# MATERIALS SCIENCE & ENGINEERING (MAT_SCI)

**MAT_SCI 190-0 MS & E Freshman Seminar (1 Unit)** Laboratory-oriented, with research projects emphasizing use of the scanning electron microscope and other modern apparatus; correlation of structure with other properties of materials. Lectures, laboratory. *SOC Additional Distro*

**MAT_SCI 195-0 Introductory Special Topics in Materials Science and Engineering (1 Unit)** Introductory topics suggested by students or faculty and approved by the department. *SOC Additional Distro*

**MAT_SCI 201-0 Introduction to Materials Science and Engineering Principles (1 Unit)** Basic concepts of Materials Science and Engineering: bonding, crystal structure, defects in solids, phase diagrams, and development of microstructures. Processing/structure/property/performance relationships underlying the behavior of metals, ceramics, polymers, semiconductors, and composites. Mechanical, electrical, and chemical properties of engineering materials. Broadly, how materials? performance influences technological development, the economy, the environment, and society. Not to be taken for credit with or after MAT_SCI 301-0. Prerequisites: CHEM 131-0, CHEM 151-0, or CHEM 171-0. *SoC Mathematics, Science, and Technology Distro*

**MAT_SCI 301-0 Introduction to Materials Science and Engineering Principles (1 Unit)** Basic concepts of Materials Science and Engineering: bonding, crystal structure, defects in solids, phase diagrams, and development of microstructures. Processing/structure/property/performance relationships underlying the behavior of metals, ceramics, polymers, semiconductors, and composites. Mechanical, electrical, and chemical properties of engineering materials. Broadly, how materials? performance influences technological development, the economy, the environment, and society. Prerequisites: CHEM 131-0, CHEM 151-0, or CHEM 171-0; major in materials science and engineering or chemical and biological engineering; concurrent enrollment in MAT_SCI 302-0. *SoC Mathematics, Science, and Technology Distro*

**MAT_SCI 302-0 Introduction to Materials Laboratories (0 Unit)**
Lab for students taking MAT_SCI 301. Topics related to: Bonding, crystal structure and defects in solids. Phase diagrams in condensed matter systems. Equilibrium and nonequilibrium development of microstructures. Processing/structure/property/performance relationships underlying behavior of metals, ceramics, polymers, and composites. Mechanical, electrical, chemical properties of engineering materials. To be taken concurrently with MAT_SCI 301-0. *SoC Mathematics, Science, and Technology Distro*

**MAT_SCI 314-0 Thermodynamics of Materials (1 Unit)**
Classical and statistical thermodynamics; entropy and energy functions in liquid and solid solutions, and their applications to phase equilibria. Lectures, problem solving. Materials science and engineering degree candidates may not receive credit for 314 with or after CHEM 342-1.
Prerequisite: CHEM 132-0, CHEM 152-0, or CHEM 172-0; MATH 228-1 or MATH 230-1; GEN_ENG 150; PHYSICS 135-1 to be taken concurrently.
*SoC Mathematics, Science, and Technology Distro*

**MAT_SCI 315-0 Phase Equilibria & Diffusion of Materials (1 Unit)**
Application of thermodynamics to ternary phase equilibria. Defects and diffusion in solids. Interdiffusion. Short-circuit diffusion. Defects and transport in ionic solids. Lectures, problem solving, and laboratory.
Prerequisite: MAT_SCI 201-0 or MAT_SCI 301-0 or equivalent and MAT_SCI 314-0 or equivalent.
*SoC Mathematics, Science, and Technology Distro*

**MAT_SCI 316-1 Microstructural Dynamics (1 Unit)**
Principles underlying development of microstructures. Defects, diffusion, phase transformations, nucleation and growth, thermal and mechanical treatment of materials. Lectures, laboratory.
Prerequisite: MAT_SCI 315-0 or equivalent.
*SoC Mathematics, Science, and Technology Distro*

**MAT_SCI 316-2 Microstructural Dynamics (1 Unit)**
Principles underlying development of microstructures. Defects, diffusion, phase transformations, nucleation and growth, thermal and mechanical treatment of materials. Lectures, laboratory.
Prerequisite: MAT_SCI 316-1 or instructor consent.
*SoC Mathematics, Science, and Technology Distro*

**MAT_SCI 318-0 Materials Selection (1 Unit)**
Methods of specifying materials and the processes for making them in the context of a given application. Service performance of materials based on their physical and chemical properties. Case studies and use of high-level databases.
Prerequisite: MAT_SCI 201-0 or MAT_SCI 301 or permission by instructor.
*SoC Mathematics, Science, and Technology Distro*

**MAT_SCI 331-0 Soft Materials (1 Unit)**
Different kinds of polymeric materials. Relationships between structure and physical properties; rubber elasticity, the glassy state, crystallinity in polymers. Lectures, laboratory.
Prerequisites: MAT_SCI 301-0 or equivalent; MAT_SCI 314-0 or CHEM 342-1; MAT_SCI 316-1 and MAT_SCI 316-2.
*SoC Mathematics, Science, and Technology Distro*

**MAT_SCI 332-0 Mechanical Behavior of Solids (1 Unit)**
Plastic deformation and fracture of metals, ceramics, and polymeric materials; structure/property relations. Role of imperfections, state of stress, temperatures, strain rate. Lectures, laboratory.
Prerequisites: MAT_SCI 316-1; MAT_SCI 316-2.
*SoC Mathematics, Science, and Technology Distro*

**MAT_SCI 336-0 Synthetic Design of New Materials (1 Unit)**
The design of new materials targeting important technological functions through processes requiring chemical reactions, synthesis of molecules, and molecular design for self-assembly and 3D printing. Fundamental principles and design strategies, including polymerization, biosynthesis and biocompatibility, design of molecular precursors for electronic materials and ceramics, synthesis of nanomaterials, composite and hierarchical structures.
Prerequisite: junior standing in materials science and engineering or consent of instructor.
*SoC Mathematics, Science, and Technology Distro*

**MAT_SCI 340-0 Ceramic Processing (1 Unit)**
Steps in production of fired ceramic articles. Powder preparation and characterization, compact formation, slip casting, extrusion and injection molding; firing, liquid-phase and solid-state sintering. Lectures, laboratory.
Prerequisite: MAT_SCI 316-1 or equivalent.
*SoC Mathematics, Science, and Technology Distro*

**MAT_SCI 345-0 Corrosion of Materials (1 Unit)**
Corrosion is the deterioration of materials due to electrochemical attack by the environment, driven by the flow of electrons and ions. We will develop fundamental understanding of these electrochemical reactions at equilibrium and their behavior away from equilibrium. This will be followed by the exploration of various corrosion phenomena, their scientific and quantitative basis, and how we can mitigate the adverse effects of corrosion. We will also learn that corrosion can be good and plays an integral role in developing sustainable energy resources and maintaining our infrastructure.

Prerequisite: MAT_SCI 201-0 or MAT_SCI 301-0 or consent of instructor.
*SoC Mathematics, Science, and Technology Distro*

**MAT_SCI 351-1 Introductory Physics of Materials (1 Unit)**
Quantum mechanics; applications to materials and engineering. Band structures and cohesive energy; thermal behavior; electrical conduction; semiconductors; amorphous semiconductors; magnetic behavior of materials; liquid crystals. Lectures, laboratory, problem solving.
Prerequisites: MAT_SCI 301 or equivalent; GEN_ENG 251 or equivalent; PHYSICS 135-2, PHYSICS 135-3; MAT_SCI 351-1 is a pre-req for MAT_SCI 351-2.
*SoC Mathematics, Science, and Technology Distro*

**MAT_SCI 351-2 Introductory Physics of Materials (1 Unit)**
Quantum mechanics; applications to materials and engineering. Band structures and cohesive energy; thermal behavior; electrical conduction; semiconductors; amorphous semiconductors; magnetic behavior of materials; liquid crystals. Lectures, laboratory, problem solving.
Prerequisites: MAT_SCI 301 or equivalent; GEN_ENG 251 or equivalent; PHYSICS 135-2, PHYSICS 135-3; MAT_SCI 351-1 is a pre-req for MAT_SCI 351-2.
*SoC Mathematics, Science, and Technology Distro*

**MAT_SCI 353-0 Bioelectronics (1 Unit)**
Development and design of sensors, stimulators, and their medical devices for biointegrated electronics. Materials design and fabrication of passive and active components for sensitive, multimodal, and robust wearable and implantable devices.
Prerequisite: junior or senior standing recommended.
*SoC Mathematics, Science, and Technology Distro*

**MAT_SCI 354-0 Bioelectronics Lab (1 Unit)**
Laboratories focused on the practical implementation, instrumentation, and fabrication of wearables and skinsensing. Applications range from vital sign monitoring to rehabilitation.
Prerequisites: BMD_ENG 353 or MAT_SCI 353. Concurrent enrollment is acceptable.
*SoC Mathematics, Science, and Technology Distro*

**MAT_SCI 355-0 Electronic Materials (1 Unit)**
Principles, models, and characterization of semiconductor materials. Crystal growth and doping. Diffusion, epitaxy, and monolithic processes. Current transport, non-equilibrium processes, thin films, low-mobility materials, and interfaces.
Prerequisite: MAT_SCI 316-1 or consent of instructor.
*SoC Mathematics, Science, and Technology Distro*

**MAT_SCI 357-0 Nanomagnetic Materials for Information Storage (1 Unit)**
Overview of materials used for magnetic data storage and of the recording and read processes. Information storage systems, such as optical, solid-state, and probe. Theoretical background for understanding the four energy terms that control the properties of magnetic materials when they are patterned at the nanoscale.
*SoC Mathematics, Science, and Technology Distro*

**MAT_SCI 358-0 Modeling and Simulation in Materials Science and Engineering (1 Unit)**
The course covers the essential methods and principles for modeling and simulating the structure, properties, and behavior of materials. It focuses on constructing models and identifying approaches to test either theoretical descriptions or experimental observations of materials phenomena on a computer. The course balances breadth versus depth of topics with the goal of producing researchers literate in computational materials science and its applicability across different length scales. Students will construct structure-property models of atomic assemblies, molecules, and solids using first-principles electronic structure (such as density-functional theory), deterministic (molecular dynamics), statistical methods (Monte Carlo and (Un)Supervised Learning), and finite elements models. Computational laboratories will give students extensive hands-on experience with several powerful modern materials modeling codes.
Prerequisite: MAT_SCI 314-0, MAT_SCI 315-0, MAT_SCI 316-1, and MAT_SCI 351-1.
*SoC Mathematics, Science, and Technology Distro*

**MAT_SCI 360-0 Introduction to Electron Microscopy (1 Unit)**
Theories and practice involved in application of scanning electron microscopy and transmission electron microscopy. Lectures, laboratory. Primarily for undergraduates and for graduate students in other departments.
Prerequisites: MAT_SCI 301-0; PHYSICS 135-2, PHYSICS 135-3 or equivalent.
*SoC Mathematics, Science, and Technology Distro*

**MAT_SCI 361-0 Crystallography & Diffraction (1 Unit)**
Elementary crystallography. Basic diffraction theory; reciprocal space. Applications to structure analysis, preferred orientation. Film and counter techniques. Lectures, laboratory.
Prerequisites: GEN_ENG 241 or equivalent; GEN_ENG 251 or equivalent; PHYSICS 135-2; PHYSICS 135-3.
*SoC Mathematics, Science, and Technology Distro*

**MAT_SCI 371-0 Biominerals: Hierarchical Architecture & Function (1 Unit)**
How biologically based processing of mineralorganic composites used by living organisms inspires new approaches to materials synthesis in many critical applications-locomotion (bones), defense (shells), and sensing (light, acceleration, magnetic fields).
Prerequisite: MAT_SCI 316-2 or equivalent, or consent of instructor.
*SoC Mathematics, Science, and Technology Distro*

**MAT_SCI 376-0 Nanomaterials (1 Unit)**
Introduction to structure-property relationships of materials processed at the nanometer scale. Highly interdisciplinary course appropriate for undergraduate and graduate students in other departments.
Prerequisite: MAT_SCI 351-1 or consent of instructor.
*SoC Mathematics, Science, and Technology Distro*

**MAT_SCI 377-0 Supramolecular Design of Materials and Nanostructures (1 Unit)** Introduction to frontier research at the interface of chemistry and materials science. *SoC Mathematics, Science, and Technology Distro*

**MAT_SCI 380-0 Intro Surface Science & Spectroscopy (1 Unit)**
Surface spectroscopy, including Auger spectroscopy, photoemission, and LEED. Surface dynamics and thermodynamics. Electronic properties of surfaces and interfaces. Gas-surface interactions.
Prerequisite: MAT_SCI 351-1 or equivalent.
*SoC Mathematics, Science, and Technology Distro*

**MAT_SCI 381-0 Materials for Energy-Efficient Technology (1 Unit)**
A materials science approach to the challenges of energy efficient technology: energy content of materials; advanced materials for energy harvesting, transmission, storage, and conversion; materials for energy efficient transportation and housing. Term paper and oral presentation.
Prerequisite: MAT_SCI 201-0, MAT_SCI 301-0, or consent of instructor.
*SoC Mathematics, Science, and Technology Distro*

**MAT_SCI 382-0 Electrochemical Energy Materials and Devices (1 Unit)**
Thermodynamics and kinetics of electrochemical processes. Materials for fuel cells, batteries, and electrochemical capacitors, including electrolytes and electrodes. Electrical and mass transport. Effect of microstructure. Electrochemical characterization. Device configurations.
Prerequisite: senior standing or consent of instructor.

*SoC Mathematics, Science, and Technology Distro*

**MAT_SCI 385-0 Electronic and Thermal Properties of Materials (1 Unit)**
Thermoelectric Devices. Solid-state electronic structure from a solid-state chemistry perspective, phonons in complex materials, electronic and thermal transport at room temperature and above (semi-classical) of metals, semiconductors and some insulators. Familiarity with quantum mechanics and the concept of density-of-states for electrons and phonons. MAT_SCI 351-1 or equivalent is recommended but not required. *SoC Mathematics, Science, and Technology Distro*

**MAT_SCI 390-1 Process and Experimental Design (1 Unit)**
This course introduces students to materials processing techniques used in research and industrial settings and the approaches scientists and engineers take to optimize processing-structure-property-performance relationships. Students are introduced to the systems design approach and design of experiments in order to define their own problems in materials science and engineering. Students develop core competencies in problem identification, experimental decision making, and technical communication.
Prerequisite: MatSci 316-2 and MatSci 351-2 or consent of instructor. MatSci 331 is recommended. MatSci 390-1 is a prerequisite for MatSci 390-2.
*SoC Humanities and Fine Arts Distro SoC Mathematics, Science, and Technology Distro*

**MAT_SCI 390-2 Materials Design (1 Unit)**
In this course, students apply a systems design approach to address contemporary problems in materials science and engineering. Using fundamental materials science principles, students implement their own methods and approaches to investigate processing-structure-properties-performance relationships. Students develop core competencies in project management, data collection and analysis, experimental decision making, and technical communication.
Prerequisites: MAR_SCI 316-2 and MAT_SCI 351-2 or consent of instructor. MAT_SCI 331-0 and MAT_SCI 332-0 are recommended. MAT_SCI 390-1 is a prerequisite for MAT_SCI 390-2.
*SoC Humanities and Fine Arts Distro SoC Mathematics, Science, and Technology Distro*

**MAT_SCI 394-0 Honors Project in Materials Science (1 Unit)**
Independent study and/or research linked to MAT_SCI 396-1 and MAT_SCI 396-2. Comprehensive report on a specific area of modern materials science and engineering. Prerequisite: registration in department honors program. *SOC Additional Distro*

**MAT_SCI 395-0 Special Topics in Materials Science and Engineering (1 Unit)**
Topics suggested by students or faculty and approved by the department. *SOC Additional Distro*

**MAT_SCI 396-1 Senior Project in Materials Science and Engineering (1 Unit)** To be taken in two consecutive quarters. Independent basic or applied research project, conceived and performed under the direction of a department faculty member. Prerequisite: senior standing in the materials science and engineering or materials science program. *SOC Additional Distro*

**MAT_SCI 396-2 Senior Project in Materials Science and Engineering (1 Unit)** To be taken in two consecutive quarters. Independent basic or applied research project, conceived and performed under the direction of a department faculty member. Prerequisite: senior standing in the materials science and engineering or materials science program. *SOC Additional Distro*

**MAT_SCI 397-0 Special Topics in Materials Science and Engineering (0 Unit)**
Special Topics in Materials Science and Engineering; laboratory emphasis.
*SOC Additional Distro*

**MAT_SCI 399-0 Projects (1 Unit)** Individual problems, including library and design work; comprehensive report on a specific phase of modern materials science. Credit to be arranged. *SOC Additional Distro*