**LOWER-DIVISION COURSES
MSE 001 Fundamentals of Materials Science and Engineering** (2) Lecture, 1 hour; discussion, 1 hour; laboratory, 1 hour. An introduction of properties and applications of different types of materials essential for various areas of engineering. Explores the relationship between structure and properties as well as processing of the materials. Illustrates a wide range of properties required for different types of applications. Graded Satisfactory (S) or No Credit (NC).

**UPPER-DIVISION COURSES
MSE 136 Tissue Engineering** (4) Lecture, 3 hours; term paper, 3 hours. Prerequisite(s): BIOL 005A and BIOL 005B, CHEM 001C or CHEM 01HC or equivalents; junior or senior standing or consent of instructor. Covers progress in cellular and molecular biology and engineering. Provides the basis for advancing tissue repair and regeneration with the goal of restoring compromised tissue functions. Presents methods for cell culture, tissue design and development, manipulation of the cell/tissue microenvironment, and current strategies for functional reconstruction of injured tissues. Cross-listed with BIEN 136.

**MSE 160 Nanostructure Characterization Laboratory** (4) Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): ME 114. Covers structure of materials at the nanoscale, including semiconductors, ceramics, metals, and carbon nanotubes. Explores relationships among morphology, properties, and processing. Addresses primary methods of characterization, including scanning electron microscopy, scanning probe microscopy, X-ray diffraction, and transmission electron microscopy. Also covers elementary discussions of X-ray, vibrational, and electron waves in solids and introductory diffraction theory.

**MSE 161 Analytical Materials Characterization** (4) Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): MSE 160. Analysis of the surfaces of materials via ion, electron, and photon spectroscopies. Includes Rutherford back scattering; secondary ion mass spectroscopy; electron energy loss spectroscopy; Auger electron spectroscopy; X-ray photoelectron spectroscopy; photoluminescence; extended X-ray absorption fine structure; Fourier transform infrared spectroscopy; and Raman spectroscopy. Also covers sputtering, high-vacuum generation, and focused ion beam milling.

**MSE 175A Senior Design** (4) Lecture, 2 hours; discussion, 1 hour; practicum, 3 hours. Prerequisite(s): CHE 116 or ME 116A; EE 139; senior standing in Materials Science and Engineering. Covers preparation of formal engineering reports and statistical analysis on a series of problems illustrating methodology from various branches of applied materials science and engineering. Addresses the entire design process: design problem definition; generation of a design specification; documentation; design review process; prototype fabrication; testing and calibration; cost estimation; and federal guidelines. Requires a term project and oral presentation. Graded In-Progress (IP) until MSE 175A and MSE 175B are completed, at which time a final, letter grades is assigned.

**MSE 175B Senior Design** (4) Lecture, 1 hour; discussion, 1 hour; practicum, 6 hours. Prerequisite(s): MSE 175A; senior standing in Materials Science and Engineering. Covers preparation of formal engineering reports and statistical analysis on a series of problems illustrating methodology from various branches of applied materials science and engineering. Addresses the entire design process: design problem definition; generation of a design specification; documentation; design review process; prototype fabrication; testing and calibration; cost estimation; and federal guidelines. Requires a term project and oral presentation. Satisfactory (S) or No Credit (NC) grading is not available.

**MSE 197 Research for Undergraduates** (1-4) Laboratory, 3-12 hours. Prerequisite(s): sophomore or junior or senior standing in Materials Science and Engineering or consent of instructor. Research conducted under the supervision of a MSE faculty member on selected problems in materials science and engineering supporting the focus area of the student. Course is repeatable to a maximum of 8 units; maximum of 4 units may count toward the technical elective requirement.

**GRADUATE COURSES
MSE 200 Graduate Studies in Materials Science and Engineering** (2) Lecture, 2 hours. Prerequisite(s): graduate standing in Materials Science and Engineering or consent of instructor. Introduction to graduate studies in Materials Science and Engineering. Covers the fundamental methods of the discipline. Provides an overview of the areas of specialization, as well as research opportunities and facilities. Summarizes employment opportunities for graduates from the Materials Science and Engineering program. Normally graded Satisfactory (S) or No Credit (NC), but students may petition the instructor for a letter grade on the basis of assigned extra work or examination. Course is repeatable as content changes to a maximum of 4 units.

**MSE 20x SERIES: FOUNDATIONS OF MATERIALS
MSE 201 Thermodynamic Foundations of Materials** (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): graduate standing in Materials Science and Engineering or consent of instructor. Covers the laws of thermodynamics and fundamental equations for multi-component elastic solids, electromagnetic media, and equilibrium criteria. Describes applications to solution thermodynamics, point defects in solids, elastic effects, phase diagrams, transitions, and interfaces. Includes nucleation theory, kinetics (diffusion of heat, mass, and charge), and coupled flows.

**MSE 204 Thermodynamics and Statistical Mechanics** (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): graduate standing; consent of instructor. Covers thermodynamics, statistical mechanics, ideal Bose systems, ideal Fermi systems, and bulk motion. Cross-listed with PHYS 212A.

**MSE 205 Advanced Physical Chemistry: Thermodynamics** (3) Lecture, 3 hours. Prerequisite(s): CHEM 110A and CHEM 110B with grades of “C” or better. Covers concepts in thermodynamics including fundamental equations, potentials, Maxwell relations, and stability criteria. Cross-listed with CHEM 201D.

**MSE 207 Applied Quantum Mechanics** (4) Lecture, 3 hours; outside research, 3 hours. Prerequisite(s): MATH 046, PHYS 040A; or consent of instructor. Covers topics in quantum mechanics including Schroedinger equation; operator formalism; harmonic oscillator; quantum wells; spin, bosons, and fermions; solids; perturbation theory; Wentzel-Kramers-Brillouin approximation; tunneling; tight-binding model; quantum measurements; quantum cryptography; and quantum computing. Cross-listed with EE 201.

**MSE 208 Mechanics and Physics of Materials** (4) Lecture, 4 hours. Prerequisite(s): graduate standing or consent of instructor. Introduces the structure and properties of materials; the characterization and modeling of mechanical, thermal, electric, and magnetic properties of materials; and coupling properties. Topics include phase transformations and brittle-to-ductile transitions. Cross-listed with ME 266.

**MSE 21X SERIES: MATERIALS STRUCTURE
MSE 210 Crystal Structure and Bonding** (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): graduate standing in Materials Science and Engineering or consent of instructor. Covers regular and irregular arrays of points and spheres. Includes lattices (direct and reciprocal); crystallographic point and space groups; and atomic structures. Also addresses bonding in molecules and solids; ionic Pauling rules; and covalent and metallic bonding. Surveys the structure of elements, compounds, minerals, and polymers.

**MSE 214 Condensed Matter Physics** (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): PHYS 221C; graduate standing or consent of instructor. Topics include classical and quantum theories of the electron gas; crystal and reciprocal lattices; X-ray diffraction; crystal symmetries; electrons in a periodic potential; nearly free electrons; tight binding; semiclassical dynamics; and semiclassical transport. Students whose research is related to condensed matter physics receive a letter grade; other students receive a letter grade or Satisfactory (S) or No Credit (NC) grade. Cross-listed with PHYS 240A.

**MSE 217 Fundamentals of Semiconductors and Nanostructures** (4) Lecture, 3 hours; outside research, 3 hours. Prerequisite(s): EE 133, EE 201/MSE 207; or consent of instructor. Examines principles of semiconductor materials and nanostructures. Topics include periodic structures, electron and phonon transport, defects, optical properties, and radiative recombination. Also covers absorption and emission of radiation in nanostructures and nonlinear optics effects. Emphasizes properties of semiconductor superlattices, quantum wells, wires, and dots. Cross-listed with EE 202.

**MSE 218 Imperfections in Solids** (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): graduate standing in Chemical and Environmental Engineering or Computer Science or Electrical Engineering or Materials Science and Engineering or Mechanical Engineering. Covers fundamentals of crystal structures and crystal defects, including the generation of point defects; nucleation and propagation of dislocations; perfect and partial dislocations; twins, stacking faults, and transformations; mechanics of semiconductor and metallic thin films and multilayered structures. Cross-listed with ME 278.

**MSE 22X SERIES: MATERIALS CHARACTERIZATION AND SIMULATION
MSE 220 Materials Characterization Techniques** (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): graduate standing in Materials Science and Engineering or consent of instructor. Covers basic principles of techniques used in the characterization of engineering materials by electron microscopy, diffraction, and spectroscopy. Provides analysis of defects responsible for materials properties. Addresses modern electrical, optical, and particle beam techniques for material characterization. Includes Hall Effect and Raman spectroscopy.

**MSE 221 Electron Microscopy and Microanalysis** (3) Lecture, 3 hours. Prerequisite(s): graduate standing in Materials Science & Engineering or consent of instructor. Introduces electron microscopy and microanalysis of inorganic solids including synthetic nanomaterials and minerals. Provides the underlying physical principles of electron microscopy and microanalysis; the strengths and limitations of the method; and the potential applications in characterization of morphology, structure, composition, and defects of inorganic materials and nanostructures. Optional, related laboratory courses are available: MSE 222L, MSE 223L.

**MSE 222L Laboratory in Transmission Electron Microscopy** (1) Laboratory, 2 hours; written work, 1 hour. Prerequisite(s): Concurrent or previous enrollment in MSE 221 or consent of instructor. Provides practical training in transmission electron microscopy and associated techniques including sample preparation.

**MSE 223L Laboratory in Scanning Electron Microscopy** (1) Laboratory, 2 hours; written work, 1 hour. Prerequisite(s): Concurrent or previous enrollment in MSE 221 or consent of instructor. Provides practical training in scanning electron microscopy and associated techniques including sample preparation.

**MSE 225A Spectrometry in Organic Structure Analysis** (3) Lecture, 3 hours. Prerequisite(s): graduate standing or consent of instructor. Utilizes modern spectroscopic techniques such as IR, mass spectrometry, and 1H and 13C NMR to determine the structure of complex organic molecules. Topics include advanced NMR techniques such as 2D NMR, NMR pulse sequences, diffusion NMR, and MRI. Cross-listed with CHEM 211D.

**MSE 225B Advanced Analytical Chemistry: Optical Spectroscopy** (3) Lecture, 3 hours. Prerequisite(s): CHEM 125. Provides an overview of modern analytical optical spectroscopic techniques including theory, instrumentation, and applications. Cross-listed with CHEM 221B.

**MSE 225C Introduction to Computational Quantum Chemistry** (3) Lecture, 3 hours. Prerequisite(s): CHEM 113 or equivalent, graduate standing; or consent of instructor. Introduces computational techniques in quantum chemistry. Includes Hartree-Fock theory, Density Functional Theory, and electron correlation methods. Emphasizes practical applications in a research setting. Cross-listed with CHEM 206A.

**MSE 226 Optical Methods in Biology, Chemistry, and Engineering** (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): CHEM 109 or equivalent; graduate standing; consent of instructor. Covers the origin of fluorescence and other emission processes that modulate the characteristics of molecular emissions. Presents emission-based analytical and bioanalytical methods and techniques. Reviews state-of-the-art instrumentation, including their applicability, limitations, and source. Also provides interpretation and meaning of the measured signals as applied to biological systems. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor. Course is repeatable as content changes. Cross-listed with BIEN 245.

**MSE 227 Nanoscale Characterization Techniques** (4) Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): EE 201/MSE 207, EE 202/MSE 217, EE 203/MSE 237C; or consent of instructor. An in-depth study of nanoscale materials and device characterization techniques. Laboratory emphasizes atomic force microscopy (AFM) and scanning tunneling microscopy (STM). Topics include semiconductor fabrication fundamentals; metrology requirements; in situ monitoring; interconnects and failure analysis; principles of AFM, STM, and scanning electron microscopy; X-ray methods; optical and infrared techniques; and electrical characterization. Cross-listed with EE 206.

**MSE 23X SERIES: FUNCTIONAL MATERIALS
MSE 230 Functional Materials: Semiconductors** (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): graduate standing in Materials Science and Engineering or consent of instructor. Covers semiconductor crystal growth techniques; purification; doping; radiation damage; annealing; metal-semiconductor interfaces; defects and impurities; and major electronic and optical methods for the analysis of semiconductors. Includes semiconductor device fabrication issues.

**MSE 234A Physics of Nanoscale Systems** (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): graduate standing or consent of instructor. Explores the fundamental concepts and techniques of nanoscale physics, including nanoscale fabrication and characterization techniques, electronic properties in reduced dimensions, properties of carbon nanotubes, nanoelectromechanical systems, superconductivity in reduced dimensions, and nanophotonics. Students whose research is related to materials and nanoscale systems physics receive a letter grade; other students receive a letter grade or Satisfactory (S) or No Credit (NC) grade. Cross-listed with PHYS 234.

**MSE 234B Spintronics and Nanoscale Magnetism** (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): graduate standing or consent of instructor. Provides an overview of contemporary issues in nanoscale magnetism and spin-dependent phenomena in solids, including the fundamentals of magnetism, magnetism in reduced dimensions, novel magnetic materials, spin-polarized transport, spin coherence in semiconductors, magnetization dynamics, and device applications. Students whose research is related to materials and nanoscale systems physics receive a letter grade; other students receive a letter grade or Satisfactory (S) or No Credit (NC) grade. Cross-listed with PHYS 235.

**MSE 236 Nanomaterials for Regenerative Medicine** (4) Lecture, 4 hours. Prerequisite(s): BIOL 005C, CHEM 001C (or CHEM 01HC), MSE 001, or equivalents; graduate standing or consent of instructor. Covers recent advances in nanomaterial synthesis, fabrication, and characterization. Focuses on the medical applications of nanomaterials and nanotechnologies. Addresses methods of synthesis of nanomaterials such as nanoparticles, nanotubes, and nanofibers. Includes critical design criteria and assessment methods for properties of nanomaterials to meet medical requirements. Cross-listed with BIEN 236.

**MSE 237A Applied Ferromagnetism** (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): EE 116; consent of instructor. Introduces fundamentals of ferromagnetism necessary to develop next-generation nanomagnetic and spintronics-related devices. Includes basics of magnetism, magnetic circuits, ferromagnetic resonance (FMR), nuclear magnetic resonance (NMR), spintronics, and analyses of applications. Cross-listed with EE 220.

**MSE 237B Nanoscale Phonon Engineering** (4) Lecture, 3 hours; outside research, 3 hours. Prerequisite(s): EE 202/MSE 217. Studies acoustic and optical phonons that affect electrical, thermal, and optical properties of materials. Focuses on the confinement-induced changes of phonon properties in nanostructures and their implications for performance of electronic, thermoelectric, and optoelectronic devices. Explores phonon theory, Raman spectroscopy and other phonon characterization techniques, thermal conductivity, and related measurements. Cross-listed with EE 216.

**MSE 237C Solid-State Devices** (4) Lecture, 3 hours; outside research, 3 hours. Prerequisite(s): EE 133 or consent of instructor. Covers electronic devices including p-n junctions, field-effect transistors, heterojunction bipolar transistors, and nanostructure devices. Explores electrical and optical properties of semiconductor heterostructures, superlattices, quantum wires, and dots, as well as devices based on these structures. Cross-listed with EE 203.

**MSE 238 Introduction to Microelectromechanical Systems** (4) Lecture, 4 hours. Prerequisite(s): ME 110, ME 114, or equivalents. An introduction to the design and fabrication of microelectromechanical systems (MEMS). Topics include micromachining processes; material properties; transduction; applications in mechanical, thermal, optical, radiation, and biological sensors and actuators; microfluidic devices; BioMEMS and applications; packaging and reliability concepts; and metrology techniques for MEMS. Cross-listed with ME 270.

**MSE 24X SERIES: MATERIALS SYNTHESIS AND PROCESSING
MSE 240 Materials Synthesis and Processing** (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): graduate standing or consent of instructor. Covers synthesis of functional materials and materials processing. Functional materials include semiconductors, metals, polymers, and nanoscaled-materials such as nanotubes and nanoparticles. Focuses on methods of semiconductor fabrication and their physical and chemical foundation.

**MSE 245A Advanced Organic Reactions** (3) Lecture, 3 hours. Prerequisite(s): graduate standing or consent of instructor. Covers modern organic reactions and reagents and their mechanistic pathways with emphasis on recent developments and practical organic chemistry. Cross-listed with CHEM 211E.

**MSE 245B Structure and Bonding in Inorganic Chemistry** (3) Lecture, 3 hours. Prerequisite(s): CHEM 150A, CHEM 150B. Covers advanced synthesis, structure, and bonding in inorganic, coordination, and organometallic chemistry. Cross-listed with CHEM 231A.

**MSE 245C Nanoscience and Nanotechnology** (3) Lecture, 3 hours. Prerequisite(s): graduate standing in Chemistry, Physics, Engineering, or a related subject or consent of instructor. Provides a condensed, interdisciplinary overview of selected fields of nanoscience and emerging nanotechnological applications. Focuses on applications relevant for the campus research community that are not based on electronic applications of silicon. Cross-listed with CHEM 203.

**MSE 245D Interdisciplinary Overview of Current Issues in Semiconductor Processing** (3) Lecture, 3 hours. Prerequisite(s): graduate standing in Chemistry, Physics, Engineering, or a related subject or consent of instructor. An interdisciplinary overview of present-day semiconductor processing. Introduces topics such as properties of semiconductors, cleanroom environment, epitaxy, ion implantation, etching, lithography, device architecture, testing, and fault detection. May offer field trips. Cross-listed with CHEM 208 and PHYS 202.

**MSE 246 Cellular and Molecular Engineering** (4) Lecture, 2 hours; discussion, 1 hour; practicum, 3 hours. Prerequisite(s): graduate standing or consent of instructor. Emphasizes biophysical and engineering concepts intrinsic to specific topics at the cellular and molecular level. Includes receptor-ligand dynamics in cell signaling and function; DNA replication and RNA processing; cellular and protein sorting; control of gene expression; membrane structure, transport and traffic; biological signal transduction; and mechanics of cell division. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor. Cross-listed with BIEN 224. Credit is awarded for only one of BIEN 224/MSE 246 or BIEN 224V.

**MSE 248 Nanoscale Science and Engineering** (4) Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): graduate standing or consent of instructor. An overview of the machinery and science of the nanometer scale. Topics include patterning of materials via scanning probe lithography; electron beam lithography; nanoimprinting; self-assembly; mechanical, electrical, magnetic, and chemical properties of nanoparticles, nanotubes, nanowires, and biomolecules (DNA, protein); self-assembled monolayers; and nanocomposites and synthetic macromolecules. Cross-listed with ME 272.

**MSE 25X SERIES: COLLOQUIA AND SEMINARS
MSE 250 Colloquium in Materials Science and Engineering** (1) Colloquium, 1 hour. Prerequisite(s): graduate standing in Materials Science and Engineering or consent of instructor. Presentations on current topics in Materials Science and Engineering presented by invited speakers, UCR faculty, and graduate students. Students who present a seminar receive a letter grade; other students receive a Satisfactory (S) or No Credit (NC) grade. Course is repeatable.

**MSE 251 Topics in Materials Science and Engineering** (1) Seminar, 1 hour. Prerequisite(s): graduate standing in Materials Science & Engineering or consent of instructor. Presentations on current topics in Materials Science and Engineering by special speakers, UCR faculty, and graduate students. Students who present a seminar receive a letter grade; other students receive a Satisfactory (S) or No Credit (NC) grade. Course is repeatable to a maximum of 21 units.

**MSE 280 Special Topics in Biomaterials and Tissue Engineering** (1-2) Seminar, 1-2 hours; term paper, 0-3 hours. Prerequisite(s): graduate standing or consent of instructor. Focuses on advanced biomaterials and tissue engineering for medical applications. Explores the design, processing, characterization, and evaluation of biomaterials. Examines current development in novel materials and recent advances in their applications in tissue engineering, drug delivery, gene therapy, cell therapy, medical devices, and implants. Students who present a seminar or submit a term paper receive a letter grade; other students receive a Satisfactory (S) or No Credit (NC) grade. Course is repeatable as content changes to a maximum of 30 units. Cross-listed with BIEN 272.

**MSE 290 Directed Studies** (1-6) Individual study, 3-18 hours. Prerequisite(s): consent of instructor and graduate advisor. Individual study directed by a faculty member on selected topics in Materials Science and Engineering. Graded Satisfactory (S) or No Credit (NC). Course is repeatable to a maximum of 12 units.

**MSE 297 Directed Research** (1-6) Outside research, 3-18 hours. Prerequisite(s): consent of instructor and graduate advisor. Research conducted under the supervision of a faculty member on selected topics in Materials Science and Engineering. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

**MSE 299 Research for the Thesis or Dissertation** (1-12) Outside research, 3-36 hours. Prerequisite(s): consent of instructor; graduate standing. Research in materials science and engineering for the M.S. thesis or Ph.D. dissertation. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

**PROFESSIONAL COURSE
MSE 302 Teaching Practicum** (1-2) Consultation, 1-2 hours. Prerequisite(s): appointment as a teaching assistant in Materials Science and Engineering; consent of instructor and graduate advisor. Topics include effective teaching methods, such as those involved in leading discussion sections and preparing and grading examinations, as well as student-instructor relations in lower- and upper-division Materials Science and Engineering courses. Required each quarter of teaching assistants and associates in Materials Science and Engineering. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

**learn more about**

**Materials Science and Engineering**

Visit
cmsmse.engr.ucr.edu

