MATERIALS SCIENCE AND ENGINEERING

ECH 6726 Interfacial Phenomena I 3 Credits
Grading Scheme: Letter Grade
Introduction to the forces responsible for unique physical properties at interfaces, including wetting phenomena, the adsorption of polymers and surface-active molecules at interfaces, and the structure of these solutions.

ECH 6727 Interfacial Phenomena II 3 Credits
Grading Scheme: Letter Grade
Discussion on the forces responsible for unique physical properties at solid-liquid interfaces and their application in various engineering problems. Topics include the role and application of colloids, spreading of liquids on surfaces, lubrication, flotation, and nanomaterial synthesis.

EGN 5949 Practicum/Internship/Cooperative Work Experience 1-6 Credits, Max 6 Credits
Grading Scheme: S/U
Practical cooperative engineering work under approved industrial and faculty supervision.
Prerequisite: graduate student.

EGN 6640 Entrepreneurship for Engineers 3 Credits
Grading Scheme: Letter Grade
Introduction to entrepreneurship, idea generating and feasibility analysis, and business planning. Lectures, case studies, student-led discussions, team business plans, and investor presentations.

EGN 6913 Engineering Graduate Research 0-3 Credits, Max 12 Credits
Grading Scheme: S/U
Course will provide the student with supervised research in a laboratory setting.

EMA 5095 Critical Analysis of Research in Materials Science & Engineering 3 Credits
Grading Scheme: Letter Grade
Critical methods for reviewing technical papers, for writing effective technical papers, and for developing meaningful research projects, in the field of materials science and engineering.
Corequisite: EMA 6313

EMA 6001 Properties of Materials - A Survey 3 Credits
Grading Scheme: Letter Grade
Review of physical properties of materials such as mechanical, electrical, optical, magnetic, and thermal properties.
Prerequisite: Bachelor's degree in physics, chemistry, or engineering.

EMA 6005 Thin and Thick Films 3 Credits
Grading Scheme: Letter Grade
Techniques for depositing thin metallic semiconductor and dielectric films. The relationships between deposition technique and thin film properties. Properties unique to thin films.
Prerequisite: (EMA3010 & CHM2046 & PHY2048) or equivalents

EMA 6105 Fundamentals and Applications of Surface Science 3 Credits
Grading Scheme: Letter Grade
Fundamental and experimental description of phenomena occurring at surface of solids, including structure, composition, atomic and molecular processes, and electronic properties. Experimental approaches and data used to support theoretical models.
Prerequisite: (CHM2045 & MAP2302) or equivalents or consent of instructor

EMA 6106 Advanced Phase Diagrams 3 Credits
Grading Scheme: Letter Grade
Phase diagrams considering systems with as many as four components; emphasis on pressure temperature composition diagrams.
Prerequisite: (EMA4120 & EMA4224) or equivalents

EMA 6107 High Temperature Materials 3 Credits
Grading Scheme: Letter Grade
Physical and mechanical metallurgy. Principles of strengthening alloys, alloy and process selection, alloy development, and design principles for elevated temperature applications.
Prerequisite: (EMA4120 & EMA4224) or equivalents

EMA 6110 Electron Theory of Solids for Materials Scientists I 3 Credits
Grading Scheme: Letter Grade
Wave equation and its application to free electrons, bound electrons, and electrons in crystals. Electron-band theory and its applications. Electrical properties of metals, alloys, and semiconductors, heat capacity and thermal properties.
Prerequisite: (EMA3010 & MAP2302 & PHY2049) or equivalents

EMA 6111 Electron Theory of Solids for Materials Scientists II 3 Credits
Grading Scheme: Letter Grade
Atomistic (classical) and electron theory of optical properties of metals, alloys, and dielectrics. Nonlinear optics, lasers. Raman-spectra.

EMA 6114 Properties of Functional Materials 3 Credits
Grading Scheme: Letter Grade
The course will cover fundamental principles governing the structure of materials and its implications on properties. Structure-property relations will be showcased by covering the mechanical properties of materials.
Prerequisite: EMA 6313 or EMA 6001 or an undergraduate class in electronic materials, solid state physics, quantum mechanics or a related topic.

EMA 6128 Materials Microstructures 3 Credits
Grading Scheme: Letter Grade
Geometry of microstructures: kinematics and kinetics of microstructural evolution in materials processing.
Prerequisite: EMA 6316 or equivalent.

EMA 6136 Diffusion, Kinetics, and Transport Phenomena 3 Credits
Grading Scheme: Letter Grade
Physical basis, equation, and theories of diffusion, tracer, chemical, multicomponent, and multiphase diffusion in general force fields.
Prerequisite: EMA 4125 or equivalent.

EMA 6165 Polymer Physical Science 3 Credits
Grading Scheme: Letter Grade
Solid state properties of amorphous and semi-crystalline polymers.
Prerequisite: EMA3066 or equivalent

EMA 6166 Polymer Composites 3 Credits
Grading Scheme: Letter Grade
Physical and mechanical properties of polymers and polymer composites as related to preparation and microstructure.

EMA 6227 Advanced Mechanical Metallurgy II 3 Credits
Grading Scheme: Letter Grade
Continuation of EMA 6226.

EMA 6265 Mechanical Properties of Polymers 3 Credits
Grading Scheme: Letter Grade
Linear and nonlinear viscoelastic behavior of polymers with emphasis on molecular and microstructure aspects.
Prerequisite: EMA 3066 or equivalent.

EMA 6313 Structure and Mechanical Properties of Materials 3 Credits
Grading Scheme: Letter Grade
Covers fundamental principles governing the structure of materials and its implications on properties. Structure-property relations will be showcased by covering the mechanical properties of materials.

EMA 6316 Materials Thermodynamics 3 Credits
Grading Scheme: Letter Grade
Thermodynamics of materials systems, surfaces in solids, irreversible processes.
Prerequisite: EMA4314 or equivalent

EMA 6412 Synthesis and Characterization of Electronic Materials 3 Credits
Grading Scheme: Letter Grade
Principles of materials growth and characterization in electronic and photonic industries. Bulk and epitaxial growth technologies, corresponding characterization methods for evaluation and quality control. Theoretical bases for these techniques.
Prerequisite: (EMA3413 & EMA4314) or equivalents

EMA 6416 Organic Electronics 3 Credits
Grading Scheme: Letter Grade
Basics of semiconductors, electronic structures, charge transport properties, and optoelectronic devices based on organic semiconductors.
Prerequisite: EMA3413 or equivalent

EMA 6445 Electroceramics 3 Credits
Grading Scheme: Letter Grade
Basic physical, chemical and mathematical principles of ceramic conductors, dielectrics and ferroelectrics and their applications are discussed. Emphasizes structure-processing-microstructure property relationships.

EMA 6446 Solid State Ionics 3 Credits
Grading Scheme: Letter Grade
Defect solid state and its relation to electronic properties of ceramic materials; defect equilibria and transport; influence of chemical and electric potentials and interfaces; and application of ionically conducting solids in solid-state electrochemical transducer systems and devices.
Prerequisite: EMA 6316 or equivalent, or consent of instructor.

EMA 6448 Ceramic Processing 3 Credits
Grading Scheme: Letter Grade
Introduction to the science of ceramic processing, with emphasis on theoretical fundamentals. Examples of state-of-the-art industrial processes discussed.

EMA 6461 Polymer Characterization 3 Credits
Grading Scheme: Letter Grade
Use of a broad variety of spectroscopic and other scattering phenomena in polymer research.
Prerequisite: EMA3066 or equivalent

EMA 6507 Scanning Electron Microscopy and Microanalysis 3 Credits
Grading Scheme: Letter Grade
Principles and theories of microscopy with an emphasis on scanning electron microscopy (SEM). Provides the necessary theoretical background to become an effective user of MAIC SEM facilities.
Prerequisite: EMA3010 or equivalent

EMA 6507L Scanning Electron Microscopy and Microanalysis Lab 1 Credit
Grading Scheme: Letter Grade
Practical training to become a proficient user of MAIC SEM facilities, leading to an authorization as a JEOL SEM-6400 user at the MAIC.
Corequisite: EMA 6507.

EMA 6510 Survey of Materials Analysis Techniques 3 Credits
Grading Scheme: Letter Grade
Principles and techniques used in characterization of materials. Chemical, microstructural, and surface analysis of materials; metals, ceramics, polymers, and semiconductor systems.
Prerequisite: EMA3010 or equivalent

EMA 6516 X-Ray Methods for Materials Characterization 3 Credits
Grading Scheme: Letter Grade
Provides an introduction to the principles and methods of materials characterization via x-ray interactions. The course will focus primarily on diffraction and scattering techniques for crystallographic and thin film analysis.

EMA 6516L X-Ray Methods Laboratory for Materials Characterization 1 Credit
Grading Scheme: Letter Grade
Provides an introduction to the practical use of xray diffraction for materials characterization.
Prerequisite: EMA6XXX - X-Ray Methods for Materials Characterization

EMA 6518 Transmission Electron Microscopy 3 Credits
Grading Scheme: Letter Grade
Instrumentation associated with transmission electron microscopy. Kinematical and dynamical theories of diffraction contrast and their application. Diffraction analysis in TEM for structural determination. Analytical techniques for obtaining structural and compositional information at high spatial resolution. Phase contrast and high resolution electron microscopy.
Prerequisite: EMA 3513C or equivalent.

EMA 6518L Transmission Electron Microscopy Laboratory 1 Credit
Grading Scheme: Letter Grade
Specimen preparation for analysis in TEM. Demonstration of principles of contrast theories. Specialized methods for characterizing structure and composition of materials at high spatial resolution.

EMA 6519L Specialized Research Techniques in Materials Science 1-2 Credits
Grading Scheme: Letter Grade
Utilizing primarily STEM, TEM, SEM, EMP, FIM, and optical metallography.
Prerequisite: EMA 6507C or equivalent.

EMA 6540 Fundamentals of Crystallography 3 Credits
Grading Scheme: Letter Grade
The course will cover the derivation and analysis of structure-property relationships in common electroceramic material systems based on their crystal structure, symmetry and anisotropy.

EMA 6541 Applied Crystallography and Powder Diffraction 3 Credits
Grading Scheme: Letter Grade
Explores crystal structures, microstructures, and diffraction. Emphasizes the determination of structure from diffraction patterns. Hands-on and practical applications directly related to graduate student research are integrated components of the course.

EMA 6580 Science of Biomaterials I 3 Credits
Grading Scheme: Letter Grade
Introduction to variables that control compatibility and performance of biomaterials, including physical and chemical properties, corrosion, fatigue, and interfacial histochemical changes.
Prerequisite: (CHM2045 or CHM2095) or equivalent

EMA 6581 Polymeric Biomaterials 3 Credits
Grading Scheme: Letter Grade
Biomedical implant and device applications of synthetic and natural polymers. Biocompatibility and interfacial properties of polymers in physiological environment, especially concerning short-term devices (catheters) and long-term implants (intraocular lenses, vascular and mammary prostheses, etc.).
Prerequisite: ((CHM2045 or CHM2095) & EMA3066) or equivalents

EMA 6583 The Science of Cell Material Interactions 3 Credits
Grading Scheme: Letter Grade
Biological aspects of the various processes involved as cells interact with biomaterial. Interactions of materials with biological systems examined from the molecular (e.g. protein), cellular, tissue and systemic (whole body) perspectives.
Prerequisite: Bachelor's degree in materials science and engineering or biomedical engineerng or related field.

EMA 6589 Mechanical Behavior of Biomaterials 3 Credits
Grading Scheme: Letter Grade
Basis for elastic and viscoelastic response of biological materials to stress and strain. Foundation for composite behavior of organic-organic and organic-inorganic materials. Description of modeling biological structures to achieve mechanical optimization.
Prerequisite: EMA 4223 or equivalent.

EMA 6590 Advances in Biomaterials and Tissue Engineering for Healthcare 3 Credits
Grading Scheme: Letter Grade
Use of new bioactive and bio-nano structures, surfaces and properties for healthcare applications, including tissue engineering, regenerative medicine, stem cell engineering, protein therapeutics, and bio-photonics testing of cell-material interactions. Socio-economic issues affecting cost and availability of new materials and technologies for healthcare.

EMA 6616 Advanced Electronic Materials Processing 3 Credits
Grading Scheme: Letter Grade
Materials requirements for high speed devices and processing modules needed for their fabrication. Examples of current industrial processes.
Prerequisite: EMA3413 or equivalent

EMA 6625 Advanced Metals Processing 3 Credits
Grading Scheme: Letter Grade
Advanced treatment of solidification phenomena during metals processing. Topics to include nucleation, kinetics, solidification structure, segregation, and effects of processing variables on structure and properties.
Prerequisite: (EMA4120 & EMA4224) or equivalents

EMA 6667 Polymer Processing 2-3 Credits, Max 3 Credits
Grading Scheme: Letter Grade
Major processing methods for polymers and polymeric composites as related to the rheological behavior of these systems. Synthesis of polymers via industrial processes.
Prerequisite: EMA 3066 or equivalent.

EMA 6715 Fracture of Brittle Materials 3 Credits
Grading Scheme: Letter Grade
Latest concepts in deformation, fracture, and toughening of brittle materials. Application of fracture mechanics and fractals to failure of brittle materials. Development of an approach to failure analysis for brittle materials.
Prerequisite: EMA 4223, EGM 3520, or equivalent.

EMA 6803 Classical Methods in Computational Materials Science 3 Credits
Grading Scheme: Letter Grade
Proficiency developing and using common tools for computational materials research at the atomic level.

EMA 6804 Quantum Methods in Computational Materials Science 3 Credits
Grading Scheme: Letter Grade
Theory, methods, and application of common quantum mechanical software (GAUSSIAN and VASP) for computational study of materials.
Prerequisite: EMA 6313, C/C++, Fortran, or other suitable scientific programming language.

EMA 6808 Error Analysis and Optimization Methodologies in Materials Research 3 Credits
Grading Scheme: Letter Grade
Statistical approach to materials research, basic and relevant statistical concepts, error analysis, factorial matrices, reducing variance, nested designs and sampling plans, mixture designs, optimization techniques, response surface method, and Taguchi method.

EMA 6905 Individual Work in Materials Science and Engineering 1-4 Credits, Max 8 Credits
Grading Scheme: Letter Grade
Individual Work in Materials Science and Engineering

EMA 6910 Supervised Research 1-5 Credits, Max 5 Credits
Grading Scheme: S/U
Supervised Research

EMA 6920 Professional Development for Materials Science and Engineering 1 Credit
Grading Scheme: S/U
Professional development training as a graduate student in Materials Science and Engineering, including serving as teaching assistant in the instruction of materials science and engineering courses, and developing and defending research proposals.
Prerequisite: Graduate Status

EMA 6936 Seminar in Materials Science and Engineering 1 Credit, Max 14 Credits
Grading Scheme: S/U
Offered in fall and spring. Required of all students.

EMA 6938 Special Topics in Materials Science and Engineering 1-4 Credits, Max 6 Credits
Grading Scheme: Letter Grade
Special Topics in Materials Science and Engineering

EMA 6941 Supervised Teaching 1-5 Credits, Max 5 Credits
Grading Scheme: S/U
A supervised teaching experience.

EMA 6971 Research for Master's Thesis 1-15 Credits
Grading Scheme: S/U
Research for Master's Thesis

EMA 7979 Advanced Research 1-12 Credits
Grading Scheme: S/U
Research for doctoral students before admission to candidacy. Designed for students with a master's degree in the field of study or for students who have been accepted for a doctoral program. Not appropriate for students who have been admitted to candidacy.

EMA 7980 Research for Doctoral Dissertation 1-15 Credits
Grading Scheme: S/U
Research for Doctoral Dissertation

ENU 6805 Introduction to Nuclear Reactor Materials 3 Credits
Grading Scheme: Letter Grade
Introducing the materials used in nuclear energy systems and their response to the reactor environment. The majority of materials related issues encountered in the nuclear power plants are discussed in this course.