# MATERIALS SCIENCE AND ENGINEERING MSE

## Department of Chemical Engineering and Materials Science
## College of Engineering

**200 Materials and Society**
Fall. 2(2-0) RB: High school physics and chemistry.
Material capabilities, limitations, and their utilization in the service and advancement of society. Role of materials in our day-to-day lives. Resource and environmental concerns including current material-related issues.

**250 Materials Science and Engineering**
Fall, Spring, Summer. 3(2-3) P: CEM 141 or CEM 151 or LB 171 SA: MSM 250
Structure of metals, ceramics and polymers. Phase diagrams, thermomechanical treatments, physical and mechanical properties, diffusion, microstructure studies, environmental effects.

**260 Electronic, Magnetic, Thermal, and Optical Properties of Materials**
Spring. 3(3-0) P: (MSE 250) and ((PHY 184 or concurrently) or (PHY 184B or concurrently) or (PHY 294H or concurrently) or (LB 274 or concurrently)) SA: MSE 350
Processing, structures, and properties of ceramics, polymers, and composites. Electrical, thermal, magnetic and optical properties of materials. Materials selection and design.

**310 Phase Equilibria in Materials**
Fall. 3(3-0) P: (MSE 250) and ((MTH 234 or concurrently) or (MTH 254H or concurrently) or (LB 220 or concurrently)) R: Open to juniors or seniors in the Materials Science and Engineering Major or in the Materials Science and Engineering Minor. SA: MSE 351
Enthalpy. Entropy. Free energy. Phase changes in metal, ceramic, and polymer materials systems. Application to alloying, phase diagram determination, and electrochemistry.

**320 Mechanical Properties of Materials**
Fall. 3(3-0) P: (ME 222 or concurrently) and MSE 250 R: Open to juniors or seniors in the Materials Science and Engineering Major or in the Materials Science and Engineering Minor. SA: MSE 355
Mechanical behavior of metals, ceramics, and polymers. Three-dimensional stress-states. Stress, strain, and compliance tensors. Test methods. Elastic, viscoelastic, and plastic deformation. Fracture, fatigue, and creep.

**331 Materials Characterization Methods I**
Fall. 2(1-3) P: MSE 310 or concurrently R: Open to juniors or seniors in the Materials Science and Engineering Major. SA: MSE 375
Thermal analysis, microindentation techniques, quantitative optical microscopy, effects of alloying on creep deformation, slip systems in ionic crystals, viscoelastic of solids, and polymer rheology.

**360 Fundamentals of Microstructural Design**
Spring. 3(3-0) P: ME 201 or MSE 310 or CHE 321 or PHY 215 RB: ((MTH 235 or concurrently) or (MTH 340 or concurrently) or (MTH 347H or concurrently)) and (MSE 260 or concurrently) R: Open to juniors or seniors in the Department of Chemical Engineering and Materials Science or in the Materials Science and Engineering Minor. SA: MSE 352
Fick's laws of diffusion. Models of solid state diffusion. Arrhenius plots. Use of non-equilibrium energy storage from solidification, phase changes, and deformation to predict and control microstructural changes and stability during processing in metal, ceramic, and polymer systems.

**370 Synthesis and Processing of Materials**
Spring. 3(3-0) P: (ME 201 or PHY 215 or MSE 310 or CHE 321) and MSE 250 RB: MSE 260 or concurrently R: Open to juniors or seniors in the Department of Chemical Engineering and Materials Science or in the Materials Science and Engineering Minor. SA: MSE 365, MSE 380
Chemical and physical processing of materials. Powder synthesis and processing, consolidation, casting, microdevice fabrication and surface treatments, corrosion mitigation

**381 Materials Characterization Methods II**
Spring. 2(1-3) P: (MSE 260 or concurrently) and (MSE 360 or concurrently) and (MSE 370 or concurrently) R: Open to juniors or seniors in the Materials Science and Engineering Major.
Characterization of materials by electron microscopy, X-ray diffraction and fluorescence spectroscopy. Fractography, surface analysis, dynamic mechanical analysis, electrical and thermal property measurements.

**410 Materials Foundations for Energy Applications**
Fall. 3(3-0) RB: MSE 310 or ME 201 or CHE 321 R: Open to seniors in the Department of Chemical Engineering and Materials Science or in the Materials Science and Engineering Minor or approval of department.
Survey of materials that enable new energy generation, storage, and distribution technologies; thermoelectric materials, electrochemistry of batteries, semiconductors for solar cells, radiation tolerant materials, processing of biobased fuels, greenhouse gas mitigation approaches

**425 Biomaterials and Biocompatibility**
Fall. 3(3-0) Interdepartmental with Biomedical Engineering. Administered by Materials Science and Engineering. P: MSE 250 RB: PSL 250 R: Open to juniors or seniors in the College of Engineering. SA: BME 424, MSE 324
Materials science of human implants. Design requirements imposed by the human body, and need for bodily protection.

**426 Introduction to Composite Materials**
Spring. 3(3-0) Interdepartmental with Mechanical Engineering. Administered by Mechanical Engineering. P: ME 222 R: Open to juniors or seniors in the College of Engineering. SA: MSM 444
Constituents and interfacial bonding. Manufacturing techniques. Microstructure and micromechanics. Theory of anisotropy. Classical laminate theory. Material characterization. Failure and damage. Composite structure design.

**460 Electronic Structure and Bonding in Materials and Devices**
Spring. 3(3-0) P: MSE 260 R: Open to seniors or juniors in the Department of Chemical Engineering and Materials Science or in the Materials Science and Engineering Minor.
Relationship between quantum mechanics and material properties. Free electron theory. Energy bands, semiconductors. Dielectrics and ferroelectrics. Dia-, para-, ferro-, and antiferro-magnetism. Superconductivity. Thermal properties.

**465 Design and Application of Engineering Materials**
Spring. 3(3-0) P: MSE 250 R: Open to seniors or graduate students in the College of Engineering or in the Materials Science and Engineering Major or in the Materials Science and Engineering Minor. SA: MSM 465
Fundamental principles of strengthening: toughening, specific strength, and stiffness. Material development based on environmental, temperature, wear, damping, fatigue, and economic considerations.

**466 Design and Failure Analysis (W)**
Spring. 3(2-3) P: (MSE 320 and MSE 331 and MSE 381) and completion of Tier I writing requirement R: Open to seniors in the Materials Science and Engineering Major. SA: MSM 466
Modes and causes of failure in mechanical components and role of design. Non-destructive evaluation. Legal and economic aspects of materials failure. Student projects.

**474 Ceramic and Refractory Materials**
Fall. 3(3-0) P: MSE 260 RB: MSE 370 and MSE 381 R: Open to seniors in the Materials Science and Engineering Major or in the Materials Science and Engineering Minor. SA: MSM 454, MSE 454
Ceramic and glassy materials. High temperature processes. Mechanical and physical properties of technical ceramics.

**476 Physical Metallurgy of Ferrous and Aluminum Alloys**
Fall. 3(3-0) P: MSE 250 RB: MSE 310 R: Open to seniors in the Materials Science and Engineering Major or in the Materials Science and Engineering Minor. SA: MSM 476
Heat treatment and properties of ferrous and aluminum alloys. Casting and solidification. Effects of alloying elements, high strength low alloy steels, hardenability, and case hardening. Joining of materials, such as welding.

**477 Manufacturing Processes**
Fall, Spring. 3(3-0) Interdepartmental with Mechanical Engineering. Administered by Mechanical Engineering. P: ME 222 and MSE 250 R: Open to students in the Applied Engineering Sciences Major or in the Materials Science and Engineering Major or in the Mechanical Engineering Major. SA: MSM 481
Fundamentals of manufacturing processes such as casting, heat treating, particulate processing, forming, machining, joining, and surface processing. Selection of manufacturing processes based on design and materials.

**481 Spectroscopic and Diffraction Analysis of Materials**
Spring. 3(2-3) P: PHY 184 or PHY 184B or PHY 234B or PHY 294H or LB 274 RB: MSE 260 and MSE 381 R: Open to juniors or seniors in the Materials Science and Engineering Major or in the Materials Science and Engineering Minor. SA: MSE 451, MSM 451
General properties, generation, and detection of x-rays interaction with solids. Crystallography, reciprocal space, diffraction analysis, and techniques. Single crystal methods. Stereographic projection. X-ray microanalysis.

**490 Independent Study**
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 6 credits in all enrollments for this course. R: Open to seniors. Approval of department. SA: MSM 490
Individualized reading and research.

**491 Selected Topics**
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 6 credits in all enrollments for this course. R: Open to students in the Department of Chemical Engineering and Materials Science or in the College of Engineering. SA: MSM 491
Topics of current interest in materials science or engineering.

**499 Senior Research and Design Project (W)**
Fall, Spring, Summer. 2 to 4 credits. A student may earn a maximum of 6 credits in all enrollments for this course. P: Completion of Tier I writing requirement. R: Open to students in the Department of Chemical Engineering and Materials Science or in the Materials Science and Engineering Major. Approval of department. SA: MSM 499
Design and analysis to solve materials and/or mechanics related problem. Preparation of written report, oral presentation, and defense of the project.

**801 Foundations of Materials Science and Engineering**
Summer. 3(3-0) RB: Undergraduate degree in science or engineering related to Materials Science.
Structure-Property-Processing-Performance interrelationship of metals, ceramics and polymers. Phase diagrams, thermomechanical treatments, physical and mechanical properties, processing, diffusion, microstructure studies, environmental effects.

**802 Research Methods**
Fall. 1(0-2) Interdepartmental with Chemical Engineering. Administered by Chemical Engineering. R: Open to graduate students in the Department of Chemical Engineering and Materials Science.
Skills required for graduate research. Critically reviewing the literature, defining a fundamental research problem, effective oral and written technical presentations.

**810 Materials for Energy Applications**
Fall. 3(3-0) RB: ME 802 or MSE 851 or CHE 821 R: Open to graduate students in the Department of Chemical Engineering and Materials Science. Not open to students with credit in MSE 410.
Enabling science and technology for new energy generation materials, storage, and distribution technologies; thermoelectric materials, electrochemistry of batteries, semiconductors for solar cells, radiation tolerant materials, processing of biobased fuels, greenhouse gas mitigation approaches

**851 Thermodynamics of Solids**
Fall. 3(3-0) SA: MSM 851
Use of Jacobians. Thermodynamic functions. Thermodynamics of solid-solid phase transformation. Thermoelastic solids, rubber elasticity, and stressed solids. Surfaces and interfaces, point defects in solids. Thermodynamics of solids under high pressure.

**855 Advanced Rate Theory and Diffusion**
Spring. 3(3-0) RB: MSE 851 SA: MSM 855
Review of Fick's Laws. Atomistic aspects of diffusion. Defects in solids. Probabilistic basis of random walk. Green's function solutions.

**860 Advanced Theory of Solids**
Spring. 3(3-0) SA: MSE 865, MSM 865
Quantum mechanics. Free electron theory. Energy bands, semiconductors. Dielectrics and ferroelectrics. Dia-, para-, ferro-, and antiferro-magnetism. Superconductivity. Thermal properties.

**862 Dislocation Theory**
Fall. 3(3-0) SA: MSM 862
Advanced theory of dislocations and other crystal defects in metals, ceramics, aggregates and ordered compounds. Elasticity theory of straight dislocations, dislocation strain energy, mobility, obstacle interactions, reactions, and core effects.

**870 Electron Microscopy in Materials Science**
Fall. 3(2-3) R: Open to graduate students in the Materials Science and Engineering major or approval of department. SA: MSM 870
Theory of electron diffraction. Electromagnetic lenses. Image formation in transmission electron microscopy. Defect analysis and diffraction contrast.

**871 Material Surfaces and Interfaces**
Fall of odd years. 3(3-0) Interdepartmental with Chemical Engineering. Administered by Materials Science and Engineering. RB: CEM 392 or CEM 434 or MSE 351 R: Open only to graduate students in the Department of Chemical Engineering and Materials Science or Department of Chemistry or School of Packaging. SA: MSM 871
Physical and chemical nature of solid surfaces and their interaction with gases, liquids, and other solids. Characterization of surfaces and solid-solid interfaces. Relation of surface and interfacial structure to engineering phenomena.

**875 Engineering Ceramics**
Fall of odd years. 3(3-0) RB: MSE 851 SA: MSM 875
Physical properties of engineering ceramics. Transport properties of ceramics, especially in ferrites and garnets. Optical ceramic materials.

**876 Advanced Polymeric Materials**
Fall of even years. 3(3-0) SA: MSM 876
Advanced topics in polymer structure and properties. Thermoplastics, thermosets, polyblends and elastomers. Processing techniques. Deformation and mechanical properties. Thermal, optical and chemical properties. Composites.

**880A Atomistic and Quantum Simulations for Materials**
On Demand. 3(2-2) RB: MSE 860 or MSE 862 or ME 820 or ME 872 R: Open to graduate students in the College of Engineering. SA: MSE 880
Modern computational techniques for the prediction of material properties beginning from the quantum electronic structure to the atomistic level. Density functional theory (DFT), molecular dynamics, Monte Carlo, and machine learning.

**880B Microstructure Evolution**
On Demand. 3(2-2) RB: (MSE 860 or MSE 862 or ME 820 or ME 872) or Basic experiences of Matlab or Python programming are strongly recommended. R: Open to graduate students in the College of Engineering. SA: MSE 880
Modeling mass transport and phase transformation at meso and microscales. Thermodynamics and kinetics of the formation of dendritic, eutectic, spinodal decomposed, and other microstructures from simulations. Monte Carlo, phase field model, and numerical methods.

**880C Mechanics of Microstructured Materials**
On Demand. 3(2-2) RB: MSE 860 or MSE 862 or ME 820 or ME 872 R: Open to graduate students in the College of Engineering. SA: MSE 880
Modeling methods and computational techniques to predict the mechanics of microstructured materials. Constitutive models to describe single crystal plasticity and techniques to solve mechanics of polycrystalline matter. Simulation tools include discrete dislocation dynamics and finite element methods.

**881 Advanced Spectroscopy and Diffraction Analysis of Materials**
Spring. 3(2-3) RB: PHY 184 or PHY 184B or PHY 234B R: Open to graduate students in the College of Engineering. SA: MSE 841 Not open to students with credit in MSE 481.
Physical basis for properties, generation, and detection of x-ray interaction with solids. Crystallography, reciprocal space, diffraction analysis, and techniques. Single crystal methods. Stereographic projection. X-ray microanalysis.

**890 Independent Study**
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 6 credits in all enrollments for this course. R: Approval of department. SA: MSM 890
Individualized reading and research of student's interest.

**891 Selected Topics**
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 6 credits in all enrollments for this course. R: Approval of department. SA: MSM 891
Special topics of current importance in materials science or engineering.

**892 Seminar**
Fall, Spring. 1(0-2) A student may earn a maximum of 2 credits in all enrollments for this course. Interdepartmental with Chemical Engineering. Administered by Chemical Engineering. R: Open to master's students in the Chemical Engineering Major or in the Materials Science and Engineering Major.
Presentations of detailed studies of specialized aspects of chemical engineering and materials science.

**899 Master's Thesis Research**
Fall, Spring, Summer. 1 to 8 credits. A student may earn a maximum of 24 credits in all enrollments for this course. SA: MSM 899
Master's thesis research.

**974B High Temperature Deformation and Processing**
Spring of even years. 3(3-0) RB: MSE 851 and MSE 862 SA: MSM 980B, MSM 974B
Theoretical and design principles applied to the control of creep, superplasticity, cavitation, recrystallization, and texture changes. Metallic, alloy, intermetallic, ceramic, and composite systems.

**990 Independent Study**
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 6 credits in all enrollments for this course. SA: MSM 990
Individualized reading and research.

**991 Selected Topics**
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 6 credits in all enrollments for this course. R: Approval of department. SA: MSM 991
Special advanced topics in materials science and engineering, and mechanics.

**992 Seminar**
Fall, Spring. 1(0-2) A student may earn a maximum of 5 credits in all enrollments for this course. Interdepartmental with Chemical Engineering. Administered by Chemical Engineering. R: Open to doctoral students in the Chemical Engineering Major or in the Materials Science and Engineering Major.
Presentations of detailed studies of specialized aspects of chemical engineering and materials science.

**999 Doctoral Dissertation Research**
Fall, Spring, Summer. 1 to 24 credits. A student may earn a maximum of 36 credits in all enrollments for this course. R: Open to graduate students in the Department of Chemical Engineering and Materials Science. SA: MSM 999
Doctoral dissertation research.