

# MATERIALS ENGINEERING (MAT E)

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*Any experimental courses offered by MAT E can be found at:*

registrar.iastate.edu/faculty-staff/courses/explistsings/ (<http://www.registrar.iastate.edu/faculty-staff/courses/explistsings/>)

**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 170: Numeric, Symbolic, and Graphical Methods for Materials Engineering**

Cr. 3. S.

*Prereq: ENGR 160*

Introduction to computer-based problem solving techniques including data analysis, data visualization, and materials simulation using spreadsheet, array, and symbolic methods that are necessary for materials science. Introduction to 3D CAD with consideration for additive manufacturing techniques.

## **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 232*

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 or MAT E 392, 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 232*

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 232 and PHYS 232L; 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 or MAT E 273 or MAT E 392*

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 232*

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.

*Prereq: Permission of instructor*

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 summer study abroad program. 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.S.

*Prereq: MAT E 216; Credit or enrollment in 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 232 and PHYS 232L; MAT E majors: MAT E 317; CPR E and E E 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*

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, biomedical applications of magnetism, magnetic evaluation of materials.

**MAT E 443: Physical Metallurgy of Ferrous Alloys**

(3-0) Cr. 3. F.

*Prereq: Credit or enrollment in MAT E 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 232*

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**

(Dual-listed with M S E 553). (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.

*Prereq: This course requires an approved proposal to the MSE Department's Undergraduate Curriculum Committee prior to the beginning of the semester.*

Investigation of individual research or special topics. Independent study that is being proposed to be used toward graduation or minor requirements.

**MAT E 490H: Independent Study: Senior Honors Project**

Cr. arr. F.S.SS.

*Prereq: This course requires an approved proposal to the College of Engineering Honors Committee.*

Independent study that is being proposed to be used for an honors project.

**MAT E 499: Undergraduate Research Opportunity**

Cr. R. Repeatable, maximum of 12 times. F.S.SS.

*Prereq: Permission of Instructor*

Independent study working in research lab with faculty member. Designed to allow students opportunity to gain experience that may assist them in obtaining future employment. Offered on a satisfactory-fail basis only. The course cannot be applied toward any graduation requirements.