

MATERIALS ENGINEERING

For the undergraduate curriculum in materials engineering leading to the degree bachelor of science. The Materials Engineering program is accredited 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 have the opportunity to gain experience in materials engineering practice through cooperative work experience or internships in industry, national laboratories, or other funded research.

Graduates can develop a global perspective of engineering through various study abroad opportunities supported by the department. Classes provide 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.

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.¹

U.S. Diversity: 3 cr.¹

Communication Proficiency/Library requirement:

| | | |
|--|--|---|
| ENGL 150 | Critical Thinking and Communication (Must have a C or better in this course) | 3 |
| ENGL 250 | Written, Oral, Visual, and Electronic Composition (Must have a C or better in this course) | 3 |
| LIB 160 | Information Literacy | 1 |
| Complete one of the following courses (Must earn a grade of C or better) | | 3 |
| ENGL 302 | Business Communication | |
| ENGL 309 | Proposal and Report Writing | |
| ENGL 314 | Technical Communication | |

Advanced Communication Courses: 6 cr.

| | | |
|--|--|---|
| ENGL 250 | Written, Oral, Visual, and Electronic Composition (Must have a C or better in this course) | 3 |
| Complete one of the following courses (Must earn a grade of C or better) | | 3 |
| ENGL 314 | Technical Communication | |
| ENGL 309 | Proposal and Report Writing | |
| ENGL 302 | Business Communication | |

General Education Electives: 12 cr.

Complete 12 cr. from approved list with a minimum of 3 cr. from 200+ level courses and maximum of 9 cr from the same designator².

Basic Program: 24 cr.³

A minimum GPA of 2.00 is required for this set of 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 (Must have a C or better in this course) | 3 |
| ENGR 101 | Engineering Orientation | R |

| | | |
|----------------------|---|-----------|
| ENGR 160 | Engineering Problems with Computer Applications Laboratory ³ | 3 |
| LIB 160 | Information Literacy | 1 |
| MATH 165 | Calculus I | 4 |
| MATH 166 | Calculus II | 4 |
| PHYS 221 | Introduction to Classical Physics I | 5 |
| Total Credits | | 24 |

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: 44 cr.

A minimum average GPA of 2.00 is required for this set of courses.

(Please note that transfer course grades will not be calculated into the Core/Specialization GPA.)

| | | |
|------------|---|---|
| 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 | 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 317 | Introduction to Electronic Properties of Ceramic, Metallic, and Polymeric Materials | 3 |
| MAT E 319 | Mechanics of Structures and 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.

Total Credits **44**

The courses below meet the specialization requirement. Students select one of the following tracks (ceramics, metals, polymers):

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 Ceramics and Electronic Materials | 3 |

Metallic Materials:

| | | |
|-----------|---|---|
| MAT E 341 | Metals Processing | 3 |
| 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 350 | Polymers and Polymer Engineering. | 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.

| | | |
|---|------------------------|----|
| STAT 305 | Engineering Statistics | 3 |
| In-department electives from list of materials courses ² | | 6 |
| Technical electives from approved departments ² | | 12 |
| Non-remedial course ² | | 3 |

Total Credits **24**

Seminar/Co-op/Internships

Co-op and internships are optional

| | | |
|-----------|---|---|
| MAT E 301 | Materials Engineering Professional Planning | R |
|-----------|---|---|

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 (<https://www.mse.iastate.edu/files/2019/08/UG-HANDBK-2019-2020-revised-08-19-19.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/2020-2021/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 | R Gen Ed Elective | 3 |
| ENGR 160 | 3 Gen Ed Elective | 3 |
| MATH 165 | 4 US Diversity | 3 |
| LIB 160 | 1 | |
| | 16 | 17 |

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 |
| | 16 | 16 |

Third Year

| Fall | Credits Spring | Credits |
|--------------------|---------------------------|-----------|
| MAT E 311 | 3 MAT E 301 | R |
| MAT E 317 | 3 MAT E 314 | 3 |
| MAT E 319 | 3 STAT 305 | 3 |
| Specialization | 3 Specialization | 3 |
| Materials Elective | 3 Technical Elective | 3 |
| | International Perspective | 3 |
| | 15 | 15 |

Fourth Year

| Fall | Credits Spring | Credits |
|--------------------|----------------------|-----------|
| MAT E 413 | 3 MAT E 414 | 3 |
| MAT E 418 | 3 Specialization | 3 |
| Specialization | 3 Technical Elective | 3 |
| Materials Elective | 3 Technical Elective | 3 |
| Technical Elective | 3 Free Elective | 3 |
| Technical Writing | 3 | |
| | 18 | 15 |

Areas of specialization:

- Ceramic Materials: 321, 322, 425, 433
- Metallic Materials: 341, 342, 443, 444
- Polymeric Materials: 350, 351, 453, 454

Well qualified students in materials engineering who are interested in graduate study may apply for concurrent enrollment in the Graduate College. This allows senior-level students to simultaneously pursue both bachelor of science and master of science degrees. See Materials Science and Engineering (<http://catalog.iastate.edu/previouscatalogs/2020-2021/collegeofengineering/materialsscienceandengineering/>) for more information.

Courses primarily for undergraduates:

MAT E 101: Materials Science & Engineering Learning Community

Seminar

Cr. R. F.

Prereq: Enrollment in Materials Science Engineering Learning Community

Introduction to the Materials Science & Engineering Department and resources available to support student success. Offered on a satisfactory-fail basis only.

MAT E 214: Structural Characterization of Materials

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

Prereq: MAT E 215, 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)

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. Engineering applications. 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, MAT E 273 or MAT E 392; 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: Globalization and Sustainability

(Cross-listed with ANTHR, ENV S, GLOBE, 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.

Prereq: 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, 273, or 392 may count toward graduation

MAT E 301: Materials Engineering Professional Planning

Cr. R. S.

Prereq: Sophomore classification in materials engineering

Preparation for a career in industry or advanced study in graduate school; Lectures and guest speakers discuss various topics, including: experiential learning, resumes, interviewing, leadership, networking, professional ethics, and graduate school opportunities. Offered on a satisfactory-fail basis only.

MAT E 311: Thermodynamics in Materials Engineering

(3-0) Cr. 3. F.

Prereq: CHEM 178, MAT E 215 or MAT E 273, and credit or enrollment in MAT E 216 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 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 319: Mechanics of Structures and Materials

Cr. 3. S.

Prereq: PHYS 221, credit or enrollment in MATH 166

Fundamentals of engineering mechanics as applied to materials. Forces and moments; stresses in loaded bodies; elasticity and stress analysis including stress / strain relationships; failure of materials including the mechanics of creep, fracture, and fatigue. Only one of MAT E 319 or E M 324 may be used for graduation requirements.

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. Thermal, electronic, optical and magnetic properties of ceramics.

MAT E 322: Introduction to Ceramic Processing

(2-3) Cr. 3. S.

Prereq: MAT E 214, 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. Alt. S., offered odd-numbered years.

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: Mat E 214 and either MAT E 215, 273 or 392

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 342: Structure/Property Relations in Nonferrous Metals

(3-0) Cr. 3. S.

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 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, and related rapid manufacturing processes.

MAT E 350: Polymers and Polymer Engineering.

(3-0) Cr. 3. S.

Prereq: MAT E 216

Fundamental concepts of soft matter, including polymer, colloid and surfactant. Their physical and chemical properties, rheology and production methods. Applications of polymers in the chemical industry. Related topics in surface, diffusion and stability.

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.

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 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, Math 165, CHEM 167 or CHEM 177

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, 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

Professional work period of at least 10 weeks during the summer.

Students must register for this course prior to commencing work. Offered on a satisfactory-fail basis only.

MAT E 398: Cooperative Education (Co-op)

Cr. R. Repeatable. F.S.

Prereq: Permission of department and Engineering Career Services

Professional work period. One semester per academic or calendar year.

Students must register for this course before commencing work. Offered on a satisfactory-fail basis only.

MAT E 413: Materials Design and Professional Practice I

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

Prereq: Senior Classification: Mat E 413-414 sequence is intended for students in their final two semesters before graduation.

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 continued project in Mat E 414.

MAT E 414: Materials Design and Professional Practice II

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

Prereq: MAT E 413

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, MAT E 319

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 419: Magnetism and Magnetic Materials

(Dual-listed with M S E 519). (Cross-listed with E E). (3-0) Cr. 3. F.

Prereq: E E 311 or MAT E 317 or PHYS 364

Magnetic fields, flux density and magnetization. Magnetic materials, magnetic measurements. Magnetic properties of materials. Domains, domain walls, domain processes, magnetization curves and hysteresis. Types of magnetic order, magnetic phases and critical phenomena. Magnetic moments of electrons, theory of electron magnetism. Technological application, soft magnetic materials for electromagnets, hard magnetic materials, permanent magnets, magnetic recording technology, magnetic measurements of properties for materials evaluation.

MAT E 425: Glass Science and Engineering

(2-3) Cr. 3. F.

Prereq: MAT E 214, 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.

MAT E 432: Microelectronics Fabrication Techniques

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

Prereq: PHYS 222; Mat E majors: MAT E 317; CprE and EE majors: E E 230

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 Ceramics and Electronic Materials

(3-0) Cr. 3. S.

Prereq: MAT E 317, MAT E 321

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 437: Electronic Properties of Materials

(Dual-listed with M S E 537). (Cross-listed with E E). Cr. 3. S.

Prereq: E E 332 or MAT E 317 or PHYS 322

Review of classical and quantum mechanical descriptions of electrons in solids, band theory, metallic conduction, lattice vibrations, semiconductors, semiconductor devices, dielectrics, polarization, dielectric relaxation, crystal anisotropy, ferroelectricity, piezoelectricity, superconductivity, magnetism, device applications.

MAT E 443: Physical Metallurgy of Ferrous Alloys

(3-0) Cr. 3. F.

Prereq: credit or enrollment in 314

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 444: Corrosion and Failure Analysis

(2-2) Cr. 3. S.

Prereq: MAT E 214, 215 or 273 or 392

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 452: Scanning and Auger Electron Microscopy

(Dual-listed with M S E 552). (2-3) Cr. 3. F.

Prereq: PHYS 222

Characterization of materials using scanning electron microscope (SEM), electron microprobe, and auger spectrometer. Compositional determination using energy and wavelength dispersive x-ray and Auger spectroscopies. Specimen preparation. Laboratory covers SEM operation.

MAT E 453: Physical and Mechanical Properties of Polymers

(2-3) Cr. 3. F.

Prereq: MAT E 214, 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: CHEM 178 and 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

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; 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 and computer models and engineering drawings.

MAT E 467: Multidisciplinary Engineering Design II

(Cross-listed with AER 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. Alt. F., offered odd-numbered years.

Prereq: MATH 265 and MAT E 311 or CH E 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 MAT E 392 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 490C: Independent Study: Approved Student Submitted Proposal

Cr. arr. Repeatable. F.S.SS.

Prereq: permission of department

Independent study that is being proposed to be used toward graduation or minor requirements as a technical elective. This requires a proposal to the department's Curriculum Committee before the semester starts.

MAT E 490H: Independent Study: Senior Honors Project

Cr. arr. F.S.SS.

Prereq: permission of department

Independent study that is being proposed to be used for a Senior Honors Project (2 credits) and possibly for extra credits toward graduation or minor requirements. This requires a proposal to the department's Curriculum Committee before the semester starts.

MAT E 490R: Independent Study: Research

Cr. arr. Repeatable. F.S.SS.

Prereq: permission of department

Independent study that is being proposed to gain research experience. This requires a proposal to the department's Curriculum Committee before the semester starts. Credits can only be used by Mat E majors toward graduation as a free elective.