MATERIALS SCIENCE AND ENGINEERING (M S E)

Courses primarily for graduate students, open to qualified undergraduates:

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. F.  
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. Alt. S., offered odd-numbered years.  
Prereq: M E 324 or MAT E 272 and 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: credit or enrollment in E E 332  
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 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 549: Structural Health Monitoring
(Dual-listed with MAT E 449). (Cross-listed with C E). (3-0) Cr. 3.
Prereq: Senior classification in Engineering or permission of instructor
Introductory and advanced topics in structural health monitoring (SHM)
of aeronautical, civil, and mechanical systems. Topics include sensors,
signal processing in time and frequency domains, data acquisition
and transmission systems, design of integrated SHM solutions,
nondestructive evaluation techniques, feature extraction methods,
and cutting-edge research in the field of SHM. Graduate students will have
a supervisory role to assist students in 449 and an additional design
project or more in-depth analysis and design.

M S E 550: Nondestructive Evaluation
(Cross-listed with E M). (3-2) Cr. 4. S.
Prereq: E M 324, MATH 385
Principles of five basic NDE methods and their application in engineering
inspections. Materials behavior and simple failure analysis. NDE
reliability, and damage-tolerant design. Advanced methods such as
acoustic microscopy, laser ultrasonics, thermal waves, and computed
tomography are analyzed. Computer-based experiments on a selection
of methods: ultrasonics, eddy currents, x-rays are assigned for student
completion.

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
crystallization.

M S E 552: Scanning and Auger Electron Microscopy
(2-3) Cr. 3. F.
Prereq: PHYS 222
Characterization of materials using scanning electron microscope
(SEM), electron microprobe, and auger spectrometer. Compositional
determination using energy and wavelength dispersive x-ray and Auger
spectroscopies. Specimen preparation. Laboratory covers SEM operation.

M S E 553: Physical and Mechanical Properties of Polymers
(Dual-listed with M S 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 and 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
design and 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: MAT E 311 or CHEM 325
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
Macromechanical behavior of lamina and laminates. Strength and
interlaminar stresses of laminates. Failure criteria. Stress analysis of
laminates. Thermal moisture and residual stresses. Joints in composites.
M S E 581: Computational Modeling of Materials
(Dual-listed with MAT E 481). (3-0) Cr. 3. Alt. F., offered odd-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. Alt. F., offered odd-numbered years.
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. Rietveded
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.S.
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.