

# MATERIALS ENGINEERING

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## Academic Program

Program name	Program type
Materials Engineering	BS

Materials engineering is a field in which engineers use their knowledge of the relationship between a material's structure and its properties to alter the material to get the performance needed. Materials engineers contribute their expertise in virtually all areas of technology: from the nano-sized materials found in biomedical and microelectronic applications to the large-scale composites found in aerospace applications.

Because engineered products are often limited by materials issues (such as performance and manufacturability), materials engineers play a vital role on engineering design teams, working closely with other engineers. As part of these teams, they apply their knowledge of science, engineering, and state-of-the-art analytical instruments.

The majority of our graduates find employment in the biomedical, electronic, aerospace and petroleum industries. Some work as consultants for large or small organizations. Others become executives. A significant number of materials engineers are involved in research and development. Some of our graduates are entrepreneurs who have started their own consulting or manufacturing companies. Others are attorneys or physicians. Because of our broad-based curriculum, our graduates are able to excel in professions of their choosing.

The curriculum in materials engineering emphasizes practical applications as well as principles. The laboratories are constantly evolving, and our students benefit from frequent exposure to a wide variety of materials testing and analysis equipment. The program is accredited by the Engineering Accreditation Commission ABET, <http://www.ABET.org>. Our students have a reputation for being immediately productive in industry, and they are also actively sought by graduate programs throughout the country.

### Vision

To collaboratively overcome the intertwined grand challenges of sustainability and transformative learning through our materials engineering program.

### Mission

To be a vibrant, creative and effectual learning community that cultivates the unique capabilities of each individual to thrive in a complex, interconnected and ever-changing world.

## Program Education Objectives

1. Holistically address complex challenges, drawing from materials engineering understanding and life experiences;
2. Live meaningful, socially-beneficial lives, enriched by their engineering education;
3. Exemplify proactive adaptive capacity throughout their lives; and
4. Communicate effectively in different contexts

## Undergraduate Program BS Materials Engineering

The Materials Engineering curriculum has received national recognition for its innovative structure and will provide both breadth and depth in your understanding of science and engineering principles and practices. The curriculum in materials engineering emphasizes practical applications as well as principles. The laboratories are constantly evolving, and our students benefit from frequent exposure to a wide variety of materials testing and analysis equipment. The program is accredited by the Engineering Accreditation Commission ABET, <http://www.ABET.org>. Our students have a reputation for being immediately productive in industry, and they are also actively sought by graduate programs throughout the country.

### MATE Courses

#### MATE 110. Introduction to Materials Engineering Design I. 1 unit

Term Typically Offered: F

Prerequisite: MATE majors only.

Laboratory work in teams to design, build and test a product. Material from math, science and engineering courses tied together. 1 laboratory.

#### MATE 120. Introduction to Materials Engineering Design II. 1 unit

Term Typically Offered: W

Prerequisite: MATE 110.

Second design laboratory, working in teams to design, build and test a complex system that benefits humanity. Focus on complete design process including project management, documentation in design, manufacturing techniques, and analysis of testing data. Issues of engineering ethics, technology and society, the environment and sustainability also studied. 1 laboratory.

#### MATE 130. Introduction to Materials Engineering Design III. 1 unit

Term Typically Offered: SP

Prerequisite: MATE 120.

Third design laboratory in a sequence. Includes working in teams on project that benefits humanity. Issues of engineering ethics, technology and society, the environment and sustainability. 1 laboratory.

#### MATE 200. Special Problems for Undergraduates. 1-4 units

Term Typically Offered: F,W,SP,SU

Prerequisite: Consent of department head.

Individual investigation, research, studies, or surveys of selected problems. Total credit limited to 8 units, with a maximum of 4 units per quarter.

**MATE 210. Materials Engineering. 3 units**

Term Typically Offered: F,W,SP,SU

Prerequisite: CHEM 111 or CHEM 124 or CHEM 127. Recommended:

Concurrent enrollment in MATE 215.

Structure of matter. Physical and mechanical properties of materials including metals, polymers, ceramics, composites, and electronic materials. Equilibrium diagrams. Heat treatments, materials selection and corrosion phenomena. 3 lectures.

**MATE 215. Materials Laboratory I. 1 unit**

Term Typically Offered: F,W,SP,SU

Prerequisite or concurrent: MATE 210.

Focus on processing-structure-properties relationships of materials, including crystal structures, electronic properties of materials, materials selection, phase diagrams, corrosion, mechanical properties of polymers, cold work and annealing of alloys and heat treatments of steels. 1 laboratory.

**MATE 222. Materials Selection Life Cycle. 4 units**

Term Typically Offered: W, SP

Prerequisite: MATE 210.

Materials selection for sustainable product design. Use of material selection software and techniques to solve design problems with multiple objectives and constraints. Focus on Triple Bottom Line design including functionality, economic viability, and sustainability. Principles and tools for weighted property optimization, production cost modeling, and life cycle analysis introduced through project-based learning mode. 4 lectures.

**MATE 225. Materials Laboratory II. 1 unit**

Term Typically Offered: F, W

Prerequisite: MATE 215. Concurrent: MATE 232.

Process-structure relationships of materials. Introduction to materials characterization techniques including differential scanning calorimetry, x-ray diffraction, and metallography. Emphasis on materials engineering professional practices and written communication. 1 laboratory.

**MATE 232. Materials, Ethics, and Society. 4 units**

Term Typically Offered: F, W

Prerequisite: MATE 210.

Materials Engineering principles through the context of historical and current events. Ethics and systems thinking are integrated in the study of the impacts of materials and technology on society during the Stone Age, Bronze Age, and Iron Ages, as well as today's world. Topics include crystallography, phase diagrams, microstructures, processing techniques, and nanotechnology. 4 lectures.

**MATE 235. Materials Laboratory III. 1 unit**

Term Typically Offered: W, SP

Prerequisite: MATE 225.

Mechanical property testing by tensile tests and hardness tests. Emphasis of data interpretation and analysis with structure-property relationships of materials. Continued materials engineering professional practices. 1 laboratory.

**MATE 270. Selected Topics. 1-4 units**

Term Typically Offered: TBD

Prerequisite: Open to undergraduate students and consent of instructor.

Directed group study of selected topics. The Schedule of Classes will list title selected. Total credit limited to 8 units. 1 to 4 lectures.

**MATE 310. Noncrystalline Material Systems. 4 units**

Term Typically Offered: SP

Prerequisite: MATE 210, MATE 340, STAT 312. Concurrent: MATE 350.

Design and synthesis of noncrystalline material systems. Synthesis, processing techniques, properties and fabrication methods of organic and inorganic polymeric materials. 3 lectures, 1 laboratory.

**MATE 325. Transport Phenomena I. 1 unit**

Term Typically Offered: F

Prerequisite: PHYS 132 and MATH 141.

Directed group laboratory study of energy transport. Focus on conduction and convection. 1 laboratory.

**MATE 326. Transport Phenomena II. 1 unit**

Term Typically Offered: W

Prerequisite: MATH 141 and ME 211.

Directed group laboratory study of fluid static and dynamic properties and behavior. Focus on non-compressible conditions. 1 laboratory.

**MATE 327. Transport Phenomena III. 1 unit**

Term Typically Offered: SP

Prerequisite: CHEM 124 and PHYS 133.

Introduction to radiative heat transfer and the material properties that control it. 1 laboratory.

**MATE 330. Composite Materials Systems. 4 units**

Term Typically Offered: F

Prerequisite: MATE 350.

Properties, design and applications of composite material systems, concentrating on polymer-matrix, ceramic-fiber composites. Materials (matrices, fibers), mechanical behavior and properties, and manufacturing methods treated in detail. Laboratory practice concentrates on the mechanical testing of fiber-reinforced composite materials. 3 lectures, 1 laboratory.

**MATE 340. Electronic Materials Systems. 4 units**

Term Typically Offered: F, W

Prerequisite: MATE 210 and PHYS 133.

Design of electronic materials systems utilizing the basic concepts in electron theory of solids, electrical properties and conduction in materials, magnetic phenomena and optical properties in materials. 3 lectures, 1 laboratory.

**MATE 350. Structural Materials Systems. 4 units**

Term Typically Offered: SP

Prerequisite: MATE 360. Corequisite: CE 204. Concurrent: MATE 310.

Design of structural materials systems. Topics include stress, strain, elasticity, anelasticity, plasticity, fracture and fatigue. 3 lectures, 1 laboratory.

**MATE 359. Living in a Material World. 4 units**

GE Area F

Term Typically Offered: F,W,SP,SU

Prerequisite: Junior standing and completion of one course from GE Area B.

Evolution of materials (ceramics, metals, polymers, composites, semiconductors) in the context of history. Traces the link between historical and technological developments enabled by materials from the Stone Age to the Electronic Age. 4 lectures. Crosslisted as HIST/MATE 359. Fulfills GE Area F.

**MATE 360. Metallurgical Materials Systems. 4 units**

Term Typically Offered: F, SP

Prerequisite: MATE 232 and MATE 235.

Physical metallurgy of engineering alloys including ferrous (steel) and nonferrous (aluminum, copper) systems. Connection to phase diagrams, microstructural development and phase transformations, physical and mechanical properties, precipitation hardening, cold work and annealing treated in detail. Laboratory focuses on microstructure development in steels and aluminum alloy casting. 3 lectures, 1 laboratory.

**MATE 370. Kinetics of Materials and Process Design. 4 units**

Term Typically Offered: F, W

Prerequisite: MATE 360 and MATE 380.

Design of processes for engineering materials. Topics include kinetics in materials: solid-state diffusion (steady-state and non-steady-state), nucleation and growth kinetics, solid state phase transformations. 3 lectures, 1 laboratory.

**MATE 380. Thermodynamics and Physical Chemistry. 4 units**

Term Typically Offered: F, W

Prerequisite: CHEM 125, PHYS 133, MATH 143, MATE 210 and MATE 215; Materials Engineering students only.

Thermodynamics concepts related to materials engineering systems and processes: process flowsheets, mass and energy balances, Ellingham diagrams. Physical chemistry concepts related to materials engineering: ideal gases, systems and surroundings, first through third laws of thermodynamics, phase equilibria, chemical reactions. 4 lectures.

**MATE 400. Special Problems for Advanced Undergraduates. 1-4 units**

Term Typically Offered: F,W,SP,SU

Prerequisite: Consent of department head.

Individual investigation, research, studies, or surveys of selected problems. Total credit limited to 8 units, with a maximum of 4 units per quarter.

**MATE 401. Materials Characterization Techniques. 4 units**

Term Typically Offered: F, W

Prerequisite: MATE 210 and MATE 215.

Hands-on experience with materials characterization instruments, such as scanning electron microscopy (SEM), light optical microscopy, x-ray diffraction (XRD), and atomic force microscopy (AFM). Open-ended projects to develop expertise with trouble-shooting ability, and the process of materials characterization and analysis 2 lectures, 2 laboratories.

**MATE 410. Nanoscale Engineering. 3 units**

Term Typically Offered: F, W, SP

Prerequisite: CHEM 125, PHYS 133 and MATE 210.

Material properties (mechanics, electronics, heat transfer, photonics, fluid mechanics and biomechanics) at the nanometer scale. Evaluation of nano-scale systems designed from a bottoms-up approach with unique properties. Exploration of integration of biology, chemistry, physics and engineering. 3 lectures.

**MATE 420. Biopolymers and Bionanocomposites. 4 units**

Term Typically Offered: W, SP

Prerequisite: MATE 310 or CHEM 444.

Exploration of the synthesis, processing, properties, and performance of biologically derived polymers. Examination of nano-scale reinforcements and their use to enhance performance of biopolymers. Emphasis on reading and interpreting contemporary scientific literature. 4 lectures.

**MATE 425. Corrosion Engineering. 4 units**

Term Typically Offered: F, W, SP

Prerequisite: CHEM 125 or CHEM 128, MATE 210, MATE 215.

Forms of corrosion. Influences of environmental variables on corrosion. Methods of corrosion control. 3 lectures, 1 laboratory.

**MATE 430. Micro/Nano Fabrication. 3 units**

Term Typically Offered: W

Prerequisite: BMED 212 or MATE 210.

Fabrication science and technology for creating micro and nano scale devices. Explore basic processes such as oxidation, diffusion, ion implantation, etching, chemical and physical vapor deposition, photolithography. Develop an understanding of the science of each process and how to select the right steps for fabricating electronic, photon and micro-electro-mechanical systems devices. 3 lectures. Crosslisted as BMED 434/EE 423/MATE 430.

**MATE 435. Microfabrication Laboratory. 1 unit**

Term Typically Offered: W

Corequisite: BMED 434/EE 423/MATE 430.

Application of basic processes involved in microfabrication: cleanroom protocol, oxidation, diffusion, photolithography etching and sputtering. Explore process development through fabrication of electronic, photonic or microfluidic devices. Each student will be part of a team that will fabricate and test a device. 1 laboratory. Crosslisted as BMED/MATE 435.

**MATE 440. Welding Metallurgy and Joining of Advanced Materials. 3 units**

Term Typically Offered: W, SP

Prerequisite: MATE 210.

Principles, primary variables, and microstructural changes associated with the joining process. Physics of energy transfer. Heat and mass balances in joining, thermodynamic and kinetic justification of solidification and near interface microstructures. Heterogeneous interfaces, adhesion, wetting. Relation between process selection, interface design, microstructure, and properties, weldability. 3 lectures.

**MATE 445. Joining of Advanced Materials Laboratory. 2 units**

Term Typically Offered: W, SP

Prerequisite: MATE 210. Corequisite: MATE 440.

Laboratory to accompany MATE 440. Illustration of principles, primary variables, and microstructural changes associated with the joining process. Physics of energy transfer. Heat and mass balances in joining, thermodynamic and kinetic justification of solidification and near interface micro-structures. Heterogeneous interfaces, adhesion, wetting. Relation between process selection, interface design, microstructure, and properties, weldability. 2 laboratories.

**MATE 446. Surface Chemistry of Materials. 3 units**

Term Typically Offered: SP

Prerequisite: CHEM 125 or CHEM 128; CHEM 351, MATE 380, or ME 302.

Surface energy. Capillarity, solid and liquid interface, adsorption. Surface areas of solids. Contact angles and wetting. Friction, lubrication and adhesion. Relationship of surface to bulk properties of materials. Applications. 3 lectures. Crosslisted as CHEM/MATE 446.

**MATE 450. Fracture and Failure Analysis. 4 units**

Term Typically Offered: F, W, SP

Prerequisite: MATE 210, MATE 215, MATE 350; and Senior standing.

Fracture processes and fracture mechanics of structural materials concentrating on engineering alloys. Topics include fracture of alloys, fracture mechanics (Griffith analysis, Linear Elastic Fracture Mechanics), and fatigue. Laboratory focuses on fracture surface analysis, failure analysis, and mechanical testing. 3 lectures, 1 laboratory.

**MATE 458. Microelectronics and Electronics Packaging. 4 units**

Term Typically Offered: F, W, SP

Prerequisite: EE 112 or EE 201. Recommended: MATE 210.

Materials, processes, and reliability of microelectronics and electronics packaging, surface mount assembly and printed circuit board fabrication. Organic substrates and ceramic substrates. Mechanical design, thermal, and electrical considerations in electronic packaging. Design for manufacturability. Overview of optoelectronics packaging and other emerging technologies in microelectronics and electronic packaging. Project on design and manufacture of an electronic device. 3 lectures, 1 laboratory. Crosslisted as CPE 488/IME 458/MATE 458.

**MATE 460. Materials Selection in Mechanical Design. 4 units**

Term Typically Offered: F, W, SP

Prerequisite: MATE 350.

Materials-based approach to mechanical design. Using mechanical and physical properties of materials (performance indices) to select structural materials for applications (Materials Selection Charts). Detailed background of material properties - information from materials and mechanics. Numerous case studies highlight the concepts covered. 4 lectures.

**MATE 470. Selected Advanced Topics. 1-4 units**

Term Typically Offered: TBD

Prerequisite: Consent of instructor.

Directed group study of selected topics for advanced students. Open to undergraduate and graduate students. The Schedule of Classes will list title selected. Total credit limited to 8 units. 1 to 4 lectures.

**MATE 471. Selected Advanced Laboratory. 1-4 units**

Term Typically Offered: TBD

Prerequisite: Consent of instructor.

Directed group laboratory study of selected topics for advanced students. Open to undergraduate and graduate students. The Schedule of Classes will list title selected. Total credit limited to 8 units. 1 to 4 laboratories.

**MATE 482. Senior Project I. 1 unit**

Term Typically Offered: F

Prerequisite: IME 144; senior standing; and Materials Engineering major.

Foundations of senior project design. Completion of the preliminary stages of selecting a senior project, designing experiments, evaluating realistic constraints, conducting initial experiments, and managing a project timeline. 1 laboratory.

**MATE 483. Senior Project II. 2 units**

Term Typically Offered: W

Prerequisite: MATE 482.

Continuation of senior project. Completion of a senior project experimental component under the guidance of a faculty supervisor. Research methodology, experimental design, experimental work and data analysis. 2 laboratories.

**MATE 484. Senior Project III. 2 units**

Term Typically Offered: SP

Prerequisite: MATE 483.

Continuation of MATE 483. Completion of a senior project data analysis and communication under the guidance of a faculty supervisor. Mathematical modeling and technical communication. 2 laboratories.

**MATE 495. Cooperative Education Experience. 12 units**

CR/NC

Term Typically Offered: F,W,SP,SU

Prerequisite: Sophomore standing and consent of instructor.

Full-time work experience in business, industry, government, and other areas of student career interest. Positions are paid and usually require relocation and registration in course for two consecutive quarters. A more fully developed formal report and evaluation by work supervisor required. Credit/No Credit grading only. No major credit allowed; total credit limited to 24 units.

**MATE 500. Individual Study. 1-4 units**

Term Typically Offered: F,W,SP,SU

Prerequisite: Consent of department head, graduate advisor, or supervising faculty member.

Advanced study planned and completed under the direction of a member of department faculty. Open only to graduate students who have demonstrated ability to do independent work. Enrollment by petition. Total credit limited to 12 units.

**MATE 510. Materials Analysis. 4 units**

Term Typically Offered: F, W, SP

Prerequisite: MATE 210 and graduate standing. Recommended: MATE 401.

Fundamentals of materials characterization methods and thin-film microanalytical techniques, including optical techniques, electron microscopy, X-ray techniques, and ion beam techniques. Selection of surface analysis techniques. 4 lectures.

**MATE 522. Advanced Ceramics. 4 units**

Term Typically Offered: F, W, SP

Prerequisite: MATE 210 and graduate standing.

Development, utilization, and control of properties in ceramic materials (inorganic-nonmetallic solids). Emphasis on application on processing to achieve structure and properties. Structure of crystalline ceramics and of glasses. Mechanical, thermal, optical, magnetic, and electrical properties. Application of ceramics in technology. Physical chemistry of ceramics. 4 lectures.

**MATE 530. Biomaterials. 4 units**

Term Typically Offered: F, W

Prerequisite: BIO 161, or BIO 213 and BMED/BRAE 213; MATE 210 and graduate standing or consent of instructor.

Structure-function relationships for materials in contact with biological systems. Interactions of materials implanted in the body. Histological and hematological considerations including foreign body responses, inflammation, carcinogenicity, thrombosis, hemolysis, immunogenic and toxic properties. Microbial interaction with material surfaces, degradation. 4 lectures. Crosslisted as BMED/MATE 530.

**MATE 550. Micro Systems. 4 units**

Term Typically Offered: F, W, SP

Prerequisite: Graduate standing.

Fundamentals of intelligent systems employing sensors, actuators and intelligent controls. Impact on material properties as devices shrink in the micrometer realm. Applications toward exploring nanotechnology. 4 lectures.

**MATE 570. Selected Advanced Topics. 1-4 units**

Term Typically Offered: TBD

Prerequisite: Graduate standing or consent of instructor.

Directed group study of selected topics for graduate students. Open to undergraduate and graduate students. The Schedule of Classes will list title selected. Total credit limited to 8 units. 1-4 lectures.

**MATE 571. Selected Advanced Laboratory. 1-4 units**

Term Typically Offered: TBD

Prerequisite: Senior or graduate standing or consent of instructor.

Directed group laboratory study of selected topics for advanced students. The Schedule of Classes will list title selected. Total credit limited to 8 units. 1-4 laboratories.

**MATE 590. Solidification and Densification. 4 units**

Term Typically Offered: F, W, SP

Prerequisite: MATE 210 and graduate standing.

Thermodynamics, kinetics and morphologies of solid-liquid interfaces. Heat flow in castings, crystal growth. Solidification mechanics, solute redistribution. Production, characterization and testing of metal powders. Compacting of powder. Sintering with/without liquid phase. Hot pressing, properties of sinterings as a function of processing conditions. Application of theory to the production of useful materials. 4 lectures.

**MATE 599. Design Project (Thesis). 2-5 units**

Term Typically Offered: F,W,SP,SU

Prerequisite: Graduate standing.

Each individual or group will be assigned a project for solution under faculty supervision as a requirement for the master's degree, culminating in a written report/thesis.