MATERIALS ENGINEERING

Charles Browning, Program Director

Doctor of Engineering, Materials Engineering (MAT)

See the Doctoral Degree Requirements section on the School of Engineering page and consult with the department chair.

Doctor of Philosophy in Engineering, Materials Engineering (MAT)

See the Doctoral Degree Requirements section on the School of Engineering page and consult with the department chair.

Master of Science in Materials Engineering (MAT)

The program of study leading to the Master of Science in Materials Engineering must include a minimum of 30 semester credit hours. Choose between **Thesis Option** or **Non-Thesis Option** shown below:

Thesis Option		
Concentration area		15
Approved electives		9
MAT 599	Thesis	6
OR		
Non-Thesis Option		
Concenctration area		12
Materials engineering project or approved Materials coursework [1]		6
Approved electives		12
Total Hours		30

See also Master's Degree Requirements in School of Engineering section in the bulletin and consult with the advisor.

1 Upon the request of the student and with approval of the advisor and the program director, the materials engineering project may be replaced by six semester hours of additional coursework in the concentration area.

Courses

MAT 501. Principles of Materials I. 3 Hours
Structure of engineering materials from electronic to atomic and crystallographic considerations. Includes: atomic structure and interatomic bonding, imperfections, diffusion, mechanical properties, strengthening mechanisms, failure, phase diagrams, phase transformations and processing. Prerequisite(s): MTH 219; college chemistry; college physics.

MAT 502. Principles of Materials II. 3 Hours
Structure, behavior, and processing of metal alloys, ceramics, polymers, and composites to include: mechanical behavior, corrosion, electrical, magnetic, and optical properties. Prerequisite(s): MAT 501 or equivalent.

MAT 504. Techniques of Materials Analysis. 3 Hours
Fundamentals and applications of the traditional analytical methods such as x-ray analysis, electron microprobe, and scanning microscopy. Techniques such as NMR, atomic absorption, Raman, Mossbauer, and field ion microscopy will be covered. Emphasis on applicability. Prerequisite(s): MAT 501 or permission of instructor.

MAT 506. Mechanical Behavior of Materials. 3 Hours
Fudamental relationships between the structure and mechanical behavior of materials. Includes fundamentals of stress and strain, the physical basis for elastic deformation, elementary, dislocation theory and plastic deformation, strengthening mechanisms, yield criteria and their application to biaxial and multi-axial behavior and failure, fracture and toughening mechanisms, creep and creep rupture, behavior and failure of cellular solids, and fatigue. Prerequisite(s): (MAT 501, MAT 502) or permission of instructor.

MAT 507. Introduction to Ceramic Materials. 3 Hours
Course presents the fundamentals of ceramics from early classical clay-based technology to today's advanced application of modern ceramic materials (i.e. protective armor, Mars rover Curiosity's nuclear fuel, high temperature fuel cells and fuel saving turbine engine blades). The physics and chemistry fundamentals associated with modern ceramic technology are first discussed followed by an understanding of the important role composition and processing technologies have on many of the physical and mechanical properties of ceramics. Prerequisite(s): MAT 501.

MAT 508. Principles of Material Selection. 3 Hours
Basic scientific and practical consideration involved in the intelligent selection of materials for specific applications. Impact of new developments in materials technology and analytical techniques. Prerequisite(s): MAT 501 or permission of instructor.

MAT 509. Introduction to Polymer Science-Thermoplastics. 3 Hours
Broad technical overview of the nature of synthetic macromolecules, including the formation of polymers and their structure, structure-property relationships, polymer characterization and processing, and applications of polymers. Fundamental topics such as viscoelasticity, the glassy state, time-temperature superposition, polymer transitions, and free volume will also be reviewed. The course focuses on thermoplastic polymers. Prerequisite(s): Organic chemistry; college physics; differential equations.

MAT 510. High Performance Thermoset Polymers. 3 Hours
Survey of high performance thermosetting resins, focusing on chemistry, processing, and properties of six general resin families: vinyl ester, epoxy, phenolic, cyanate ester, bismaleimide, and polyimides. The course will include fundamental discussions of polymerization mechanisms, network structure development, rheology and time-temperature transformation, resin toughening, and structure-processing-property relationships. Characterization techniques will also be reviewed briefly. Prerequisite(s): Organic chemistry.

MAT 511. Principles of Corrosion. 3 Hours
Theoretical and practical application of electrochemical principles to the field of corrosion covering thermodynamics, kinetics, forms of corrosion and methods for characterizing and controlling corrosion in areas of biomedical engineering, aerospace, automotive, and marine environments. Prerequisite(s): MAT 501.

MAT 521. NDE/SHM. 3 Hours
Introduction to theory and application of methods for nondestructive flaw detection and materials characterization for metals, polymers, ceramics and advanced composites using x-ray, ultrasonic, electromagnetic (magnetic particle, eddy current), thermal, and optical techniques Also, statistical analysis of reliability, probability of detection and quality assurance provided. Prerequisite(s): Permission of instructor.

MAT 527. Methods of Polymer Analysis. 3 Hours
Modern laboratory techniques used in preparation and characterization of polymers; experimental investigations of polymer structure-property relations; measurement of molecular weight averages and distributions, thermal and mechanical properties, viscoelastic and rheological properties; transitions and crystallinity. Prerequisite(s): MAT 509 or MAT 510.

MAT 528. Chemical Behavior of Materials. 3 Hours
This course will address chemical behavior as a subject complementary to mechanical behavior of materials. A special emphasis will be given to structure-property relationships of the major classes of materials. Physical/chemical periodicity, bonding, processing chemistry, and chemical behavior in the application environment will be addressed. Each major class of materials will be discussed with specific case studies for each. Prerequisite(s): College chemistry or permission of the instructor.

MAT 529. Computational Chemistry. 3 Hours
Introduction to computational chemistry including a discussion of ab initio, semiempical, and DFT metods and an overview of molecular mechanics and molecular simulation methods. Lectures are supplemented by simulation exercises using commercial programs such as Gaussiari and Molecular Studio. Prerequisite(s): CHM124, or consent of instructor.

MAT 530. Biomaterials. 3 Hours
The course introduces students with engineering materials used in dentistry, manufacture of surgical devices, prosthetics, and repair of tissues. Topics include bonding and atomic arrangement in materials, material selection, testing, and characterization, biocompatibility, tissue response to materials, and failutre analysis. A spectrum of materials including metals, polymers, ceramics, and composites used in biomedical applications will be considered.

MAT 535. High Temperature Materials. 3 Hours
This course will provide students with the basic material behavior concepts which control high-temperature properties of metals and alloys. A special emphasis will be given to creep behavior of metals and alloys including a comprehensive study of relationships between microstructure and high-temperature creep deformation of pure metals, single-phase alloys, multi-phase alloys, and dispersion-strengthened materials. In addition, the properties and applications of high-temperature materials will be discussed, especially those alloys used in the aerospace industry for gas turbine engine rotating-component, such as titanium and nickel-based superalloys. Prerequisite(s): MAT 501 or equivalent.

MAT 540. Composite Design. 3 Hours
Design with composite materials. Micromechanics. Lamination theory. Joining. Fatigue. Environmental effects. Prerequisite(s): EGM 303 or EGM 330.

MAT 541. Experimental Mechanics of Composite Materials. 3 Hours
Introduction to the mechanical response of fiber-reinforced composite materials with emphasis on the development of experimental methodology. Analytical topics include stress-strain behavior of anisotropic materials, laminate mechanics, and strength analysis. Theoretical models are applied to the analysis of experimental techniques used for characterizing composite materials. Lectures are supplemented by laboratory sessions in which characterization tests are performed on contemporary composite materials. Prerequisite(s): EGM 303 or EGM 330.

MAT 542. Advanced Composites. 3 Hours
Materials and processing. Comprehensive introduction to advanced fiber reinforced polymeric matrix composites. Constituent materials and composite processing will be emphasized with special emphasis placed on structure-property relationships, the role of matrix in composite processing, mechanical behavior and laminate processing. Specific topics will include starting materials, material forms, processing, quality assurance, test methods, and mechanical behavior. Prerequisite(s): (MAT 501 or MAT 509) or permission of instructor.

MAT 543. Analytical Mechanics of Composite Materials. 3 Hours
Analytical models are developed for predicting the mechanical and thermal behavior of fiber-reinforced composite materials as a function of constituent material properties. Both continuous and discontinuous fiber-reinforced systems are considered. Specific topics include basic mechanics of anisotropic materials, micro-mechanics and lamination theory, free-edge effects, and failure criteria. Prerequisite(s): EGM 303 or EGM 330.

MAT 544. Mechanics of Composite Materials. 3 Hours
Comprehensive treatment of laminated beams, plates, and sandwich structures. Effect of heterogeneity and anisotropy on bending under lateral loads, buckling, and free vibration are emphasized. Shear deformation and other higher-order theories and their range of parametric applications also considered. Prerequisite(s): MAT 543 or permission of instructor.

MAT 550. Fundamentals of Nanotechnology & Nanomaterials. 3 Hours
This course takes a pedagogical approach to the subject and assumes only an introductory understanding of the physics and chemistry of macroscopic solids and models developed to explain properties such as the theory of phonon and lattice vibrations and electronic band structure. The course describes how properties depend on size in the nanometer regime and explain why these changes occur using relatively simple models of the physics and chemistry of the solid state. Prerequisite(s): Basic Chemistry and Physics.

MAT 552. Composites Processing Lab. 3 Hours
The fabrication and characterization of advanced composite materials is a combined lecture/laboratory course in which carbon fiber reinforced polymeric matrix laminates will be fabricated and characterized.
The autoclave processing of high quality composite laminates from prepreg tape will be the focus of the class. Prepreg will be subjected to standard test methods; laminates will be fabricated using autoclave/vacuum bag methods; and fabricated laminates will be subjected to mechanical, physical and NDE testing. Additional topics include VARTM (vacuum infusion) and sandwich core composites. The importance of understanding key material-processing-property relationships will be developed during the class. Prerequisite(s): MAT 542.

MAT 570. Fracture Mechanics. 3 Hours
Application of the principles of fracture mechanics to problems associated with fatigue and fracture in engineering structures. The course will cover the development of models that apply to a range of materials, geometries, and loading conditions. Prerequisite(s): MAT 506 or permission of instructor.

MAT 575. Fracture & Fatigue of Metals & Alloys I. 3 Hours
This course will cover the effects of microstructure on the fracture and fatigue behavior of engineering metals and alloys, with a special emphasis on static and dynamic brittle and ductile failures and static and fatigue crack initiation. Alloy fracture resistance, fracture toughness, fatigue behavior, and methods to improve fracture and fatigue behavior will be discussed in detail. The role of materials reliability in life management of advanced alloys in turbine engines and aircraft will be reviewed, and key practical aspects will be discussed. Various analytical techniques for failure analysis of structural components will be presented. Prerequisite(s): (MAT 501 or MAT 506) or permission of instructor.

MAT 576. Fracture & Fatigue of Metals & Alloys II. 3 Hours
This course will cover the areas of the effects of microstructure on fatigue crack propagation and on final fracture by fatigue. This will include fatigue life prediction, using damage-tolerance approach to component-design and microstructural and structural synthesis for optimum behavior. Specific material-related aspects of fatigue crack propagation mechanisms for optimum damage tolerant behavior, and the related reliability and failure analysis, will also be covered. A comprehensive project in failure-analysis of aerospace metallic components will also be conducted. Prerequisite(s): MAT 575 or equivalent.

MAT 577. Light Structural Metals. 3 Hours
This course is an introduction and review of light structural metals, commonly used throughout the aerospace and automotive industries. It will include the mtallurgy of light metals, from ore extraction, smelting, alloying and shape making to heat-treatment. Design and applications of light structural metals and a comprehensive technology and economic comparisons with other groups of metals wil be presented. Prerequisite(s): MAT 501, MAT 502.

MAT 579. Materials for Advanced Energy Applications. 3 Hours
Successful long-term application of many advanced energy technologies is ultimately based on the utilization of materials in 'real world' environmental conditions. The physical/mechanical properties and application of various materials (i.e. superalloys, refractory metal alloys, ceramics) being employed in advanced energy applications are discussed. Several advanced energy technologies (i.e. fuel cells, nuclear energy, and others) are covered with emphasis on how the selection of advanced materials enhances their commercial application. Prerequisite(s): MAT 501 AND MAT 502 or permission of instructor.

MAT 580. Polymer Durability. 3 Hours
An in-depth study of the mechanisms leading to polymer decomposition and degradation, as well as methods for analyzing and preventing or minimizing these processes and thereby improving polymer durability. Topics include thermal / pyrolytic, thermo-oxidative, hydrolysis, photo/UV/weathering, flammability, mechanical, degradation in earth orbit. Prerequisite(s): MAT 509/CME 509 or MAT 510/CME 510.

MAT 581. Introduction to Nanoelectronics. 3 Hours
Introduction to the physics of materials on the nanoscale; quantum confinement theory; electronic and optical properties of semiconductor nanostructures; single electron transistors (SETs); tunneling and ballistic devices; nanostructured LEDs, photodetectors, and lasers; nanophotovoltaics and nanomagnetics; quantum computing and molecular electronics; nanoelectronic fabrication, state-of-the-art and emerging nanoscale devices and applications. Prerequisite(s): ECE 506.

MAT 589. Graduate Seminar Series. 1 Hour
Graduate seminars on various current material topics presented by guest speakers.

MAT 590. Selected Readings in Materials Engineering. 1-3 Hours
Directed readings in selected areas of materials engineering arranged and approved by the student's advisor and the program director.

MAT 595. Special Problems in Materials Engineering. 1-3 Hours
Special assignments arranged by the materials engineering faculty.

MAT 597. Research Methods. 3 Hours
This course will provide students the ability to apply research methods and problem solving skills to identify and define a research problem, develop hypotheses and research plans to test those hypotheses. Sutdents will write and present an original research proposal.

MAT 599. Thesis. 3-6 Hours
Thesis.

MAT 601. Surface Chemistry of Solids. 3 Hours
The nature of solid surfaces as determined by the techniques of x-ray photoelectron and Auger electron spectroscopy, secondary ion mass spectrometry, and ion scattering spectroscopy. Prerequisite(s): MAT 504 or permission of instructor.

MAT 603. Materials Science of Thin Films. 3 Hours
An introduction to the basic physics of film formation processes including physical vapor deposition and chemical vapor deposition, film properties, and applications. Nucleation theory, film interdiffusion and reaction, metallurgical and protective coatings, electrical, magnetic, and optical properties of thin films. Emphasis on applicability. Prerequisite(s): College physics; fundamental physical and chemical properties of materials.

MAT 604. Nanostructured Materials. 3 Hours
The course takes a pedagological approach to the subject and assumes only an introductory understanding of the physics and chemistry of macroscopic solids and models developed to explain properties, such as the theory of phonon and lattice vibrations and electronic band structure. The course describes how properties depend on size in the nanometer regime and explain why these changes occur using relatively simple models of the physics and chemistry of the solid state. Prerequisites include college physics; fundamental physical and chemical properties of materials.

MAT 605. Carbon Science and Technology. 3 Hours
Graduate-level course covering the fundamental and applied aspects of Carbon Nanoscale Science and Technology. The course has three goals: (1) an overview of the current development in carbon science and technology (2) an introduction to the surface science as a means to understand the surface interaction at molecular scale, and (3) to provide some explicit links between macro, micro, and nanoscale technologies. Some of the medical field, structural and friction application will be addressed. This course is aimed at both science and engineering students.

MAT 699. PHD Dissertation. 1-15 Hours
An original research effort which makes a definite contribution to technical knowledge. Results must be of sufficient importance to merit publication.