MECHANICAL ENGINEERING

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The Department of Mechanical Engineering offers a broad range of programs leading to the bachelor of science degree in mechanical engineering.

Mechanical engineering has always meant engines and machinery, but the character of modern engines and machinery has changed enormously because of the ever-increasing demands of performance, compactness, reliability, and productivity. The early devices were built by ingenious mechanics who possessed the know-how to reduce ideas to practice. In an increasingly competitive world, traditional know-how and creative ability are as necessary as ever but no longer sufficient. It is also necessary to know why things occur and thus be able to guide the earliest stages of planning. With finite resources and increasing awareness of the environment, mechanical engineers must cope with the undesirable effects of pollution as well as the traditional concerns of efficiency and safety. The tools they need must be more sophisticated.

Mechanical engineering plays a dominant role in a wide spectrum of industries, among them transportation (automotive, rail, air, and marine), heavy machinery (machines producing other machines), the power industry, the environmental industry (heating, ventilation, and air-conditioning), robotics, light precision-machine enterprises (optical, prosthetic devices, mechanical instruments, and the like), and numerous commercial-product industries.

Preparation for a career in mechanical engineering requires a basic understanding of the mathematical, physical, and engineering principles essential to planning, designing, and manufacturing new equipment. The curriculum provides a broad fundamental preparation for direct entry into industry as well as for further professional study. The first part of the curriculum is devoted to mathematics, physics, and chemistry. With this background, fundamental mechanical engineering subjects, such as dynamics, solid mechanics, fluid mechanics, and thermodynamics, are studied, followed by specialized subjects, such as manufacturing, heat transfer, and automatic control. During the final two years design courses, laboratory courses, and project courses allow students to acquire a taste for the complex task of designing, analyzing, and building a piece of “hardware.” In particular, students become aware of the relationships among conceptual design, subsequent analysis (mathematical modeling), manufacturing, systematic experimentation, and final testing. Supporting courses in allied fields of science and engineering broaden technical proficiency, while the elective courses in social sciences, fine arts, history, and philosophy enlarge the background in the problems of humanity.

Elective Concentrations

The program in mechanical engineering is designed to appeal to students with a wide variety of interests and professional goals. By choosing the 4 required elective courses wisely, students can develop a highly personalized curriculum. Some areas of concentration are computer-aided design and manufacturing, fluid mechanics, robotics, systems and control, and tribology. In addition, there are seven concentrations: biomedical engineering, design, energy, intelligent mechanical systems, manufacturing, nanotechnology/MEMS, and solid mechanics.

The biomedical engineering concentration is open to students interested in the biological and medical applications of mechanical engineering procedures. Students in this concentration can also satisfy the entrance requirements of medical schools.

The design concentration focuses on product design with related conceptual and manufacturing processes.

The energy concentration emphasizes the mechanical aspects of energy conversion and management.

The intelligent mechanical systems concentration focuses on the design of devices featuring mechanical hardware interfaces with electronic hardware and software.

The manufacturing concentration is directed toward planning and selecting manufacturing methods, design for manufacture, computer-aided flexible automation and robotics, and increased efficiency and productivity of current and emerging manufacturing technologies.

The nanotechnology/microelectromechanical systems concentration focuses on engineering at nanometer- and micrometer-length scales, including properties of materials and design and fabrication of devices.

The solid mechanics concentration focuses on the study of stress and strain in solid bodies, along with the application of computational methods for stress analysis.

A listing of courses that satisfy the elective requirements may be found in the department office.

Facilities

A detailed description of facilities in the reconstructed mechanical engineering laboratories is available in the department office.

Program of Study

- Mechanical Engineering Degree (https://catalogs.northwestern.edu/undergraduate/engineering-applied-science/mechanical-engineering/mechanical-engineering-degree)

MECH_ENG 202-0 Mechanics II (1 Unit) Dry friction. Kinetics of rigid bodies in planar motion. Kinetics of particles. Moments of inertia of rigid bodies. Prerequisite: GEN_ENG 205-4.

MECH_ENG 222-0 Thermodynamics & Statistical Mechanics - I (1 Unit) Basic definitions; Zeroth Law and the meaning of temperature; the First Law; the Second Law, entropy, and its applications; equations of state; the Third Law of Thermodynamics; and introduction to statistical thermodynamics.

MECH_ENG 224-0 Experimental Engineering (1 Unit) Modern electronics; analog and digital circuit construction and conversion. Modern data acquisition involving temperature measurements, control of stepper motors, transient heat transfer, fluid mechanics, deformation of beams. Prerequisites: MECH_ENG 233-0; GEN_ENG 205-4.

MECH_ENG 233-0 Electronics Design (1 Unit) Design and prototyping of analog and digital electronic circuits using semiconductor devices: diodes, transistors, op amps, logic chips, etc. Optical and other sensors, power electronics, filters, and feedback control. Extensive hands-on construction and debugging. Intended for engineers in all disciplines.

MECH_ENG 240-0 Intro to Mechanical Design & Manufactrng (1 Unit) Introduction to strategy and methods of designing, manufacturing, and testing of mechanical products. Material properties and selection methodology, engineering drawing and CAD, and simple manufacturing processes. Prerequisites: MAT_SCI 201-0; CIV_ENV 216-0.

MECH_ENG 241-0 Fluid Mechanics I (1 Unit) Fundamentals of fluid mechanics. Properties and statics of fluids. Kinematics and dynamics of fluid motion-continuity, momentum, and energy equations. Dimensional analysis, flow in closed conduits. Prerequisite: GEN_ENG 205-4.

MECH_ENG 301-0 Introduction to Robotics Laboratory (1 Unit) A laboratory-based introduction to robotics. Focus will be on both hardware (sensors and actuators) and software (sensor processing and behavior development). Topics will include: the basics in kinematics, dynamics, control and motion planning; and an introduction to Artificial Intelligence (AI) and Machine Learning (ML). Formerly EECS 295-0. Cross-listed as EECS 301-0.

MECH_ENG 314-0 Machine Dynamics (1 Unit) Three-dimensional kinematics: rotation axes and mechanism analysis, rotation matrices and Euler's angles for rigid bodies. Three-dimensional kinetics: dynamics of particles, central force problems, dynamics of rigid bodies, rotational inertia matrices and principal axes, dynamics of mechanisms, the gyroscope and other torque-free problems. Prerequisite: MECH_ENG 202-0.

MECH_ENG 315-0 Theory of Machines - Design of Elements (1 Unit) Factors influencing the proportioning of machine elements-stresses, deformations, and failure criteria-as applied to shafts, springs, belts, bearings, gears. Lectures, laboratory. Prerequisites: MAT_SCI 201-0; CIV_ENV 216-0.

MECH_ENG 316-0 Mechanical Systems Design (1 Unit) Design of mechanical systems such as cams, multi-bar linkages, and precision machines. Design principles and best practices. Case studies and team-based projects. Prerequisite: MECH_ENG 315-0.

MECH_ENG 317-0 Molecular Modeling and the Interface to Micromechanics (1 Unit) Introduction to modern computational methods for calculating thermodynamic, transport, and structural properties of materials. Computational chemistry, molecular simulation, and mesoscopic methods, with emphasis on tribology applications.

MECH_ENG 318-0 Multiscale Simulations (1 Unit) Introduction to multiscale modeling and simulation methods for studying material interactions in micro and nanomechanical systems, as well as in electronic packaging. Hands-on exercises using equipment to characterize nanoscale properties and parallel computer codes.

MECH_ENG 320-0 Micro- and Nanomechanical Properties of Surfaces (1 Unit) Micro and nanomechanical interactions between surfaces, fractal nature of surfaces, interfacial forces, principles of micromechanics, characterization of surfaces using atomic force microscopy, optical interferometry, and nanoindentation.

MECH_ENG 322-0 Thermodynamics & Statistical Mechanics - II (1 Unit) Classical and statistical thermodynamics.

MECH_ENG 327-0 Finite Elements for Stress Analysis (1 Unit) Development of finite elements from variational principles and application to static stress analysis. Introduction to techniques for transient and generalized field problems. Computer implementation of finite element techniques. Taught with CIV_ENV 327-0; may not receive credit for both courses.

MECH_ENG 333-0 Introduction to Mechatronics (1 Unit) Introduction to microprocessor-controlled electromechanical systems. Interfacing sensors and actuators to computers, electrical and mechanical prototyping, dissection of a commercial product. Final team project. Prerequisite: MECH_ENG 233-0, EECS 221-0, or consent of instructor.

MECH_ENG 340-1 Comp Integ Manufacturing: Manufacturing Processes (1 Unit) Use of computers to improve productivity and reduce costs in the manufacture of discrete parts and assemblies. Manufacturing processes: Analysis and evaluation of process usage in the contemporary manufacturing environment. Prerequisite: MECH_ENG 240-0 or consent of instructor.

MECH_ENG 340-2 Computer Integ Manufacturing: CAD/CAM (1 Unit) Use of computers to improve productivity and reduce costs in the manufacture of discrete parts and assemblies. CAD/ CAM: Geometric modeling, dimensioning systems, tolerances, design for manufacture, programming of machine tools. Prerequisite: MECH_ENG 340-1 or consent of instructor.

MECH_ENG 340-3 Computer Integ Manuf: Automation (1 Unit) Use of computers to improve productivity and reduce costs in the manufacture of discrete parts and assemblies. Manufacturing automation: sensors, actuators, and computers for automation; principles of computer control; programmable logic controllers; robotic devices; assembly automation. Prerequisite: MECH_ENG 340-2 or consent of instructor.

MECH_ENG 341-0 Computational Methods for Engineering Design (1 Unit) Introduction to a wide range of computational techniques for engineering design. Modeling, simulation, optimization, design software, examples, and projects with emphasis on computational techniques for design and manufacturing related applications. Prerequisite: senior standing or consent of instructor.

MECH_ENG 346-0 Introduction to Tribology (1 Unit) Fundamentals of surface contact: surface topography, asperity contact, interfacial phenomena. Friction theories and wear mechanisms. Temperatures in sliding contacts. Hydrodynamic, hydrostatic, elastohydrodynamic, and boundary lubrication.

MECH_ENG 359-0 Reliability Engineering (1 Unit) Probability concepts and random variables. Failure rates and reliability testing. Wearin, wear-out, random failures. Probabilistic treatment of loads, capacity, safety factors. Reliability of redundant and maintained systems. Fault tree analysis. Prerequisite: GEN_ENG 205-4.

MECH_ENG 360-0 Mechanics of Sports (1 Unit) Applications of mechanics and mathematical modeling to sports, including baseball, basketball, golf, soccer, swimming, and running, among others. Introduction to the biomechanics of sports.

MECH_ENG 362-0 Stress Analysis (1 Unit) Theory of elasticity: elastic stability, principle of minimum potential energy, Rayleigh-Ritz methods. Introduction to finite element methods of stress analysis: computer implementation and use of commercial codes. Structural analysis of rods, beams, columns, and plates. Prerequisite: CIV_ENV 216-0.

MECH_ENG 363-0 Mechanical Vibrations (1 Unit) Analysis of vibrations in single and multi-degree of freedom systems. Free and forced vibrations with various types of damping. Response to steady-state and transient excitations. Prerequisite: MECH_ENG 202-0

MECH_ENG 366-0 Finite Elements for Design & Optimizatn (1 Unit) Numerical methods for interaction and optimal CAD. Fully stressed design; design sensitivity analysis and descent methods;

optimality criteria to automated design. Prerequisites: senior standing; MECH_ENG 327-0 or consent of instructor.

MECH_ENG 367-0 Quantitative Methods in Life Cycle Analysis (1 Unit) Lifecycle analysis (LCA) framework for environmental assessment of technology systems, focusing on modeling methods for systems mass and energy flows, process and input-output-based systems inventories, environmental impact analysis, and methods for robust engineering decisions. MECH_ENG 367-0 is taught with CHEM_ENG 367-0; may not receive credit for both courses.

MECH_ENG 371-0 Combustion Engines (1 Unit) Theoretical and actual cycles, combustion, detonation, carburetion, fuels, performance characteristics, and fuel-cell power.

MECH_ENG 373-0 Engineering Fluid Mechanics (1 Unit) Laminar and turbulent duct flows. Boundary layers and potential flows. Lift and drag forces. Thermodynamics and mechanics of compressible flow. Nozzle flows and choking. Wave motion and shock waves. Applications to fluid machinery. Prerequisite: MECH_ENG 241-0.

MECH_ENG 377-0 Heat Transfer I (1 Unit) Fundamentals of heat transfer by conduction, convection, and radiation. Steady and transient heat conduction in solids. Forced and free convection in fluids. Properties of thermal radiation. Radiation heat transfer between solids. Solar radiation. Prerequisite: MECH_ENG 241-0.

MECH_ENG 380-0 Thermal Energy Systems Design (1 Unit) Applications of the principles of energy engineering analysis to the design of thermal systems. Consideration of such systems as air conditioning, oil piping, refrigeration, fluid distribution, and pneumatic control. Projects will be tailored to the class. Solution of open-ended design problems including introduction to EES (Engineering Equation Solver) software that has built-in thermophysical properties. Prerequisites: Basic Thermodynamics or equivalent.

MECH_ENG 381-0 Introduction to Micro-electro-mechanical Systems (1 Unit) Introduction to MEMS devices, with an emphasis on their manufacturing and mechanical behavior. Materials properties, microfabrication technology, mechanical behavior of microstructures, design, and packaging. Case studies on sensors, wireless communications, fluidic systems, microengines, and biological devices. Prerequisite: CIV_ENV 216-0 or consent of instructor.

MECH_ENG 382-0 Experiments in Micro- and Nano Science and Engineering (1 Unit) Interdisciplinary topics spanning the physical and biological sciences and engineering. Seven integrated labs in which students acquire hands-on experience in various aspects of micro- and nanoscience and engineering: cleanroom microfabrication, flow visualization in micro-channels, nanomechanics, AFM and dippen nanolithography, multiphysics computational tools, and experimental techniques to evaluate micro-and nanoscale devices. Prerequisite: MECH_ENG 381-0 or consent of instructor.

MECH_ENG 385-0 Nanotechnology (1 Unit) Manipulation of matter at the nanometer-length scale to produce useful devices and materials. Scientific and engineering properties of nanoscale systems. Emphasis on development of new techniques.

MECH_ENG 389-0 Molecular Machines in Biology (1 Unit) Introduction to engineering principles that govern cellular activities at the molecular level. Emphasis on the dynamics and kinematics of proteins, especially those that are locomotory or force generating. Lectures, team projects, and presentations. Prerequisite: MATH 230-0 or consent of instructor.

MECH_ENG 390-0 Intro to Dynamic Systems (1 Unit) Modeling the dynamic behavior of physical systems. Concepts of causality, dependent and independent storages, and state. Introduction to bond graphs. Generation of state equations; analytical and computer simulation of system behavior. Application to problems of engineering interest. Prerequisites: MECH_ENG 202-0, MECH_ENG 241-0; CIV_ENV 216-0; GEN_ENG 205-4.

MECH_ENG 395-0 Special Topics in Mechanical Engineering (1 Unit) Topics suggested by students or faculty members and approved by the department.

MECH_ENG 398-1 Engineering Design - Senior Capstone, Quarter 1 (1 Unit) Experience in the creative process of design. Defining product specifications, developing and analyzing ideas, using CAD drawings, building physical prototypes, demonstrating feasibility, and achieving full alpha-level functionality. Prerequisite: senior standing or consent of department.

MECH_ENG 398-2 Engineering Design II - Senior Capstone, Quarter 2 (1 Unit) Experience in the creative process of design. Defining product specifications, developing and analyzing ideas, using CAD drawings, building physical prototypes, demonstrating feasibility, and achieving full alpha-level functionality. Prerequisite: senior standing or consent of department.

MECH_ENG 399-0 Projects (1-3 Units) Special studies to be done under faculty direction. Credit to be arranged.