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 atomic or molecular 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 companies. Others are attorneys or physicians. Because of our broad-based, student focused curriculum, our graduates are able to excel in professions of their choosing.

Vision

To collaboratively address the grand challenges of our time, especially 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 member of our community to thrive in a complex, interconnected, technological 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
Sustainability Related
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
Sustainability Related
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: TBD
Sustainability Related
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. Course may be offered in classroom-based or online format. 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: TBD
Sustainability Focused
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
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
Sustainability Focused
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
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 245. Materials Engineering Analysis. 1 unit
Term Typically Offered: SP
Prerequisite: MATE 210 and MATE 235.

Introduction to quantitative and qualitative materials analysis methods and tools. Experimental design, data distributions, hypothesis testing, and regression fits. Sensor design and calibration. Qualitative and quantitative image analysis. Emphasis placed on real-world examples of materials engineering data. Not open to students with credit in MATE 130. 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 Class Schedule will list topic selected. Total credit limited to 8 units. 1 to 4 lectures.

MATE 280. Introduction to Materials Thermodynamics. 4 units
Term Typically Offered: W
Prerequisite: CHEM 125, PHYS 133, MATH 143, MATE 210 and MATE 215.

Thermodynamics concepts related to materials systems and processes: systems and surroundings, laws of thermodynamics, process flowsheets, mass and energy balances, ideal gasses, chemical reactions, steady state and transient processes. Not open to students with credit in MATE 380. 4 lectures.

MATE 300. Materials Selection for the Life Cycle. 4 units
Term Typically Offered: SP
GWR
Sustainability Related
Prerequisite: Junior standing and MATE 210.

Materials selection for sustainable product design. Use of material selection software and techniques to solve design optimization problems. Focus on Triple Bottom Line design including functionality, economic viability, and sustainability. Not open to students with credit in MATE 222. 4 lectures. Fulfills GWR.

MATE 310. Noncrystalline Material Systems. 4 units
Term Typically Offered: W
Prerequisite: MATE 210; MATE 340.

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 340. Electronic Materials Systems. 4 units
Term Typically Offered: F
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: W
Prerequisite: MATE 210. Corequisite: CE 204.

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
Term Typically Offered: F,W,SP,SU
2020-21 or later: Upper-Div GE Area B
2019-20 or earlier catalog: GE Area B5, B6, or B7
Sustainability Related
Prerequisite: Junior standing; completion of GE Area A with grades of C- or better; and one course in GE Area B4 with a grade of C- or better (GE Area B1 for students on the 2019-20 or earlier catalogs). Recommended: CHEM 124 or CHEM 127.

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. Fulfills GE Area Upper-Division B (GE Areas B5, B6, or B7 for students on the 2019-20 catalog).

MATE 360. Metallurgical Materials Systems. 4 units
Term Typically Offered: SP
Prerequisite: 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
Prerequisite: MATE 280 or 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: SP
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 390. Textile and Fiber Engineering. 4 units
Term Typically Offered: W
Prerequisite: Junior standing; MATE 210 and MATE 310.

Structure, properties and engineering applications of fibers and textiles. Investigation of natural and synthetic fibers and use in technical applications. Methods of fiber formation. Chemical functionalization. High performance fibers, wearable electronics, composites, geotextiles, medical devices and apparel. 3 lectures, 1 laboratory.

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, SP
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 402. Materials Characterization Theory. 4 units
Term Typically Offered: F, W, SP
Prerequisite: MATE 210. 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. Formerly MATE 510.

MATE 403. Computational Materials Analysis. 4 units
Term Typically Offered: SP
Prerequisite: CSC 231, ME 211, MATE 280.

Theory and practice of continuum-scale computational methods applied to engineering materials. Finite element modeling to predict mechanical, thermal, and damage behavior. Micro-structural development and heat treatments modeled using thermodynamic principles. Micro-scale materials modeling of plasticity and phase transformations. 4 lectures.

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: F, W, SP
Prerequisite: MATE 310 or CHEM 444 or CHEM 544.

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 422. Ceramics and Glasses. 4 units
Term Typically Offered: F, W, SP
Prerequisite: MATE 210.

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. Formerly MATE 522.

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 435/EE 473/MATE 435.

MATE 440. Welding Metallurgy and Joining of Advanced Materials. 3 units
Term Typically Offered: F, 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: F, 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; and MATE 350.

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 456. Materials for Electrochemical Energy Storage. 4 units
Term Typically Offered: F, W, SP
Prerequisite: MATE 210.

Exploration of electrochemical energy storage such as batteries, supercapacitors and hybrid systems. Fundamental principles with emphasis on electrochemistry of rechargeable batteries and supercapacitors. Advanced materials design, nanotechnology, testing techniques, safety issues and battery systems applications. 4 lectures.

MATE 458. Microelectronics and Electronics Packaging. 4 units
Term Typically Offered: F
Prerequisite: EE 112 or EE 113 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: TBD
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 465. Ferrous Metallurgy. 4 units
Term Typically Offered: F, W, SP
Prerequisite: MATE 360.

Physical metallurgy principles applied to iron-based systems for steel making and thermo-mechanical processing. Mechanical properties related to microstructure of steel materials and their manipulation through chemical and physical processing. Exploration of major categories of steel, applications, surface treatment and welding. 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 Class Schedule will list topic 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 Class Schedule will list topic selected. Total credit limited to 8 units. 1 to 4 laboratories.

MATE 480. 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. Formerly MATE 330.

MATE 482. Senior Project I. 1 unit
Term Typically Offered: F
Prerequisite: 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 485. Materials and the Environment. 4 units
Term Typically Offered: F, W, SP
Sustainability Focused
Prerequisite: MATE 210.

Materials impacts on air, water, land, and human health. Introduction to climate change. Life cycle assessment for quantifying environmental impact. Green materials. Overview of renewable energy technologies. Non-technical aspects of environmental technologies. Field trip required. 4 lectures.

MATE 490. Solidification and Densification. 4 units
Term Typically Offered: F, W, SP
Prerequisite: MATE 210.

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. Formerly MATE 590.

MATE 495. Cooperative Education Experience. 12 units
Term Typically Offered: F,W,SP,SU
CR/NC
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 530. Biomaterials. 4 units
Term Typically Offered: 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. Course may be offered in classroom-based or online format. 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 Class Schedule will list topic selected. Total credit limited to 8 units. 1 to 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 Class Schedule will list topic selected. Total credit limited to 8 units. 1 to 4 laboratories.

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.