

MSEN - MATERIALS SCIENCE & ENGR

MSEN 601 Fundamental Materials Science and Engineering

Credits 3. 3 Lecture Hours. Fundamentals of microstructure- properties and relationship of materials; topics include electronic and atomic structure of solids, structure of crystalline materials, imperfections in crystalline materials, introduction to dislocation theory, mechanical properties, fundamental thermodynamics of materials, phase equilibria and diagrams, diffusion, and kinetics of phase transformations.

Prerequisite: Graduate classification.

MSEN 602 Physics of Materials

Credits 3. 3 Lecture Hours. Understanding of modern molecular level description of underlying physico-chemical behavior and properties of materials; includes thermal, mechanical, kinetic (transport), electronic, magnetic and optical properties; rational basis for the synthesis, characterization and processing of such material, materials systems for engineering applications. **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; also taught at Qatar campus.

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; topics include origins of quantum theory, interpretation, Schrodinger 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 605 Field Theories in Materials Science

Credits 3. 3 Lecture Hours. Field theory concepts to understand and quantify a wide range of material behaviors, including, transportable quantities; development of constitutive relations; linear response theory and Maxwell's equations; deformation and motion of a continuum; Brownian motion; self-assembly and patterning within reaction-diffusion formulations; thermal and ion/charge transport; acoustic waves in solids; Fourier's equations. **Prerequisites:** Basic courses in materials science; graduate classification.

MSEN 606 Multifunctional Materials

Credits 3. 3 Lecture Hours. In-depth analysis of multifunctional materials and composites, and their novel applications. **Prerequisites:** AERO 603 or MEMA 602, MSEN 601. **Cross Listing:** AERO 606 and MEMA 606.

MSEN 607/MEEN 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/MSEN 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. **Cross Listing:** AERO 608 and MEMA 608.

MSEN 610/MEMA 613 Principles of Composite Materials

Credits 3. 3 Lecture Hours. Classification and characteristics of composite materials; micromechanical and macromechanical behavior of composite laminate; macromechanical behavior of laminates using classical laminate theory; interlaminar stresses and failure modes; structural design concepts, testing and manufacturing techniques. **Prerequisite:** Graduate classification; MEMA 602, or approval of instructor. **Cross Listing:** MEMA 613/MSEN 610.

MSEN 612 Fundamentals of Transmission Electron Microscopy

Credits 3. 2 Lecture Hours. 6 Lab Hours. 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.

MSEN 614 Fundamentals of Scanning Electron Microscopy and Environmental Scanning Electron Microscopy

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.

MSEN 615 Defects in Solids

Credits 3. 3 Lecture Hours. Overview of point, line and surface defects in solids; relation of defect properties to diffusion, deformation, phase transformations; focus on atomic defects in crystals, with additional examples from liquid crystals, superconductors and ferromagnets; incorporation of atomistic modeling to examine defect structure. **Prerequisites:** Grade of C or better in MSEN 601; graduate classification or approval of instructor.

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 617 Crystallography and Crystal Structure Determination

Credits 3. 3 Lecture Hours. Symmetry operations in point group and space group; reciprocal lattice and kinematical diffraction theory; crystal structure determination by X-ray diffraction and transmission electron microscopy (TEM). **Prerequisites:** Knowledge of calculus and vector algebra; graduate classification.

MSEN 618 Composites Processing and Performance

Credits 3. 3 Lecture Hours. Fundamental science and design of composites; processing and design interaction about multiphase composites; processing science, experimental characterization, laminate analysis; design structure and processing. **Prerequisite:** Graduate classification.

MSEN 619/NUEN 660 Materials Modeling of Phase Transformation and Microstructural Evolution

Credits 3. 3 Lecture Hours. Modeling and simulation of microstructural evolution during phase transformation in solids; spinodal decomposition, ordering, martensitic transformation, ferroelectric and ferromagnetic domain evolution, dislocation dynamics and crack propagation; primary focus on finite-element and phase-field methods. **Prerequisites:** Graduate classification and approval of instructor. **Cross Listing:** NUEN 660/MSEN 619.

MSEN 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; atomistic 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/MSEN 222 or equivalent materials science course; preliminary general thermodynamics course is not necessary.

MSEN 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.

MSEN 626 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.

MSEN 628 Techniques for Polymer and Soft Matter Characterization

Credits 3. 3 Lecture Hours. Basic concepts and practical aspects in analysis of macromolecules and colloids, including spectroscopic analysis of chemical composition, determination of molecular weights and measurements of dynamics; presentation of various types of material characterization using Fourier Transform Infrared Spectroscopy in transmission and in attenuated total reflection mode; introduction and comparison of the application of scattering techniques, such as small angle X-ray scattering, neutron scattering and light scattering for analysis of soft materials; introduction to basic techniques of thermomechanical characterization of soft materials; emphasis on practical aspects in selection and use of specific characterization techniques. **Prerequisites:** MSEN 603; graduate classification or approval of instructor.

MSEN 630 Nanomaterials Science

Credits 3. 3 Lecture Hours. Nanotechnology and nanomaterials; types, fabrication, characterization methods and applications; current roles in technology and future impact of such systems on industry targeting. **Prerequisite:** Graduate classification.

MSEN 634 Nano-scale Phenomena in Polymeric Systems

Credits 3. 3 Lecture Hours. Fundamental and practical knowledge related to nano-scale phenomena in polymeric systems; discussions and critiques on related research activities; preparation for nanotechnology related career. **Prerequisite:** Approval of instructor.

MSEN 635 Flow and Fracture of Polymeric Solids

Credits 3. 3 Lecture Hours. Relationship of molecular structure to flow and fracture in polymeric materials; introduction of viscoelastic fracture mechanics; micromechanisms of fracture including crazing; fatigue behavior of polymeric materials.

MSEN 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/MSEN 222 or equivalent; graduate classification.

MSEN 643 Materials Electrochemistry and Corrosion

Credits 3. 3 Lecture Hours. Survey of thermodynamic and kinetic fundamentals of electrochemistry; multiscale materials corrosion mechanisms; details of interfacial aqueous electrochemical mechanisms and the environmental effects when materials are exposed to different conditions. **Prerequisite:** Grade of C or better in MSEN 601; or approval of instructor.

MSEN 644 Corrosion and Electrochemistry Lab

Credits 3. 2 Lecture Hours. 3 Lab Hours. Laboratory practice and principles for corrosion and electrochemistry methods; design, carry out and analyze a series of labs illustrating the most important techniques in the field; builds to an open-ended corrosion engineering problem resulting in preparation of a technical report for a hypothetical client. **Prerequisite:** Grade of C or better in MSEN 643; or approval of instructor.

MSEN 645/AERO 645 Failure Mechanics of Engineering Materials

Credits 3. 3 Lecture Hours. Introduction and integration of key experimental, theoretical and computational aspects of failure in engineering materials, including metals, alloys and polymers; brittle fracture, ductile fracture and brittle-to-ductile transitions. **Prerequisites:** Graduate classification; MSEN 601. **Cross Listing:** AERO 645/MSEN 645.

MSEN 646 Corrosion Prevention and Control Methods

Credits 3. 3 Lecture Hours. Cathodic protection and coatings; functional engineering approach to controlling and preventing aqueous corrosion; impressed current, galvanic anodes, organic, inorganic and hybrid coatings; case studies in oil and gas, energy, automotive and different industries. **Prerequisite:** Grade of C or better in MSEN 643; or approval of instructor.

MSEN 648 Failure Analysis in Materials Science and Engineering

Credits 3. 3 Lecture Hours. Discussion of engineering systems failure and analysis in terms of design, manufacturing, and service environments; broad background to common mechanisms of material failures in mechanical, electrical and chemical applications; emphasis on case studies and specific engineering disasters. **Prerequisites:** MSEN 601; graduate classification, or approval of instructor.

MSEN 655 Materials Design Studio

Credits 3. 2 Lecture Hours. 3 Lab Hours. Project-driven studio based on the integration of informatics and engineering systems design to address problems in materials discovery and development; projects derived from real industry-driven needs. **Prerequisites:** Grade of C or better in ECEN 769/MSEN 660 or MSEN 660/ECEN 769, or MSEN 601 and MEEN 601, or equivalent; or approval of instructor.

MSEN 657 Multiscale Modeling in Materials

Credits 3. 2 Lecture Hours. 3 Lab Hours. Introduction to a wide range of computational methods to simulate materials behavior at multiple scales. **Prerequisite:** Approval of instructor.

MSEN 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/MSEN 222 or equivalent or approval of instructor.

MSEN 659 Materials Design ePortfolio

Credits 0. 0 Other Hours. Capture and reflect upon components of what has been learned; why it matters within an electronic portfolio aligned with learning outcomes of the interdisciplinary program. **Prerequisites:** Grade of C or better in ECEN 769/MSEN 660, MSEN 660/ECEN 769, or MSEN 601 and MEEN 601, or equivalent; MSEN 655 or concurrent enrollment; or approval of instructor.

MSEN 660/ECEN 769 Materials Informatics

Credits 3. 3 Lecture Hours. Use of informatics approaches to establish quantitative structure-property relations (QSPRs) in materials and materials systems; basic concepts of QSPRs and probability, supervised learning, unsupervised learning, optimal prediction and applications in materials discovery. **Prerequisite:** Approval of instructor. **Cross Listing:** ECEN 769/MSEN 660.

MSEN 666 Nanoindentation and Small-Scale Contact Mechanics

Credits 3. 3 Lecture Hours. Basic principles of elastic and plastic contact as they determine hardness and influence the measurement of mechanical properties by load and depth sensing indentation methods; application of nanoindentation techniques to small scale mechanical characterization of solid materials. **Prerequisites:** Grade of C or better in AERO 603, CVEN 613, MEEN 467, MEMA 602, MSEN 320, or MSEN 625; or approval of instructor.

MSEN 670/MEMA 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:** MEMA 670/MSEN 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 Other 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.