Materials Science and Engineering (MSE)

MSE 200 Mechanical Properties of Structural Materials (3 credit hours)
An introduction to the atomic and grain structure of structural materials emphasizing the mechanical properties. Effects of mechanical and heat treatments on structure and properties. Fatigue and creep of materials, fracture toughness, mechanical and non-destructive evaluation, effects of environment. Design considerations, characteristics of metals, ceramics, polymers and composites. Not for Materials majors

Prerequisite: Grade of C or better in CH 101
Typically offered in Fall, Spring, and Summer

MSE 201 Structure and Properties of Engineering Materials (3 credit hours)
Introduction to the fundamental physical principles governing the structure and constitution of metallic and nonmetallic materials and the relationships among these principles and the mechanical, physical and chemical properties of engineering materials.

Prerequisite: Grade of C or better in CH 101
Typically offered in Fall, Spring, and Summer

MSE 255 Experimental Methods for Structural Analysis of Materials (2 credit hours)
Principles and application of basic techniques for characterizing the structure of materials at different length scales. Optical microscopy, electron microscopy, scanning probe microscopy, X-ray diffraction and spectroscopic methods applied to metals, ceramics, polymers and semiconducting materials.

Corequisite: MSE 201
Typically offered in Spring only

MSE 260 Mathematical Methods for Materials Engineers (3 credit hours)
Use of MATLAB programming environment to illustrate and discuss principles and applications of analytical and numerical mathematical methods that are central to materials science and engineering. Data plotting, curve fitting, complex numbers and series, Fourier series and transforms, numerical integration and differentiation, linear algebra and matrix manipulation, initial and boundary value problems, numerical solution to ordinary differential equations and transport simulation through the use of partial differential equations.

Corequisite:MA 242
Typically offered in Spring only

MSE 270 Materials Science and Engineering Seminar (1 credit hours)
This course surveys the field of materials science and engineering and introduces students to contemporary issues. Job and career opportunities at the BS and graduate degree levels are presented. Students are introduced to opportunities for laboratory assistant jobs in the MSE department, summer internships, co-ops and summer research experiences at NCSU and other institutions. Students will learn to prepare effective resumes, technical reports and oral presentations.

Corequisite: MSE 201
Typically offered in Spring only

MSE 300 Structure of Materials at the Nanoscale (3 credit hours)
This course covers the structure of materials at the nanometer scale. Structure includes the periodic arrangements of atoms and ions in crystalline solids, the amorphous networks of atoms, ions, and molecules in glassy materials, and the molecular structure of polymeric and biological materials. The typical means of characterizing nanostructure are also reviewed. Finally, the course will introduce the structure of novel nanomaterials like nanotubes, buckyballs and self assembled monolayers.

P: C or better in MSE 201 or MSE 200
Typically offered in Fall only

MSE 301 Introduction to Thermodynamics of Materials (3 credit hours)
Review of classical thermodynamics and thermodynamic relationships. Use of statistical methods of describe entropy and other thermodynamic properties. Description of vapor-, liquid-, and solid-phase equilibrium in unary and other multicomponent material systems. Treatment of ideal and nonideal solution behavior in inorganic alloys and organic polymers. Application of gas-phase reaction kinetics and identification of the criteria required for reaction equilbria.

P: C or better in MSE 201 and MA 242
Typically offered in Fall only

MSE 320 Introduction to Defects in Solids (3 credit hours)
Classification of defects as point, line, surface or volume types. Geometrical and crystallographic aspects of defects. Defects in metallic, ionic and covalently bonded crystal structures. Physical, chemical, electronic and magnetic aspects of defects. Field quantities and forces associated with defects. Novel defects in nanostructured materials and semicrystalline materials.

Prerequisite: C or better in MSE 201
Typically offered in Fall only

MSE 335 Experimental Methods for Analysis of Material Properties (2 credit hours)
Principles and application of basic techniques for characterizing the properties of materials. Mechanical, thermal, electrical, optical and magnetic property measurements applied to metals, ceramics, polymers and semiconducting materials.

Prerequisite: C- or better in MSE 201
Typically offered in Fall only

MSE 355 Electrical, Magnetic and Optical Properties of Materials (3 credit hours)
Fundamental treatment of the electronic properties of materials, including the electrical, magnetic and optical characteristics. The role of electrons, band structure, and Bruillouin zones on the various classes of materials is discussed from the semiclassical and quantum mechanical viewpoints. Applications of these principles to specific technological devices is also covered.

Prerequisite: PY 208 and MA 341
Typically offered in Spring only

MSE 360 Kinetic Processes in Materials (3 credit hours)
Types, mechanisms, and kinetics of solid state phase transformations are covered with selected applications to all classes of materials. Mechanisms of diffusion and techniques for diffusion calculations are presented. The role of surface energy and strain in the evolution of structure during transformation is presented. Phenomena at different size scales (atomic, nano, micro) are described relative to the evolution of structure during transformation.

Prerequisite: MA 341 and MSE 301
Typically offered in Spring only

MSE 370 Microstructure of Inorganic Materials (3 credit hours)
Structure-property relationships in metallic and ceramic materials. Crystal structures of important metallic and ceramic elements, alloys, and compounds. Binary and ternary phase diagrams for notable systems will be presented. Microstructural features to be covered include grain size and distribution, multiphase microstructures, and defects. Examples of important metallic and ceramic systems for structural, electrical, optical and magnetic applications will be given.

Prerequisites: MSE 300, MSE 301, and MSE 320
Typically offered in Spring only

MSE 380 Microstructure of Organic Materials (3 credit hours)
Covers microstructure and properties of soft materials including polymer molecular weight distributions, amorphous polymers, semicrystalline polymers, copolymers, elastomers, biopolymers, soft tissue, bone and cellular structure. The design and function of implantable biomaterials are also covered.

Prerequisite: (CH 220 or CH 221) and MSE 300
Typically offered in Spring only

MSE 409/NE 509/MSE 509/NE 409 Nuclear Materials (3 credit hours)
Introduces students to properties and selection of materials for nuclear steam supply systems and to radiation effects on materials. Implications of radiation damage to reactor materials and materials problems in nuclear engineering are discussed. Topics include an overview of nuclear steam supply systems, crystal structure and defects, dislocation theory, mechanical properties, radiation damage, hardening and embrittlement due to radiation exposure and problems concerned with fission and fusion materials. Students cannot receive credit for both 409 and 509.

Prerequisite: MSE 201
Typically offered in Fall only

MSE 420 Mechanical Properties of Materials (3 credit hours)
Basic concepts for mechanical properties of materials, elasticity, plasticity, viscoelasticity, rubber elasticity, strengthening mechanisms, creep, fracture and fatigue. Includes metals, ceramics, polymers and composites. Describes mechanical properties for nanostructured materials and biomaterials.

Prerequisite: MSE 370 and MSE 380
Typically offered in Fall only

MSE 423 Introduction to Materials Engineering Design (1 credit hours)
Materials selection in engineering design involving lecture, cooperative and problem-based learning techniques. Course stresses creative thinking, problem solving methodology, interdependence of design with analysis and evaluation, teamwork and sharpening of communication skills. Real industrial problems are introduced which are analyzed by student teams. This a half-semester course. The classroom lectures end at mid-semester. In the second half of the semester, student teams develop a proposal which is submitted to the industrial sponsors at the end of the semester. The proposal defines future work to be conducted under MSE 470. Senior standing in MSE.

Prerequisite: Senior standing in MSE
Typically offered in Fall only

MSE 440/MSE 540 Processing of Metallic Materials (3 credit hours)
Fundamental concepts of solidification and their application to foundry and welding practices; metal forming concepts applied to forging, rolling, extrusion, drawing, and sheet forming operations; machining mechanisms and methods; powder metallurgy;advanced processing methods including rapid solidification and mechanical alloying. Credit for both MSE 440 and MSE 540 is not allowed

Prerequisite: MSE 360 and MSE 370. Corequisite: MSE 420
Typically offered in Fall only

MSE 445/MSE 545 Ceramic Processing (3 credit hours)
Ceramic processing of powders includes powder synthesis, characterization, mixing, and size reduction. Theoretical aspects include particle packing, particles in suspension, and some aspects of surface chemistry. Forming methods include compaction, casting, and extrusion. Firing and sintering are examined. Credit for both MSE 445 and MSE 545 is not allowed

Prerequisite: MSE 370
Typically offered in Fall only

MSE 455 Polymer Technology and Engineering (3 credit hours)
This course will cover commercial polymers, polymer blends and miscibility, dynamic mechanical behavior, Boltzmann superposition principle, ultimate properties of polymers, polymer rheology and processing, recycling and design and selection of polymeric materials. Guest instructors from industry will give presentations on contemporary topics in polymer technology and engineering. Field trips are required.

Prerequisite: MSE 380
Typically offered in Spring only

MSE 456/MSE 556 Composite Materials (3 credit hours)
The course covers the basic principles underlying properties of composite materials as related to the properties of individual constituents and their interactions. Polymer, metal and ceramic matrix composites are included. Property averaging and micromechanics of composites are covered at an introductory level. Emphasis is placed on design and processing of composite systems to yield desired combinations of properties. Credit for both MSE 456 and MSE 556 is not allowed.

Prerequisite: MSE 420
Typically offered in Spring only

MSE 460 Microelectronic Materials (3 credit hours)
Processes and characterization techniques relevant to microelectronic materials science and technology. Boule growth, wafer preparation, oxidation, epitaxial growth, doping techniques, metallization, and device applications of elemental and compound semiconductors. Electrical, structural and chemical characterization of semiconductors is included as well as materials considerations relevant to device fabrication. Credit for both MSE 460 and MSE 560 is not allowed

Prerequisite: MSE 355
Typically offered in Fall only

MSE 465/MSE 565 Introduction to Nanomaterials (3 credit hours)
Introduction to nanoparticles, nanotubes, nanowires, and nanostructured films, emphasizing their synthesis, structural and property characterization, novel physical and chemical properties, applications and contemporary literature.

Prerequisite: MSE 201
Typically offered in Spring only

MSE 470 Materials Science and Engineering Senior Design Project (3 credit hours)
Design project in materials science and engineering requiring problem definition and analysis, synthesis, and presentation of a designed solution. Students work in groups with a faculty adviser on problems submitted by local industrial sponsors or emerging research issues that represent the major specialty areas including ceramics, metals, polymers, or electronic materials.

Prerequisite: MSE 423
Typically offered in Spring only

MSE 480/MSE 580 Materials Forensics and Degradation (3 credit hours)
Covers principles and prevention of the degradation of materials. The topics will include dissolution of polymer and ceramic materials, electrochemical corrosion, oxidation of metals and polymers, degradation of polymers, friction and wear, degradation of electrical device components, bio-deterioration of materials, and failure analysis. The general practice in failure analysis will be applied to a variety of case studies to illustrate important failure mechanisms. Credit will not be given for both MSE 480 and MSE 580.

Prerequisite: MSE 370 and MSE 380
Typically offered in Spring only

MSE 485 Biomaterials (3 credit hours)
The course introduces fundamental aspects associated with synthesis, properties, processing/fabrication and application of materials derived from or associated with bio-entities. The course focuses on biomaterials with broad applications beyond medical or clinical uses. The course emphasizes the biological systems unique machinery and function in the context of desired outcome that utilizes a material or materials' systems. Fundamental concepts covered in the course include: differences among classes of biomaterials; toxicity vs biocompatibility of biomaterials; bulk vs surface properties of biomaterials; interactions of biomaterials with different environments; biomaterials stability and degradation; biomaterials for sensing and bioelectronics applications; biomaterials for energy, soft robotics and responsive materials applications; and biomaterials for drug delivery.

Prerequisite: MSE 201 and BIO 183
Typically offered in Spring only

MSE 489/MSE 589/PY 489/PY 589/ECE 489/ECE 589 Solid State Solar and Thermal Energy Harvesting (3 credit hours)
This course studies the fundamental and recent advances of energy harvesting from two of the most abundant sources, namely solar and thermal energies. The first part of the course focuses on photovoltaic science and technology. The characteristics and design of common types of solar cells is discussed, and the known approaches to increasing solar cell efficiency will be introduced. After the review of the physics of solar cells, we will discuss advanced topics and recent progresses in solar cell technology. The second part of the course is focused on thermoelectric effect. The basic physical properties, Seebeck coefficient, electrical and thermal conductivities, are discussed and analyzed through the Boltzmann transport formalism. Advanced subject such as carrier scattering time approximations in relation to dimensionality and the density of states are studied. Different approaches for further increasing efficiencies are discussed including energy filtering, quantum confinement, size effects, band structure engineering, and phonon confinement.

P: ECE 302 or E 304 or MSE 355 or PY 407
Typically offered in Spring only

MSE 490 Special Topics in Materials Engineering (1-4 credit hours)
Offered as needed for the development of new courses in materials engineering, including areas such as metals, ceramics, polymers, or microelectronic materials.

MSE 495 Materials Engineering Projects (1-6 credit hours)
Application of engineering principles to a specific materials engineering project by a student or small group of students under supervision of a faculty member. A written report required.

Prerequisite: Junior standing or Senior standing
Typically offered in Fall, Spring, and Summer

MSE 500 Modern Concepts in Materials Science (3 credit hours)
Fundamentals of structure, structure modification and properties of materials with emphasis on structure-property relationships and modern theory of solids.

Prerequisite: Graduate standing
Typically offered in Fall and Spring

MSE 509/NE 409/MSE 409/NE 509 Nuclear Materials (3 credit hours)
Introduces students to properties and selection of materials for nuclear steam supply systems and to radiation effects on materials. Implications of radiation damage to reactor materials and materials problems in nuclear engineering are discussed. Topics include an overview of nuclear steam supply systems, crystal structure and defects, dislocation theory, mechanical properties, radiation damage, hardening and embrittlement due to radiation exposure and problems concerned with fission and fusion materials. Students cannot receive credit for both 409 and 509.

Prerequisite: MSE 201
Typically offered in Fall only

MSE 531 Physical Metallurgy (3 credit hours)
Application and design of selected metals and alloys in a theoretical and practical context. Relationships between mechanical behavior, and alloy chemistry, microstructure, and processing. Corrosion resistance; fatigue failure; creep; brittle fracture. Design of specific microstructures. Credit for both MAT 431 and MSE 531 is not allowed

Prerequisite: MAT 321, MAT 450, Corequisite: MAT 430
Typically offered in Fall only

MSE 539/MAE 539 Advanced Materials (3 credit hours)
Introduces production/structure/property/function relation and application of a number of materials mainly for biomedical, mechanical and aerospace applications. Topics include ultra light materials (production, processing and applications of cellular solids), biomaterials (classes and application of materials in medicine and dentistry), composites (classes and application), refractory materials and coatings for high temperature applications, thin film shape memory alloys for micro-electro mechanical systems (MEMS).

Prerequisite: MSE 201 and MAE 314
Typically offered in Fall only

MSE 540/MSE 440 Processing of Metallic Materials (3 credit hours)
Fundamental concepts of solidification and their application to foundry and welding practices; metal forming concepts applied to forging, rolling, extrusion, drawing, and sheet forming operations; machining mechanisms and methods; powder metallurgy;advanced processing methods including rapid solidification and mechanical alloying. Credit for both MSE 440 and MSE 540 is not allowed

Prerequisite: MSE 360 and MSE 370. Corequisite: MSE 420
Typically offered in Fall only

MSE 545/MSE 445 Ceramic Processing (3 credit hours)
Ceramic processing of powders includes powder synthesis, characterization, mixing, and size reduction. Theoretical aspects include particle packing, particles in suspension, and some aspects of surface chemistry. Forming methods include compaction, casting, and extrusion. Firing and sintering are examined. Credit for both MSE 445 and MSE 545 is not allowed

Prerequisite: MSE 370
Typically offered in Fall only

MSE 555 Polymer Technology and Engineering (3 credit hours)
Classes of commercially important polymers, advanced topics in phase behavior, viscoelasticity, fracture and ultimate properties of polymers; polymer rheology, and processing; design of polymeric materials. Credit for both MSE 455 and MSE 555 is not allowed.

Prerequisite: MSE 424 or equivalent
Typically offered in Spring and Summer

MSE 556/MSE 456 Composite Materials (3 credit hours)
The course covers the basic principles underlying properties of composite materials as related to the properties of individual constituents and their interactions. Polymer, metal and ceramic matrix composites are included. Property averaging and micromechanics of composites are covered at an introductory level. Emphasis is placed on design and processing of composite systems to yield desired combinations of properties. Credit for both MSE 456 and MSE 556 is not allowed.

Prerequisite: MSE 420
Typically offered in Spring and Summer

MSE 560 Microelectronic Materials Science and Technology (3 credit hours)
Processes and characterization techniques relevant to microelectronic materials science and technology. Boule growth, water preparation, oxidation, epitaxial growth, doping techniques, metallization, and device applications of elemental and compound semiconductors. Electrical, structural and chemical characterization of semiconductors as well as materials considerations relevant to device fabrication. Credit for both MAT 460 and MSE 560 is not allowed

Prerequisite: MAT 331, Corequisite: MAT 431
Typically offered in Fall only

MSE 561/TC 561 Organic Chemistry Of Polymers (3 credit hours)
Principles of step reaction and addition polymerizations; copolymerization; emulsion polymerization; ionic polymerization; characterization of polymers; molecular structure and properties.

Prerequisite: TC 461 and CH 231 or CH 431
Typically offered in Fall only

MSE 565/MSE 465 Introduction to Nanomaterials (3 credit hours)
Introduction to nanoparticles, nanotubes, nanowires, and nanostructured films, emphasizing their synthesis, structural and property characterization, novel physical and chemical properties, applications and contemporary literature.

Prerequisite: MSE 201
Typically offered in Spring only

MSE 566 Mechanical Properties of Nanostructured Materials (3 credit hours)
The course covers mechanical behavior that is unique to nanostructured materials Â¿ typically nanocrystalline metals and alloys. The various methods for processing nanostructured materials will be presented, emphasizing those that are suitable for mechanical property studies. The thermal stability of nanocrystalline microstructures will be covered and strategies for inhibiting grain growth described. Mechanical testing methods for uniaxial loading, creep, fracture and fatigue will be covered. Testing methods will also be discussed in context with structure-property relations, deformation mechanisms and failure modes.

Prerequisite: MSE 500 or an instructor approved equivalent.
Typically offered in Spring only

MSE 576/MBA 576 Technology Entrepreneurship and Commercialization I (3 credit hours)
First course in a two-course entrepreneurship sequence focusing on opportunities for technology commercialization. Evaluation of commercialization of technologies in the context of new business startups. Emphasis is placed on creating value through technology portfolio evaluation and fundamentals of technology-based new business startups. This includes development of value propositions and strong technology-product-market linkages. The process based approach is appropriate for new business startup as well as entrepreneurship in existing organizations through spinoffs, licensing, or new product development. Credit not allowed for MBA 576 if the student has already taken MBA 570 or MBA 571.

Credit not allowed in MBA 576 if the student has already taken MBA 570 or MBA 571
Typically offered in Fall and Spring

MSE 577/MBA 577 Technology Entrepreneurship and Commercialization II (3 credit hours)
Continuation of evaluation of technologies for commercialization through new business startups. Emphasis is placed on creating value through strong technology-products-markets linkages using the TEC algorithm. Topics include industry and market testing of assumptions, legal forms of new business startups, funding sources and creating a quality, integrative new business startup plan. Credit not allowed in 577 for students who have already taken 570 or 571.

Prerequisite: MBA/MSE 576. Credit not allowed in 577 for students who have already taken 570 or 571.
Typically offered in Spring only

MSE 580/MSE 480 Materials Forensics and Degradation (3 credit hours)
Covers principles and prevention of the degradation of materials. The topics will include dissolution of polymer and ceramic materials, electrochemical corrosion, oxidation of metals and polymers, degradation of polymers, friction and wear, degradation of electrical device components, bio-deterioration of materials, and failure analysis. The general practice in failure analysis will be applied to a variety of case studies to illustrate important failure mechanisms. Credit will not be given for both MSE 480 and MSE 580.

Prerequisite: MSE 370 and MSE 380
Typically offered in Spring only

MSE 589/PY 489/PY 589/ECE 489/ECE 589/MSE 489 Solid State Solar and Thermal Energy Harvesting (3 credit hours)
This course studies the fundamental and recent advances of energy harvesting from two of the most abundant sources, namely solar and thermal energies. The first part of the course focuses on photovoltaic science and technology. The characteristics and design of common types of solar cells is discussed, and the known approaches to increasing solar cell efficiency will be introduced. After the review of the physics of solar cells, we will discuss advanced topics and recent progresses in solar cell technology. The second part of the course is focused on thermoelectric effect. The basic physical properties, Seebeck coefficient, electrical and thermal conductivities, are discussed and analyzed through the Boltzmann transport formalism. Advanced subject such as carrier scattering time approximations in relation to dimensionality and the density of states are studied. Different approaches for further increasing efficiencies are discussed including energy filtering, quantum confinement, size effects, band structure engineering, and phonon confinement.

P: ECE 302 or E 304 or MSE 355 or PY 407
Typically offered in Spring only

MSE 591 Special Topics In Materials Science and Engineering (1-4 credit hours)
Topics of current interest in Materials Science and Engineering not covered in existing courses.

Typically offered in Fall and Spring

MSE 601 Seminar (1 credit hours)
Reports and discussion of special topics in materials science and engineering and allied fields.

Typically offered in Fall and Spring

MSE 685 Master's Supervised Teaching (1-3 credit hours)
Teaching experience under the mentorship of faculty who assist the student in planning for the teaching assignment, observe and provide feedback to the student during the teaching assignment, and evaluate the student upon completion of the assignment.

Prerequisite: Master's student
Typically offered in Fall, Spring, and Summer

MSE 690 Master's Examination (1-9 credit hours)
For students in non thesis master's programs who have completed all other requirements of the degree except preparing for and taking the final master's exam.

Prerequisite: Master's student
Typically offered in Summer only

MSE 693 Master's Supervised Research (1-9 credit hours)
Instruction in research and research under the mentorship of a member of the Graduate Faculty.

Prerequisite: Master's student
Typically offered in Fall, Spring, and Summer

MSE 695 Master's Thesis Research (1-9 credit hours)
Prerequisite: Master's student
Typically offered in Fall, Spring, and Summer

MSE 696 Summer Thesis Research (1 credit hours)
For graduate students whose programs of work specify no formal course work during a summer session and who will be devoting full time to thesis research.

Prerequisite: Master's student
Typically offered in Summer only

MSE 699 Master's Thesis Preparation (1-9 credit hours)
For students who have completed all credit hour requirements and full-time enrollment for the master's degree and are writing and defending their thesis.

Prerequisite: Master's student
Typically offered in Fall, Spring, and Summer

MSE 702 Defects In Solids (3 credit hours)
Prerequisite: MSE 500
Typically offered in Spring only

MSE 703 Interaction of Electrons with Materials (3 credit hours)
This course reviews basic interaction of electrons with solids through the free electron theory, quantum mechanics and quantum phenomena, and band theory. The course provides a practical foundation for understanding of electrical behavior of metals, semiconductors, dielectrics and non-crystalline materials and how this behavior relates to structure and materials processing. Graduate standing in MSE, CBME, ECE, PY, CH, or consent of the instructor required.

Prerequisite: MSE 500
Typically offered in Fall only

MSE 704 Interaction of Photons with Materials (3 credit hours)
This course will answer basic questions on photon-matter interaction: Why do materials appear the way we see them? How can we change and control that? How can we apply their optical properties in various optical elements and optoelectronic devices? The course provides a practical foundation for working with and developing of materials for modern optoelectronic and photonic technologies. Graduate standing in MSE, CBME, ECE, PY, CH, or consent of the instructor required.

Prerequisite: MSE 703
Typically offered in Spring only

MSE 705 Mechanical Behavior Of Engineering Materials (3 credit hours)
Coverage of both fundamental and engineering aspects of mechanical behavior of materials. Elasticity, plasticity and dislocation theory concepts used to describe phenomenological behavior and micro-mechanical mechanisms. Strengthening mechanisms in crystals, high-temperature deformation, fracture mechanics, fracture toughening mechanisms and cyclic deformation.

Prerequisite: MAT 450, MAT 702
Typically offered in Spring only

MSE 706 Phase Transformations and Kinetics (3 credit hours)
Homogeneous and heterogeneous nucleation, spinodal decomposition, interface and diffusion-controlled growth, formal theory of transformation kinetics, precipitation, coarsening, order-disorder, and martensitic transformations.

Prerequisite: MAT 700, MAT 710, and MSE 500
Typically offered in Spring only

MSE 708 Thermodynamics Of Materials (3 credit hours)
Review of first and second laws of thermodynamics, equilibrium and irreversible processes, open and closed systems, partition functions and particle distribution functions. Applications include extension of thermodynamic potentials to situations where electrical, magnetic and stress fields present, heat capacity of crystals, electron gas in metals, solution models, binary phase diagrams and rubber elasticity in polymers.

Prerequisite: MAT 301 and MSE 500
Typically offered in Fall only

MSE 709 Metastable Materials: Processing, Structure, and Properties (3 credit hours)
The thermodynamics and kinetics of the synthesis and stability of a variety of important metastable materials - those materials that are not in the lowest free energy state for the composition and structure - will be described. The common methods for non-equilibrium processing will be covered. A significant part of the course will be devoted to amorphous materials, including their synthesis, structure, and properties. Other topics will include quasi-crystalline materials, metastable crystalline materials, and shape memory alloys. As background for shape memory alloys, diffusionless phase transformations with emphasis on martensitic transformations will be reviewed.

Prerequisite: MSE 500 or Instructor Consent
Typically offered in Fall only

MSE 710 Elements Of Crystallography and Diffraction (3 credit hours)
Crystal symmetry, lattices and space groups; elementary diffraction by crystalline matter; experimental methods of x-ray diffraction.

Typically offered in Fall only

MSE 712 Scanning Electron Microscopy (3 credit hours)
Electron optics, sources and detectors. Beam specimen interactions, secondary and backscattered electrons, and EDS. Resolution limits, experimental conditions, related techniques, beam-induced damage and materials modifications.

Typically offered in Fall only

MSE 715 Fundamentals Of Transmission Electron Microscopy (4 credit hours)
Electron optics, electron-solid interactions, electron diffraction, image contrast, defect characterization, analytical and high resolution microscopy. Parallel laboratory demonstrations and exercises. Laboratory enrollment limited to twelve, but laboratory may be waived with consent of instructor.

Prerequisite: MAT 710
Typically offered in Spring only

MSE 718 Advanced Transmission Electron Microscopy (3 credit hours)
This course provides the advanced graduate student with a detailed knowledge of transmission electron microscopy covering: advanced topics in electron sources, details of electron optics and aberrations, aberration corrected electron microscopy, modeling and simulating interactions of electrons with the specimen, image processing and analysis, and analytical techniques (EELS and EDX). Graduate standing in MSE, CHE, ECE, PHY, CH required or consent of the instructor.

Prerequisite: MSE 715
Typically offered in Fall only

MSE 721 Nanoscale Simulations and Modeling (3 credit hours)
The course is designed to assist engineering students in learning the fundamentals and cutting-edge nature of various simulations methods. The modeling tools range from accurate first principles quantum-based approaches to multi-scale approaches that combine atomic and continuum modeling. Previous knowledge of simulations is not required. The course is appropriate for graduate students in materials science, engineering, chemistry, physics and biomedical fields.

Typically offered in Fall only

MSE 723 Materials Informatics (3 credit hours)
The course aims to introduce the emergent field of materials informatics and current approaches that employ informatics and experimental and computational data to accelerate the process of materials optimization, discovery and development. An emphasis will be placed on practical implementation of machine learning techniques to various materials science problems.

Typically offered in Fall only

MSE 731/MAE 731 Materials Processing by Deformation (3 credit hours)
Presentation of mechanical and metallurgical fundamentals of materials processing by deformation. Principles of metal working, friction, forging, rolling, extrusion, drawing, high energy rate forming, chipless forming techniques, manufacturing system concept in production.

Prerequisite: Six hrs. of solid mechanics and/or materials
Typically offered in Fall only

MSE 741 Principles of Corrosion (3 credit hours)
Fundamentals of metallic corrosion and passivity. Electro-chemical nature of corrosive attack, basic forms of corrosion, corrosion rate factors, methods of corrosion protection. Laboratory work included.

Prerequisite: MAT 201 and CH 431 or MAT 301

MSE 751 Thin Film and Coating Science and Technology I (3 credit hours)
Vacuum science and technology including gas kinetics, gas flow calculations, system design and use of various pumps, materials and components. Atomistics of solid surfaces. Nucleation and growth of films and coatings.

Prerequisite: MAT 700
Typically offered in Spring only

MSE 752 Thin Film and Coating Science and Technology II (3 credit hours)
Techniques for thin films and coatings deposition and their applications. Interfaces, adhesion and surface modification. Artificially structured and chemically modulated layered materials. Pseudomorphic structures. Characterization of thin films andcoatings.

Prerequisite: MSE 751
Typically offered in Spring only

MSE 757 Radiation Effects on Materials (3 credit hours)
Interaction of radiation with matter with emphasis on microstructural modification, physical and mechanical effects. Defects generation and annealing, void swelling, irradiation growth and creep, and irradiation induced effects in reactor materialsare discussed. Current theories and experimental techniques are discussed.

Typically offered in Spring only

MSE 760 Materials Science in Processing of Semiconductor Devices (3 credit hours)
Ion implantation and doping for advanced semiconductor devices, thin films and epitaxy, silicides, ohmic contacts and interconnection metallurgy, oxidation and nitridation, gettering of impurities and dopant segregation phenomena, electromigration, electronic packaging materials science and advanced device concepts.

Prerequisite: MAT 460 and MSE 500
Typically offered in Fall only

MSE 761/CHE 761 Polymer Blends and Alloys (3 credit hours)
Thermodynamics, morphological characteristics and properties of multiphase polymer systems composed of homopolymers or copolymers. Interfacial characteristics and modification of multicomponent polymer blends through emulsification and reactive blending. Microphase ordering in block copolymers, and emerging technolgies employing these nanostructured materials. Conformational properties and dynamics of macromolecules constrained near an interface.

Prerequisite: CHE 316 or MAT 301
Typically offered in Fall only

MSE 763/TMS 763 Characterization Of Structure Of Fiber Forming Polymers (3 credit hours)
Theories, experimental evidence and characterization methods of the molecular fine structure of fiber forming polymers in the solid state. Characterization methods include X-ray diffraction, microscopy, infrared, thermal and magnetic resonance.

Prerequisite: Graduate standing
Typically offered in Fall only

MSE 770 Defects, Diffusion and Ion Implantation In Semiconductors (3 credit hours)
Thermodynamics of vacancies and interstitials, defect complexes, electronic defects, defect annealing processes, self diffusion, dopant and impurity diffusion, substitutional/interstitial diffusion, diffusion in amorphous solids, electro transport, fundamentals of ion-solid interactions, semiconductor doping atomic structure of defects, damage annealing processes, supersaturated alloys, laser annealing, ion beam mixing phenomena, ion implantation and rapid thermal annealing processes, shallow junctions and devices.

Prerequisite: MAT 701
Typically offered in Spring only

MSE 771 Materials Science of Nanoelectronics (3 credit hours)
Effects of scale less than 100 nm on the electrical properties & processing of all materials (metals, semiconductors, ceramics, polymers and biomaterials). Current status and future prospects for the semiconductor industry summarized by invited scientists and by review and discussion of selected current literature. Student presentations and research proposals are required.

Prerequisite: MSE 500
Typically offered in Fall only

MSE 775 Structure of Semicrystalline Polymers (3 credit hours)
Structure and organization of semicrystalline polymers, from molecular scale to bulk state, including chain configuration, unit cell geometries, polymer crystallography, single crystals, spherulites, epitaxial crystallization, morphology, crystal defects, annealing and deformation mechanisms. Emphasis on analysis of x-ray diffraction, electron diffraction and electron microscopy data for structural characterization.

Prerequisite: MAT 425
Typically offered in Fall only

MSE 791 Advanced Topics in Materials Science and Engineering (1-3 credit hours)
Special studies of advanced topics in materials science and engineering.

Prerequisite: Graduate standing
Typically offered in Fall, Spring, and Summer

MSE 795 Advanced Materials Experiments (1-3 credit hours)
Advanced engineering principles applied to a specific experimental project dealing with materials. A seminar period provided; required written report.

Prerequisite: Senior standing or Graduate standing
Typically offered in Fall, Spring, and Summer

MSE 801 Seminar (1 credit hours)
Reports and discussion of special topics in materials science and engineering and allied fields.

Typically offered in Fall and Spring

MSE 885 Doctoral Supervised Teaching (1-3 credit hours)
Teaching experience under the mentorship of faculty who assist the student in planning for the teaching assignment, observe and provide feedback to the student during the teaching assignment, and evaluate the student upon completion of the assignment.

Prerequisite: Doctoral student
Typically offered in Fall, Spring, and Summer

MSE 890 Doctoral Preliminary Exam (1-9 credit hours)
For students who are preparing for and taking written and/or oral preliminary exams.

Prerequisite: Doctoral student
Typically offered in Summer only

MSE 893 Doctoral Supervised Research (1-9 credit hours)
Instruction in research and research under the mentorship of a member of the Graduate Faculty.

Prerequisite: Doctoral student
Typically offered in Fall, Spring, and Summer

MSE 895 Doctoral Dissertation Research (1-9 credit hours)
Dissertation Research

Prerequisite: Doctoral student
Typically offered in Fall, Spring, and Summer

MSE 896 Summer Dissertation Research (1 credit hours)
For graduate students whose programs of work specify no formal course work during a summer session and who will be devoting full time to thesis research.

Prerequisite: Doctoral student
Typically offered in Summer only

MSE 899 Doctoral Dissertation Preparation (1-9 credit hours)
For students who have completed all credit hour requirements, full-time enrollment, preliminary examination, and residency requirements for the doctoral degree, and are writing and defending their dissertations.

Prerequisite: Doctoral student
Typically offered in Fall, Spring, and Summer