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
(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). (2-4) Cr. 4.
Prereq: PHYS 222, MATH 267. E E 332 or MAT E 334 recommended
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. F.
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 characterization.

M S E 552: Scanning and Auger Electron Microscopy  
(2-3) Cr. 3. F.  
*Prereq: PHYS 222*  

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: 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: MAT E 311 or CHEM 325 AND CHEM 324 or PHYS 322*  
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 570: Toying With Technology for Practicing Teachers  
(Cross-listed with C I). (2-0) Cr. 2. SS.  
*Prereq: C I 201 or 202 or 505 or equivalent*  
A project-based, hands-on learning course. Technology literacy, appreciation for technological innovations, principles behind many technological innovations, hands-on experiences based upon simple systems constructed out of LEGO's and controlled by microcomputers. Other technological advances with K-12 applications will be explored. K-12 teachers will leave the course with complete lesson plans for use in their classrooms.

M S E 581: Computational Modeling of Materials  
(Dual-listed with MAT E 481). (3-0) Cr. 3. F.  
*Prereq: Math 265 and (MatE 311 or Che 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 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 even-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*  

**M S E 652: Transmission Electron Microscopy**  
(2-3) Cr. 3. Alt. F., 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.