Department of Mechanical Engineering

Chairperson: John Borg, Ph.D., FASME
Department of Mechanical Engineering website (http://www.marquette.edu/engineering/mechanical)

Mission

We immerse individuals in an active environment to cultivate broadly educated mechanical engineers who balance theory with practice for advancing knowledge, solving problems and serving society.

Educational Objectives

Marquette University Mechanical Engineering graduates completing the Bachelor of Science degree in Mechanical Engineering will:

- Have successful careers.
- Continue their professional development.
- Serve their profession and society.
- Attain leadership roles in their professions and in society.
- Make strong contributions to their professions.

Synopsis

Mechanical engineering is that branch of engineering, which is concerned with mechanical and energy systems, along with the intelligent use of modern materials. Mechanical engineers conceive, plan, design and direct the manufacturing, distribution and operation of a wide variety of devices, machines and systems for energy conversion, environmental control, materials processing, transportation, materials handling and other purposes. The field of mechanical engineering is very broad, and the profession thus provides an ideal base for interdisciplinary activities.

Engineers are constantly challenged to advance and implement modern technologies. This challenge can be met provided that one obtains a sound knowledge of the fundamental principles of the engineering sciences. The mechanical engineering curriculum is designed to provide not only a thorough understanding of the engineering sciences but also of the principles of manufacturing and organization that are used to implement these fundamentals in practical engineering applications.

Integrated with the technical and scientific content of the program is a series of required and elective courses in the humanities, social sciences, theology, philosophy and communication arts. These courses provide the student with an understanding of society and an awareness of his or her social responsibilities.

In order to accommodate the students' professional interests, the department offers electives in a number of areas of study within mechanical engineering. In choosing electives, the student and faculty adviser confer to determine those courses which best meet the needs and interests of the individual student. By carefully selecting technical elective course work, the student can obtain in-depth knowledge in one or possibly two areas of study to compliment the broad, fundamental, required courses.

The mechanical engineering curriculum is outlined below and then followed by a description of the areas of study and the corresponding technical elective courses for each.

Five Year B.S./M.S. Program

This program allows students to receive a bachelor of science degree and a master of science degree in mechanical engineering in as few as five years. Only the thesis option is available with this program. Qualified students (3.500/4.000 GPA) who are enrolled in the Mechanical Engineering Department at Marquette University may apply for admission to this program during their undergraduate junior year. Students must submit an application to the Graduate School, indicate their interest in the five year program, and meet all other admission criteria as stated in the Application Requirements section, including GRE test scores. See Mechanical Engineering section of Graduate School Bulletin for details.

Mechanical Engineering Major

Typical Program for Mechanical Engineering Majors

Freshman			
First Term	**Hours**	**Second Term**	**Hours**
GEEN 1200	3	GEEN 1210	3
MATH 1450	4	MATH 1451	4
PHYS 1003	4	PHYS 1004	4

ENGL 1001 or ESSV1 (MCC)	3	ENGL 1001 or ESSV1 (MCC)	3
PHIL 1001 or THEO 1001 (MCC)	3	PHIL 1001 or THEO 1001 (MCC)	3
	17		17

Sophomore

First Term	Hours	Second Term	Hours
GEEN 2110	3	GEEN 2120	3
GEEN 2952	1	GEEN 2130	3
MEEN 2460	3	ELEN 3001	3
CHEM 1001	4	CHEM 1002	4
MATH 2450	4	MATH 2451	4
CORE 1929 (MCC)	3		
	18		17

Junior

First Term	Hours	Second Term	Hours
MEEN 3210	3	MEEN 3250	4
MEEN 3220	3	MEEN 3330	3
MEEN 3310	3	MEEN 3340	3
MEEN 3320	3	MEEN 3426	3
MEEN 3443	3	DSCV (MCC)[1, 2]	3
DSCV (MCC)[1, 2]	3		
	18		16

Senior

First Term	Hours	Second Term	Hours
MEEN 3260	3	MEEN 4998	3
MEEN 4590	1	Technical elective[3]	3
MEEN 4920	3	Technical elective[3]	3
Technical elective[3]	3	CORE 4929 (MCC)	3
DSCV (MCC)[1, 2]	3	DSCV (MCC)[1, 2]	3
	13		15

Total credit hours: 131

1 The four courses in the Discovery Tier (DSCV) of the MCC must be completed in the same theme and include the following content areas: Humanities (HUM), Social Science (SSC), Natural Science and Mathematics (NSM) and one elective (ELE), which is an additional course from any of the three content areas. A maximum of two courses in the Discovery Tier can apply towards a primary major.

2 Students must also complete the Writing Intensive (WRIT) and Engaging Social System and Values 2 (ESSV2) requirements of the MCC. These requirements can be fulfilled through designated courses in the Discovery Tier or other degree requirements.

3 At least two of three technical electives must be taken from the approved list of courses offered by the Mechanical Engineering Department. One technical elective may be taken outside of the Mechanical Engineering Department. See below for an approved list of technical electives.

Fundamentals of Engineering (FE) Exam

All mechanical engineering students must take the National Council of Examiners for Engineering and Surveying (NCEES) Fundamentals of Engineering (FE) Exam in order to graduate. Students normally take this exam in their senior year at the same time that they take MEEN 4590 Engineering Fundamentals Review, a one credit hour review course designed to prepare them for the exam. Students may take the exam at any of a large number

of testing facilities in the USA; however, most take the exam at a testing facility in the Milwaukee area. Taking the exam is the first step that an engineer takes in becoming a licensed Professional Engineer (PE).

Areas of Study

Energy Systems

Economic growth and development is strongly dependent upon the development and conversion of energy resources. Assurance that supplies can meet demands without excessive monetary and environmental costs will depend upon political, economic and technological decisions. But, in any case, the key to solving the technical problems is engineering the technological development of new and better energy conversion processes and systems. The courses offered in the energy area provide a most up-to-date background for the design of traditional energy systems and for design, research and development of new systems.

Students interested in Energy Systems may select courses from the following list as their technical electives:

MEEN 4260	Introduction to Continuum Mechanics	3
MEEN 4265	Intermediate Finite Element Methods	3
MEEN 4310	Combustion: Thermochemistry, Kinetics and Applications	3
MEEN 4325	Intermediate Fluid Mechanics	3
MEEN 4330	Optics, Lasers and Spectroscopy in Engineering	3
MEEN 4350	Transport Phenomena	3
MEEN 4360	Intermediate Thermodynamics	3
MEEN 4410	Experimental Design	3
MEEN 4931	Topics in Mechanical Engineering	3

Manufacturing Systems

Manufacturing engineering is that specialty which requires such education and experience to understand, apply and control engineering procedures and methods of production of industrial commodities and products. It requires the ability to plan the practices of manufacturing, to research and develop the tools, processes, machines, materials and equipment and to integrate the facilities and systems for producing quality products with optimal expenditures. The courses, including manufacturing processes, material processing, manufacturing system and reliability, offered in this area have the aim of preparing the student to face the challenges of rapidly changing technologies present in the modern manufacturing environment.

Students interested in Manufacturing Systems may select courses from the following list as their technical electives:

MEEN 4220	Intermediate Dynamics	3
MEEN 4240	Polymers and Polymer Composites	3
MEEN 4260	Introduction to Continuum Mechanics	3
MEEN 4275	Mechatronics	3
MEEN 4410	Experimental Design	3
MEEN 4420	Failure Analysis	3
MEEN 4430	Powder Metallurgy	3
MEEN 4440	Processing and Forming of Materials	3
MEEN 4460	Work Measurement and Facilities Design	3
MEEN 4475	Ergonomics	3
MEEN 4485	Welding Engineering	3
MEEN 4931	Topics in Mechanical Engineering	3

Mechanical Systems

This area provides the students with the theoretical, computational and experimental tools that are necessary for the detailed analysis and design of mechanical systems including machine elements such as linkages, gears, and other power transmission components, precision tools and machinery, etc. The courses offered in this area enable the student to understand the rationale and methodology of the overall design process of mechanical systems, proceeding from the conceptualization stage through the detailed design and implementation phases.

Students interested in Mechanical Systems may select courses from the following list as their technical electives:

MEEN 4220	Intermediate Dynamics	3
MEEN 4230	Intermediate Mechanics of Materials	3
MEEN 4240	Polymers and Polymer Composites	3
MEEN 4245	Fatigue and Fracture Mechanics	3

MEEN 4250	Design of Machine Elements 2	3
MEEN 4260	Introduction to Continuum Mechanics	3
MEEN 4265	Intermediate Finite Element Methods	3
MEEN 4270	Physical Systems Modeling	3
MEEN 4275	Mechatronics	3
MEEN 4410	Experimental Design	3
MEEN 4420	Failure Analysis	3
MEEN 4450	Mechanical Behavior of Materials	3
MEEN 4570	Biomaterials Science and Engineering	3
MEEN 4931	Topics in Mechanical Engineering	3

APPROVED TECHNICAL ELECTIVES

The following is an approved list of courses that may be taken from outside of the Mechanical Engineering Department that satisfies one of the technical electives. This list is not inclusive and other courses may be considered with department approval through a Curriculum Substitution.

BIEN 4410	Applied Finite Element Analysis	3
BIEN 4420	Biomaterials Science and Engineering	3
BIEN 4500	Medical Imaging Physics	3
BIEN 4510	Image Processing for the Biomedical Sciences	3
BIEN 4600	Neural Engineering	3
BIEN 4610	Introduction to Rehabilitation Robotics	3
BIEN 4620	Rehabilitation Science and Engineering	3
BIEN 4630	Rehabilitation Engineering: Prosthetics, Orthotics, Seating and Positioning	3
BIEN 4710	Analysis of Physiological Models	3
CEEN 3210	Hydraulic Engineering	3
CEEN 3410	Structural Analysis	3
CEEN 4145	Advanced Strength and Applied Stress Analysis	3
CEEN 4560	Environmental Fate and Transport	3
CEEN 4715	Sustainable Engineering	3
CHEM 2111	Organic Chemistry 1	4
CHEM 4431	Physical Chemistry: Fundamentals with Applications in Biological Sciences	3
CHEM 4433	Physical Chemistry 1	3
COEN 4830	Introduction to Computer Graphics	3
COSC 4600	Fundamentals of Artificial Intelligence	3
COSC 4610	Data Mining	3
ELEN 4310	Control Systems	3
ELEN 4460	Sensor Devices: Theory, Design, and Applications	3
MATH 3100	Linear Algebra and Matrix Theory	3
MATH 3520	Operational Methods in Physics and Engineering	3
MATH 4210	Complex Variables	3
MATH 4500	Theory of Differential Equations	3
MATH 4510	Elementary Partial Differential Equations	3
MATH 4540	Numerical Analysis	3
MATH 4630	Mathematical Modeling and Analysis	3
MATH 4650	Theory of Optimization	3
MATH 4760	Time Series Analysis	3
NASC 3142	Naval Ship Systems 1	3
NASC 3162	Naval Ship Systems 2	3
PHYS 3011	Classical Mechanics	3
PHYS 4012	Quantum Mechanics	3
PHYS 4024	Modern Optics	3
PHYS 4031	Electricity and Magnetism 1	3

PHYS 4046	The Physical Basis of Biological Structure and Function	3
PHYS 4050	Introduction to Einstein's General Theory of Relativity	3

Mechanical Engineering Minor

The Department of Mechanical Engineering offers a minor in mechanical engineering to all undergraduate students in the university. The minor is not available to students majoring in mechanical engineering. Completion of the minor is noted on the student's transcript if the following requirements are met.

At least thirty-one (31) credit hours of undergraduate mechanical engineering or engineering mechanics courses are required for the minor. Requirements include the following:

GEEN 2110	Statics	3
GEEN 2120	Dynamics	3
GEEN 2130	Mechanics of Materials	3
MEEN 2460	Materials Science	3
MEEN 3220	Dynamics of Mechanical Systems	3
MEEN 3250	Design of Machine Elements 1	4
MEEN 3310	Thermodynamics 1	3
MEEN 3320	Fluid Mechanics	3
MEEN 3330	Fundamentals of Heat Transfer	3
One MEEN elective		3
Total Credit Hours		31

The program, as a whole, must have departmental approval and be completed with a C average. Interested students should consult with the department in order to develop an acceptable program. At least 15 credit hours must be taken at Marquette University.

Minor's Learning Outcomes:

- Students will be able to identify, formulate and solve mechanical engineering problems.

Courses

MEEN 2460. Materials Science. 3 cr. hrs.
Atomic structure of matter, types of bonding, crystallography, role of imperfections, and ionic diffusion. Electric, magnetic, dielectric, and semiconducting properties. Mechanical properties, corrosion, and phase diagrams. 2 hrs. lec.; 2 hrs. lab. Prereq: CHEM 1001, which may be taken concurrently. Enrolled in the Opus College of Engineering.

MEEN 2470. Freehand Sketching for Engineers. 1 cr. hr.
Engineering students learn how to sketch with only a #2 wooden pencil on blank white paper to visually communicate their ideas and concepts. No instruments such as rulers and compasses are used, and no visual art talent is required. Students practice drawing engineered products such as small electrical and mechanical devices, machines and household products. A final project consists of a set of drawings of an engineered product that demonstrates the student’s ability to draw freehand with the orthographic, isometric and oblique drawing systems. Offered in a 7-week session within the term. Students can register for the first 7-week session or the second 7-week session of the term. Prereq: Enrolled in the Opus College of Engineering.

MEEN 2930. Special Topics in Mechanical Engineering. 1-5 cr. hrs.
Offered as an experimental course to evaluate and determine if a course should be incorporated into the regular curriculum of a program, or courses in the approval process pipeline, but not yet officially approved. Once the same course has been offered twice as a Special Topic, it cannot be offered again until it moves through the curriculum approval process and is approved with a regular curriculum course number. Prereq: Enrolled in the Opus College of Engineering.

MEEN 3210. Measurements and Controls. 3 cr. hrs.
Fundamentals of measurement/instrumentation systems and control systems. Measurement topics include: sensors, signal conditioners, data acquisition, and transducers for measurement of strain, force, displacement, temperature, flow, pressure, and other engineering parameters. Control system topics include: mathematical modeling of dynamic systems, and analysis and design of systems using sensors, actuators, and controllers. Time-domain and frequency-domain methods for design of feedback control systems. Computer and laboratory exercises using MATLAB and LabVIEW. 2 hrs. lec., 2 hrs. lab. Prereq: MEEN2120 and ELEN3001.

MEEN 3220. Dynamics of Mechanical Systems. 3 cr. hrs.
Analytical and computational analysis of the kinematics and kinetics of planar multi-body mechanical systems. Vibration analysis of single degree of freedom systems. Engineering applications including dynamic balancing, vibration absorption and vibration isolation. Prereq: MATH 2451 or MATH 2455; and MEEN 2120.

MEEN 3250. Design of Machine Elements 1. 4 cr. hrs.
Detailed design of structural elements, shafts, gears, bearings, and other machine elements. Laboratory activities which cover the theoretical and experimental analysis of machine elements. 3 hrs. lec., 2 hrs. lab. Prereq: CEEN 2110 or MEEN 2110; and CEEN 2130 or MEEN 2130.

MEEN 3260. Numerical Methods of Mechanical Systems. 3 cr. hrs.
Numerical algorithms (math analysis, optimization, function approximation) for analysis and preliminary design of engineering systems. Development and use of MATLAB functions. Finite element software for solid modeling and analysis of elastic systems. 3 hrs. lec., 1 hr. lab. Prereq: MEEN 3220 and CEEN 2130 or MEEN 2130.

MEEN 3310. Thermodynamics 1. 3 cr. hrs.
Elementary principles of equilibrium thermodynamics of pure and mixed substances, including applications to systems and processes. Relationships between heat and work, the first law of thermodynamics, are applied to either open or closed systems, operating at either steady or unsteady conditions. Second law of thermodynamics is applied to assessing the efficiency of devices and systems. Prereq: MATH 1451 or MATH 1455; PHYS 1003 or PHYS 1013.

MEEN 3320. Fluid Mechanics. 3 cr. hrs.
Fundamental conservation laws of mass, momentum and energy as applied to fluid systems. Properties of fluids, hydrostatics, flow of real fluids in closed and open systems, dynamic similarity, dimensional analysis and viscid and inviscid fluid flow. Prereq: MATH 2450 or MATH 2455; and MEEN 2120.

MEEN 3330. Fundamentals of Heat Transfer. 3 cr. hrs.
Overview of principal mechanisms of heat transfer: conduction, convection, and thermal radiation. Application of conduction and forced convection to heat exchangers. Discussion of theory and applications of conduction, forced and natural convection, boiling and condensation and thermal radiation. Prereq: MATH 2451, MEEN 3310, and MEEN 3320.

MEEN 3340. Thermodynamics 2. 3 cr. hrs.
The culmination of thermodynamic, fluid and heat transfer concepts to the application of power and refrigeration cycles, psychrometrics systems, and combustion processes. Includes a laboratory section in which experiments are conducted to demonstrate, test and assess devices, processes and cycles. 2 hrs. lec.; 2 hrs. lab. Prereq: MEEN 3310; MEEN 3330, which may be taken concurrently.

MEEN 3426. Engineering Statistics. 3 cr. hrs.
Introductory course in statistics, which is the field of study concerned with the collection, analysis and interpretation of uncertainty in data. Topics include summary statistics, basic probability, commonly used distributions, confidence intervals, and hypothesis testing. In addition, introductory concepts of engineering economy and cash flow diagrams will be covered in the first few weeks of the course to prepare students for the FE exam. Prereq: MATH 1451.

MEEN 3443. Manufacturing Engineering. 3 cr. hrs.
The types of processes available to manufacture various products. The characteristics of these processes and how they interact with design requirements, tolerances, safety and the environment. Integration of basic concepts into complete processes. Determination of the process to manufacture various assigned products. 2 hrs. lec., 2 hrs. lab. Prereq: MEEN 2460.

MEEN 3460. Materials Selection in Mechanical Design. 3 cr. hrs.
Design methodology and the criteria for the selection of materials from the four classes of materials (metals, plastics, ceramics and composites) are discussed. Criteria include processing requirements, mechanical properties, and environmental resistance. A rationale for selecting materials based on materials selection charts is presented. The process-structure-property relationship for ferrous and non-ferrous alloys, plastics, ceramics and composites is presented from the point of view of understanding selection criteria. Considerations of cost and availability are also taken into consideration. 3 hrs. lec. Prereq: MEEN 2460.

MEEN 4220. Intermediate Dynamics. 3 cr. hrs.
Develop an understanding of the principles of 3D rigid body kinematics (motion) and kinetics (forces and accelerations). Use these principles to analyze the dynamic behavior of mechanical systems. Learn to use analytical mechanics tools including virtual work and Lagrange's method. Develop a systematic approach for solving engineering problems. Prereq: MEEN 2120.

MEEN 4230. Intermediate Mechanics of Materials. 3 cr. hrs.
Review of beam theory; asymmetric bending, shear center, thin-walled sections; torsion of non-circular sections, open and closed thin-walled sections; energy methods, Castigliano's second theorem, statically indeterminate structures, internal static indeterminacy; curved beams. Prereq: CEEN 2130 or MEEN 2130.

MEEN 4240. Polymers and Polymer Composites. 3 cr. hrs.
Introduction to physical/chemical structure of polymers, polymer characterization, polymer material properties and mechanical testing methods, elastic and viscoelastic polymer response, processing methods, composite materials, and the selection of polymers in design applications. Prereq: CEEN 2130 or MEEN 2130.

MEEN 4245. Fatigue and Fracture Mechanics. 3 cr. hrs.
Application of fatigue and fracture models to engineering design. Stress-life (high-cycle), strain-life (low cycle), and fatigue crack growth models for fatigue. Introduction to linear elastic fracture mechanics. Statistical considerations in failure. Fail safe design practices. Course includes illustrative case studies. Prereq: CEEN 2130 or MEEN 2130.

MEEN 4250. Design of Machine Elements 2. 3 cr. hrs.
Detailed design of gears and cams. Integration of dynamics into design of machinery is emphasized. Topics include balancing of machinery, selection of motors and critical frequency analysis, and miscellaneous power transmission components. Use of spreadsheets and computer programs to assist in the design of various components. Prereq: MEEN 3250 or equiv.

MEEN 4260. Introduction to Continuum Mechanics. 3 cr. hrs.
Introduction to tensor notation, tensor analysis and coordinate system invariance; analysis of stress, strain and rate of strain for infinitesimal and finite deformation; application of Newtonian mechanics to deformable media; mechanical constitutive equations; field equations for solid and fluid mechanics. Prereq: MATH 2451, Co-req: MATH 3100 or MEEN 3260, or equivalent.

MEEN 4265. Intermediate Finite Element Methods. 3 cr. hrs.
Introduces the finite element solution method for linear, static problems. Includes calculation of element stiffness matrices, assembly of global stiffness matrices, exposure to various finite element solution methods, and numerical integration. Emphasizes structural mechanics, and also discusses heat transfer and fluid mechanics applications in finite element analysis. Computer assignments include development of finite element code (FORTRAN or C) and also use of commercial finite element software (ANSYS and/or MARC). Prereq: MEEN 3260.

MEEN 4270. Physical Systems Modeling. 3 cr. hrs.
Principles of modeling of physical systems, including devices and processes. Development of models of physical systems: mechanical, electrical, fluid, thermal and coupled systems. Time-dependent behavior of interconnected devices and processes. Computer-based modeling and simulation of physical systems. Identification using models and measured data. Introduction to control systems analysis and design. Prereq: MATH 2451.

MEEN 4275. Mechatronics. 3 cr. hrs.
Mechatronics, as an engineering discipline, is the synergistic combination of mechanical engineering, electronics, control engineering, and computer science, all integrated through the design process. This course covers mechatronic system design, modeling and analysis of dynamic systems, control sensors and actuators, analog and digital control electronics, interfacing sensors and actuators to a microcomputer/microcontroller, discrete and continuous controller design, and real-time programming for control. Prereq: MEEN 3210 and MEEN 3220.

MEEN 4310. Combustion: Thermochemistry, Kinetics and Applications. 3 cr. hrs.
Fundamentals of combustion, including thermodynamics, chemical equilibrium and chemical kinetics. The application of the principles are emphasized for the development of mathematical models in MATLAB that can be used to simulate combustion in fundamental reactors and internal combustion engines. Prior experience with computer programming is recommended. Prereq: MEEN 3340 and MEEN 3260.

MEEN 4325. Intermediate Fluid Mechanics. 3 cr. hrs.
Intermediate Fluid Mechanics continues to develop fluid mechanic concepts, building on a working knowledge of the Reynolds Transport Theorem. Topics include: differential analysis, irrotational flow theory, boundary layer theory and compressible flow theory. Both laminar and turbulent flows are discussed. Some working knowledge of computer programming is necessary. Prereq: MATH 2450 or MATH 2455, and MEEN 3320 or equiv.

MEEN 4330. Optics, Lasers and Spectroscopy in Engineering. 3 cr. hrs.
Topical overview on the uses of optics, lasers, and spectroscopic measurement techniques in engineering and scientific disciplines. Technical content includes basic principles of geometric optics, principles behind and characteristics of laser operation, and linear spectroscopy. Emphasis on absorption and emission techniques for sensor development. Prereq: PHYS 1004 or PHYS 1014.

MEEN 4350. Transport Phenomena. 3 cr. hrs.
The subject of transport phenomena includes three closely related topics: fluid dynamics, mass transfer, and heat transfer. Fluid dynamics involves the transport of momentum, mass transfer is concerned with the transport of mass of various chemical species, and heat transfer deals with the transport of energy. In practice, rarely are these phenomena acting alone. Thus in this introductory course, these three topics are studied together so that a more cohesive understanding of these interrelated processes is developed. Prereq: MEEN 3340.

MEEN 4360. Intermediate Thermodynamics. 3 cr. hrs.
This intermediate course will cover fundamentals of thermodynamics, including classical and statistical approaches with application to equilibrium and non-equilibrium, non-reactive and reactive systems. Topics relevant to micro/nanoscale and biological systems may be covered. Prereq: MEEN 3340.

MEEN 4410. Experimental Design. 3 cr. hrs.
Application of statistical concepts to design engineering experiments to improve quality, production techniques, and reliability. Use and advantages of various models; factorial, fractional factorial, orthogonal arrays and fractional designs. Prereq: MATH 4720 or MEEN 3426 or cons. of instr.

MEEN 4420. Failure Analysis. 3 cr. hrs.
Methodology of failure analysis. Studies of brittle fracture, ductile fracture, fatigue, stress corrosion and electro-chemical corrosion as applied to the failure of metals. Involves some laboratory work and analyses of a variety of metallurgical failures. Prereq: MEEN 3460 and CEEN 2130 or MEEN 2130.

MEEN 4430. Powder Metallurgy. 3 cr. hrs.
The course introduces a modern technology with growing importance. It covers the basics of powder metallurgy with main emphasis on sintered steel. The primary topics covered are powder production, die compacting, sintering theory and practice, full density processing, properties under static and dynamic loading conditions. Prereq: MEEN 2460.

MEEN 4440. Processing and Forming of Materials. 3 cr. hrs.
Solidification and microstructural development in metal casting with an overview of selected melting processes. Overview of primary and secondary working principles involved in ferrous materials processing. Stress based and finite element analyses are applied to both sheet and bulk forming to develop a fundamental understanding of deformation processing principles and technology associated with processes such as drawing, open and closed die forging and rolling. Prereq: MEEN 2460 and MEEN 3443, which can be taken concurrently.

MEEN 4450. Mechanical Behavior of Materials. 3 cr. hrs.
Stress and strain relationships for elastic behavior. Theory of plasticity. Plastic deformation of single crystals and polycrystalline aggregates. Dislocation theory, fracture, internal friction, creep and stress rupture and brittle failure. Prereq: MEEN 3460 and CEEN 2130 or MEEN 2130; or cons. of instr.

MEEN 4460. Work Measurement and Facilities Design. 3 cr. hrs.
Concentrates on how to quantify work and how to design work tasks, based on measurement and methods engineering, to achieve optimal performance. Involves analysis and evaluation of facilities for industrial and service operations and designing facilities, regardless of size, for various types of operations. Prereq: MEEN 3426 or MATH 4720 or equiv.

MEEN 4475. Ergonomics. 3 cr. hrs.
Ergonomics maximizes the health and safety of workers, while maintaining productivity and quality. Covers biomechanical and physiologic aspects of workplace design, such as engineering anthropometry, cumulative trauma disorders, (including carpal tunnel syndrome), low back injuries, hand tool design and evaluation, methods of surveillance in industrial environments, modeling, and ergonomics guidelines. Laboratory experiences are offered to demonstrate ergonomic principles and also provide students with hands-on experience in collecting data and conducting experiments. Prereq: MEEN 3426 or MATH 4720 or equiv.

MEEN 4485. Welding Engineering. 3 cr. hrs.
Arc welding physics, fundamentals of power supplies and welding circuits, fusion and solid-state welding processes, weld testing, analysis of welded joints, demonstrations using various processes. Prereq: CEEN 2130 or MEEN 2130; and MEEN 3443.

MEEN 4570. Biomaterials Science and Engineering. 3 cr. hrs.
Designed to introduce the uses of materials in the human body for the purposes of healing, correcting deformities and restoring lost function. The science aspect of the course encompasses topics including: characterization of material properties, biocompatibility and past and current uses of materials for novel devices that are both biocompatible and functional for the life of the implanted device. Projects allow students to focus and gain knowledge in an area of biomaterials engineering in which they are interested. Same as BIEN 4420. Prereq: MEEN 2460 or consent of instructor.

MEEN 4590. Engineering Fundamentals Review. 1 cr. hr.
Review of basic science, mathematics, engineering science, and economics. S/U grade assessment. Prereq: Sr. stndg.

MEEN 4920. Principles of Design. 3 cr. hrs.
Course content focuses on a structured product design and development process that includes project definition, customer needs identification, product specification, concept generation, and concept selection. Course also focuses on issues related to teamwork, project management, and effective communication. Student team design projects culminate in the development of a technically and economically viable concept and a proposal for future development of this concept (done in the second semester of this two-course sequence). 2 hrs. lec., 1 hr. disc. Prereq: Sr. stndg; Co-op students, Jr. stndg. Cross-listed with BIEN 4920, COEN 4920, EECE 4920.

MEEN 4931. Topics in Mechanical Engineering. 3 cr. hrs.
Covers a unique perspective or in-depth topic in: energy conversion, mechanical analysis and design and manufacturing systems.

MEEN 4995. Independent Study in Mechanical Engineering. 1-3 cr. hrs.
Undergraduate independent study project of either theoretical or experimental nature. Prereq: Jr. stndg., 3.000 GPA, cons. of instr., and cons. of dept. ch.

MEEN 4998. Senior Design Project. 3 cr. hrs.
Course focuses on detailed design, prototyping, and testing design concepts. Course includes topics directly relevant to student design projects and careers in the engineering profession. Student team design projects culminate in a final report that documents the performance and details (engineering drawings and/or documentation) of their final design. 2 hrs. lec., 1 hr. disc. Prereq: MEEN 4920. Cross-listed with BIEN 4998, COEN 4998, and EECE 4998.