MSEN 601 Fundamental Materials Science and Engineering
Credits 4.4 Lecture Hours.
Prerequisite: Graduate classification.

MSEN 602 Advanced Materials Science and Engineering
Credits 4.4 Lecture Hours.
Fundamentals of quantum mechanics, physics of solid state, and physical electronics and photonics for advanced materials. Topics will include: basic quantum mechanical problems, quantum basis for structural and physical properties of solids, lattice vibrational effects in solids, free electron model for magnetism in solids, semiconductor materials and devices, nanostructures and mesoscopic phenomena, superconductivity, recent advances in new types of materials.
Prerequisite: MSEN 604, undergraduate quantum mechanics course, or approval of instructor.

MSEN 603 Fundamentals of Soft and Biomaterials
Credits 3.3 Lecture Hours.
Introductory graduate-level survey on the general areas of soft materials and biomaterials; includes basic concepts of colloidal particle physics, polymer physics and chemistry, and general concepts in biomaterials.
Prerequisites: Undergraduate general chemistry course; graduate classification.

MSEN 604 Quantum Mechanics for Materials Scientists
Credits 3.3 Lecture Hours.
Provides a background in quantum mechanics for graduate materials scientists or engineers with little or no quantum mechanics background. The following topics will be covered: origins of quantum theory, interpretation, Schroedinger equation and its applications, operator mechanics, approximation methods, angular momentum, the hydrogen atom, and quantum statistics.
Prerequisites: MATH 601, MATH 311 or approval of instructor; graduate classification.

MSEN 606 Multifunctional Materials
Credits 3.3 Lecture Hours.
In-depth analysis of multifunctional materials and composites, and their novel applications.
Prerequisites: MEMA 602/AERO 603/AERO 603/MEMA 602, MSEN 601.
Cross Listing: AERO 606 and MEMA 606.

MSEN 607/MEE 607 Polymer Physical Properties
Credits 3.3 Lecture Hours.
Macromolecular concepts; molecular weight characterization; solubility parameters; phase diagrams; viscoelasticity; rheology; thermal behavior; damage phenomena; morphology; crystallization; liquid crystallinity; nanocomposites.
Prerequisites: MEEN 222 (or other intro to materials science course).
Cross Listing: MEEN 607/MSEN 607.

MSEN 608 Nanomechanics
Credits 3.3 Lecture Hours.
Application of mechanics concepts to nano-scale behavior of materials. Review of continuum mechanics; Extensions to generalized continua; Nonlocal elasticity; Nano-scale plasticity. Focus on multi-scale modeling: Dislocation Dynamics; Quasi-Continuum method; Molecular dynamics with introductions to quantum mechanics and statistical mechanics.
Prerequisite: AERO 603/MEMA 602.
Cross Listing: AERO 608 and MEMA 608.

MSEN 612/BIO 602 Fundamentals of Transmission Electron Microscopy
Credits 3.2 Lecture Hours. 2 Lab Hours.
(2-6) State-of-the-art fundamentals in TEM; theoretical background supporting a strong hands-on course component comprising specimen preparation and image acquisition/interpretation; practical experience to attain a proficiency level permitting independent operation of one of the transmission electron microscopes in the Microscopy and Imaging Center.
Prerequisite: Graduate classification or approval of instructor.
Cross Listing: BIOL 602/MSEN 612.

MSEN 613/BIO 603 Advanced Transmission Electron Microscope (TEM) Methodologies in Life and Materials Science (TEM II)
Credits 3.1 Lecture Hour. 6 Lab Hours.
Advanced TEM methodologies, including specimen preparation and TEM imaging/analysis techniques as applicable to both biological and material samples; theory designed to support a strong hands-on component comprising specimen preparation, different imaging/diffraction/ spectroscopic techniques and data interpretation.
Prerequisite: BIOL 602/MSEN 612 or MSEN 612/BIO 602.
Cross Listing: BIOL 603/MSEN 613.

Credits 2.1 Lecture Hour. 3 Lab Hours.
Fundamentals of Scanning Electron Microscopy (SEM) and Environmental Scanning Electron Microscopy (ESEM). Provides biologists, material scientists and students from other disciplines with the techniques of operation of the scanning electron microscope (SEM) and the environmental SEM (ESEM) coupled with the appropriate theoretical background knowledge; individual instruction in support of their research endeavors involving SEM/ESEM.
Prerequisite: Graduate classification.
Cross Listing: BIOL 604/MSEN 614.

MSEN 616/MEEN 616 Surface Science
Credits 3.2 Lecture Hours. 2 Lab Hours.
Properties of surfaces, principles of classic and contemporary surface characterization techniques, recent development and roles of surface science in advanced technology.
Prerequisite: Graduate classification.
Cross Listing: MEEN 616/MSEN 616.
MSEN 618/MEEN 686 Composite Materials Processing and Performance  
Credits 3.3 Lecture Hours.  
Fundamental science and design; processing and design interaction regarding multiphase composites; processing science, experimental characterization, laminate analysis; design structure and processing.  
Prerequisite: Elasticity, continuum mechanics, or equivalent; graduate classification.  
Cross Listing: MEEN 686/MSEN 618.

MSEN 619 Materials Modeling of Phase Transformation and Microstructural Evolution  
Credits 3.3 Lecture Hours.  
Computer modeling and simulation of microstructural evolution during various phase transformation processes in solid materials, including spinodal decomposition, ordering, martensitic transformation, ferroelectric and ferromagnetic domain evolution, dislocation dynamics, and crack propagation.  
Prerequisites: Graduate classification and approval of instructor.  
Cross Listing: MEEN 620/MSEN 620.

MSEN 620/MEEN 620 Kinetic Processes in Materials Science  
Credits 3.3 Lecture Hours.  
Atomistic and mesoscale levels; foundation for microstructural evolution and behavior of materials; basic and irreversible thermodynamics; diffusion equations solutions; atomic diffusion, nucleation; phase transformations: gas-solid, liquid-solid and solid-solid reactions; FiPy (finite volume solver for PDE) to simulate kinetic processes.  
Prerequisites: MEEN 222 or equivalent materials science course; preliminary general thermodynamics course is not necessary.  
Cross Listing: MEEN 620/MSEN 620.

MSEN 625/MEEN 625 Mechanical Behavior of Materials  
Credits 3.3 Lecture Hours.  
Examination of deformation and microstructure mechanisms responsible for deformation and failure in metals; fatigue, creep, and fracture mechanisms of materials; emphasis on microstructural-mechanical property relationship.  
Prerequisite: Undergraduate-level materials science course.  
Cross Listing: MEEN 625/MSEN 625.

MSEN 626/MEEN 606 Polymers Laboratories  
Credits 3.2 Lecture Hours. 3 Lab Hours.  
Introduction to basic experimental skills relating to polymers; experiments include polymerization, molecular weight determination, FTIR, tensile test, NMR, DSC, swelling index, viscosity, x-ray diffraction.  
Prerequisite: Graduate classification.  
Cross Listing: MEEN 606/MSEN 626.

MSEN 636 Damage Mechanics and Failure in Composite Materials  
Credits 3.3 Lecture Hours.  
Mechanisms and models related to damage and failure in composite materials subjected to mechanical loads.  
Prerequisites: Courses in composite materials, elasticity; graduate classification.  
Cross Listing: AERO 616 and MEMA 616.

MSEN 640/MEEN 640 Thermodynamics in Materials Science  
Credits 3.3 Lecture Hours.  
Use of thermodynamic methods to predict behavior of materials; codification of thermodynamic properties into simplified models; principles, methods, and models to generate accurate equilibrium maps through computational thermodynamics software; applications to bulk metallic, polymeric and ceramic materials, defects, thin films, electrochemistry, magnetism.  
Prerequisites: MEEN 222 or equivalent; graduate classification.  
Cross Listing: MEEN 640/MSEN 640.

MSEN 641 Plasticity Theory  
Credits 3.3 Lecture Hours.  
Theory of plastic yield and flow of two and three-dimensional bodies; classical plasticity theories, unified viscoplastic theories, numerical considerations; applications and comparisons of theory to experiment.  
Prerequisite: MEMA 602/AERO 603.  
Cross Listing: MEEN 666 and MEMA 641.

MSEN 656/MEEN 656 Mechanical and Physical Properties of Thin Films  
Credits 3.3 Lecture Hours.  
Mechanical properties (hardness, stress, strain, delamination, fracture) of films; nanomechanical testing techniques; electrical properties of thin films; electrical properties measurement techniques; magnetic properties of films; magnetic properties measurement techniques; laboratory includes (1) thin film fabrication (sputtering, PVD); (2) nanomechanical testing; (3) electrical/magnetic measurement.  
Prerequisite: MEEN 222, MSEN 601, or basic materials science background.  
Cross Listing: MEEN 656/MSEN 656.

MSEN 658/MEEN 658 Fundamentals of Ceramics  
Credits 3.3 Lecture Hours.  
Atomic bonding; crystalline and glassy structure; phase equilibria and ceramic reactions; mechanical, electrical, thermal, dielectric, magnetic, and optical properties; ceramic processing.  
Prerequisite: MEEN 222 or equivalent or approval of instructor.  
Cross Listing: MEEN 658/MSEN 658.

MSEN 670 Computational Materials Science and Engineering  
Credits 3.3 Lecture Hours.  
Modern methods of computational modeling and simulation of materials properties and phenomena, including synthesis, characterization, and processing of materials, structures and devices; quantum, classical, and statistical mechanical methods, including semi-empirical atomic and molecular-scale simulations, and other modeling techniques using macroscopic input.  
Prerequisites: Approval of instructor; graduate classification.  
Cross Listing: CHEN 670 and MEMA 670.

MSEN 681 Seminar  
Credit 1.1 Lecture Hour.  
Selected research topics in materials science and engineering presented by faculty, students, and outside speakers.  
Prerequisite: Graduate classification.

MSEN 684 Professional Internship  
Credits 1 to 9. 1 to 9 Other Hours.  
Directed internship in an industrial or laboratory setting under the supervision of successful, experienced personnel; work related to the student’s career aspirations and areas of specialization. May be taken 2 times for credit.  
Prerequisite: Graduate classification.
MSEN 685 Directed Studies
Credits 1 to 12. 1 to 12 Other Hours.
Special topics not within the scope of thesis research and not covered by other formal courses.
Prerequisite: Graduate classification.

MSEN 689 Special Topics in...
Credits 1 to 4. 1 to 4 Lecture Hours.
Selected topics in an identified area of materials science and engineering. Potential topics include: advanced phase transformations, advanced materials and processing, nanomaterials and nanotechnologies, computational modeling of materials, advanced techniques of spectroscopy, surface and interface phenomena, thin film processing, ceramic engineering, organic materials for electronic and photonic devices, biomedical microdevices, materials fabrication, processing and fabrication of semiconductors, and materials and processing for MEMS. May be repeated for credit.
Prerequisite: Approval of instructor.

MSEN 691 Research
Credits 1 to 23. 1 to 23 Other Hours.
Research toward thesis or dissertation.