**LOWER-DIVISION REQUIREMENTS
MATH 009A First-Year Calculus** (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): MATH 005 with a grade of “C-” or better or equivalent. Introduction to the differential calculus of functions of one variable. Credit is awarded for only one of MATH 008B, MATH 009A, or MATH 09HA.

**MATH 009B First-Year Calculus** (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): MATH 008B with a grade of “C-” or better or MATH 009A with a grade of “C-” or better or MATH 09HA with a grade of “C-” or better. Introduction to the integral calculus of functions of one variable. Credit is awarded for only one of MATH 009B or MATH 09HB.

**MATH 009C First-Year Calculus** (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): MATH 009B with a grade of “C-” or better or MATH 09HB with a grade of “C-” or better. Further topics from integral calculus, improper integrals, infinite series, Taylor’s series, and Taylor’s theorem. Credit is awarded for only one of MATH 009C or MATH 09HC.

**MATH 010A Calculus of Several Variables** (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): MATH 009B with a grade of “C-” or better or MATH 09HB with a “C-” or better or equivalent. Topics include Euclidean geometry, matrices and linear functions, determinants, partial derivatives, directional derivatives, Jacobians, gradients, chain rule, and Taylor’s theorem for several variables.

**MATH 010B Calculus of Several Variables** (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): MATH 010A with a grade of “C-” or better or equivalent. Covers vectors; differential calculus, including implicit differentiation and extreme values; multiple integration; line integrals; vector field theory; and theorems of Gauss, Green, and Stokes.

**MATH 046 Introduction to Ordinary Differential Equations** (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): MATH 009B with a grade of “C-” or better or MATH 09HB with a grade of “C-” or better or equivalent. Introduction to first-order equations, linear second-order equations, and Laplace transforms, with applications to the physical and biological sciences.

**CHEM 001A General Chemistry** (4) F, W, Summer Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): a score of 3, 4, or 5 on the College Board Advanced Placement Chemistry Examination or a passing score on the California Chemistry Diagnostic Test or a grade of “C-” or better in MATH 005 or concurrent enrollment in MATH 008B or a grade of “C-” or better in MATH 008B or a grade of “C-” or better in an equivalent college-level mathematics or chemistry course; concurrent enrollment in CHEM 01LA or a grade of “C-” or better in CHEM 01LA. An introduction to the basic principles of chemistry. Credit is awarded for only one of CHEM 001A or CHEM 01HA.

**CHEM 01LA General Chemistry Laboratory** (1) F, W, Summer Laboratory, 3 hours. Prerequisite(s): concurrent enrollment in CHEM 001A or a grade of “C-” or better in CHEM 001A. An introduction to laboratory principles and techniques related to lecture topics in CHEM 001A. Credit is awarded for only one of CHEM 01LA or CHEM 1HLA.

**CHEM 001B General Chemistry** (4) W, S, Summer Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): grades of “C-” or better in CHEM 001A and CHEM 01LA or grades of “C-” or better in CHEM 01HA and CHEM 1HLA; concurrent enrollment in CHEM 01LB or a grade of “C-” or better in CHEM 01LB. An introduction to the basic principles of chemistry. Credit is awarded for only one of CHEM 001B or CHEM 01HB.

**CHEM 01LB General Chemistry Laboratory** (1) W, S, Summer Laboratory, 3 hours. Prerequisite(s): grades of “C-” or better in CHEM 001A and CHEM 01LA or grades of “C-” or better in CHEM 01HA and CHEM 1HLA; concurrent enrollment in CHEM 001B or a grade of “C-” or better in CHEM 001B. An introduction to laboratory principles and techniques related to lecture topics in CHEM 001B. Credit is awarded for only one of CHEM 01LB or CHEM 1HLB.

**CHEM 001C General Chemistry** (4) F, S, Summer Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): grades of “C-” or better in CHEM 001B and CHEM 01LB or grades of “C-” or better in CHEM 01HB and CHEM 1HLB; concurrent enrollment in CHEM 01LC or a grade of “C-” or better in CHEM 01LC. An introduction to the basic principles of chemistry. Credit is awarded for only one of CHEM 001C or CHEM 01HC.

**CHEM 01LC General Chemistry Laboratory** (1) F, S, Summer Laboratory, 3 hours. Prerequisite(s): grades of “C-” or better in CHEM 001B and CHEM 01LB or grades of “C-” or better in CHEM 01HB and CHEM 1HLB; concurrent enrollment in CHEM 001C or a grade of “C-” or better in CHEM 001C. An introduction to laboratory principles and techniques related to lecture topics in CHEM 001C. Credit is awarded for only one of CHEM 01LC or CHEM 1HLC.

**PHYS 040A General Physics** (5) Lecture, 3 hours; discussion, 1 hour; laboratory, 3 hours. Prerequisite(s): MATH 008B with a grade of “C-” or better or MATH 009A with a grade of “C-” or better or MATH 09HA with a grade of “C-” or better; MATH 009B or MATH 09HB (MATH 009B or MATH 09HB may be taken concurrently). Designed for engineering and physical sciences students. Covers topics in classical mechanics including Newton’s laws of motion; friction; circular motion; work, energy, and conservation of energy; dynamics of particle systems; collisions; rigid-body motion; torque; and angular momentum. Laboratories provide exercises illustrating experimental foundations of physical principles and selected applications. Credit is not awarded for PHYS 040A if it has already been awarded for PHYS 002A or PHYS 041A.

**PHYS 040B General Physics** (5) Lecture, 3 hours; discussion, 1 hour; laboratory, 3 hours. Prerequisite(s): MATH 009C or MATH 09HC (may be taken concurrently); PHYS 040A with a grade of “C-” or better. Designed for engineering and physical sciences students. Covers topics in mechanics and thermodynamics including elasticity; oscillations; gravitation; fluids; mechanical waves and sound; temperature, heat, and the laws of thermodynamics; and the kinetic theory of gases. Laboratories provide exercises illustrating the experimental foundations of physical principles and selected applications.

**PHYS 040C General Physics** (5) Lecture, 3 hours; discussion, 1 hour; laboratory, 3 hours. Prerequisite(s): MATH 009C or MATH 09HC; PHYS 040B with a grade of “C-” or better. Designed for engineering and physical sciences students. Covers topics in electricity and magnetism including electric fields and potential; Gauss’ law; capacitance; magnetic fields; Ampere’s law; Faraday’s law and induction; electromagnetic oscillations; dc and ac current; and circuits. Laboratories provide exercises illustrating the experimental foundations of physical principles and selected applications. Credit is not awarded for PHYS 040C if it has been awarded for PHYS 002B or PHYS 041B.

**CS 030 Introduction to Computational Science and Engineering** (4) Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): MATH 009C (may be taken concurrently); consent of instructor if credit has been awarded for CS 010 or CS 010V. Examines fundamental programming concepts using the Matlab language including problem decomposition, control structures, elementary data structures, file input/output, graphics, and code libraries. Focuses on applications problems in engineering and science such as numerical equation solvers; matrix operations; searching and sorting; and data analysis. Emphasizes good programming style and computational efficiency.

**EE 001A Engineering Circuit Analysis I** (3) Lecture, 3 hours. Prerequisite(s): MATH 046, PHYS 040C (both may be taken concurrently); concurrent enrollment in EE 01LA. Ohm’s law and Kirchoff’s laws; nodal and loop analysis; analysis of linear circuits; network theorems; transients in RLC circuits. Application of SPICE to circuit analysis.

**EE 01LA Engineering Circuit Analysis I Laboratory** (1) Laboratory, 3 hours. Prerequisite(s): EE 001A (may be taken concurrently). Laboratory experiments closely tied to the lecture material of EE 001A: resistive circuits, attenuation and amplification, network theorems and superposition, operational amplifiers, transient response, application of SPICE to circuit analysis.

**ME 010 Statics** (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): MATH 009C, PHYS 040A. Covers equilibrium of coplanar force systems; analysis of frames and trusses; noncoplanar force systems; friction; and distributed loads.

**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
CHEM 112A Organic Chemistry** (4) F, W, Summer Lecture, 3 hours; laboratory, 4 hours. Prerequisite(s): CHEM 001C and CHEM 01LC with grades of “C-” or better or CHEM 01HC and CHEM 1HLC with grades of “C-” or better. Covers modern organic chemistry including structure, nomenclature, reactivity, synthesis, and reaction mechanisms and the chemistry of carbohydrates, lipids, nucleic acids, amino acids, and proteins. Also includes laboratory techniques of purification, isolation, synthesis, reactions, and spectroscopic analysis.

**CEE 135 Chemistry of Materials** (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): PHYS 040C, CHEM 112A. An introduction to the synthesis, structure, properties, and performance of modern materials. Topics include the science of materials, bonding and structure, the strength of materials, electrons in materials, semiconductors, superconductors, and optical properties of materials.

**CHE 100 Engineering Thermodynamics** (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): CHEM 001C, MATH 010A, PHYS 040B; or consent of instructor. An introduction to engineering thermodynamics with emphasis on chemical and environmental engineering systems. Topics include concepts of equilibrium, temperature, and reversibility; the first law and concept of energy; and the second law and concept of entropy. Also examines equations of state, thermodynamic properties, and engineering applications used in the analysis and design of closed and open systems. Credit is awarded for only one of CHE 100 or ME 100A.

**EE 138 Electrical Properties of Materials** (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): upper-division standing; PHYS 040C or equivalent. Introduces the electrical properties of materials. Includes the electron as a particle and a wave; hydrogen atom and the periodic table; chemical bonds; free-electron theory of metals; band theory of solids; semiconductors and dielectrics; measurements of material properties; and growth and preparation of semiconductors.

**ENGR 180W Technical Communications** (4) Lecture, 3 hours; workshop, 3 hours. Prerequisite(s): ENGL 001B with a grade of “C” or better; upper-division standing in the Bourns College of Engineering or consent of instructor. Develops oral, written, and graphical communication skills. Includes preparing and critiquing reports, proposals, instructions, and business correspondence. Emphasizes professional and ethical responsibilities and the need to stay current on technology and its global impact on economics, society, and the environment. Fulfills the third-quarter writing requirement for students who earn a grade of “C” or better for courses that the Academic Senate designates, and that the student’s college permits, as alternatives to English 001C.

**ME 110 Mechanics of Materials (4) Lecture**, 3 hours; discussion, 1 hour. Prerequisite(s): CS 030 or ME 018, MATH 046, ME 010 with a grade of “C-” or better. Topics include mechanics of deformable bodies subjected to axial, torsional, shear, and bending loads; combined stresses; and their applications to the design of structures.

**ME 114 Introduction to Materials Science and Engineering** (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): CHEM 001B, PHYS 040C; upper-division standing. Covers materials classification, atomic structure and interatomic bonding, crystal structure of metals, imperfections in solids, diffusion, mechanical properties of engineering materials, strengthening mechanisms, basic concepts of fracture and fatigue, phase diagrams, ceramics, polymers, and composites.

**ME 156 Mechanical Behavior of Materials** (4) Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): senior standing; ME 110; ME 114. Introduces the theory and experimental techniques for testing the mechanical behavior of materials and structures. Covers the fundamental mechanisms of deformation and failure of metals, ceramics, polymers, composite materials, and electronic materials as well as structural design and materials selection.

**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.

**STAT 155 Probability and Statistics for Science and Engineering** (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): MATH 009C or MATH 09HC (MATH 009C or MATH 09HC may be taken concurrently). Covers sample spaces and probability; random variables and probability distributions; elements of statistical inference; and testing and estimation. Also addresses selected topics in multivariate distributions and introduces stochastic processes.

**TECHNICAL ELECTIVES**There is a requirement of 20 units of technical electives, chosen with the approval of a faculty advisor. The purpose of these electives is to add depth and breadth to the major and direct a student along a specific materials focus area. He four courses can be selected, in consultation with an advisor, from the following list:

**BIEN 140A/CEE 140A**
BIEN 140A Biomaterials (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): BCH 100, CHEM 112C, MATH 010B, PHYS 040B. Covers the principles of materials science and engineering, with attention to topics in bioengineering. Explores atomic structures, hard treatment, fundamentals of corrosion, manufacturing processes, and characterization of materials. Cross-listed with CEE 140A.

CEE 140A Biomaterials (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): BCH 100, CHEM 112C, MATH 010B, PHYS 040B. Covers the principles of materials science and engineering, with attention to topics in bioengineering. Explores atomic structures, hard treatment, fundamentals of corrosion, manufacturing processes, and characterization of materials. Cross-listed with BIEN 140A.

**BIEN 140B/CEE 140B**
BIEN 140B Biomaterials (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): BIEN 140A/CEE 140A. Covers the structure-property relations of metals, ceramics, polymers, and composites, as well as hard and soft tissues such as bone, teeth, cartilage, ligament, skin, muscle, and vasculature. Focuses on behavior of materials in the physiological environment. Cross-listed with CEE 140B.

CEE 140B Biomaterials (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): BIEN 140A/CEE 140A. Covers the structure-property relations of metals, ceramics, polymers, and composites, as well as hard and soft tissues such as bone, teeth, cartilage, ligament, skin, muscle, and vasculature. Focuses on behavior of materials in the physiological environment. Cross-listed with BIEN 140B.

**CEE 147 Bio-Microelectromechanical Systems (BioMEMS)** (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): BIOL 005C, CEE 011, CHEM 112C, MATH 046, PHYS 040C; or consent of instructor. An introduction to bio-microelectromechanical systems with applications in bioengineering. Topics include biocompatible materials, device fabrication techniques, and principles of practical biomedical devices. Exposes students to the biotech industry and possible career paths in bioengineering.

**EE 133 Solid-State Electronics** (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): EE 100A. Presents the fundamentals of solid-state electronics. Topics include electronic band structure, Fermi and quasi-Fermi levels; doping; contacts; junctions; field-effect, bipolar, and metal-oxide-semiconductor (MOS) transistors; and charge-coupled devices. Also reviews device fabrication concepts.

**EE 136 Semiconductor Device Processing** (4) Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): EE 133 or equivalent. Presents device simulations and hands-on experience in integrated-circuit fabrication techniques and device characterization. Using fourmask metal-oxide semiconductor (MOS) technology, students fabricate resistors, junctions, capacitors, and MOS transistors and perform electrical evaluation.

**EE 137 Introduction to Semiconductor Optoelectronic Devices** (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): EE 133. An introduction to semiconductor optoelectronic devices for optoelectronic communications and signal processing. Topics include basic optical processes in semiconductors, semiconductor light-emitting diode, semiconductor heterojunction lasers, photodetectors, solar cells, optoelectronic modulation, and switching devices.

**EE 139 Magnetic Materials** (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): upper-division standing; PHYS 040C or equivalent. Introduces fundamentals of magnetic materials for the next-generation magnetic, nanomagnetic, and spintronics-related technologies. Includes basics of magnetism, models of the equivalent magnetic charge and current, paramagnetic and diamagnetic materials, soft and hard magnetic materials, equivalent magnetic circuits, and magnetic system design foundations.

**ME 113 Fluid Mechanics** (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): MATH 046, PHYS 040B, ME 010 with a grade of “C-” or better, ME 018. Introduces principles of fluid mechanics relevant to mechanical engineering. Topics include shear stresses and viscosity, fluid statics, pressure, forces on submerged surfaces, Bernoulli and mechanical energy equations, control volume approach, mass conservation, momentum and energy equations, the differential approach, turbulent flow in pipes, and lift and drag. Credit is awarded for only one of CHE 114 or ME 113.

**ME 116A Heat Transfer** (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): MATH 046, ME 100A, ME 113 (ME 113 may be taken concurrently). Introduces the analysis of steady and transient heat conduction, fin and heat generating systems, two-dimensional conduction, internal and external forced convection, natural convection, radiation heat transfer, heat exchangers, and mass transfer. Credit is awarded for only one of CHE 116 or ME 116A.

**ME 116B Heat Transfer** (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): ME 116A. Covers analytical and numerical methods in heat transfer and fluid mechanics. Topics include heat conduction and convection, gaseous radiation, boiling and condensation, general aspects of phase change, mass transfer principles, multimode heat transfer and the simulation of thermal fields, and the heat transfer process.

**ME 138 Transport Phenomena in Living Systems** (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): BIEN 105 or ME 113, MATH 046, PHYS 040B. An introduction to the application of the basic conservation laws of mechanics (mass, linear momentum, and energy) to the modeling of complex biological systems. Emphasizes how these concepts can explain and predict life processes.

* **Humanities/Social Sciences courses fulfill the breadth requirements specific to the College of Engineering and are available on the College of Engineering Student Academic Affairs website:** [**http://www.engr.ucr.edu/studentaffairs**](http://www.engr.ucr.edu/studentaffairs)
* **English Composition – A “C” or better is required in all English Composition courses to satisfy the graduation requirement. ENGR 180W fulfills the third quarter of English Composition.**
* **Technical Electives are courses in materials Science and Engineering which explore specific topics. A list of Technical Electives is available on the College of Engineering Student Academic Affairs website:** [**www.engr.ucr.edu/studentaffairs**](http://www.engr.ucr.edu/studentaffairs)**, and the UCR College Catalog website:** [**www.catalog.ucr.edu**](http://www.catalog.ucr.edu)**.**

**ME 153 Finite Element Methods** (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): ME 118. Covers weak form formulation, the Galerkin method and its computational implementation, mesh generation, data visualization, as well as programming finite element codes for practical engineering applications.

**ME 180 Optics and Lasers in Engineering** (4) Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): senior standing; ME 010, ME 110, ME 170A. Focuses on principles of optics and lasers, wave equations, interferometry, diffraction, laser-material interactions. Applications in analytical characterization including confocal microscopy, Raman spectroscopy, mechanical deformation analysis, scanning probe microscopy, ultraviolet-visible spectrophotometry, photoluminescence, optical detectors, and lasers in materials processing.

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