

# MATERIALS ENGINEERING

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, structure, 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.

## 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.** Any transfer credit courses applied to the degree program require a grade of C or better (but will not be calculated into the ISU cumulative GPA, Basic Program GPA or Core GPA). See also **Basic Program and Special Programs.**

**International Perspectives: 3 cr.**<sup>1</sup>

**U.S. Diversity: 3 cr.**<sup>1</sup>

**Communication Proficiency/Library requirement:**

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

**General Education Electives: 15 cr.**

Complete 12 cr. from approved list with a maximum of 9 cr. of 100-level courses<sup>2</sup>. Also complete the one selected course (3 cr.) from the four choices shown above to complete your communication proficiency requirement (must have a grade of C or better in this course).

**Basic Program: 27 cr.**<sup>3</sup>

A minimum GPA of 2.00 required for this set of courses, including any transfer courses (please note that transfer course grades will not be calculated into the Basic Program GPA). See Requirement for Entry into Professional Program in College of Engineering Overview section.

CHEM 177	General Chemistry I	4
or CHEM 167	General Chemistry for Engineering Students	
ENGL 150	Critical Thinking and Communication	3
ENGL 250	Written, Oral, Visual, and Electronic Composition	3
ENGR 101	Engineering Orientation	R
ENGR 160	Engineering Problems with Computer Applications Laboratory <sup>3</sup>	3
LIB 160	Information Literacy	1
MATH 165	Calculus I	4
MATH 166	Calculus II	4
PHYS 221	Introduction to Classical Physics I	5
<b>Total Credits</b>		<b>27</b>

**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
<b>Total Credits</b>		<b>18</b>

**Materials/Specialties Engineering Core: 44 cr.**

A minimum GPA of 2.00 required for this set of courses, including any transfer courses (please note that transfer course grades will not be calculated into the Core/Specialization GPA):

MAT E 214	Structural Characterization of Materials	3
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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	3
MAT E 216L	Introduction to Materials Science and Engineering II - Lab	1
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 (12 cr.): ceramic, metallic and polymeric materials.		12
<b>Total Credits</b>		<b>44</b>

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	Glass Science and Engineering	3
MAT E 433	Advanced Electronic Materials	3

**Metallic Materials:**

MAT E 341	Metals Processing	3
MAT E 343	Physical Metallurgy of Ferrous Alloys	3
MAT E 442	Structure/Property Relations in Nonferrous Metals	3
MAT E 444	Corrosion and Failure Analysis	3

**Polymeric Materials:**

CHEM 331	Organic Chemistry I	3
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: 24 cr.**

E M 274	Engineering Statics	3
E M 324	Mechanics of Materials	3
Technical electives from list of materials courses <sup>2</sup>		6
Technical electives from approved departments <sup>2</sup>		9
Non-remedial course <sup>2</sup>		3
<b>Total Credits</b>		<b>24</b>

**Seminar/Co-op/Internships**

MAT E 401	Materials 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 ([http://www.mse.iastate.edu/files/2014/12/UG-HANDBK2014revised-12-5-14\\_web.pdf](http://www.mse.iastate.edu/files/2014/12/UG-HANDBK2014revised-12-5-14_web.pdf)).
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. (<http://catalog.iastate.edu/previouscatalogs/2016-2017/collegeofengineering/materialsengineering/#fouryearplante>)

Materials Engineering, B.S.

**First Year**

Fall	Credits	Spring	Credits
CHEM 177	4	CHEM 178	3
CHEM 177L	1	CHEM 178L	1
ENGL 150	3	MATH 166	4
ENGR 101	0	Gen Ed Elective	3
ENGR 160	3	Gen Ed Elective	3
MATH 165	4	US Diversity	3
LIB 160	1		
		<b>16</b>	<b>17</b>

**Second Year**

Fall	Credits	Spring	Credits
MATH 265	4	MATH 267	4
MAT E 215	3	MAT E 214	3
MAT E 215L	1	MAT E 216	3
PHYS 221	5	MAT E 216L	1
ENGL 250	3	PHYS 222	5
		<b>16</b>	<b>16</b>

**Third Year**

Fall	Credits	Spring	Credits
MAT E 311	3	MAT E 314	3
MAT E 317	3	MAT E 316	3
E M 274	3	E M 324	3
Materials Elective	3	Specialization	3
Specialization	3	Technical Elective	3
		International Perspective	3
		<b>15</b>	<b>18</b>

**Fourth Year**

Fall	Credits	Spring	Credits
MAT E 401	0	MAT E 414	3
MAT E 413	3	Specialization	3
MAT E 418	3	Technical Elective	3
Specialization	3	Technical Writing	3
Materials Elective	3	Free Elective	3

Technical Elective	3	
	<b>15</b>	<b>15</b>

**Total Credits: 128**

## Areas of specialization:

- Ceramic Materials: 321, 322, 425, 433
- Metallic Materials: 341, 343, 442, 444
- Polymeric Materials: Chem 331, 351, 453, 454

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 (<http://catalog.iastate.edu/previouscatalogs/2016-2017/collegeofengineering/materialsscienceandengineering>) for more information.

**Courses primarily for undergraduates:****MAT E 214: Structural Characterization of Materials**

(2-2) Cr. 3. F.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.S.

*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**

(0-2) Cr. 1. F.S.

*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**

(3-0) Cr. 3. F.S.

*Prereq: MAT E 215, Chem 178, 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.

**MAT E 216L: Introduction to Materials Science and Engineering II - Lab**

(0-2) Cr. 1. F.S.

*Prereq: Credit or enrollment in 216*

Materials Engineering majors only. Laboratory exercise in materials.

**MAT E 220: Global Sustainability**

(Cross-listed with ANTHR, ENV S, GLOBE, M E, SOC, T SC). (3-0) Cr. 3. F.S. An introduction to 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: CHEM 178, credit or enrollment in MAT E 216, PHYS 222, and MATH 267*

Basic laws of thermodynamics applied to phase equilibria, transformations, and reactions in multicomponent multiphase materials systems; Thermodynamic descriptions of heterogeneous systems; Binary and ternary phase diagrams; interfaces, surfaces, and defects.

**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.

**MAT E 316: Computational Methods in Materials**

(3-0) Cr. 3. S.SS.

*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.

**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.

**MAT E 322: Introduction to Ceramic Processing**

(2-3) Cr. 3. S.

*Prereq: MAT E 216, 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.

**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 317; 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.

**MAT E 334: Electronic & Magnetic Properties of Metallic Materials**

(3-0) 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.

**MAT E 341: Metals Processing**

(2-2) Cr. 3. F.

*Prereq: 215 or 273 or 392, Mat E majors only*

Theory and practice of metal processing, including casting; powder metallurgy; additive manufacturing; rolling; forging; extrusion; drawing; material removal; joining; surface modification; and heat treatment. Use of processing software.

**MAT E 343: Physical Metallurgy of Ferrous Alloys**

(3-0) Cr. 3. S.

*Prereq: 214, 215 or 273 or 392, 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.

**MAT E 348: Solidification Processes**

(Cross-listed with I E). (2-2) Cr. 3. S.

*Prereq: I E 248 and MAT E 273, or MAT E 215*

Theory and applications related to metal casting, welding, polymer processing, powder metallurgy, and composites manufacturing.

**MAT E 351: Introduction to Polymeric Materials**

(3-0) Cr. 3. S.

*Prereq: MAT E 216, CHEM 331*

Introduction to polymeric materials, synthesis, structure and properties. Relationship between polymer composition, processing and properties.

**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.

**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.

**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 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 394: Topics in Sustainable Engineering in Italy**

(3-0) Cr. 3. S.

*Prereq: Chem 167 or Chem 177*

Fundamentals of sustainable engineering related to biofuels. Basics of food and biofuel chemistry and fluid dynamics. Preparation course for Italy as a case study for food and sustainable engineering. Orientation for summer study abroad program in Torino, Italy. Credit for graduation allowable only upon completion of the following summer's offering of Mat E 316 taught in Italy, along with additional sustainability lessons/tours.

**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 401: Materials Engineering Professional Planning**

Cr. R. F.

*Prereq: Senior classification in materials engineering*

Preparation for a career in materials engineering or graduate school; experiential learning, resumes, interviewing, Myers-Briggs Type Indicator, leadership, international opportunities, professional ethics, graduate school preparation and opportunities, and alternative career paths (med school, law school, etc.). Offered on a satisfactory-fail basis only.

**MAT E 413: Materials Design and Professional Practice I**

(2-2) Cr. 3. F.S.

*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. F.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. F.

*Prereq: MAT E 216*

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.

**MAT E 425: Glass Science and Engineering**

(2-3) Cr. 3. F.

*Prereq: MAT E 216, MAT E 321*

Composition, structure, properties manufacturing, and applications of inorganic glasses. Mechanical, structural, thermal, optical, ionic, electronic, and biological applications of inorganic glasses, especially silicate glasses. Contemporary topics in glass science and engineering such as glass optical fiber communication and flat panel display technologies. Laboratory exercises in the preparation and characterization of silicate glasses. Nonmajor graduate credit.

**MAT E 432: Microelectronics Fabrication Techniques**

(Dual-listed with M S E 532). (Cross-listed with E E). (2-4) Cr. 4.

*Prereq: credit or enrollment in E E 332*

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).

**MAT E 433: Advanced Electronic Materials**

(2-3) Cr. 3. S.

*Prereq: MAT E 317*

Charged point defects and formation equations. Non-stoichiometric conductors, dielectric, ferroelectric, and piezoelectric materials and applications. Optical properties, optical spectra of materials, optoelectronic devices. Magnetic and superconducting materials. Contemporary topics in advanced ceramics.

**MAT E 442: Structure/Property Relations in Nonferrous Metals**

(3-0) Cr. 3. F.

*Prereq: MAT E 215 or 273 or 392*

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.



**MAT E 444: Corrosion and Failure Analysis**

(2-2) Cr. 3. S.

*Prereq: MAT E 215 or 273 or 392 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.

**MAT E 449: Structural Health Monitoring**

(Dual-listed with M S E 549). (Cross-listed with C E). (3-0) Cr. 3.

*Prereq: Senior classification in Engineering or permission of instructor*

Introductory and advanced topics in structural health monitoring (SHM) of aeronautical, civil, and mechanical systems. Topics include sensors, signal processing in time and frequency domains, data acquisition and transmission systems, design of integrated SHM solutions, nondestructive evaluation techniques, feature extraction methods, and cutting edge research in the field of SHM. Graduate students will have a supervisory role to assist students in 449 and an additional design project or more in-depth analysis and design.

**MAT E 453: Physical and Mechanical Properties of Polymers**

(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.

**MAT E 454: Polymer Composites and Processing**

(Dual-listed with M S 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.

**MAT E 456: Biomaterials**

(Dual-listed with M S E 556). (Cross-listed with B M E). (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 M S E 557). (3-0) Cr. 3. Alt. S., offered even-numbered years.

*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 B E, AER E, B M 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 permission of 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, ENGR, I E, M E). (1-4) Cr. 3.

Repeatable, maximum of 2 times. Alt. F., offered irregularly. Alt. S., offered irregularly.

*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 481: Computational Modeling of Materials**

(Dual-listed with M S E 581). (3-0) Cr. 3. F.

*Prereq: Math 265 and (MatE 311 or ChE 381 or Chem 325 or Phys 304)*

Introduction to the basic methods used in the computational modeling and simulation of materials, from atomistic simulations to methods at the mesoscale. Students will be expected to develop and run sample programs. Topics to be covered include, for example, electronic structure calculations, molecular dynamics, Monte Carlo, phase-field methods, etc.

**MAT E 488: Eddy Current Nondestructive Evaluation**

(Dual-listed with M S E 588). (Cross-listed with E E). (3-0) Cr. 3. Alt. F., offered odd-numbered years.

*Prereq: MATH 265 and (MAT E 216 or MAT E 273 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.