Mechanical and Industrial Engineering

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Mission of the Department

The mission of the Department of Mechanical and Industrial Engineering is to educate students for professional and technical excellence; to perform research to advance the science and practice of engineering; to engage in service activities that advance the department, the university, and the profession; and to instill in ourselves and our students habits and attitudes that promote ethical behavior, professional responsibility, and careers that advance the well-being of society.

The program educational objectives for the mechanical engineering and industrial engineering programs are as follows. Graduates from our undergraduate programs will demonstrate technical excellence in their chosen fields, anticipate and respond to societal changes, and develop careers with depth and flexibility, while retaining a professional and intellectual thrust throughout. Specifically:

1. Graduates will contribute to the advancement of the mechanical or industrial engineering field, displaying leadership and innovation in the larger community while fulfilling the expectations of their employers.
2. Graduates will engage in activities that promote professional development and personal growth.

Mechanical Engineering

Mechanical engineers design, develop, and support the manufacture of machinery and devices to transmit power or to convert energy from thermal to mechanical form in order to power the modern world and its machines. Traditionally, mechanical engineers have designed and tested devices, such as heating and air-conditioning systems, machine tools, internal-combustion engines, and steam power plants. Today they also play primary roles in the development of new technologies in a variety of fields—energy conversion, solar energy utilization, environmental control, prosthetics, transportation, manufacturing, robotics, and new-materials development.

Mechanical engineers use computers to formulate preliminary and final designs of systems or devices, to perform calculations that predict the behavior of the design, and to collect and analyze performance data from system testing or operation. Mechanical engineering has been heavily influenced by recent advances in computer hardware and software.

The curriculum in mechanical engineering focuses on four areas: applied mechanics, thermofluids engineering, materials science, and controls. Applied mechanics is the study of the motion and deformation of structural elements acted on by forces in devices that range from rotating industrial dynamos to dentists’ drills. Thermofluids engineering deals with the motion of fluids and the transfer of energy, as in the cooling of electronic components or the design of gas turbine engines. Materials science is concerned with the relationship between the structure and properties of materials and with the control of structure, through processing, to achieve desired properties. Practical applications are in the development of composite materials, metallurgical process industries, and advanced functional materials. Controls are critical to any engineered system in which sensors and actuators of several types communicate and function.

Courses in each area form the foundation for advanced analytical and creative design courses that culminate in a two-semester capstone design project. Faculty encourage students throughout the curriculum to use computer-aided design tools and high-performance computer workstations.

Industrial Engineering

Industrial engineers design and analyze systems that include people, equipment, and materials and their interactions and performance in the workplace. An industrial engineer collects this information and evaluates alternatives to make decisions that best advance the goals of the enterprise. Industrial engineers work in manufacturing firms, hospitals, banks, public utilities, transportation, government agencies, insurance companies, and construction firms. Among the projects they undertake are design and implementation of a computer-integrated supply chain or manufacturing system, facilities planning for a variety of industries, design of a robotics system in a manufacturing environment, long-range corporate planning, development and implementation of a quality-control system, simulation analyses to improve processes and make operational decisions, design of healthcare operations to enhance patient safety and improve efficiency, productivity, and development of computer systems for information control.

The program in industrial engineering offers students a base of traditional engineering courses, such as work design, human-machine systems, probability, statistics, and engineering economy, while emphasizing such contemporary areas as simulation modeling, engineering database systems, quality assurance, logistics and supply chain management, operations research, and facilities planning. Students integrate the knowledge acquired in these courses in a two-semester capstone design project.

Other Programmatic Features

More than 90 percent of the department’s undergraduate students take advantage of the cooperative education program. Cooperative education assignments increase in responsibility and technical challenge as students progress through the program. Entry level co-op positions in mechanical engineering may be in manufacturing, quality assurance and testing, or involve 3-D CAD modeling, while more advanced-level positions will allow students to gain experience in the design process, including advanced 3-D modeling, design for manufacturability, prototyping, and systems engineering. Students in the industrial engineering discipline may utilize co-op to concentrate on one industry segment and build an increasingly technical skill set with each experience or explore the breadth of career opportunities over the course of several co-op rotations such as healthcare process improvement, supply chain logistics, business analytics, manufacturing operations, and more.

The department also offers significant research opportunities throughout all fields of mechanical and industrial engineering, including participating
in research centers based in our department and college, as well as new interdisciplinary graduate and professional master’s programs.

Our students have an opportunity to obtain a broad knowledge base in science, engineering, and general studies that allows them flexibility in career development and graduate education. At the same time, our graduates should be responsible and scientifically educated citizens, prepared to contribute personally as well as professionally to an educated, democratic society.

**Programs**

**Bachelor of Science in Industrial Engineering (BSIE)**
- Industrial Engineering (http://catalog.northeastern.edu/undergraduate/engineering/mechanical-industrial/bsie)

**Bachelor of Science in Mechanical Engineering (BSME)**
- Mechanical Engineering (http://catalog.northeastern.edu/undergraduate/engineering/mechanical-industrial/bsme)
- Mechanical Engineering and Physics (http://catalog.northeastern.edu/undergraduate/engineering/mechanical-industrial/mechanical-engineering-physics-bsme)

**Minors**
- Biomechanical Engineering (http://catalog.northeastern.edu/undergraduate/engineering/mechanical-industrial/biomechanical-engineering-minor)
- Industrial Engineering (http://catalog.northeastern.edu/undergraduate/engineering/mechanical-industrial/industrial-engineering-minor)
- Mechanical Engineering (http://catalog.northeastern.edu/undergraduate/engineering/mechanical-industrial/mechanical-engineering-minor)

**Accelerated Programs**

See Accelerated Bachelor/Graduate Degree Programs (http://catalog.northeastern.edu/undergraduate/engineering/accelerated-bachelor-graduate-degree-programs/#programtext)

**Courses**

**Engineering Management Courses**

**EMGT 5220. Engineering Project Management. 4 Hours.**
Examines the theory and practice of managing projects. Explores human, mathematical, entrepreneurial, managerial, and engineering aspects of project management. The systems development life cycle is the framework for the course. Addresses needs analysis, requirements definition, design, and implementation in the context of project management. Introduces mathematical and software tools for planning, monitoring, and controlling projects.

**EMGT 5300. Engineering/Organizational Psychology. 4 Hours.**
Offers an analysis of the purpose and functioning of organizations as the basic networks for achieving goals through coordination of effort, communication, and responsibility. Studies the role and function of engineering organizations based on modern behavioral science concepts as well as the application of psychology to industry relative to human relations, group dynamics, tests and measurements, personnel practices, training, and motivation. Examines the evolution of the learning organization and its role in the management of R&D and technology, the influence of the rapid changes in technology, and the globalization of the marketplace through group-oriented case studies.

**EMGT 5964. Experiential Project. 0 Hours.**
Offers students an applied project setting in which to apply their curricular learning. Working with a sponsor, students refine an applied research topic, perform research, develop recommendations that are shared with a partner sponsor, and create a plan for implementing their recommendations. Seeks to benefit students with a curriculum that supports the development of key business communication skills, project and client management skills, and frameworks for business analysis. Offers students an opportunity to learn from sponsor feedback, review lessons learned, and incorporate suggestions from this review to improve and further develop their career development and professional plan. May be repeated up to three times.

**Industrial Engineering Courses**

**IE 1990. Elective. 1-4 Hours.**
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

**IE 2310. Introduction to Industrial Engineering. 4 Hours.**
Provides an overview of the history of industrial engineering and of the most common methods that industrial engineers use to solve problems and design efficient processes. The emphasis is on how these methods are used to study, improve, and/or optimize a product or process. Topics include work design, ergonomic design, engineering statistics, quality engineering, engineering economics, project management, and process optimization. Also discusses the design of the production processes, facilities, and material handling systems. Studies applications in manufacturing, product design, and service industries. Laboratory experiments and written reports are required.

**IE 2311. Recitation for IE 2310. 0 Hours.**
Provides small group demonstration and hands-on labs for IE 2310.

**IE 2990. Elective. 1-4 Hours.**
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

**IE 3412. Engineering Probability and Statistics. 4 Hours.**
Presents probability theory axiomatically, with emphasis on sample space presentation of continuous and discrete random variables. Covers descriptive statistics, expected value of random variables, covariance and correlation, sampling distribution, and point and interval estimations. Introduces hypothesis testing including tests for means, variances, and proportions.

**IE 3425. Engineering Database Systems. 4 Hours.**
Examines the representation of data and its creation and management in engineering enterprises. Discusses the client/server model of database access. Presents the fundamentals of data modeling and management, data mining and warehousing, multiterapplication, and the use of the SQL query language. Emphasizes the use and applications of database systems in engineering including design and manufacturing. Topics include design schema of tables, records and fields of databases, SQL statements, security issues, and the use of a scripting language such as Perl or Visual Basic.

**IE 3426. Recitation for IE 3425. 0 Hours.**
Provides small group demonstration and problem solving for IE 3425.
IE 3500. Introduction to Healthcare Systems Engineering. 4 Hours.
Introduces systems engineering methods in healthcare system applications for students who are not industrial engineering majors. Using principles drawn from operations research and industrial engineering, this course focuses on analysis, design, management, and control of health systems (e.g., hospitals, emergency departments, surgery departments, and outpatient clinics) and processes which are critical to the delivery of quality healthcare. Topics include an overview of queueing, simulation, data envelopment analysis, and spreadsheet modeling as applied to real-world healthcare problems such as staffing and scheduling, resource allocation, patient flow management, process improvement, and medical decision making.

IE 3990. Elective. 1-4 Hours.
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

IE 4510. Simulation Modeling and Analysis. 4 Hours.
Covers process model design and development, validation, and experimentation for discrete-event simulation models. Topics include problem formulation, data collection and analysis, random-variable generation, model development, scenario experimentation, statistical analysis of output, and resultant decision management. Utilizes a major industry-standard simulation software application with animation capabilities.

IE 4512. Engineering Economy. 4 Hours.
Introduces students to economic modeling and analysis techniques for selecting alternatives from potential solutions to an engineering problem. Presents basic methods of economic comparison such as present worth, annual worth, rate of return, and benefit/cost techniques. Studies effects of taxes on investment analysis. Also covers decision tree analysis and statistical decision techniques.

IE 4515. Operations Research. 4 Hours.
Introduces deterministic models including linear programming; duality and postoptimality analysis; transportation and assignment problems; and network flow problems such as the shortest path, minimum spanning tree, and maximum flow.

IE 4516. Quality Assurance. 4 Hours.
Reviews the distributions and statistical approximations commonly applied in statistical quality control methods. Introduces analysis of variance and simple linear regression. Covers basic principles to state-of-the-art concepts and application of statistical process control and design. Applies principles to a variety of products. Topics include product quality measures and controls, Shewhart control charts, quality cost, Pareto analysis, discrete and variable sampling, and military standards in quality control.

IE 4520. Stochastic Modeling. 4 Hours.
Covers the analytical development and solution to stochastic models in operations research. Topics include Markov chains, queuing theory, and dynamic programming.

IE 4522. Human-Machine Systems. 4 Hours.
Emphasizes and addresses human sensory and motor performance, information processing, learning and training methodology, skilled-task development, psychophysical models, response time, and relevant aspects of attention and memory. Topics include system design and development, hazard and error evaluation, and properties of effective visual displays. Endorses experimentation as a source of knowledge of human performance characteristics. Covers research and statistical analyses related to human-asset engineering, fundamentals of vision, audition, somesthesis, signal detection, and some aging effects. Safety and usability of environments, machines, products, and devices consider principles of human-machine interaction, decision making, and anthropometric characteristics. Laboratory experiences include literature review, experimental design, data collection and analysis, hypothesis testing, and generation of reports to inform the design of safe, usable, and marketable engineering products, processes, and systems.

IE 4523. Lab for IE 4522. 1 Hour.
Accompanies IE 4522. Covers topics from the course through various activities.

IE 4525. Logistics and Supply Chain Management. 4 Hours.
Introduces the analysis, design, control, and operation of logistics and supply chain management systems. Includes the integration of supply chain components, logistics information systems, forecasting, production scheduling, inventory management, transportation and warehousing, and facility location planning.

IE 4530. Manufacturing Systems and Techniques. 4 Hours.
Focuses on manufacturing and design and their impact on each other. Covers the basics of design-manufacturing integration, manufacturing systems, manufacturing processes and techniques, manufacturing automation, and production planning and control. Topics include concurrent engineering, design for assembly, design for manufacturability, rapid prototyping, mechanical tolerancing, bill of materials, group technology, computer-aided process planning, NC part programming, programmable logic controllers, flexible manufacturing systems, computer-integrated manufacturing, and just-in-time philosophy. Topics also include traditional manufacturing processes such as casting, forming, machining, welding, molding, and particulate processing, and nontraditional manufacturing processes such as electrical discharge machining, laser machining, and water-jet machining. Students are required to conduct manufacturing-related experiments in the manufacturing lab to gain hands-on experience.

IE 4531. Lab for IE 4530. 1 Hour.
Accompanies IE 4530. Covers topics from the course through various activities.

IE 4550. Systems Design for Sustainability. 4 Hours.
Covers the fundamental process of designing and building systems, from systems identification to the entire systems life cycle. Discusses sustainability, functionality, and capability of systems with respect to systems' objectives. Presents factors affecting systems design, operation, and sustainability. Focusing on design of sustainable systems and improvement of systems, encompasses communications, defense, logistics, manufacturing, transportation, and others. Discusses concept and preliminary design phases to detail, production, and operation phases of design. Seeks to provide the concepts, methodologies, models, and tools needed to understand and implement a total life-cycle approach to systems analysis. Includes different categories of systems, various applications of analytical methods, and related problems and cases. Students who do not meet course prerequisites may seek permission of instructor.
IE 4625. Facilities Planning and Material Handling. 4 Hours.
Explores engineering tools, techniques, and concepts for the design of facilities. The term facility is defined broadly. Industrial plants, schools, hospitals, or places in which things are produced or services are provided to a customer are all considered facilities. Provide students with a broad but practical understanding of the facilities planning and design process. The critical nature of material handling is discussed and approaches to designing optimal handling systems are examined. The tools of operations, research, statistical methods, and software applications are the focus of the problem-solving activities.

IE 4990. Elective. 1-4 Hours.
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

IE 4991. Research. 4 Hours.
Offers an opportunity to conduct research under faculty supervision.

IE 4993. Independent Study. 1-4 Hours.
Offers theoretical or experimental work under individual faculty supervision. May be repeated without limit.

IE 5374. Special Topics in Industrial Engineering. 4 Hours.
Offers topics of current interest in industrial engineering. May be repeated up to two times.

IE 5400. Healthcare Systems Modeling and Analysis. 4 Hours.
Discusses the key functions of healthcare operations management, such as patient and process flow, process improvement, facility layout, staffing and scheduling, capacity planning, and resource allocation. Focuses on analysis, design, management, and control of health systems and processes that are necessary to provide clinical care. The applications of systems engineering methods, such as optimization, simulation, and queuing models, are discussed through papers and case studies in different care settings (e.g., hospitals, emergency departments, surgery departments, and outpatient clinics) for different diseases (e.g., diabetes, cancer, mental health, cardiovascular disease). Uses spreadsheet tools to model and solve simulation and optimization problems. Requires equivalent course work if prerequisites are not met.

IE 5500. Systems Engineering in Public Programs. 4 Hours.
Introduces the design, development, analysis, and application of mathematical modeling for addressing public programs and societal needs. Systems engineering and mathematical models form the basis for decision making in both public and private applications. Focusing on societal applications, offers students an opportunity to discover how to incorporate public objectives and characteristics of large systems in the development of models and policies. Examines applications in the operation of public programs (e.g., public health systems, government programs) and public safety (e.g., security, emergency preparedness, and disaster response). Modeling techniques include game theory, data envelopment analysis, cost-benefit analysis, simulation, differential equations, and stochastic optimization. Requires equivalent course work if prerequisites are not met.

IE 5617. Lean Concepts and Applications. 4 Hours.
Covers the fundamentals of lean thinking and how to apply this knowledge to practical problems. Lean thinking is imperative for organizations aspiring to stay competitive in global markets. It calls for process changes to eliminate waste, shorten product delivery time, improve product quality, and curtail costs, while improving customer satisfaction. Offers students an opportunity to learn concepts, a kit of process improvement tools, implementation methods, and best practices for lean workforce development. Makes extensive use of active learning exercises and simulations, and case studies from different disciplines, to help students learn how lean principles are applied in manufacturing and also in less traditional areas such as knowledge work and healthcare systems.

IE 5620. Mass Customization. 4 Hours.
Provides students with conceptual understanding and implementation strategies of mass customization (MC). MC is both a business and production paradigm where a company provides the customers with goods and services that suit their individual needs but does so with the efficiency and costs of mass production. MC is important in many sectors including computers, automotive, healthcare, banking, insurance, and tourism. It is based on principles of industrial engineering, mechanical engineering, management science, and marketing. Topics include typology of mass-customized production systems, manufacturing processes for MC, information needs of MC, customer focus, marketing issues, technology enablers, implementation methods, and case studies. Methodology includes lectures, case discussions, plant visits, guest lectures, and a term project. Cross-disciplinary activities, particularly between engineering and business students, are encouraged wherever possible.

IE 5630. Biosensor and Human Behavior Measurement. 4 Hours.
Emphasizes the measurement of human behavior in complex human-machine interaction. Topics include introduction of complex human-machine interactions; research methods in complex human-machine interactions; various kinds of human psychophysiological signals/cues, including physiological cues, facial expressions, eye-gaze movement, head movement, contextual cues; human cues and behavior relationship; transducers and measurement for these human cues/signals; basic principles of biosensors; general classification of biosensors; current technologies for building biosensors; conventional transducers and new technologies including micro-/nanotechnology; general systematic design process for biosensors; application of biosensors to understand human behavior in human-machine interactions. Also introduces the latest relevant research advancements in sensor fusion, affective computing, and emotion recognition.

IE 5640. Data Mining for Engineering Applications. 4 Hours.
Introduces data mining concepts and statistics/machine learning techniques for analyzing and discovering knowledge from large data sets that occur in engineering domains such as manufacturing, healthcare, sustainability, and energy. Topics include data reduction, data exploration, data visualization, concept description, mining association rules, classification, prediction, and clustering. Discusses data mining case studies that are drawn from manufacturing, retail, healthcare, biomedical, telecommunication, and other sectors.

Mechanical Engineering Courses

ME 1990. Elective. 1-4 Hours.
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.
ME 2340. Introduction to Material Science. 4 Hours.
Introduces the materials science field, which emphasizes the structure-processing property-performance relationships for various classes of materials including metals, ceramics, polymers, electronic materials, and magnetic materials. Topics include crystallography, structure of solids, imperfections in crystals, mechanical properties, dislocation theory, slip, strengthening mechanisms, phase equilibrium, phase transformations, diffusion, thermal and optical physical properties, and electrical and magnetic properties. Issues associated with materials selection, including economic and environmental consequences of materials choices, are also addressed. Laboratory experiments, with written memo and report submissions, are required. Includes individual and team-based projects.

ME 2341. Lab for ME 2340. 1 Hour.
Accompanies ME 2340. Covers topics from the course through various activities.

ME 2350. Engineering Mechanics and Design. 4 Hours.
Introduces the vector representation of force and moment, the equivalent force systems, free body diagrams, and equations of equilibrium. Discusses centroids and center of gravity of rigid bodies. Applications to beams, trusses, and pin-connected frames and elementary concepts of friction are examined. The kinematics of particles and kinetics of particles are treated using force mass and acceleration. Energy and momentum methods for particles are also covered. Includes a design project that demonstrates the fundamental concepts of equilibrium.

ME 2355. Mechanics of Materials. 4 Hours.
Discusses concepts of stress and strain; transformation of stress and strain at a point; stress-strain relations material properties; second moments of cross-sectional areas; stresses and deformations in simple structural members due to axial torsional, and flexural loading for statically determinate and indeterminate cases; design of beams under combined loading; and stability of structures and buckling of columns with various supports. Laboratory experiments and written reports are required.

ME 2356. Lab for ME 2355. 1 Hour.
Accompanies ME 2355. Covers topics from the course through various activities.

ME 2380. Thermodynamics. 4 Hours.
Defines and calculates thermodynamic properties such as energy, entropy, temperature, and pressure. Work and heat interactions are defined. The first and second laws of thermodynamics and concepts of thermodynamic equilibrium are introduced. Conservation of energy and mass and the entropy balance relation are discussed for open and closed systems. Irreversibility, energy, and the energy balance relation are introduced and applied in analyzing thermodynamic systems. Fundamentals of thermodynamics are used to model power generation and refrigeration systems. Covers thermodynamics of nonreacting gas mixtures with applications to air-water vapor mixtures for air-conditioning systems.

ME 2990. Elective. 1-4 Hours.
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

ME 3455. Dynamics and Vibrations. 4 Hours.
Covers kinematics of rigid bodies in general plane motion and mass moments of inertia. Examines kinetics of rigid bodies using force-mass-acceleration, work and energy, and impulse and momentum. Explores continued development of problem-solving ability in dynamics, free and forced vibration of undamped and damped on-degree-of-freedom systems. Topics includes viscous and non-viscous damping, support motion, rotational unbalance, vibration isolation, vibration measuring instruments, general periodic excitation, and general excitation using numerical methods. Laboratory experiments and written reports are required.

ME 3456. Lab for ME 3455. 1 Hour.
Accompanies ME 3455. Covers topics from the course through various activities.

ME 3460. Robot Dynamics and Control. 4 Hours.
Covers fundamental components and mechanisms of robotic systems and their multidisciplinary nature. Introduces the robot's kinematics, dynamics, and control. Presents a quick overview of forward and inverse kinematics, robot dynamics, as well as path planning and control techniques. Topics also include dynamic modeling and analysis of mechanically, electrically, and magnetically driven hydraulic and pneumatic drives; kinematics and motion analysis of linkages; as well as sensing technologies (e.g., position, linear and angular displacements, velocity and acceleration, force and torque sensors) used in robotic systems. Presents kinematics and control of automatic machinery and manufacturing processes, automatic assembly, and inspection robotic systems as representative examples.

ME 3475. Fluid Mechanics. 4 Hours.
Studies fundamental principles in fluid mechanics. Topics include hydrostatics (pressure distribution, forces on submerged surfaces and buoyancy); Newton's law of viscosity; dimensional analysis; integral forms of basic laws (conservation of mass, momentum, and energy); pipe flow analysis; differential formulation of basic laws including Navier-Stokes equations; and the concept of boundary layer and drag coefficient. Includes a team-based independent project.

ME 3480. International Applications of Fluid Mechanics. 4 Hours.
Studies fundamental principles in fluid mechanics in an international setting. Students have an opportunity to travel to a foreign locale to develop theoretical understanding while experiencing the issues that affect applications of fluids engineering in a culture and environment different from their own. Topics include hydrostatics (pressure distribution, forces on submerged surfaces, and buoyancy); Newton's law of viscosity; dimensional analysis; integral forms of basic laws (conservation of mass, momentum, and energy); pipe flow analysis; differential formulation of basic laws including Navier-Stokes equations; and the concept of boundary layer and drag coefficient. Includes a team-based independent project that focuses on applications that allow students to delve into issues that affect engineering and technology development in their host country.

ME 3990. Elective. 1-4 Hours.
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.
ME 4505. Measurement and Analysis with Thermal Science Application. 4 Hours.
Introduces basic measurements and data analysis techniques. Offers students an opportunity to become familiar with various types of measurement systems and to set up and perform experiments according to a given procedure. Covers basic measurement methods of rotational frequency; temperature, pressure, and power; and analog-to-digital conversion techniques and data acquisition. Data analysis topics include statistical analysis of data, probability and inherent uncertainty, basic measurement techniques, primary and secondary standards, system response characteristics, and computerized data acquisition methods. Includes experiments in thermodynamics, fluid mechanics, and heat transfer. Topics include cycle performance, flow discharge coefficient and heat transfer coefficient measurements, and psychrometric applications in the air-conditioning field.

ME 4506. Lab for ME 4505. 1 Hour.
Accompanies ME 4505. Covers topics from the course through various activities.

ME 4508. Mechanical Engineering Computation and Design. 4 Hours.
Highlights the role of finite element analysis in product development. Introduces the theory of finite elements in elastic/plastic, static, and transient problems. Emphasis is on solid modeling in design using available commercial finite element software. Also covers other numerical techniques such as finite difference schemes in the solution of systems of partial differential equations, and numerical solution to systems of linear and nonlinear equations.

ME 4550. Mechanical Engineering Design. 4 Hours.
Explores development of the mechanical design process and its open-ended nature. Reviews fundamentals of stress and theories of failure including fatigue considerations in the analysis of various machine components. Treatment is given to shafts, springs, screws, connections, lubrications, bearings, gears, and tolerances. Includes team-based design projects that involve modeling and the design process.

ME 4555. System Analysis and Control. 4 Hours.
Presents the theoretical backgrounds for the analysis and design of simple feedback control systems, differential equations, and Laplace transforms. Treats system modeling, linear approximations, transfer functions, and block diagrams; and transient and frequency response and stability-frequency domain and root locus methods. Other topics may include linear systems with time lag and relay servomechanisms with small nonlinearities.

ME 4565. Introduction to Computational Fluid Dynamics. 4 Hours.
Introduces numerical methods applied to solve fluid flow problems. Includes basic mathematics and physics related to computational fluid dynamics (CFD), together with practical assignments that use commercial CFD packages. Emphasizes finite difference and finite volume methods. Other topics include mathematical properties of partial differential equations, accuracy and stability analysis of numerical solution, CFD verification and validation, application to variety of fluid dynamics problems, grid generation, and turbulence modeling.

ME 4570. Thermal Systems Analysis and Design. 4 Hours.
Introduces theories of thermal energy transport, including conduction, convection, and thermal radiation, and the design of thermal systems. Solution methods are developed for steady-state and transient conduction problems including thermal circuit analogies, internal energy sources and extended surfaces. Convective heat transfer mechanisms are introduced and correlations to evaluate the heat transfer coefficient are discussed. Methodologies for calculating the thermal radiation heat transfer between surfaces are introduced. These theories are integrated with thermodynamics and fluid mechanics in the design of thermal systems, including heat exchangers. Includes an open-ended design project and students are expected to use computational methods throughout the course.

ME 4640. Mechanical Behavior and Processing of Materials. 4 Hours.
Continues studies of the physical basis for the mechanical behavior of solid materials including elasticity, plasticity, viscoelasticity, fracture, fatigue, and creep properties. Also covers materials processing and includes casting, forming, joining, and machining.

ME 4670. Internal Combustion Engine. 4 Hours.
Presents the concepts and theories of operation of internal combustion engines based upon the fundamental engineering sciences of thermodynamics, gas dynamics, heat transfer, and mechanics. Discusses the design and operating characteristics of conventional spark-ignition, compression-ignition, Wankel, and stratified charge. Explores the relationship between vehicle load and engine load through differential and transmission gear-ratio selections. Includes laboratory experiments.

ME 4699. Special Topics in Mechanical Engineering. 4 Hours.
Focuses on an advanced mechanical engineering project agreed upon between the student and instructor. May be repeated without limit.

ME 4970. Junior/Senior Honors Project 1. 4 Hours.
Focuses on in-depth project in which a student conducts research or produces a product related to the student’s major field. Combined with Junior/Senior Project 2 or college-defined equivalent for 8-credit honors project. May be repeated without limit.

ME 4971. Junior/Senior Honors Project 2. 4 Hours.
Focuses on second semester of in-depth project in which a student conducts research or produces a product related to the student’s major field. May be repeated without limit.

ME 4990. Elective. 1-4 Hours.
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

ME 4991. Research. 4 Hours.
Offers an opportunity to conduct research under faculty supervision.

ME 4992. Directed Study. 1-4 Hours.
Offers theoretical or experimental work under the direction of members of the department on a chosen topic. Course content depends on instructor. May be repeated without limit.

ME 5240. Computer Aided Design and Manufacturing. 4 Hours.
Covers basic aspects of computer graphics and CAD/CAM. Topics include hardware and software concepts, generic structure of CAD/CAM software and its modules, and CAD/CAM database structure. Also covers the parametric representations of curves, surfaces, solids, and features that are widely used in existing commercial CAD/CAM systems. Discusses geometrical transformations, CAD/CAM data exchange formats, prototyping techniques, and PDM. Presents applications such as mass properties calculations, assemblies, mechanical tolerancing, simulation, finite element mesh generation, process planning and CAPP, CNC part programming, and Web-based CAD/CAM.
Covers integration of electronic/electrical engineering, computer technology, and control engineering with mechanical engineering to provide a self-contained, modern treatment of mixed systems along with their computer simulation and applications. Topics include mixed-systems integration; sensors, actuation systems; brief overview of dynamic systems modeling, response characterization, and closed-loop controllers; interfacing; data presentation systems and processes; microprocessors; real-time monitoring and control; and applications of mechatronic systems. The course also offers numerous MATLAB/ Simulink examples of select mechatronic systems and devices along with open-ended design projects and assignments.

Covers kinematics and dynamics of robot manipulators, including the development of kinematics equations of manipulators, the inverse kinematics problem, and motion trajectories. Employs Lagrangian mechanics to cover dynamics of manipulators for the purpose of control. Covers control and programming of robots, steady state errors, calculations of servoparameters, robot vision systems and algorithms, as well as imaging techniques and the concept of mobile robots.

ME 5374. *Special Topics in Mechanical Engineering*. 4 Hours.
Offers topics of current interest in mechanical engineering.

Covers the fundamentals and usage of processes and techniques for bulk, thick film, thin film, and patterned structures. Covers techniques for improvement of mechanical or functional properties, for reliability, or for operation in harsh environments. Includes case studies for which processes are selected based on efficacy, material input, and cost. Systems studied include biocompatible implants and materials for the telecommunication, semiconductor, energy, and aerospace industries.

Explores environmental and economic aspects of different materials used in products throughout the product life cycle. Introduces concepts of industrial ecology, life cycle analysis, and sustainable development. Students work in teams to analyze case studies of specific products fabricated using metals, ceramics, polymers, or paper. These case studies compare cost, energy, and resources used and emissions generated through the mining, refining, manufacture, use, and disposal stages of the product life cycle. Debates issues in legislation (extended product responsibility, recycling mandates, and ecotagging) and in disposal strategies (landfill, incineration, reuse, and recycling). Discusses difficulties associated with environmental impact assessments and the development of decision analysis tools to weigh the tradeoff in technical, economic, and environmental performance, and analyzes specific case studies.

Covers stress, strain, and deformation analysis of simple structures including beams, plates, and shells. Topics include classical theory of circular and rectangular plates; combined effects of bending and in-plane forces; buckling of plates; effects of shear deformation and of large deflections; membrane theory of shells; analysis of cylindrical shells; introduction to energy methods with applications to beams, frames, and rings; Ritz method; and the concept of stability as applied to one and two degree-of-freedom systems buckling of bars, frames, and rings. Permission of instructor required for undergraduate students.

ME 5655. *Dynamics and Mechanical Vibration*. 4 Hours.
Covers dynamic response of discrete and continuous media. Topics include work and energy, impulse and momentum, Lagrangian dynamics, free and forced response to periodic and transient excitations, vibration absorber, free and forced response of multiple degree-of-freedom systems with and without damping, method of modal analysis, vibrations of continuous media such as extensional, torsional, and bending vibrations of bars, and approximate methods of analysis. Permission of instructor required for undergraduate students.

ME 5657. *Finite Element Method*. 4 Hours.
Focuses on numerical techniques for solving engineering problems. Topics include introduction to the finite element method; methods of approximations and variational methods; Rayleigh-Ritz method and Galerkin formulation; interpolation functions; truss, beam, plate, shell, and solid elements; stiffness matrix and assembly of element equations; application of finite element method in fluid and heat transfer problems; linear, nonlinear, and transient problems; numerical integration and methods of solving systems of equations for static and dynamic problems; and use of a finite element general-purpose commercial package. Permission of instructor required for undergraduate students.

Covers concepts in design and control of dynamical systems. Topics include review of continuous-time system modeling and dynamic response; principles of feedback, classical and modern control analyses, and design techniques such as root locus, frequency response (e.g., Bode plots and Nyquist Criteria), and state-space feedback; dynamic analysis, design, and control of electromechanical systems; block diagram algebra or signal-flow graphs, effects of poles and zeros on system response characteristics; principles of controllability, observability, observer designs, and pole placement techniques; introduction to adaptive and learning control and digital implementation of control algorithms.

ME 5665. *Musculoskeletal Biomechanics*. 4 Hours.
Using a three-part format, emphasizes the quantitative analysis of human musculoskeletal system statics and dynamics, including, in part I, gait analysis and estimation of the complex loads on human joint systems. Investigates how the form of connective tissue and bone is derived from function in part II, including a quantitative analysis of the material properties of bone, ligament, tendon, and cartilage. Working in groups in part III, students select and investigate a relevant, current topic in musculoskeletal biomechanics and present their findings to the class. Requires prior completion of an undergraduate course in biomechanics (Northeastern’s BIOE 2350 or equivalent). Permission of instructor required for undergraduate students.

Focuses on the multiscale mechanical behavior of biological tissues. The mechanical integrity of a single cell depends on the mechanical properties and geometrical arrangements of the fiber network in the extracellular matrix. Introduces the statistical concept of persistent length and entanglement of long-chain polymer molecules, linear elasticity and viscoelasticity, membrane undulations, stability of vesicles. Discusses the interfacial forces that cause cells to adhere and to form microscopic, mesoscopic, and macroscopic two-dimensional membranes and three-dimensional structures. Introduces experimental techniques and measurements involving atomic force microscope, surface force apparatus, optical tweezers, micropipette aspiration. Examples are given for specific physiological and path-physiological phenomena related to mechanical and adhesion behavior of cells and membranes. Requires prior completion of an undergraduate course in biomechanics (Northeastern’s BIOE 2350 or equivalent). Permission of instructor required for undergraduate students.
ME 5685. Solar Thermal Engineering. 4 Hours.
Develops a model for the hourly direct and diffuse radiation under a cover of scattered clouds and the transmission and absorption of this radiation by passive and active systems. Considers the design of air heating systems and the storage of the collected energy by a pebble bed, and considers elements of heater exchanger design. Makes a study of the economics of a domestic water and/or space heating system using f-chart analysis. Requires prior completion of ME 4570 or equivalent.

ME 5690. Gas Turbine Combustion. 4 Hours.
Offers students an opportunity to obtain an understanding of the basic physical, chemical, and aerodynamic processes associated with combustion in gas turbine engines and their relevance to combustor design and performance in applications ranging from aeronautical to power generation. Topics include the history and evolution of gas turbine engines, thermodynamic cycles, conventional and alternative aviation fuels, combustion fundamentals, fuel injection and atomization, advanced wall cooling techniques, mechanisms of combustion noise and approaches to noise control, and design and performance for ultra-low emissions.

ME 5695. Aerodynamics. 4 Hours.
Focuses on topics of practical importance in applications of fluid mechanics to external flows over bodies. Covers compressible flow analysis in order to use the concepts of sound speed and Mach number and to design subsonic and supersonic nozzles, diffusers, and airfoils. Introduces normal and oblique shock waves and the Prandtl-Meyer expansion applied to supersonic flows over bodies and surfaces. Discusses Rayleigh and Fanno flows. Studies and applies the Bernoulli equation and potential flow theory to external flow analyses and the theory of lift generation on airfoils.

ME 5978. Independent Study. 1-4 Hours.
Offers theoretical or experimental work under individual faculty supervision. May be repeated without limit.

ME 5984. Research. 1-4 Hours.
Offers an opportunity to conduct research under faculty supervision. May be repeated without limit.