MSEN - MATERIALS SCIENCE & ENGR (MSEN)

MSEN 201 Fundamentals of Materials Science and Engineering

Credits 3. 3 Lecture Hours. Fundamental principles of materials science and engineering and their application toward complex engineering challenges; relationship between materials structure and structural and functional properties of engineered materials; property-performance relationships; principle classes of materials, as illustrated through key materials advances; current directions in the field. **Prerequisites:** Grade of C or better in CHEM 107 or CHEM 119 and PHYS 206.

MSEN 205 Materials in Society

Credits 2. 2 Lecture Hours. Introduction to the study and practice of materials science and engineering; current topics in materials research and development, focusing on the impact of advanced materials on engineering fields and society; application of scientific engineering principals to guiding materials engineering process, with examples drawn from real-life case studies. **Prerequisite:** Grade of C or better in MSEN 201, or concurrent enrollment; or approval of instructor.

MSEN 210 Thermodynamics of Materials

Credits 3. 3 Lecture Hours. Basic concepts and fundamental laws of thermodynamics; processes and thermodynamic engines; phase equilibria and phase diagrams of simple substances; chemical reactions of condensed phases; computational software for thermodynamic and phase diagram calculations. **Prerequisites:** Grade of C or better in MSEN 201, AERO 413, BMEN 343, CHEN 322, CVEN 306, MEEN 222/MSEN 222, MMET 206, MSEN 222/MEEN 222, or NUEN 265, or concurrent enrollment; grade of C or better in MATH 152 or concurrent enrollment.

MSEN 222/MEEN 222 Materials Science

Credits 3. 3 Lecture Hours. Mechanical, optical, thermal, magnetic and electrical properties of solids; differences in properties of metals, polymers, ceramics and composite materials in terms of bonding and crystal structure. **Prerequisites:** Grade of C or better in CHEM 107 or CHEM 119; grade of C or better in PHYS 206. **Cross Listing:** MEEN 222/MSEN 222.

MSEN 250 Soft Matter

Credits 3. 3 Lecture Hours. Structure, properties and function of various classes of soft matter including colloids, polymers, amphiphils, liquid crystals and biomacromolecules; basic concepts of viscoelasticity, glass transition, liquid-liquid and liquid-solid transitions and gelation; forces acting between mesoscopic objects; supramolecular self-assembly in soft condensed matter. **Prerequisites:** Grade of C or better in CHEM 120; MSEN 201, or concurrent enrollment.

MSEN 260 Structure of Materials

Credits 3. 3 Lecture Hours. Materials structure over many orders of scale; structure of non-crystalline materials; symmetry, unit cell and the atomic structure of crystalline materials; liquid crystals; structural defects in ordered solids; microstructures and hierarchical structures. **Prerequisites:** Grade of C or better in MSEN 201, AERO 413, BMEN 343, CHEN 322, CVEN 306, MEEN 222/MSEN 222, MMET 206, MSEN 222/MEEN 222, or NUEN 265, or concurrent enrollment.

MSEN 281 Materials Science and Engineering Seminar

Credit 1. 1 Other Hour. Presentation of technical advances in the field of materials science and engineering; applications toward solving engineering challenges; presentations from visiting industry, academic speakers, and faculty; introduction to current research themes and focal points in industry. **Prerequisite:** Grade of C or better in MSEN 201, or concurrent enrollment.

MSEN 285 Directed Studies

Credits 1 to 4. 1 to 4 Other Hours. Directed study of selected problems in the area of materials science and engineering. May be taken for credit 4 times. **Prerequisite:** Approval of instructor.

MSEN 289 Special Topics In...

Credits 1 to 3. 1 to 3 Lecture Hours. 0 to 3 Lab Hours. Selected topics in an identified area of materials science and engineering. May be repeated for credit. **Prerequisite:** Approval of instructor.

MSEN 291 Research

Credits 0 to 4. 0 to 4 Other Hours. Research conducted under the direction of faculty member in materials science and engineering. May be taken three times for credit. **Prerequisites:** Freshman or sophomore classification and approval of instructor.

MSEN 301 Unified Materials Lab I

Credits 3. 2 Lecture Hours. 3 Lab Hours. Integration of materials synthesis, structural characterization and property evaluation; theory and practice of experimental and simulation techniques; emphasis on relationship between processing parameters and resulting materials structure. **Prerequisites:** Grade of C or better in MSEN 210 and MSEN 260, or concurrent enrollment.

MSEN 302 Unified Materials Lab II

Credits 3. 2 Lecture Hours. 3 Lab Hours. Integration of materials synthesis, structural characterization and property evaluation; theory and practice of experimental and simulation techniques; emphasis on relationship between materials structure and resulting materials physical properties. **Prerequisite:** Grade of C or better in MSEN 301 and MSEN 380; grade of C or better in MSEN 320, or concurrent enrollment.

MSEN 305 Kinetics of Materials

Credits 3. 3 Lecture Hours. Application of physical principles that drive evolution of materials as they approach thermodynamic equilibrium states; includes Gibbs free energy, driving forces, point defects, diffusion in solids, interface and grain boundary motion, nucleation, growth, transformation diagrams, precipitation, phase separation, ordering and solidification. **Prerequisite:** Grade of C or better in MSEN 210.

MSEN 320 Deformation and Failure Mechanisms in Engineering Materials

Credits 3. 3 Lecture Hours. Survey of deformation and failure mechanisms in different materials, including metals, ceramics, polymers and composites; effect of atomistic structure, defects and microstructure on deformation and failure; deformation and failure mechanism maps and effects of temperature and deformation rate. **Prerequisite:** Grade of C or better in MSEN 260.

MSEN 325 Properties of Functional Materials

Credits 3. 3 Lecture Hours. Origins of functional materials properties from their electronic and molecular structure; electron theory in solids; electronic transport and dielectric behavior; optical and magnetic properties; current applications of functional materials. **Prerequisite:** Grade of C or better in MSEN 260.

MSEN 330 Numerical Methods for Materials Scientists and Engineers

Credits 3. 3 Lecture Hours. Computing platforms addressing scientific/engineering problems related to materials science and engineering; analyze data; implement mathematical models of materials behavior; numerical methods to solve materials-related problems. **Prerequisite:** Grade of C or better in MATH 307, MSEN 305, and MSEN 320.

MSEN 360 Materials Characterization

Credits 3. 2 Lecture Hours. 3 Lab Hours. Principles and techniques used in characterization of different materials, including metals, ceramics, polymers, composites and semiconductor systems; microstructural, chemical/compositional and surface analysis methods; interpretation and analysis of the characterization results. **Prerequisites:** Grade of C or better in MSEN 250 and MSEN 260.

MSEN 380 Communicating Materials Science and Engineering

Credit 1. 1 Lecture Hour. Effective communication of technical topics in materials science and engineering to technical and non-technical audiences; emphasis on written reports. **Prerequisite:** Grade of C or better in MSEN 301, or concurrent enrollment.

MSEN 399 High Impact Professional Development

Credits 0. 0 Other Hours. Student participation in an approved high-impact learning practice; reflection on professional outcomes from engineering body of knowledge; documentation and self-assessment of learning experience at mid-curriculum point. **Prerequisites:** Grade of C or better in MSEN 205 and MSEN 281; junior or senior classification.

MSEN 400 Design and Analysis of Materials Experiments

Credits 3. 2 Lecture Hours. 3 Lab Hours. Systematic design of experimental investigations; team approach to identification of topics and development of experiment designs including establishing the need, associated requirements and objective; conduction of experiments; characterization of materials; analysis and interpretation of results; documentation of the procedures, analysis, results and conclusions; presentation of written and oral reports. **Prerequisite:** Grade of C or better in MSEN 301; grade of C or better in MSEN 302 or concurrent enrollment.

MSEN 401 Materials Design I

Credits 3. 2 Lecture Hours. 3 Lab Hours. Design process; need definition, functional analysis, performance requirements, evaluation criteria, conceptual design evaluation; introduction to systems engineering; parametric and risk analysis, failure analysis, material selection and manufacturability; cost and life cycle issues, project management; industry-relevant design projects. **Prerequisite:** Grade of C or better in MSEN 281, MSEN 205 and MSEN 400.

MSEN 402 Materials Design II

Credits 3. 2 Lecture Hours. 3 Lab Hours. Development of innovative solutions to industry-relevant design challenges; structured framework and methodology for design activities; innovation, computational materials science, synthesis and processing and analysis and characterization of material components; project definition, management, customer interaction and effective team participation; presentations and design reviews. **Prerequisite:** Grade of C or better in MSEN 401.

MSEN 410 Materials Processing

Credits 3. 3 Lecture Hours. Synthesis, properties and processing of technologically important materials, metals, ceramics and polymers; thermodynamics and kinetics of different materials processing methods, casting, deformation processing, heat treatments, powder processing and sintering, coating, thin films processing, etc. **Prerequisite:** Grade of C or better in MSEN 250, MSEN 305, and MSEN 320; junior or senior classification.

MSEN 415 Defects in Solids

Credits 3. 3 Lecture Hours. Overview of point, line and surface defects in solids; relates defect properties to diffusion, deformation, phase transformations; focuses on atomic defects in crystals, with additional examples from liquid crystals, superconductors and ferromagnets; incorporates atomistic modeling to examine defect structure. **Prerequisite:** Grade of C or better in MSEN 260; junior or senior classification; or approval of instructor.

MSEN 418 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:** Grade of C or better in MSEN 320 or MEEN 360.

MSEN 420 Polymer Science

Credits 3. 3 Lecture Hours. Types of polymerization; molecular characteristics of polymer chains; single chain statistics and rubber elasticity; phase transitions, glass transition, viscoelasticity and time-temperature superposition; polymer structure at the molecular, microscopic and macroscopic level; polymer thermosets, thermoplastics, elastomers, fibers, and advanced nanoparticle-filled composites. **Prerequisite:** Grade of C or better in PHYS 206 and CHEM 120; junior or senior classification; or approval of instructor.

MSEN 426 Polymer Laboratories

Credits 3. 2 Lecture Hours. 3 Lab Hours. Laboratory to prepare those interested in polymer research with necessary experimental and analytical skills to conduct and analyze experimental work. **Prerequisite:** Grade of C or better in MSEN 250, junior or senior classification; or approval of instructor.

MSEN 430 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:** Grade of C or better in MSEN 260, junior or senior classification; or approval of instructor.

MSEN 440 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 201, AERO 413, BMEN 344, CHEN 322, CVEN 306, MEEN 222/MSEN 222, MMET 207, MSEN 222/MEEN 222, or NUEN 265; or approval of instructor.

MSEN 444 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 440, or approval of instructor.

MSEN 446 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. **Prerequisites:** Grade of C or better in MSEN 440, or approval of instructor.

MSEN 448 Failure Analysis in Materials Science and Engineering

Credits 3. 3 Lecture Hours. Discussion and analysis of failure of engineering systems 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:** Grade of C or better in MSEN 320; or approval of instructor.

MSEN 458 Fundamentals of Ceramics

Credits 3. 3 Lecture Hours. Structure-property relationships of ceramics and ceramic composites; atomic bonding in ceramics; crystalline and glassy structures; phase equilibria and ceramic reactions; mechanical, electrical, thermal, dielectric, magnetic and optical properties; ceramic processing; different properties of ceramics will be related to their underlying structure. **Prerequisite:** Grade of C or better in MSEN 260; junior or senior classification; or approval of instructor.

MSEN 468 Fabrication and Characterization of Electronic Materials

Credits 3. 3 Lecture Hours. Properties, processing, and characterization of electronic materials; fabrication of semiconductors, patterning and etching of electronic and optical films; characterization of film structure, morphology, composition, and electronic and optical properties through different material analysis methods. **Prerequisites:** Grade of C or better in MSEN 325 or ECEN 370.

MSEN 470 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. **Prerequisite:** Grade of C or better in MATH 307, MSEN 305, and MSEN 320.

MSEN 472 Atomistic Simulation of Materials

Credits 3. 3 Lecture Hours. Modern methods of computational modeling and simulation of materials properties and phenomena at the atomistic scale; quantum, classical and statistical mechanical methods, including semi-empirical atomic and molecular-scale simulations, and other modeling techniques using macroscopic input. **Prerequisite:** Grade of C or better in MSEN 470, or approval of instructor.

MSEN 484 Internship

Credits 0 to 4. 0 to 4 Other Hours. Practical experience working in a professional materials science and engineering setting offered on an individual basis. Must be taken on a satisfactory/unsatisfactory basis. **Prerequisites:** Junior or senior classification and approval of instructor.

MSEN 485 Directed Studies

Credits 0 to 4. 0 to 4 Other Hours. Directed study of selected problems in the area of materials science and engineering. May be taken four times for credit. **Prerequisite:** Grade of C or better in MSEN 301.

MSEN 489 Special Topics In...

Credits 1 to 4. 1 to 4 Lecture Hours. 0 to 4 Lab Hours. Selected topics in an identified area of materials science and engineering. May be repeated for credit. **Prerequisite:** Approval of instructor.

MSEN 491 Research

Credits 0 to 4. 0 to 4 Other Hours. Research conducted under the direction of a faculty member in materials science and engineering. May be taken four times for credit. **Prerequisites:** Grade of C or better in MSEN 301.