COURSES OF INSTRUCTION

MAT 501. PRINCIPLES OF MATERIALS I: 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. Prerequisites: College chemistry, physics and MTH 219. 3 sem. hrs.

MAT 502. PRINCIPLES OF MATERIALS II: Structure, behavior, and processing of metal alloys, ceramics, polymers, and composites to include: mechanical behavior, corrosion, electrical, magnetic, and optical properties.
Prerequisite: MAT 501 or equivalent. 3 sem. hrs.

MAT 503. X-RAY CRYSTALLOGRAPHY: A broad coverage of fundamental crystallography, the interaction of x-rays with matter, and the x-ray scattering techniques used to study materials.
Prerequisite: MAT 501 or consent of instructor. 3 sem. hrs.

MAT 504. TECHNIQUES OF MATERIALS ANALYSIS: 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: MAT 501 or consent of instructor. 3 sem. hrs.

MAT 505. THERMODYNAMICS OF SOLIDS: Laws of thermodynamics, auxiliary functions, thermodynamic relations, phase transitions, thermodynamic equilibrium, thermodynamic properties of solid solutions, surfaces and interfaces.
Prerequisite: MAT 501 or consent of instructor. 3 sem. hrs.

MAT 506 MECHANICAL BEHAVIOR OF MATERIALS: Fundamental 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.
Prerequisites: MAT 501 and MAT 502 or consent of instructor 3 sem. hrs.

MAT 507. INTRODUCTION TO CERAMIC MATERIALS: The course begins with an overview of the diverse ceramic fields and of the historical evolution of ceramics. The physics and chemistry fundamentals associated with modern ceramic technology are reviewed. The scope of ceramic compositions and processing technologies are described. The physical, chemical, mechanical and electrical properties of ceramics and the associated methods for measuring these properties are presented. The effects of time, temperature and environmental conditions on material behavior are studied. The design concepts used for ceramic products and the range of applications for modern ceramics are

discussed. The course also includes a history of the development and use of ceramics in turbine engines.
Prerequisite: MAT 501. 3 sem. hrs.

MAT 508. PRINCIPLES OF MATERIAL SELECTION: 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: MAT 501 or consent of instructor. 3 sem. hrs.

MAT 509. INTRODUCTION TO POLYMER SCIENCE - THERMOPLASTICS: 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.
Prerequisites: Organic chemistry, college physics, differential equations. 3 sem. hrs.

MAT 510. HIGH PERFORMANCE THERMOSET POLYMERS: Survey of high performance thermoset 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.
Prerequisites: Organic chemistry. 3 sem. hrs.

MAT 511. PRINCIPLES OF CORROSION: 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: MAT 501. 3 sem. hrs.

MAT 512. ENGINEERING MAGNETIC MATERIALS AND THEIR FUNCTION IN GREEN ENERGY: This course covers the fundamental magnetics including spontaneous magnetization & technical magnetization, and advanced magnetic materials, as well as their function in electric machines for green energy. This course also includes introduction to computer modeling of magnetic circuits using 2D/3D finite element analyses (FEA). After taking this course, students should understand the basics of magnetics and the functions of magnetic material in electric machines, and use Ansoft 2D/3D Maxwell software for modeling PM (permanent magnet) motors and other electric machines.
Prerequisite: College physics and MAT 501 or consent of instructor. 3 sem hrs.

MAT 513. ADVANCED MAGNETIC MATERIALS: A more detailed descriptions of magnetics and magnetic materials, including spontaneous magnetization, domain structure, magnetic anisotropy, energies involved in magnetic materials, technical magnetization, Fe, Fe-Si, Fe-Ni, Fe-Co, Fe-Al, soft ferrites, amorphous soft magnetic materials, nanocrystalline soft magnetic materials, Alnico, Fe-Cr-Co, hard ferrites, SmCo5, Sm2Co17, Nd2Fe14B, Sm-Fe-N, nanocomposite permanent magnet materials and coercivity mechanisms.
Prerequisite: MAT 512. 3 sem hrs.

MAT 514. APPLIED SUPERCONDUCTIVITY - AN INTRODUCTION: Basic phenomena. Theoretical concepts, superconductive materials - types, properties, physics, metallurgy, superconducting magnets. Other present and future engineering applications.
Prerequisite: Consent of instructor. 3 sem. hrs.

MAT 515. STATISTICAL THERMODYNAMICS: Microscopic thermodynamics; Boltzmann, Bose-Einstein, Fermi-Dirac statistics; statistical interpretation of thermodynamic quantities. Applications to perfect and real gases, liquids, cyrstalline solids, and thermal radiation.
Prerequisites: MEE 301, MTH 219. 3 sem. hrs.

MAT 516. SOLIDIFICATION IN METALS: Solidification, diffusion, phase diagrams, phase transformations--diffusional and diffusionless, microstructure.
Prerequisite: MAT 501 or consent of instructor. 3 sem. hrs.

MAT 517. PHASE DIAGRAMS: Introduction to phase equilibria; construction, interpretation, and application of phase diagrams for unary, binary, ternary, and higher order systems.
Prerequisite: MAT 501. 3 sem. hrs.

MAT 518. DIFFUSION IN SOLIDS: Considers the rate of response on condensed matter to changes in environmental conditions such as temperature. Specific topics include basic rate theory, heavy emphasis on diffusion, and phase transformations.
Prerequisites: MAT 501, MAT 505. 3 sem. hrs.

MAT 519. PHASE TRANSFORMATIONS: Classical treatment of phase transformation, nucleation and growth, recovery and recrystallization, and advanced processes in control of microstructures and properties. New developments in the area of phase transformations.
Prerequisite: MAT 501. 3 sem. hrs.

MAT 520. POWDER METALLURGY: Detailed treatment of scientific principles behind rapid solidification processing, powder production methods: metal and ceramic powders, powder analysis and powder consolidation, principles of mechanical alloying, processing methods and steps involved in producing P/M product forms, implications of powder metallurgy microstructures on mechanical behavior.
Prerequisite: MAT 501. 3 sem. hrs.

MAT 521. NDE/SHM: 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.
Prerequisites: Consent of instructor. 3 sem hrs.

MAT 525. DESIGN OF MACROMOLECULAR SYSTEMS: Polymer preparation by chain polymerization and stepwise polymerization; copolymerization; stereospecific polymerizations; formation of network polymers: heterogeneous reaction systems; aging and stabilization.
Prerequisites: CHM 314, MAT 510. 3 sem. hrs.

MAT 526. POLYMER ENGINEERING: Rheology of polymeric materials; fundamentals of polymer processing; design of processing operation and their relation to the physical and mechanical behavior of polymers in molten and solid states; control of polymer processing through proper material selection.
Prerequisites: MEE 308, MEE 410, MAT 510. 3 sem. hrs.

MAT 527. METHODS OF POLYMER ANALYSIS: 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.
Prerequisites: MAT 509 or MAT 510. 3 sem. hrs.

MAT 528 CHEMICAL BEHAVIOR OF MATERIALS: 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.
Prerequisites: College chemistry or consent of instructor 3 sem. hrs.

MAT 530. INTRODUCTION TO ANALYTICAL ELECTRON MICROSCOPY: This course is an introduction to the use of analytical transmission electron microscopy applied to the study of materials. Techniques and principles of the following will be covered: design and operation of the AEM, image formation, crystallography and the reciprocal space construction, selected area diffraction, convergent beam electron diffraction, energy dispersive X-ray microanalysis, and electron energy loss spectroscopy.
Prerequisite: College physics. 3 sem. hrs.

MAT 535. HIGH-TEMPERATURE MATERIALS: This course will provide students with 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 common high-temperature materials will be discussed, especially for those alloys used in the aerospace industry for gas turbine engine rotating-component, such as titanium alloys and nickel-based superalloys.
Prerequisite: MAT 501 or equivalent. 3 sem. hrs.

MAT 539. THEORY OF PLASTICITY: Fundamentals of plasticity theory including elastic, viscoelastic, and elastic-plastic constitutive models: plastic deformation on the macroscopic and microscopic levels; stress-strain relations in the plastic regime; strain hardening; limit analysis; numerical procedures.
Prerequisite: EGM 503 or 533 3 sem. hrs.

MAT 540. COMPOSITE DESIGN: Design with composite materials. Micromechanics. Lamination theory. Joining. Fatigue. Environmental effects.
Prerequisite: EGM 303 or EGM 330. 3 sem. hrs.

MAT 541. EXPERIMENTAL MECHANICS OF COMPOSITE MATERIALS: 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: EGM 303 or EGM 330. 3 sem. hrs.

MAT 542. ADVANCED COMPOSITES: 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 the 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: Consent of instructor. 3 sem. hrs.

MAT 543. ANALYTICAL MECHANICS OF COMPOSITE MATERIALS: 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: EGM 303 or EGM 330. 3 sem. hrs.

MAT 544. MECHANICS OF COMPOSITE STRUCTURES: 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: MAT 543 or consent of instructor. 3 sem. hrs.

MAT 550. MATERIALS ENGINEERING PROJECT: Student participation in a mterials engineering project under the direction of a project advisor. The student prepares a satisfactory written report, as determined by the project advisor, and presents an open seminar on the subject of the project. 1-6 sem. hrs.

MAT 560. DYNAMIC BEHAVIOR OF MATERIALS: Introduction to impact phenomena, characteristics of elastic stress waves in bars, elastic-plastic stress waves in bars and plates, introduction to shock waves, material characterization at high strain rates, experimental techniques, and material models for ductile and brittle solids, impact on ductile, brittle, and composite materials, computer codes for impact simulation.
3 sem. hrs.

MAT 562. SHOCK WAVES AND PENETRATION MECHANICS: Shock waves in ductile, brittle and composite materials, penetration mechanics of projectiles in metals, composites, and brittle materials, analytical and computational modeling.
Prerequisite: MAT 560. 3 sem. hrs.

MAT 570. FRACTURE MECHANICS: 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: MAT 506 or consent of instructor. 3 sem hrs.

MAT 575. FRACTURE AND FATIGUE OF METALS AND ALLOYS I: 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. Various analytical techniques for failure analysis of structural components will be presented. A practical failure-analysis project will be performed.
Prerequisite: MAT 501, MAT 506 or consent of instructor. 3 sem. hrs.

MAT 576. FRACTURE AND FATIGUE OF METALS AND ALLOYS II: 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 failure analysis will

also be covered. A comprehensive project in failure-analysis of aerospace metallic components will also be conducted.
Prerequisite: MAT 575 or equivalent. 3 sem. hrs.

MAT 577 LIGHT STRUCTURAL METALS: This course is an introduction and review of light structural metals, commonly used throughout the aerospace and the automotive industries. It will include the metallurgy 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 will be presented.
Prerequisites: MAT 501, MAT 502. 3 sem. hrs.

MAT 579 MATERIALS FOR ADVANCED ENERGY APPLICATIONS: Various advanced energy technologies (AMTEC, Fuel Cells, Thermoelectrics, Nuclear, etc.) will be discussed with an emphasis on the role that materials have/will play in their development. Critical "bottlenecks" in materials development delaying the introduction of new advanced energy systems will be identified. In addition, how material selections are made based on operational system environments in "real world" scenarios will be presented.
Prerequisites: MAT 501 and MAT 502 or consent of instructor 3 sem. hrs.

MAT 580 POLYMER DECOMPOSITION, DEGRADATION, AND DURABILITY: 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, biodegradation, high energy radiation, and physical aging.
Prerequisites: MAT 509, MAT 510 3 sem hrs.

MAT 581 INTRODUCTION TO NANOELECTRONICS: 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.
Prerequisites: ECE 506 3 sem. hrs.

MAT 589 GRADUATE SEMINAR SERIES: Graduate seminars on various current material topics presented by guest speakers. 1 sem. hr.

MAT 590 SELECTED READINGS IN MATERIALS ENGINEERING: Directed readings in selected areas of materials engineering arranged and approved by the student's advisor and the program director. 1-3 sem. hrs.

MAT 595 SPECIAL PROBLEMS IN MATERIALS ENGINEERING: Special assignments arranged by the materials engineering faculty. 1-3 sem. hrs.

MAT 599 THESIS 3-6 sem. hrs.

MAT 601 SURFACE CHEMISTRY OF SOLIDS: 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: MAT 501 or consent of instructor. 3 sem. hrs.

MAT 602 ELECTRONIC PROPERTIES OF MATERIALS: An introduction to quantum mechanics, the electronic properties of isolated atoms, and the evolution of these properties in the formation of condensed matter. Topics covered include an introduction to quantum mechanics, the hydrogen atom, the periodic table, free electron theory of metals, band theory of solids, semiconductors, dielectric materials, magnetic materials, lasers, and optoelectronics.
Prerequisites: College physics, calculus and differential equations. 3 sem. hrs.

MAT 603 MATERIALS SCIENCE OF THIN FILMS: 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.
Prerequisites: College physics, fundamental physical and chemical properties of materials. 3 sem. hrs.

MAT 604 NANOSTRUCTURED MATERIALS: A graduate-level course covering the fundamental physics, properties, and applications of nanostructured materials. Includes carbon nanotubes, nanostructured ceramics, metals, and semiconductor materials.
Prerequisites: College physics, fundamental physical and chemical properties of materials. 3 sem. hrs.

MAT 605 INTRODUCTION TO CARBON NANOTECHNOLOGY: A 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 nano scale technologies. Some of the medical field, structural and friction application will be addressed. This course is aimed at both science and engineering students. 3 sem. hrs.

MAT 690 SELECTED READINGS IN MATERIALS ENGINEERING: Directed readings in materials engineering area arranged and approved by the chair of the student's advisory committee and the program director. May be repeated. 1-3 sem hrs.

MAT 695 SPECIAL PROBLEMS IN MATERIALS ENGINEERING: Special assignments in materials engineering subject matter arranged and approved by the student's doctoral advisory committee and the program director. May be repeated.
1-3 sem. hrs.

MAT 698 D.E. DISSERTATION: An original investigation as applied to materials engineering practice. Results must be of sufficient importance to merit publication.
1-15 sem. hrs.

MAT 699 Ph.D. DISSERTATION: An original research effort which makes a definite contribution to technical knowledge. Results must be of sufficient importance to merit publication. 1-15 sem. hrs.