Courses primarily for graduate students, open to qualified undergraduates:

(1-0) Cr. 1. F.  
An examination of structure-property-process relationships in materials, focusing on control and measurement of end-use performance characteristics. Materials design fundamentals are discussed as they pertain to various critical industries, applications, and manufacturing technologies. Offered on a satisfactory-fail basis only.

M S E 502: Fundamentals of Materials Science and Engineering II  
(1-0) Cr. 1. Repeatable, maximum of 1 credits. S.  
Prereq: M S E 501  
An examination of the physical behavior of materials, as underpinned by multiphase multicomponent thermodynamics, transport phenomena, interfaces, defect structures, the kinetics of phase transformations, and the mechanistic origins of structure-property-processing relationships in various types of materials. Offered on a satisfactory-fail basis only.

M S E 503: Fundamentals of Materials Science and Engineering III  
(1-0) Cr. 1. SS.  
Prereq: M S E 501, M S E 502 and enrollment in the M S E Ph.D. program  
Directed study of advanced topics in Materials Science and Engineering. Fundamental principles and relationships connecting structure, chemistry, stability, physical behavior, properties, and processing response are reviewed. Experimental and computational methods for materials research are emphasized. Offered on a satisfactory-fail basis only.

M S E 510: Fundamentals of Structure and Chemistry of Materials  
(3-0) Cr. 3. F.  
Prereq: MATH 165, PHYS 221, and CHEM 167  

M S E 519: Magnetism and Magnetic Materials  
(Dual-listed with MAT E 419). (Cross-listed with E E). (3-0) Cr. 3. Alt. F., offered odd-numbered years.  
Prereq: E E 311 or MAT E 317 or PHYS 364  

M S E 520: Thermodynamics and Kinetics in Multicomponent Materials  
(3-0) Cr. 3. F.  
Prereq: MAT E 311 or CHEM 321, MATH 266 or MATH 267  
A review of the fundamental principles of heat, work, basic thermodynamic relations, and criteria for equilibrium. Analytical treatments for the thermodynamic description of multicomponent chemical solutions and reacting systems are developed and employed to predict phase equilibria in materials systems. Builds on the thermodynamic construction to treat the kinetics of chemical reactions and phase transformations. Topics include general first order and second order transitions, along with chemical diffusion. Detailed examples involving nucleation and diffusion limited growth, spinodal decomposition, martensitic transformations, magnetic and electric transitions, and glass formation will be considered.

M S E 521: Mechanical Behavior and Manufacturing of Polymers and Composites  
(Cross-listed with M E). (3-0) Cr. 3. S.  
Prereq: M E 324, E M 324  

M S E 530: Solid State Science  
(3-0) Cr. 3. S.  
Prereq: MAT E 334 or E E 332 or PHYS 322  
M S E 532: Microelectronics Fabrication Techniques
(Dual-listed with MAT E 432). (Cross-listed with E E). (2-4) Cr. 4.
**Prereq:** CPR E and E E majors: E E 230; MAT E majors: MAT E 317
Techniques used in modern integrated circuit fabrication, including diffusion, oxidation, ion implantation, lithography, evaporation, sputtering, chemical-vapor deposition, and etching. Process integration. Process evaluation and final device testing. Extensive laboratory exercises utilizing fabrication methods to build electronic devices. Use of computer simulation tools for predicting processing outcomes. Recent advances in processing CMOS ICs and micro-electro-mechanical systems (MEMS).

M S E 537: Electronic Properties of Materials
(Dual-listed with MAT E 437). (Cross-listed with E E). Cr. 3. S.
**Prereq:** E E 332 or MAT E 317 or PHYS 322

M S E 540: Mechanical Behavior of Materials
(3-0) Cr. 3. S.
**Prereq:** MAT E 418, MATH 266 or MATH 267
Mechanical behavior of materials with emphasis on micromechanics of deformation in three generic regimes: elasticity, plasticity, and fracture. A materials science approach is followed to understand and model the mechanical behavior that combines continuum mechanics, thermodynamics, kinetics, and microstructure. Some topics include elastic properties of materials, permanent deformation mechanisms at different temperatures (e.g., via dislocation motion and creep), and fracture in ductile and brittle materials. Specific classes of materials that are studied: metals, ceramics, polymers, glasses and composites.

M S E 551: Characterization Methods in Materials Science
(2-3) Cr. 3. Alt. S., offered odd-numbered years.
**Prereq:** MAT E 214
Characterization of ceramic, metal, polymer and glassy materials using modern analytical techniques. Spectroscopic (IR, Raman, UV/VIS/NIR, and NMR), thermal (DSC, DTA/TGA, and DMA) methods, mechanical and rheological testing, magnetic and electrical characterization, and powder characterization.

M S E 552: Scanning and Auger Electron Microscopy
(Dual-listed with MAT E 452). (2-3) Cr. 3. F.
**Prereq:** PHYS 232

M S E 553: Physical and Mechanical Properties of Polymers
(Dual-listed with MAT E 453). (2-3) Cr. 3. F.
**Prereq:** MAT E 351
Overview of polymer chemical composition, microstructure, thermal and mechanical properties, rheology, and principles of polymer materials selection. Intensive laboratory experiments include chemical composition studies, microstructural characterization, thermal analysis, and mechanical testing.

M S E 554: Polymer Composites and Processing
(Dual-listed with MAT E 454). (3-0) Cr. 3. S.
**Prereq:** MAT E 351
Basic concepts in polymer composites, blends, and block copolymers. Phase separation and miscibility, microstructures and mechanical behavior. Fiber reinforced and laminated composites. Viscosity, rheology, viscoelasticity of polymers. Polymer melt processing methods such as injection molding and extrusion; selection of suitable processing methods and their applications.

M S E 556: Biomaterials
(Dual-listed with MAT E 456). (3-0) Cr. 3. F.
**Prereq:** CHEM 178; (MAT E 216 or MAT E 273 or MAT E 392)
Presentation of the basic chemical and physical properties of biomaterials, including metals, ceramics, and polymers, as they are related to their manipulation by the engineer for incorporation into living systems. Role of microstructure properties in the choice of biomaterials and design of artificial organs, implants, and prostheses.
M S E 557: Chemical and Physical Metallurgy of Rare Earth Metals
(Dual-listed with MAT E 457). (3-0) Cr. 3. Alt. S., offered even-numbered years.
*Prereq: CHEM 325 or MAT E 311*
Electronic configuration, valence states, minerals, ores, beneficiation, extraction, separation, metal preparation and purification. Crystal structures, phase transformations and polymorphism, and thermochemical properties of rare earth metals. Chemical properties: inorganic and organometallic compounds, alloy chemistry, nature of the chemical bonding. Physical properties: mechanical and elastic properties, magnetic properties, resistivity, and superconductivity.

M S E 564: Fracture and Fatigue
(Cross-listed with AER E, E M, M E). (3-0) Cr. 3. Alt. F., offered even-numbered years.
*Prereq: E M 324 and either MAT E 216 or MAT E 273 or MAT E 392. Undergraduates: Permission of instructor*
Materials and mechanics approach to fracture and fatigue. Fracture mechanics, brittle and ductile fracture, fracture and fatigue characteristics, fracture of thin films and layered structures. Fracture and fatigue tests, mechanics and materials designed to avoid fracture or fatigue.

M S E 569: Mechanics of Composite and Combined Materials
(Cross-listed with AER E, E M). (3-0) Cr. 3. Alt. S., offered even-numbered years.
*Prereq: E M 324*

M S E 581: Computational Modeling of Materials
(3-0) Cr. 3. Alt. F., offered even-numbered years.
*Prereq: (MATH 265 and MAT E 311) or CH E 381 or CHEM 325 or PHYS 304*
Introduction to the basic methods used in the computational modeling and simulation of materials, from atomistic simulations to methods at the mesoscale. Students will be expected to develop and run sample programs. Topics to be covered include, for example, electronic structure calculations, molecular dynamics, Monte Carlo, phase-field methods, etc.

M S E 588: Eddy Current Nondestructive Evaluation
(Dual-listed with MAT E 488). (Cross-listed with E E). (3-0) Cr. 3. Alt. F., offered odd-numbered years.
*Prereq: MATH 265 and (MAT E 216 or MAT E 273 or MAT E 392 or E E 311 or PHYS 364)*
Electromagnetic fields of various eddy current probes. Probe field interaction with conductors, cracks and other material defects. Ferromagnetic materials. Layered conductors. Elementary inversion of probe signals to characterize defects. Special techniques including remote-field, transient, potential drop nondestructive evaluation and the use of Hall sensors. Practical assignments using a 'virtual' eddy current instrument will demonstrate key concepts.

M S E 590: Special Topics
Cr. arr. Repeatable.
*Prereq: Permission of instructor*

M S E 599: Creative Component
Cr. arr. Repeatable.

Courses for graduate students:

M S E 601: Materials Seminar
(1-0) Cr. 1. Repeatable. F.S.
*Prereq: MSE Graduate Student Status*
Seminar course - presentations given on a weekly basis by leading U.S. and international researchers that are experts in their respective fields closely related to Materials Science. Offered on a satisfactory-fail basis only.

M S E 620: Fundamentals of Phase Transformations
(3-0) Cr. 3. Alt. S., offered even-numbered years.
*Prereq: M S E 520*
Explores various advanced theoretical treatments of the energetics and kinetics of multicomponent materials. Topics include analytical and computational descriptions of thermodynamic quantities, experimental measurement of essential physical properties, analytical and computational treatments of kinetic processes, and the use of theoretical predictions of phase equilibria and evolution in materials systems.

M S E 630: Physical Properties of Solids
(3-0) Cr. 3.
*Prereq: M S E 530*
Advanced course in the behavior of solids within the framework of solid state physics and chemistry. Includes magnetic, dielectric, transport, and optical phenomena in solids. Influence of phase transformations and crystal symmetry on the physical properties.
M S E 651: Powder Diffraction Methods
(3-0) Cr. 3. Alt. S., offered odd-numbered years.
Prereq: M S E 510
Advanced structural characterization of materials using powder
diffraction. Production of X-ray and neutron radiation. Review of
symmetry, group and kinematical theories of diffraction. Mathematical
and computational backgrounds of powder diffraction data. Introduction
to single crystal diffraction methods, origin of powder diffraction
pattern, history of the technique. Modern powder diffraction methods.
Indexing of powder diffraction patterns, figures of merit, precise lattice
parameters. Phase problem, determining crystal structures from
symmetry and geometry. Patterson, direct and Fourier methods. Rietveld
method, precise crystal structures: atomic parameters, qualitative
and quantitative phase identification, preferred orientation, grain size,
strain, residual stress, order-disorder. Powder diffraction at non-ambient
conditions. Applications of powder diffraction: data bases, phase
transformations, phase diagrams, local structures, magnetism.

M S E 652: Transmission Electron Microscopy
(2-3) Cr. 3. Alt. S., offered odd-numbered years.
Prereq: M S E 510
Theory and application of transmission electron microscopy to inorganic
materials. Specimen preparation, selected area and convergent
beam electron diffraction, bright field/dark field/high resolution
imaging. Compositional analysis using X-ray and electron energy loss
spectroscopy.

M S E 690: Advanced Topics in Materials Science
Cr. arr. Repeatable.
Prereq: Permission of instructor

M S E 697: Engineering Internship
Cr. R. Repeatable. F.S.SS.
Prereq: Permission of department, graduate classification
One semester and one summer maximum per academic year professional
work period. Offered on a satisfactory-fail basis only.

M S E 699: Research
Cr. arr. Repeatable.