Involves computer programming projects in C++.

MAE 476: Mechatronics

Credits: 3
Semester(s): Spring
Pre-requisites: MAE 334; refer to MAE Progression Criteria in your academic advising report for additional requirements.
Type: LEC/LAB

Studies the theory and practice of hardware and software interfacing of microprocessors with analog and digital sensor/actuators to realize mechatronic systems. Coverage includes microprocessor architectures, programming, digital and analog circuits, sensors, actuators, communication protocols, and real-time and operator interface issues as applicable to the design and implementation of simple mechatronic subsystems. Lectures emphasize basics of theory, architecture, and operation and are supplemented by labs aimed at building basic competence by hands-on practical implementation.

MAE 477: Computer-Aided Design Applications

Credits: 3
Semester(s): Spring
Type: LEC/LAB

Considers concepts in computer-aided engineering including principles of computer graphics, finite element analysis, kinematic analysis, and animation of mechanical systems. Studies the use of integrated CAD/CAE tools. Incorporates projects in solid modeling, stress analysis of machine parts and structures, and mechanism response and animation.

MAE 478: Cardiovascular Biomechanics

Credits: 3
Semester(s): Spring
Pre-requisites: EAS 209 and MAE 335; refer to MAE Progression Criteria in your academic advising report for additional requirements; Approved ASE and ME majors only
Type: LEC

Introduces the mechanical behavior of the cardiovascular system, basic physiology, and application of engineering fundamentals to obtain quantitative descriptions. Major topics include rheology of blood, mechanics of the heart, dynamics of blood flow in the heart and circulation, control of cardiac output, blood pressure, and regional blood flow.

MAE 482: Introduction to Composite Materials

Credits: 3
Semester(s): Fall
Pre-requisites: EAS 209 and MAE 381; refer to MAE Progression Criteria in your academic advising report for additional requirements; Approved ASE and ME majors only.
Type: LEC

Provides a basic understanding of composite materials (manufacturing and mechanical properties). Examines behavior of unidirectional and short-fiber composites; analysis of laminated composites; performance of composites, including fracture, fatigue, and creep under various conditions; fracture modes of composites; manufacturing and micro-structural characterization of composites; experimental characterization and statistical analysis; and polymeric, metallic, and ceramic composites.

MAE 484: Principles and Materials for Micro-Electro-Mechanical Systems (Mems)

Credits: 3
Semester(s): Spring
Pre-requisites: MAE 381; refer to MAE Progression Criteria in your academic advising report for additional requirements.
Type: LEC

Current interest in micro-electro-mechanical systems, or MEMS, is driven by the need to provide a physical window to the micro-electronics systems, allowing them to sense and control motion, light, sound, heat, and other physical phenomena. Such micro-systems that integrate microelectronics and sensing elements on the same chip present an interesting engineering problem in terms of their design, fabrication, and choice of materials.

Aerospace Engineering

Addresses the design, fabrication, and materials issues involving MEMS. Displays these issues within the context of MEMS for mechanical sensing and actuation, magnetic devices, thermal devices, automotive applications, and Bio-MEMS for biomedical applications.

MAE 487: Modern Theory of Materials

Credits: 3
Pre-requisites: MAE 381
Mechanical Or Aerospace Engineering Majors Only; refer to MAE Progression Criteria in your academic advising report for additional requirements.
Type: LEC

Develops fundamentals of modern theories of solids. Topics include reciprocal lattices, diffraction theory, electron energy bands, and phonon dispersion.

MAE 493: Mathematical Methods in Robotics

Credits: 3
Pre-requisites: MAE 376; refer to MAE Progression Criteria in your academic advising report for additional requirements; Approved ASE and ME majors only.
Type: LEC

A mathematical introduction to modeling, analysis and control of robotic systems. The first part of the course deals with the theoretical frameworks for modeling, analysis (kinematics and dynamics) and control of generic robotic mechanical systems, rooted in rich traditions of mechanics and geometry. The rest of the course will examine many of these issues in the context of serial-chain and parallel-chain manipulators, wheeled mobile robots (and hybrid combinations of these systems).

MAE 494: Design Project

Credits: 3
Semester(s): Fall, Spring
Type: LEC/TUT

Students working in teams of two or three under the supervision of a faculty member complete an original engineering design, which in some cases results in hardware. Design problems are drawn from industry and initiated by faculty. Where practical, two or more teams compete to solve the same problem. Teams meet individually with faculty on a weekly basis to discuss their projects.

MAE 496: Engineering Internship

Credits: 3
Semester(s): Fall, Spring
Type: LEC

Provides experience in real-world engineering problems for senior mechanical and aerospace students. Assigns projects from local industry. Normally requires students to spend eight hours weekly in an engineering office. Students must present written and oral reports. Students interested in an internship or co-op experience should also consider the EAS 396 and EAS 496 sequence.

MAE 498: Undergraduate Research & Creative Activity

Credits: 1-3
Semester(s): Fall, Spring, Summer
Type: TUT

The content of this course is variable and therefore it is repeatable for credit. The University Grade Repeat Policy does not apply.

Students collaborate with faculty research mentors on an ongoing project in a faculty member's laboratory or conduct independent research under the guidance of a faculty member. This experience provides students with an inquiry based learning opportunity and engages them as active learners in a research setting. Arrangements must be made with a specific faculty member before registration.

MAE 499: Independent Study in Mechanical Engineering

Credits: 1-12
Semester(s): Fall, Spring
Type: TUT

The content of this course is variable and therefore it is repeatable for credit. The University Grade Repeat Policy does not apply.

Independent engineering projects or reading courses may be arranged with individual faculty members. Students must make arrangements with a specific faculty member for work on a particular topic before registering.