MATERIALS ENGINEERING (MAT E)

Courses primarily for undergraduates:

MAT E 214: Structural Characterization of Materials
(2-2) Cr. 3. F.S.
Prereq: MAT E 215, credit or enrollment in 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)
Materials Engineering majors only. Structure and properties of ceramic, electronic, polymeric and metallic materials, emphasizing differences based on structure and bonding. Phase equilibria and phase transformations. 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, Chem 178, Credit or enrollment in PHYS 222
Materials Engineering majors only. Fundamentals of ceramic, polymeric, and composite materials; degradation, electronic, thermal, magnetic, and optical properties of materials. Materials for energy, biomaterials, and nanomaterials.

MAT E 216L: Introduction to Materials Science and Engineering II - Lab
(0-2) Cr. 1. F.S.
Prereq: Credit or enrollment in 216
Materials Engineering majors only. Laboratory exercise in materials.

MAT E 220: Global Sustainability
(Cross-listed with ANTHR, ENV S, GLOBE, M E, SOC, T SC). (3-0) Cr. 3. F.S.
An introduction to 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.SS.
Prereq: Sophomore classification; 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, 272, 273. or 392 may count toward graduation

MAT E 298: Cooperative Education
Cr. R. F.S.SS.
Prereq: Permission of department and Engineering Career Services
First professional work period in the cooperative education program. Students must register for this course before commencing work.

MAT E 311: Thermodynamics in Materials Engineering
(3-0) Cr. 3. F.
Prereq: CHEM 178, credit or enrollment in MAT E 216, PHYS 222, 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 316: Computational Methods in Materials
(3-0) Cr. 3. S.SS.
Prereq: MAT E 215
Use of mathematical and statistical computer tools for materials design and analysis. Applications of statistical principles to problems concerned with materials. Computer-assisted design of experiments.

MAT E 317: Introduction to Electronic Properties of Ceramic, Metallic, and Polymeric Materials
(3-0) Cr. 3. F.
Prereq: MAT E 216 and PHYS 222
Materials Engineering majors only. Introduction to electronic properties of materials and their practical applications. Classical conduction models and electronic properties of metallic and ceramic materials. Elementary quantum mechanics and band theory of electron states in solids. Quantum theory of metallic conduction. Elementary semiconductor theory and devices. Polarization and dielectric properties of materials. Electron conduction in polymeric systems. Magnetic properties and applications of metals and ceramics.

MAT E 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. Powder packing. Thermal, electronic, optical and magnetic properties of ceramics.

MAT E 322: Introduction to Ceramic Processing
(2-3) Cr. 3. S.
Prereq: MAT E 216, MAT E 321
Synthesis and characterization of ceramic powders. Colloidal phenomena, rheology of suspensions, ceramic forming methods, and drying. High temperature ceramic reactions, liquid and solid-state sintering, grain growth, microstructure development. Processing/microstructure/property relationships.

MAT E 332: Semiconductor Materials and Devices
(Cross-listed with E E). (3-0) Cr. 3. S.
Prereq: PHYS 222; MAT E majors: MAT E 317; CPR E and E E majors: E E 230
Introduction to semiconductor material and device physics. Quantum mechanics and band theory of semiconductors. Charge carrier distributions, generation/recombination, transport properties. Physical and electrical properties and fabrication of semiconductor devices such as MOSFETs, bipolar transistors, laser diodes and LED's.

MAT E 334: Electronic & Magnetic Properties of Metallic Materials
(3-0) Cr. 3. S.
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: 215 or 273 or 392, Mat E majors only
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 343: Physical Metallurgy of Ferrous Alloys
(3-0) Cr. 3. S.
Prereq: 214, 215 or 273 or 392, credit or enrollment in 311
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 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.

MAT E 351: Introduction to Polymeric Materials
(3-0) Cr. 3. S.
Prereq: MAT E 216, CHEM 331
Introduction to polymeric materials, synthesis, structure and properties. Relationship between polymer composition, processing and properties.

MAT E 362: Principles of Nondestructive Testing
(Cross-listed with E M). (3-0) Cr. 3. S.
Prereq: PHYS 112 or PHYS 222
Radiography, ultrasonic testing, magnetic particle inspection, eddy current testing, dye penetrant inspection, and other techniques. Physical bases of tests; materials to which applicable; types of defects detectable; calibration standards, and reliability safety precautions.

MAT E 362L: Nondestructive Testing Laboratory
(Cross-listed with E M). (0-3) Cr. 1. S.
Prereq: Credit or enrollment in MAT E 362
Application of nondestructive testing techniques to the detection and sizing of flaws in materials and to the characterization of material's microstructure. Included are experiments in hardness, dye penetrant, magnetic particle, x-ray, ultrasonic and eddy current testing. Field trips to industrial laboratories.

MAT E 370: Toying with Technology
(Cross-listed with CPR E). (2-2) Cr. 3. F.S.
Prereq: C I 201 or C I 202
A project-based, hands-on learning course. Technology literacy, appreciation for technological innovations, principles behind many technological innovations, hands-on laboratory experiences based upon simple systems constructed out of LEGOs and controlled by small microcomputers. Future K-12 teachers will leave the course with complete lesson plans for use in their upcoming careers.

MAT E 391: Introduction to US Women's roles in Industry and Preparation for Summer Study
(3-0) Cr. 3. S.
Introduction to the historical role of women as related to US industry, family and community with emphasis on the years 1830 - 1945, but also related to the current climate. Topics completed in 392 with arranged lectures at Brunel University. Orientation for Brunel summer study program. Offered on a satisfactory-fail basis only. Credit for graduation allowable only upon completion of Mat E 392.
Meets U.S. Diversity Requirement

MAT E 392: Principles of Materials Science and Engineering
(3-0) Cr. 3. SS.
Prereq: MAT E 391, CHEM 167 or CHEM 177
Structure and properties of ceramic, electronic, polymeric and metallic materials, emphasizing differences based on structure and bonding. Phase equilibria and phase transformations. Taught on Brunel University campus. Offered on a satisfactory-fail basis only. Only one of Mat E 215, 273, or 392 may count toward graduation.
Meets International Perspectives Requirement.

MAT E 394: Topics in Sustainable Engineering in Italy
(3-0) Cr. 3. S.
Prereq: Chem 167 or Chem 177
Fundamentals of sustainable engineering related to biofuels. Basics of food and biofuel chemistry and fluid dynamics. Preparation course for Italy as a case study for food and sustainable engineering. Orientation for summer study abroad program in Torino, Italy. Credit for graduation allowable only upon completion of the following summer's offering of Mat E 316 taught in Italy, along with additional sustainability lessons/tours.

MAT E 396: Summer Internship
Cr. R. Repeatable. SS.
Prereq: Permission of department and Engineering Career Services
Summer professional work period.

MAT E 397: Engineering Internship
Cr. R. Repeatable. F.S.
Prereq: Permission of department and Engineering Career Services; junior classification
Professional work period, one semester maximum per academic year.

MAT E 398: Cooperative Education
Cr. R. F.S.SS.
Prereq: MAT E 298, permission of department and Engineering Career Services
Second professional work period in the cooperative education program. Students must register for this course before commencing work.

MAT E 401: Materials Engineering Professional Planning
Cr. R. F.
Prereq: Senior classification in materials engineering
Preparation for a career in materials engineering or graduate school; experiential learning, resumes, interviewing, Myers-Briggs Type Indicator, leadership, international opportunities, professional ethics, graduate school preparation and opportunities, and alternative career paths (med school, law school, etc.). Offered on a satisfactory-fail basis only.

MAT E 413: Materials Design and Professional Practice I
(2-2) Cr. 3. F.S.
Prereq: Senior status in Mat E
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 spring project.

MAT E 414: Materials Design and Professional Practice II
(2-2) Cr. 3. F.S.
Prereq: Senior status in Mat E
Integration of materials processing, structure/composition, properties and performance principles in materials engineering problems. Multi-scale design of materials, materials processing, case studies including cost analysis, ethics, risk and safety. Team projects specified by either industry or academic partners. Written and oral final project reports.

MAT E 418: Mechanical Behavior of Materials
(3-0) Cr. 3. F.
Prereq: MAT E 216
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 425: Glass Science and Engineering
(2-3) Cr. 3. F.
Prereq: MAT E 216, 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. Nonmajor graduate credit.

MAT E 432: Microelectronics Fabrication Techniques
(Dual-listed with M S E 532). (Cross-listed with E E). (2-4) Cr. 4.
Prereq: credit or enrollment in E E 332
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 Electronic Materials
(2-3) Cr. 3. S.
Prereq: MAT E 317
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 442: Structure/Property Relations in Nonferrous Metals
(3-0) Cr. 3. F.
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 444: Corrosion and Failure Analysis
(2-2) Cr. 3. S.
Prereq: MAT E 215 or 273 or 392 and credit or enrollment in MAT E 418
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 449: Structural Health Monitoring
(Dual-listed with M S E 549). (Cross-listed with C E). (3-0) Cr. 3.
Prereq: Senior classification in Engineering or permission of instructor
Introductory and advanced topics in structural health monitoring (SHM) of aeronautical, civil, and mechanical systems. Topics include sensors, signal processing in time and frequency domains, data acquisition and transmission systems, design of integrated SHM solutions, nodestructive evaluation techniques, feature extraction methods, and cutting edge research in the field of SHM. Graduate students will have a supervisory role to assist students in 449 and an additional design project or more in-depth analysis and design.

MAT E 453: Physical and Mechanical Properties of Polymers
(2-3) Cr. 3. F.
Prereq: 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: 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 AND CHEM 324 or PHYS 322
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 and 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, computer models and engineering drawings.

MAT E 467: Multidisciplinary Engineering Design II
(Cross-listed with AER E, CPR E, E 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. F.
Prereq: Math 265 and (MatE 311 or ChE 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 E E 311 or PHYS 364)
Electromagnetic fields of various eddy current probes. Probe field interaction with conductors, cracks and other material defects. Ferromagnetic materials. Layered conductors. Elementary inversion of probe signals to characterize defects. Special techniques including remote-field, transient, potential drop nondestructive evaluation and the use of Hall sensors. Practical assignments using a 'virtual' eddy current instrument will demonstrate key concepts.

MAT E 490: Independent Study
Cr. arr. Repeatable.
Investigation of individual research or special topics.

MAT E 498: Cooperative Education
Cr. R. Repeatable. F.S.SS.
Prereq: MAT E 398, permission of department and Engineering Career Services
Third and subsequent professional work periods in the cooperative education program. Students must register for this course before commencing work.