Materials Engineering

Undergraduate Study

For the undergraduate curriculum in materials engineering leading to the degree bachelor of science. This curriculum is accredited under the General Criteria and the Materials Engineering Program Criteria by the Engineering Accreditation Commission of ABET, http://www.abet.org/ Materials engineering is a broadly-based discipline relating the composition, microstructure, and processing of materials to their properties, uses and performance. Materials engineering includes a variety of traditional and modern technologies involving metals, ceramics, polymers, composites, and electronic materials.

Because of its interdisciplinary nature, career opportunities for materials engineers bridge all industrial and government sectors including: materials based technologies (materials production), communication/information technologies (semiconducting materials, fiber optics), medical/environmental technologies (biomedical, energy production, waste containment), nanotechnologies, consumer products (building and construction, durable goods), and transportation industries (automotive, aerospace).

The objectives of the materials engineering program are to produce graduates who:

- practice materials engineering in a broad range of industries including materials production, semiconductors, medical/environmental, consumer products, and transportation products
- engage in advanced study in materials and related or complementary fields

Graduates in materials engineering are able to apply scientific and engineering principles to select or design the best materials to solve engineering problems. They are also able to control the microstructure of materials through processing to optimize properties and performance. They are skilled in creative, independent problem solving under time and resource constraints. Graduates will have gained experience in materials engineering practice through cooperative work experience or internships in industry, national laboratories, or other funded research work. They will have hands-on skills with a broad range of modern materials processing and characterization equipment and methods.

A degree in materials engineering relies on a strong foundation of math, chemistry and physics. The core materials courses include fundamentals of materials, kinetics and thermodynamics, mechanical properties, computational methods, design, and professional practice experience. Students tailor their programs to their goals and interests through the selection of a specialization from the three available: ceramic materials, metallic materials and polymeric materials. Additional technical electives can be taken in other areas of interest. The breadth and depth of the program provide excellent preparation for both immediate entry into industry or further study in graduate school.

The department also offers a cooperative education program that combines classroom learning with work experience.

Well qualified juniors in materials engineering who are interested in graduate study may apply for concurrent enrollment during their senior year in the Graduate College to simultaneously pursue both bachelor of science and master of science degrees. See Materials Science and Engineering for more information.

Curriculum in Materials Engineering

Administered by the Department of Materials Science and Engineering.

Leading to the degree bachelor of science.

Total credits required: 128 cr. See also Basic Program and Special Programs.

International Perspectives: 3 cr. [1]

U.S. Diversity: 3 cr. [1]

Communication Proficiency/Library requirement (minimum grade of C):

ENGL 150	Critical Thinking and Communication	3
ENGL 250	Written, Oral, Visual, and Electronic Composition	3
LIB 160	Information Literacy	1
One of the following (minimum grade of C)		3
ENGL 302	Business Communication	
ENGL 309	Report and Proposal Writing	
ENGL 314	Technical Communication	
JL MC 347	Science Communication	

General Education Electives: 15 cr.

Complete 12 cr. from approved list with a minimum of 6 cr. but no more than 9 cr. from one designator, and a maximum of 9 cr. of 100-level courses[2]. Complete one course (3 cr.) from the following with a minimum grade of C:

ENGL 302	Business Communication	3
ENGL 309	Report and Proposal Writing	3
ENGL 314	Technical Communication	3
JL MC 347	Science Communication	3

Basic Program: 27 cr.

Complete with 2.00 GPA including transfer courses:

CHEM 167	General Chemistry for Engineering Students	4
or CHEM 177	General Chemistry I	
ENGL 150	Critical Thinking and Communication	3
ENGL 250	Written, Oral, Visual, and Electronic Composition (see above for grade requirements)	3
ENGR 101	Engineering Orientation	R
ENGR 160	Engineering Problems with Computer Applications Laboratory	3
LIB 160	Information Literacy	1
MATH 165	Calculus I	4
MATH 166	Calculus II	4
PHYS 221	Introduction to Classical Physics I (See Basic Program)	5
Total Credits		27

Math and Physical Science: 18 cr.

CHEM 177L	Laboratory in General Chemistry I	1
CHEM 178	General Chemistry II	3
CHEM 178L	Laboratory in College Chemistry II	1
MATH 265	Calculus III	4
MATH 267	Elementary Differential Equations and Laplace Transforms	4
PHYS 222	Introduction to Classical Physics II	5
Total Credits		18

Materials/Specialties Engineering Core: 41 cr.

Complete with 2.00 GPA including transfer courses:

MAT E 214	Structural Characterization of Materials	3
MAT E 215	Introduction to Materials Science and Engineering I	3
MAT E 215L	Introduction to Materials Science and Engineering I - Lab	1
MAT E 216	Introduction to Materials Science and Engineering II	4
MAT E 311	Thermodynamics in Materials Engineering	3
MAT E 314	Kinetics and Phase Equilibria in Materials	3
MAT E 316	Computational Methods in Materials	3
MAT E 317	Introduction to Electronic Properties of Ceramic, Metallic, and Polymeric Materials	3
MAT E 413	Materials Design and Professional Practice I	3
MAT E 414	Materials Design and Professional Practice II	3
MAT E 418	Mechanical Behavior of Materials	3
Students must choose one from the three areas of specialization (9 cr.): ceramic, metallic and polymeric materials.		9
Total Credits		41

The options below meet that expectation by using the following specialization courses:

Ceramic Materials:

MAT E 321	Introduction to Ceramic Science	3
MAT E 322	Introduction to Ceramic Processing	3
MAT E 425	Glasses and Advanced Ceramics	3

Metallic Materials:

MAT E 342	Structure/Property Relations in Nonferrous Metals	3
MAT E 443	Physical Metallurgy of Ferrous Alloys	3
MAT E 444	Corrosion and Failure Analysis	3

Polymeric Materials:

MAT E 351	Introduction to Polymeric Materials	3
MAT E 453	Physical and Mechanical Properties of Polymers	3
MAT E 454	Polymer Composites and Processing	3

Other Courses: 27 cr.

E M 274	Statics of Engineering	3
E M 324	Mechanics of Materials	3
Technical electives from list of materials courses		9
Technical electives from approved departments		9
Non-remedial course		3
Total Credits		27

Seminar/Co-op/Internships

MAT E 201	Materials Science and Engineering - Professional Planning	R

Co-op and internships are optional

1. These university requirements will add to the minimum credits of the program unless the university-approved courses are also approved by the department to meet other course requirements within the degree program. U.S. diversity and international perspectives courses may not be taken Pass/Not Pass.
2. Choose from department approved list.
3. See Basic Program for Professional Engineering Curricula for accepted substitutions for curriculum designated courses in the Basic Program.

Note: A Mat E student may take up to 9 credit hours from General Education and free electives on a P/NP basis, except for courses used to meet the diversity and international perspectives requirement. S/F courses (different from P/NP) will be considered for these requirements on a course-by-course basis.

See also: A 4-year plan of study grid showing course template by semester. (https://nextcatalog.registrar.iastate.edu/planofstudy/engineering/#materialsengineeringbs)

Courses primarily for undergraduates:

MAT E 201. Materials Science and Engineering - Professional Planning.
Cr. R. F.S. *Prereq: Sophomore classification in Mat E*
Preparation for a career in materials engineering; experiential learning, resumes, interviewing, Myers-Briggs Type Indicator, leadership, undergraduate research, international opportunities, graduate school preparation and opportunities, and alternative career paths. Offered on a satisfactory-fail basis only.

MAT E 214. Structural Characterization of Materials.
(2-3) Cr. 3. S. *Prereq: MAT E 215, credit or enrollment in PHYS 221*
Structural characterization of ceramic, electronic, polymeric and metallic materials. Techniques include optical and electron microscopy, x-ray diffraction, and thermal analysis. Identification of materials type, microstructure, and crystal structure.

MAT E 215. Introduction to Materials Science and Engineering I.
(3-0) Cr. 3. F. *Prereq: Math 165 AND (CHEM 177 or CHEM 167)*
Materials Engineering majors only. Structure and properties of ceramic, electronic, polymeric and metallic materials, emphasizing differences based on structure and bonding. Phase equilibria and phase transformations. Only one of Mat E 215, 273, or 392 may count toward graduation.

MAT E 215L. Introduction to Materials Science and Engineering I - Lab.
(0-3) Cr. 1. F. *Prereq: Credit or enrollment in MAT E 215 or MAT E 273 or MAT E 392*
Materials Engineering majors only. Laboratory exercise in materials.

MAT E 216. Introduction to Materials Science and Engineering II.
(3-2) Cr. 4. S. *Prereq: MAT E 215, Credit or enrollment in PHYS 222*
Materials Engineering majors only. Fundamentals of ceramic, polymeric, and composite materials; degradation, electronic, thermal, magnetic, and optical properties of materials. Materials for energy, biomaterials, and nanomaterials. Laboratory exercises in materials property measurements.

MAT E 220. Globalization and Sustainability.
(Cross-listed with ANTHR, ENV S, GLOBE, T SC, M E, SOC). (3-0) Cr. 3. F.S.
An introduction to understanding the key global issues in sustainability. Focuses on interconnected roles of energy, materials, human resources, economics, and technology in building and maintaining sustainable systems. Applications discussed will include challenges in both the developed and developing world and will examine the role of technology in a resource-constrained world. Cannot be used for technical elective credit in any engineering department.
Meets International Perspectives Requirement.

MAT E 273. Principles of Materials Science and Engineering.
(3-0) Cr. 3. F.S.SS. *Prereq: Sophomore classification; CHEM 167 or CHEM 177; MATH 165*
Introduction to the structure and properties of engineering materials. Structure of crystalline solids and imperfections. Atomic diffusion. Mechanical properties and failure of ductile and brittle materials. Dislocations and strengthening mechanisms. Phase equilibria, phase transformations, microstructure development, and heat treatment principles of common metallurgical systems including steels and aluminum alloys. Structure and mechanical properties of ceramic, polymeric and composite materials. Thermal properties of materials. Corrosion and degradation. Basic electronic properties of materials. Engineering applications. Only one of Mat E 215, 272, 273. or 392 may count toward graduation

MAT E 298. Cooperative Education.
Cr. R. F.S.SS. *Prereq: Permission of department and Engineering Career Services*
First professional work period in the cooperative education program. Students must register for this course before commencing work.

MAT E 311. Thermodynamics in Materials Engineering.
(3-0) Cr. 3. F. *Prereq: MAT E 216, CHEM 178, PHYS 222, credit or enrollment in MATH 267*
Basic laws of thermodynamics applied to materials systems. Thermodynamics of chemical reactions. Homogeneous and heterogeneous equilibrium. Phase diagrams for materials systems. Nonmajor graduate credit.

MAT E 314. Kinetics and Phase Equilibria in Materials.
(3-0) Cr. 3. S. *Prereq: MAT E 216, MAT E 311*
Kinetic phenomena and phase equilibria relevant to the origins and stability of microstructure in metallic, ceramic and polymeric systems. Application of thermodynamics to the understanding of stable and metastable phase equilibria, interfaces and their effects on stability: defects and diffusion, empirical rate equations for transformation kinetics, driving forces and kinetics of nucleation, diffusional and diffusionless phase transformations. Nonmajor graduate credit.

MAT E 316. Computational Methods in Materials.
(2-2) Cr. 3. S. *Prereq: MAT E 215*
Use of mathematical and statistical computer tools for materials design and analysis. Applications of statistical principles to problems concerned with materials. Computer-assisted design of experiments. Nonmajor graduate credit.

MAT E 317. Introduction to Electronic Properties of Ceramic, Metallic, and Polymeric Materials.
(3-0) Cr. 3. F. *Prereq: MAT E 216 and PHYS 222*
Materials Engineering majors only. Introduction to electronic properties of materials and their practical applications. Classical conduction models and electronic properties of metallic and ceramic materials. Elementary quantum mechanics and band theory of electron states in solids. Quantum theory of metallic conduction. Elementary semiconductor theory and devices. Polarization and dielectric properties of materials. Electron conduction in polymeric systems. Magnetic properties and applications of metals and ceramics.

MAT E 321. Introduction to Ceramic Science.
(3-0) Cr. 3. F. *Prereq: MAT E 216*
Ceramic crystal structures, defects, diffusion and transport. Phase equilibria and microstructures. Powder packing. Thermal, electronic, optical and magnetic properties of ceramics. Nonmajor graduate credit.

MAT E 322. Introduction to Ceramic Processing.
(2-3) Cr. 3. S. *Prereq: MAT E 321*
Synthesis and characterization of ceramic powders. Colloidal phenomena, rheology of suspensions, ceramic forming methods, and drying. High temperature ceramic reactions, liquid and solid-state sintering, grain growth, microstructure development. Processing/microstructure/property relationships. Nonmajor graduate credit.

MAT E 332. Semiconductor Materials and Devices.
(Cross-listed with E E). (3-0) Cr. 3. S. *Prereq: PHYS 222; MAT E majors: MAT E 334; CPR E and E E majors: E E 230*
Introduction to semiconductor material and device physics. Quantum mechanics and band theory of semiconductors. Charge carrier distributions, generation/recombination, transport properties. Physical and electrical properties and fabrication of semiconductor devices such as MOSFETs, bipolar transistors, laser diodes and LED's. Nonmajor graduate credit.

MAT E 334. Electronic & Magnetic Properties of Metallic Materials.
(2-2) Cr. 3. S. *Prereq: MAT E 317*
Electronic conduction in metals and the properties of conducting materials. Quantum mechanical behavior of free electrons and electrons in potentials wells, bonds and lattices. Development of the band theory of electron states in solids and the Free and Nearly Free Electron models. Density-of-states in energy bands and the Fermi-Dirac statistics of state occupancy. Quantum mechanical model of metallic conduction; Brillouin zones and Fermi surfaces. Additional topics include the thermal properties of metals, electron phase transitions in metallic alloys and the BCS theory of superconductivity. Classical and quantum mechanical treatment of the origins of magnetism in materials; orbital and spin angular momentum. Theory of magnetic behavior in dia-, para-magnetic, ferromagnetic materials. Nonmajor graduate credit.

MAT E 342. Structure/Property Relations in Nonferrous Metals.
(2-3) Cr. 3. S. *Prereq: MAT E 216*
Processing of metals and alloys to obtain desired mechanical properties by manipulation of their microstructure and composition of constituent phase(s). Relevance of defects to mechanical properties, plastic flow. Strengthening mechanisms in metals and alloys. Microstructure, heat treatment and mechanical properties of engineering alloys. Metal-matrix composites. Nonmajor graduate credit.

MAT E 351. Introduction to Polymeric Materials.
(3-0) Cr. 3. F. *Prereq: MAT E 216*
Introduction to polymeric materials, synthesis, structure and properties. Relationship between polymer composition, processing and properties. Nonmajor graduate credit.

MAT E 362. Principles of Nondestructive Testing.
(Cross-listed with E M). (3-0) Cr. 3. S. *Prereq: PHYS 112 or PHYS 222*
Radiography, ultrasonic testing, magnetic particle inspection, eddy current testing, dye penetrant inspection, and other techniques. Physical bases of tests; materials to which applicable; types of defects detectable; calibration standards, and reliability safety precautions. Nonmajor graduate credit.

MAT E 362L. Nondestructive Testing Laboratory.
(Cross-listed with E M). (0-3) Cr. 1. S. *Prereq: Credit or enrollment in MAT E 362*
Application of nondestructive testing techniques to the detection and sizing of flaws in materials and to the characterization of material's microstructure. Included are experiments in hardness, dye penetrant, magnetic particle, x-ray, ultrasonic and eddy current testing. Field trips to industrial laboratories. Nonmajor graduate credit.

MAT E 370. Toying with Technology.
(Cross-listed with CPR E). (2-2) Cr. 3. F.S. *Prereq: C I 201 or C I 202*
A project-based, hands-on learning course. Technology literacy, appreciation for technological innovations, principles behind many technological innovations, hands-on laboratory experiences based upon simple systems constructed out of LEGOs and controlled by small microcomputers. Future K-12 teachers will leave the course with complete lesson plans for use in their upcoming careers.

MAT E 388. Sustainable Engineering and International Development.
(Cross-listed with A E, E E, M E, C E, BSE). (2-2) Cr. 3. F. *Prereq: Junior classification in engineering*
Multi-disciplinary approach to sustainable engineering and international development, sustainable development, appropriate design and engineering, feasibility analysis, international aid, business development, philosophy and politics of technology, and ethics in engineering. Engineering-based projects from problem formulation through implementation. Interactions with partner community organizations or international partners such as nongovernment organizations (NGOs). Course readings, final project/design report.
Meets International Perspectives Requirement.

MAT E 389. Applied Methods in Sustainable Engineering.
(Cross-listed with M E). (3-0) Cr. 3. Repeatable, maximum of 2 times. SS.
Learning how to work in a cross disciplinary engineering team to develop and implement appropriate solutions for cooking, lighting, farming, and sanitation in a rural village in Mali. Engineering principles necessary for the projects to be worked on including lighting solutions in a village without electricity, new construction materials, water, etc. Application of engineering principles from core courses. Design conception, feasibility, production, and implementation within context of local cultures and needs. Emphasis on creating real solutions that can be implemented with the constraints imposed by cost, time, manufacturing capability, and culture.
Meets International Perspectives Requirement.

MAT E 391. Introduction to US Women's roles in Industry and Preparation for Summer Study.
(3-0) Cr. 3. S.
Introduction to the historical role of women as related to US industry, family and community with emphasis on the years 1830 - 1945, but also related to the current climate. Topics completed in 392 with arranged lectures at Brunel University. Orientation for Brunel summer study program. Offered on a satisfactory-fail basis only. Credit for graduation allowable only upon completion of Mat E 392.
Meets U.S. Diversity Requirement

MAT E 392. Principles of Materials Science and Engineering.
(3-0) Cr. 3. SS. *Prereq: MAT E 391, CHEM 167 or CHEM 177*
Structure and properties of ceramic, electronic, polymeric and metallic materials, emphasizing differences based on structure and bonding. Phase equilibria and phase transformations. Taught on Brunel University campus. Offered on a satisfactory-fail basis only. Only one of Mat E 215, 273, or 392 may count toward graduation.
Meets International Perspectives Requirement.

MAT E 396. Summer Internship.
Cr. R. Repeatable. SS. *Prereq: Permission of department and Engineering Career Services*
Summer professional work period.

MAT E 397. Engineering Internship.
Cr. R. Repeatable. F.S. *Prereq: Permission of department and Engineering Career Services; junior classification*
Professional work period, one semester maximum per academic year.

MAT E 398. Cooperative Education.
Cr. R. F.S.SS. *Prereq: MAT E 298, permission of department and Engineering Career Services*
Second professional work period in the cooperative education program. Students must register for this course before commencing work.

MAT E 413. Materials Design and Professional Practice I.
(2-2) Cr. 3. F. *Prereq: Senior status in Mat E*
Fundamentals of materials engineering design, information sources, team behavior, professional preparation, quantitative design including finite-element analysis and computer aided design, materials selection, informatics and combinatorial methods. Analysis of design problems, development of solutions, selected case studies. Oral presentation skills. Preparations for spring project.

MAT E 414. Materials Design and Professional Practice II.
(2-2) Cr. 3. S. *Prereq: Senior status in Mat E*
Integration of materials processing, structure/composition, properties and performance principles in materials engineering problems. Multi-scale design of materials, materials processing, case studies including cost analysis, ethics, risk and safety. Team projects specified by either industry or academic partners. Written and oral final project reports.

MAT E 418. Mechanical Behavior of Materials.
(3-0) Cr. 3. S. *Prereq: MAT E 216 and credit or enrollment in E M 324*
Mechanical behavior of ceramics, metals, polymers, and composites. Relationships between materials processing and atomic aspects of elasticity, plasticity, fracture, and fatigue. Life prediction, stress-and failure analysis. Nonmajor graduate credit.

MAT E 425. Glasses and Advanced Ceramics.
(2-3) Cr. 3. F. *Prereq: MAT E 321*
Composition, structure, properties and manufacturing of inorganic glasses. Properties and applications of advanced ceramics. Structural, thermal, optical, electronic, magnetic and biological applications of ceramic materials. Contemporary topics in ceramic engineering. Laboratory exercises in preparation and characterization of glasses and advanced ceramics. Nonmajor graduate credit.

MAT E 432. Microelectronics Fabrication Techniques.
(Dual-listed with MSE 532). (Cross-listed with E E). (2-4) Cr. 4. *Prereq: PHYS 222, MATH 267. E E 332 or MAT E 334 recommended*
Techniques used in modern integrated circuit fabrication, including diffusion, oxidation, ion implantation, lithography, evaporation, sputtering, chemical-vapor deposition, and etching. Process integration. Process evaluation and final device testing. Extensive laboratory exercises utilizing fabrication methods to build electronic devices. Use of computer simulation tools for predicting processing outcomes. Recent advances in processing CMOS ICs and micro-electro-mechanical systems (MEMS). Nonmajor graduate credit.

MAT E 433. Advanced Electronic Materials.
(2-3) Cr. 3. F. *Prereq: MAT E 334*
Advanced concepts in band theory of solids including chemical bonding in solids and the linear combination of atomic orbitals, phase transitions in electronic, magnetic, and optical materials. Dielectric materials, ferroelectricity, piezoelectricity, sensors, and non-stoichiometric conductors. Optical properties, optical spectra of materials, optoelectronic devices. Magnetic and superconducting materials. Nonmajor graduate credit.

MAT E 443. Physical Metallurgy of Ferrous Alloys.
(2-3) Cr. 3. F. *Prereq: 214, 216, credit or enrollment in 311*
Production and processing of ferrous metals. Extraction of pig iron from ore. Steelmaking processes. Equilibrium and nonequilibrium phases in the Fe-C system. Properties and processing of cast irons, plain carbon and alloy steels, stainless and specialty steels. Transformation diagrams, hardenability, and surface treatments. Continuous casting, forging, hot rolling, quenching, and tempering as they apply to ferrous materials. Cost and mechanical performance considerations in cast iron and steel selection and heat treatment. Nonmajor graduate credit.

MAT E 444. Corrosion and Failure Analysis.
(2-2) Cr. 3. S. *Prereq: MAT E 216 and credit or enrollment in MAT E 418*
Corrosion and corrosion control of metallic systems. Corrosion fundamentals, classification of different types of metallic corrosion, corrosion properties of various engineering alloys, corrosion control. Failure analysis. Characteristics of common types of metallic failures, case studies of failures, designing to reduce failure risk. Nonmajor graduate credit.

MAT E 453. Physical and Mechanical Properties of Polymers.
(Dual-listed with MAT E 553). (2-3) Cr. 3. F. *Prereq: MAT E 351*
Overview of polymer chemical composition, microstructure, thermal and mechanical properties, rheology, and principles of polymer materials selection. Intensive laboratory experiments include chemical composition studies, microstructural characterization, thermal analysis, and mechanical testing. Nonmajor graduate credit.

MAT E 454. Polymer Composites and Processing.
(Dual-listed with MAT E 554). (3-0) Cr. 3. S. *Prereq: MAT E 351*
Basic concepts in polymer composites, blends, and block copolymers. Phase separation and miscibility, microstructures and mechanical behavior. Fiber reinforced and laminated composites. Viscosity, rheology, viscoelasticity of polymers. Polymer melt processing methods such as injection molding and extrusion; selection of suitable processing methods and their applications. Nonmajor graduate credit.

MAT E 456. Biomaterials.
(Dual-listed with MAT E 556). (Cross-listed with BIOE). (3-0) Cr. 3. F. *Prereq: MAT E 216 or MAT E 273 or MAT E 392*
Presentation of the basic chemical and physical properties of biomaterials, including metals, ceramics, and polymers, as they are related to their manipulation by the engineer for incorporation into living systems. Role of microstructure properties in the choice of biomaterials and design of artificial organs, implants, and prostheses.

MAT E 457. Chemical and Physical Metallurgy of Rare Earth Metals.
(Dual-listed with MAT E 557). (3-0) Cr. 3. Alt. S., offered 2014. *Prereq: MAT E 311 or CHEM 325 AND CHEM 324 or PHYS 322*
Electronic configuration, valence states, minerals, ores, beneficiation, extraction, separation, metal preparation and purification. Crystal structures, phase transformations and polymorphism, and thermochemical properties of rare earth metals. Chemical properties: inorganic and organometallic compounds, alloy chemistry, nature of the chemical bonding. Physical properties: mechanical and elastic properties, magnetic properties, resistivity, and superconductivity.

MAT E 466. Multidisciplinary Engineering Design.
(Cross-listed with A E, AER E, CPR E, E E, ENGR, I E, M E). (1-4) Cr. 3. Repeatable. F.S. *Prereq: Student must be within two semesters of graduation and receive permission of the instructor*
Application of team design concepts to projects of a multidisciplinary nature. Concurrent treatment of design, manufacturing and life cycle considerations. Application of design tools such as CAD, CAM, and FEM. Design methodologies, project scheduling, cost estimating, quality control, manufacturing processes. Development of a prototype and appropriate documentation in the form of written reports, oral presentations, computer models and engineering drawings.

MAT E 467. Multidisciplinary Engineering Design II.
(Cross-listed with AER E, CPR E, E E, I E, ENGR, M E). (1-4) Cr. 3. Repeatable, maximum of 2 times. F.S. *Prereq: Student must be within two semesters of graduation or receive permission of instructor.*
Build and test of a conceptual design. Detail design, manufacturability, test criteria and procedures. Application of design tools such as CAD and CAM and manufacturing techniques such as rapid prototyping. Development and testing of a full-scale prototype with appropriate documentation in the form of design journals, written reports, oral presentations and computer models and engineering drawings.

MAT E 488. Eddy Current Nondestructive Evaluation.
(Dual-listed with MAT E 588). (Cross-listed with E E). (3-0) Cr. 3. Alt. F., offered 2013. *Prereq: MATH 265 and (MAT E 216 or MAT E 272 or E E 311 or PHYS 364)*
Electromagnetic fields of various eddy current probes. Probe field interaction with conductors, cracks and other material defects. Ferromagnetic materials. Layered conductors. Elementary inversion of probe signals to characterize defects. Special techniques including remote-field, transient, potential drop nondestructive evaluation and the use of Hall sensors. Practical assignments using a 'virtual' eddy current instrument will demonstrate key concepts.

MAT E 490. Independent Study.
Cr. arr. Repeatable.
Investigation of individual research or special topics.

MAT E 498. Cooperative Education.
Cr. R. Repeatable. F.S.SS. *Prereq: MAT E 398, permission of department and Engineering Career Services*
Third and subsequent professional work periods in the cooperative education program. Students must register for this course before commencing work.