MATERIALS ENGINEERING (MATE)

Courses primarily for undergraduates:

MATE 1010: Materials Science & Engineering Learning Community Seminar
Credits: Required. Contact Hours: Lecture 1.
Introduction to the Materials Science & Engineering Department and resources available to support student success. Offered on a satisfactory-fail basis only. (Typically Offered: Fall)

MATE 1700: Numeric, Symbolic, and Graphical Methods for Materials Engineering
Credits: 3.
Prereq: ENGR 1600
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. (Typically Offered: Spring)

MATE 2140: Structural Characterization of Materials
Credits: 3. Contact Hours: Lecture 2, Laboratory 2.
*Prereq: (*MATE 2150 *or* MATE 2730 *or* MATE 3920*);* PHYS 2310
Structural characterization of materials. Techniques include optical and electron microscopy, x-ray diffraction, and thermal analysis. Identification of materials type, microstructure, and crystal structure. (Typically Offered: Fall, Spring)

MATE 2150: Introduction to Materials Science and Engineering I
Credits: 3. Contact Hours: Lecture 3.
*Prereq: (*CHEM 1670 *or* CHEM 1770*);* MATH 1650
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. Graduation Restriction: Only one of MATE 2150, MATE 2730, or MATE 3920 may count toward graduation. (Typically Offered: Fall, Spring)

MATE 2150L: Introduction to Materials Science and Engineering I - Lab
Credits: 1. Contact Hours: Laboratory 2.
Prereq: Credit or enrollment in MATE 2150 *or* MATE 2730 *or* MATE 3920
Materials Engineering majors only. Laboratory exercise in materials. (Typically Offered: Fall, Spring)

MATE 2160: Introduction to Materials Science and Engineering II
Credits: 3. Contact Hours: Lecture 3.
Prereq: MATE 2150*,* MATE 2730 *or* MATE 3920*; credit or enrollment in* PHYS 2320
Materials Engineering majors only. Fundamentals of ceramic, polymeric, and composite materials; electronic, thermal, magnetic, and optical properties of materials. Materials for energy, biomaterials, and nanomaterials. (Typically Offered: Fall, Spring)

MATE 2160L: Introduction to Materials Science and Engineering II - Lab
Credits: 1. Contact Hours: Laboratory 2.
Prereq: Credit or enrollment in MATE 2160
Materials Engineering majors only. Laboratory exercise in materials. (Typically Offered: Fall, Spring)

MATE 2200: Globalization and Sustainability
(Cross-listed with ANTHR 2200/ ENVS 2200/ GLOBE 2200/ ME 2200/ SOC 2200).
Credits: 3. Contact Hours: Lecture 3.
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. Graduation Restriction: Cannot be used for technical elective credit in any engineering department. Meets International Perspectives Requirement. (Typically Offered: Fall, Spring)

MATE 2730: Principles of Materials Science and Engineering
Credits: 3. Contact Hours: Lecture 3.
*Prereq: (*CHEM 1670 *or* CHEM 1770*);* MATH 1650
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. Graduation Restriction: Only one of MATE 2150, MATE 2730, or MATE 3920 may count toward graduation. (Typically Offered: Fall, Spring)

MATE 3010: Materials Engineering Professional Planning
Credits: Required. Contact Hours: Lecture 1.
Prereq: Sophomore classification and MATE majors only
Preparation for a career in industry or advanced study in graduate school. Lectures and guest speakers discuss various topics, including: strategies to achieve academic and technical success; strategies for effective communication and teamwork; professional ethics, safety, and standards; entrepreneurial/intrapreneurial skills; resumes and interviewing; leadership and networking; and career pathways and graduate school opportunities. Offered on a satisfactory-fail basis only. Offered on a satisfactory-fail basis only. (Typically Offered: Spring)

MATE 3110: Thermodynamics in Materials Engineering
Credits: 3. Contact Hours: Lecture 3.
Prereq: CHEM 1780*;* MATE 2150 *or* MATE 2730 *or* MATE 3920*; and credit or enrollment in* MATE 2160 *and* MATH 2670
Basic laws of thermodynamics applied to phase stability, phase equilibria, transformations, and reactions in materials. Concepts of heat, work, energy, and entropy. Reversible and irreversible processes. Ideal and non-ideal behavior in single-component and multi-component systems. Interpretation of unary, binary, and ternary phase diagrams. Methods for experimental measurement and computational modeling. Applications in materials design. (Typically Offered: Fall)

MATE 3140: Kinetics and Phase Equilibria in Materials
Credits: 3. Contact Hours: Lecture 3.
Prereq: MATE 2140*;* MATE 2160*;* MATE 3110
The energetics and kinetics of transformations in materials. Quantitative descriptions of materials state, stability, and time-dependent evolution of constitution and microstructure. Relationships between phenomenology, driving forces, mechanisms, and kinetics as tools for controlling material state and associated properties. Fundamental concepts of thermodynamics, diffusional transport, interfaces, and other heterogeneities - applied to various types of diffusional and diffusionless transformations in materials state. Methods for experimental measurement and computational modeling. Applications in process design. (Typically Offered: Spring)

MATE 3170: Introduction to Electronic Properties of Materials
Credits: 3. Contact Hours: Lecture 3.
Prereq: MATE 2160*;* PHYS 2320
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. (Typically Offered: Fall)

MATE 3190: Mechanics of Structures and Materials
Credits: 3. Contact Hours: Lecture 3.
Prereq: PHYS 2310*; credit or concurrent enrollment in* MATH 1660
Fundamentals of engineering mechanics as applied to materials. Forces and moments; stresses in loaded bodies; elasticity and stress analysis including stress / strain relationships. Graduation Restriction: Only one of MATE 3190 or EM 3240 may be used for graduation requirements. (Typically Offered: Spring)

MATE 3210: Introduction to Ceramic Science
Credits: 3. Contact Hours: Lecture 3.
Prereq: MATE 2160
Ceramic crystal structures, defects, diffusion and transport. Phase equilibria and microstructures. Thermal, electronic, optical and magnetic properties of ceramics. (Typically Offered: Fall)

MATE 3220: Introduction to Ceramic Processing
Credits: 3. Contact Hours: Lecture 2, Laboratory 3.
Prereq: MATE 3210
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. (Typically Offered: Spring)

MATE 3320: Semiconductor Materials and Devices
(Cross-listed with EE 3320).
Credits: 3. Contact Hours: Lecture 3.
Prereq: CPRE and EE majors; EE 2300 *OR MATE majors and* MATE 3170
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. (Typically Offered: Spring)

MATE 3340: Electronic & Magnetic Properties of Metallic Materials
Credits: 3. Contact Hours: Lecture 3.
Prereq: MATE 3170
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. Additiol 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. Offered odd-numbered years. (Typically Offered: Spring)

MATE 3410: Metals Processing
Credits: 3. Contact Hours: Lecture 3.
Prereq: MATE 2150 *or* MATE 2730 *or* MATE 3920
Theory and practice of metal processing, including: extractive metallurgy; casting and solidification; welding and joining; deformation processes (e.g., forging, extrusion); powder metallurgy; and additive manufacturing. (Typically Offered: Fall)

MATE 3420: Structure/Property Relations in Nonferrous Metals
Credits: 3. Contact Hours: Lecture 3.
Prereq: MATE 2150 *or* MATE 2730 *or* MATE 3920
Physical properties of non-ferrous metals and their dependence on compositions microstructure and microstructures. Strengthening mechanisms in non-ferrous metals and alloys. Principles and practices to engineer compositions and processes to enhance these properties. Shape memory and elastocaloric alloy development and applications. (Typically Offered: Spring)

MATE 3480: Solidification Processes
(Cross-listed with IE 3480).
Credits: 3. Contact Hours: Lecture 2, Laboratory 2.
Prereq: IE 2480 *and* MATE 2730*, or* MATE 2150
Theory and applications related to metal casting, welding, polymer processing, powder metallurgy, and composites manufacturing, and related rapid manufacturing processes. (Typically Offered: Spring)

MATE 3500: Polymers and Polymer Engineering.
Credits: 3. Contact Hours: Lecture 3.
Prereq: MATE 2160 *or* MATE 2730 *or* MATE 3920
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. (Typically Offered: Spring)

MATE 3510: Introduction to Polymeric Materials
Credits: 3. Contact Hours: Lecture 3.
Prereq: MATE 2160 *or* MATE 2730 *or* MATE 3920
Introduction to polymer synthesis, structure, and properties. Develop a foundation in polymer chemistry and physics for in-depth polymer engineering. Relationship between polymer composition, processing, and properties. (Typically Offered: Fall)

MATE 3620: Principles of Nondestructive Testing
(Cross-listed with EM 3620).
Credits: 3. Contact Hours: Lecture 3.
Prereq: PHYS 1320 *OR* PHYS 2320 *or* PHYS 2320H
Radiography, ultrasonic testing, magnetic particle inspection, eddy current testing, dye penetrant inspection, and other techniques. Physical bases of nondestructive tests, materials to which applicable, effects of material condition, types of defects detectable, calibration standards, and reliability safety precautions. (Typically Offered: Fall, Spring)

MATE 3620L: Nondestructive Testing Laboratory
(Cross-listed with EM 3620L).
Credits: 1. Contact Hours: Laboratory 2.
Prereq: Credit or enrollment in MATE 3620 *or EM 3620*
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. (Typically Offered: Fall, Spring)

MATE 3910: Introduction to US Women's Roles in Industry and Preparation for Summer Study
Credits: 3. Contact Hours: Lecture 3.
Prereq: Instructor Permission for Course
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 3920 with arranged lectures at Brunel University. Orientation for Brunel summer study program. Graduation Restriction: Credit for graduation allowable only upon completion of summer study abroad program. Offered on a satisfactory-fail basis only. (Typically Offered: Spring)

MATE 3920: Principles of Materials Science and Engineering
Credits: 3. Contact Hours: Lecture 3.
*Prereq: (*CHEM 1670 *or* CHEM 1770*);* MATH 1650*;* MATE 3910
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. Graduation Restriction: Only one of MATE 2150, MATE 2730, or MATE 3920 may count toward graduation. Meets International Perspectives Requirement. (Typically Offered: Summer)

MATE 4130: Materials Design and Professional Practice I
Credits: 3. Contact Hours: Lecture 3.
Prereq: Senior classification or above
Fundamentals of engineering team behavior and professional preparation; Materials selection and design. Alysis of design problems, development of solutions, selected case studies. Oral presentation skills. Preparations for continued project in MATE 4140. MATE 4130-4140 sequence is intended for students in their final two semesters before graduation. (Typically Offered: Fall, Spring)

MATE 4140: Materials Design and Professional Practice II
Credits: 3. Contact Hours: Lecture 2, Laboratory 2.
Prereq: MATE 4130
Team projects specified by either industry or academic partners. Written and oral final project reports. 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. (Typically Offered: Fall, Spring)

MATE 4180: Mechanical Behavior of Materials
Credits: 3. Contact Hours: Lecture 3.
Prereq: MATE 2160*; Credit or enrollment in* MATE 3190
Mechanical behavior of ceramics, metals, polymers, and composites. Relationships between materials processing and atomic aspects of elasticity, plasticity, creep, fracture, and fatigue. Life prediction, stress-and failure analysis. (Typically Offered: Fall)

MATE 4190: Magnetism and Magnetic Materials
(Dual-listed with MSE 5190/ EE 5190). (Cross-listed with EE 4190).
Credits: 3. Contact Hours: Lecture 3.
Prereq: EE 3110 *or* MATE 3170 *or* PHYS 3640
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 phenome. 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. Offered odd-numbered years. (Typically Offered: Fall)

MATE 4250: Glass Science and Engineering
Credits: 3. Contact Hours: Lecture 2, Laboratory 3.
Prereq: MATE 3210
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. (Typically Offered: Fall)

MATE 4320: Microelectronics Fabrication Techniques
(Dual-listed with EE 5320/ MSE 5320). (Cross-listed with EE 4320).
Credits: 4. Contact Hours: Lecture 2, Laboratory 4.
Prereq: CPRE and EE majors; EE 2300 *OR MATE majors and* MATE 3170
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).

MATE 4330: Advanced Ceramics and Electronic Materials
Credits: 3. Contact Hours: Lecture 3.
Prereq: MATE 3170 *and* MATE 3210
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. (Typically Offered: Spring)

MATE 4370: Electronic Properties of Materials
(Dual-listed with EE 5370/ MSE 5370). (Cross-listed with EE 4370).
Credits: 3. Contact Hours: Lecture 3.
Prereq: EE 3320 *or* MATE 3170 *or* PHYS 3220
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. (Typically Offered: Spring)

MATE 4430: Physical Metallurgy of Ferrous Alloys
Credits: 3. Contact Hours: Lecture 3.
Prereq: MATE 3110
Production and processing of ferrous metals with emphasis on control of structure and properties. Industrial processes for ironmaking, steelmaking, alloying, melt treatment, casting, and forming. Heat treatment and thermomechanical processing. Equilibrium and nonequilibrium phases in the Fe-C system. Transformation diagrams, hardenability, and surface treatments. Properties and processing of cast irons, plain carbon and alloy steels, stainless steels, tool steels, and advanced high-strength steels. Alloy specifications and testing standards. Alloy selection and process design. (Typically Offered: Fall)

MATE 4440: Corrosion and Failure Analysis
Credits: 3. Contact Hours: Lecture 2, Laboratory 2.
Prereq: MATE 2150 *or* MATE 2730 *or* MATE 3920
Failure analysis. Characteristics of common types of metallic failures, case studies of failures, designing to reduce failure risk. Corrosion and corrosion control of metallic systems. Fundamentals of corrosion and oxidation, classification of different types of metallic corrosion/oxidation, their properties of various engineering alloys, and their engineering control. (Typically Offered: Spring)

MATE 4520: Scanning and Auger Electron Microscopy
(Dual-listed with MSE 5520).
Credits: 3. Contact Hours: Lecture 2, Laboratory 3.
Prereq: PHYS 2320
Characterization of materials using scanning electron microscopes (SEM) and variants thereof, including electron microprobe, Auger spectrometer, and DualBeam focused ion beams (FIB)/SEMs). Compositional determination using energy and wavelength dispersive x-ray and Auger spectroscopies. Orientation determination using electron backscattered diffraction. Specimen preparation. Laboratory covers SEM operation. (Typically Offered: Fall)

MATE 4530: Physical and Mechanical Properties of Polymers
(Dual-listed with MSE 5530).
Credits: 3. Contact Hours: Lecture 2, Laboratory 3.
Prereq: MATE 3510
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. (Typically Offered: Fall)

MATE 4540: Polymer Composites and Processing
(Dual-listed with MSE 5540).
Credits: 3. Contact Hours: Lecture 3.
Prereq: MATE 3510
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. (Typically Offered: Spring)

MATE 4560: Biomaterials
(Dual-listed with MSE 5560). (Cross-listed with BME 4560).
Credits: 3. Contact Hours: Lecture 3.
Prereq: CHEM 1780 *and (*MATE 2160 *or* MATE 2730 *or* MATE 3920*)*
Presentation of the basic chemical and physical properties of biomaterials, with special emphasis on metallic, ceramic, polymeric, and composite biomaterials, as they are related to their manipulation by the engineer for incorporation into living systems. Role of microstructure and properties needed to select and design biomaterials used in medical devices, artificial organs, implants, and prostheses. Overview of medical science vis-à-vis materials science. (Typically Offered: Fall)

MATE 4570: Chemical and Physical Metallurgy of Rare Earth Metals
(Dual-listed with MSE 5570).
Credits: 3. Contact Hours: Lecture 3.
Prereq: MATE 3110 *or* CHEM 3250
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. Offered even-numbered years. (Typically Offered: Spring)

MATE 4800: Ultrasonic Nondestructive Evaluation
(Cross-listed with AERE 4800/ EM 4800).
Credits: 3. Contact Hours: Lecture 3.
Prereq: EM 3240 *or* MATE 3190*;* MATH 2660 *or* MATH 2670*;* PHYS 2320
Introduction to stress/strain, Hooke's law, and elastic wave propagation in two dimensions in isotropic media. Ultrasonic plane-wave reflection and transmission; and simple straight-crested guided waves. Transducer construction, behavior, and performance. Simple signal analysis and discrete signal processing. The last few weeks of the course are devoted to case studies. (Typically Offered: Spring)

MATE 4880: Eddy Current Nondestructive Evaluation
(Dual-listed with EE 5880/ MSE 5880). (Cross-listed with EE 4880).
Credits: 3. Contact Hours: Lecture 3.
Prereq: MATH 2650 *and (*MATE 2160 *or* MATE 2730 *or* MATE 3920 *or EE 3110 or* PHYS 3640*)*
Electromagnetic fields of various eddy current probes. Probe field interaction with conductors, crack 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. Offered odd-numbered years. (Typically Offered: Fall)

MATE 4900: Independent Study
Credits: 1-30. Repeatable.
Prereq: Department Permission for Course
Investigation of individual research or special topics. Independent study that is being proposed to be used toward graduation or minor requirements. This course requires an approved proposal to the MSE Department's Undergraduate Curriculum Committee prior to the beginning of the semester. (Typically Offered: Fall, Spring, Summer)

MATE 4900H: Independent Study: Senior Honors Project
Credits: 1-30.
Prereq: Department Permission for Course; Membership in the University Honors Program
Independent study that is being proposed to be used for an honors project. This course requires an approved proposal to the College of Engineering Honors Committee.Arranged: Additional Meetings or Activity Required. (Typically Offered: Fall, Spring, Summer)

MATE 4990: Undergraduate Research Opportunity
Credits: Required. Repeatable, maximum of 12 times.
Prereq: Department Permission for Course
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. Graduation Restriction: The course cannot be applied toward any graduation requirements. Offered on a satisfactory-fail basis only. (Typically Offered: Fall, Spring, Summer)