Curriculum Committee Approval: 05/05/2020

*Lecture Contact Hours: 48-54; Homework Hours: 96-108; Total Student Learning Hours: 144-162*

**CUYAMACA COLLEGE**
COURSE OUTLINE OF RECORD

# ENGINEERING 260 – ENGINEERING MATERIALS

3 hours lecture, 3 units

**Catalog Description**
Atomic and molecular structure of materials used in engineering. Analysis of the relationships between structure of materials and their mechanical, thermal, electrical, corrosion and radiation properties, together with examples of specific application to engineering problems.

**Prerequisite**
"C" grade or higher or "Pass" in PHYC 190 or equivalent

**Corequisite**
CHEM 141 or previous enrollment

**Entrance Skills**
Without the following skills, competencies and/or knowledge, students entering this course will be highly unlikely to succeed:
1) Understand the structure of atoms and the nature of subatomic particles; determine the number of each type of subatomic particle present within a given atom.
2) Understand and apply the mole concept.
3) Determine to which class–ionic or covalent–a compound belongs; write the formula for the compound and/or determine the name of the formula.
4) Understand and interpret the periodic table including periodic trends such as atom size and ionization energy.
5) Write Lewis dot structures; predict and draw the geometry of molecules and polyatomic ions with as many as four regions of electron density around the central atom.
6) Classify bonds into their various types: nonpolar, polar, ionic.
7) Predict the products of chemical reactions and write balanced chemical equations for specific types of reactions.
8) Perform stoichiometric calculations; calculate percent yield and limiting reactant of a reaction.
9) Use integral and differential calculus.
10) Understand vector representation of forces and be able to decompose forces into components.

**Course Content**
1) Atomic structure and atomic bonding in solids
2) The structure of crystalline solids: unit cells, density computations, crystal systems; directions, planes; linear and planar atomic densities
3) Crystalline vs. non-crystalline materials
4) Imperfections in solids: point and linear defects, interfacial defects and volume defects
5) Diffusion mechanisms: steady-state and non-steady state
6) Mechanical properties of metals: stress-strain behavior, tensile properties, compressive, shear and torsional deformation, hardness
7) Dislocations and strengthening mechanisms: slip systems, plastic deformation of polycrystalline materials, re-crystallization and grain growth
8) Fundamentals of fracture: impact, cyclic stresses, crack propagation
9) Phase diagrams: phases, microstructure
10) Iron-Iron Carbide phase diagram: eutectic and eutectoid reactions, iron-carbon alloys

11) Phase transformations in metals: continuous cooling transformation diagrams, mechanical behavior of Iron-Carbon alloys
12) Thermal processing of metal alloys
13) Metal alloys: fabrication methods
14) Structures and properties of ceramics
15) Polymer structures
16) Composites: particle-reinforced and fiber-reinforced
17) Corrosion and degradation of metals

**Course Objectives**

Students will be able to:

1) Define and determine mechanical properties of materials including tensile strength, yield strength, hardness, stiffness, specific weight, melting temperature, toughness, hardenability. Apply these material properties to select the appropriate metal, ceramic, polymer, or composite material for a particular application.
2) Describe and explain the mechanisms for common mechanical and thermal processing techniques including strain hardening, case hardening, quenching, tempering, annealing, precipitation hardening. Describe and explain solid-solution strengthening. Describe industrial processes that employ these techniques (e.g., forging, drawing, annealing) and specify a series of processes to achieve desired mechanical properties in a metal.
3) Describe and explain various mechanisms for material failure, including ductile and brittle fracture, fatigue, and creep.
4) Relate macroscopic properties of materials such as melting temperature, modulus of elasticity, strength, electrical and thermal conductivities to the type and characteristics of their interatomic/intermolecular bonds.
5) Compare crystalline to noncrystalline materials. Sketch unit cells for face-centered cubic (FCC), body-centered cubic (BCC), and hexagonal close-packed (HCP) crystal structures. Compute material density using the unit cell concept. Specify directions and planes in FCC, BCC, and HCP structures and use them to explain the mechanism of plastic deformation in crystals.
6) Compute weight and atom percentages of the components of an alloy.
7) Explain edge and screw dislocations, how they are generated, and their role in strengthening metals.
8) Explain the mechanisms of solid-state diffusion, and apply Fick's first and second laws to compute the concentration of solute atoms as functions of diffusion distance, time, and temperature.
9) Explain the concepts of phase and microstructure in the context of a phase diagram. Apply the lever rule to compute relative abundance of the phases present. Use a phase diagram to predict the development of microstructure in equilibrium cooling. In particular, apply these techniques to eutectic alloys and to the iron-carbon system.
10) Explain phase transformation kinetics and use the concept to develop the isothermal transformation diagram for an iron-carbon alloy. Use the isothermal transformation diagram to predict the microstructure developed for a given cooling rate. Predict the mechanical properties in terms of microstructure.
11) Predict ceramic crystal structure from ionic charges and size ratios. Compare the mechanical properties of ceramics to those of metals and explain various ceramic applications and processing techniques.
12) Describe the mer structure, basic properties and basic processing techniques of some of the chemically simple polymers, both thermoplastic and thermosetting.
13) Explain the function of particle- and fiber-reinforced composite materials, and predict the mechanical properties of simple composite materials. List common composite materials and give examples of their applications.
14) Compare and describe the deteriorative (corrosive) mechanism for metals and ceramic materials and the degration behavior of polymers.

**Method of Evaluation**

A grading system will be established by the instructor and implemented uniformly. Grades will be based on demonstrated proficiency in subject matter determined by multiple measurements for evaluation, one of which must be essay exams, skills demonstration or, where appropriate, the symbol system.

1) Classroom assessment tools, including reading quizzes, concept quizzes, attention quizzes, muddiest point questions, and one-minute papers, that measure students' ability to apply concepts just discussed in class. An example would be a multiple choice question answered using an audience response system in which students determine the number of atoms in a body-centered cubic unit cell, after a presentation in which the number of atoms is computed in a face-centered cubic unit cell.
2) Homework that requires students to interact with the course material outside the classroom to evaluate their ability to extend the classroom and reading experience to novel situations. Question types include word problems requiring calculations and analysis of graphical data, short answer questions, and essay questions. An example would be a problem in which students would propose a series of hot and cold-rolling operations on a brass bar that will result in a 50% reduction in thickness with a final tensile strength of at least 400 MPa and a final ductility of at least 20%, supporting their ideas with calculations and graphical data.
3) Periodic quizzes and midterm examinations to evaluate student learning and retention of the material on the time scale of weeks. Question types include word problems requiring calculations and analysis of graphical data, short answer questions, and essay questions. An example would be a problem in which students would propose a series of hot and cold-rolling operations on a brass bar that will result in a 50% reduction in thickness with a final tensile strength of at least 400 MPa and a final ductility of at least 20%, supporting their ideas with calculations and graphical data.
4) Final examination to evaluate students' ability to integrate the course material as a whole and to assess overall retention of the material. Question types include word problems requiring calculations and analysis of graphical data, short answer questions, and essay questions. An example would be a problem in which students would propose a series of hot and cold-rolling operations on a brass bar that will result in a 50% reduction in thickness with a final tensile strength of at least 400 MPa and a final ductility of at least 20%, supporting their ideas with calculations and graphical data.

**Special Materials Required of Student**

Scientific graphical calculator

**Minimum Instructional Facilities**

Smart classroom

**Method of Instruction**

1) Lecture and discussion
2) Group problem-solving
3) Homework

**Out-of-Class Assignments**

1) Homework including reading and writing assignments
2) Group projects

**Texts and References**

1) Required (representative example): Callister, William and David Rethwisch. *Materials Science and Engineering, An Introduction*. 10th edition. Wiley, 2018.
2) Supplemental: None

**Student Learning Outcomes**

Upon successful completion of this course, students will be able to:

1) Describe properties of materials, such as mechanical, chemical, thermal, and electrical properties.
2) Describe how processing of materials affects the properties of the materials.
3) Describe and explain various mechanisms for material failure, including ductile and brittle fracture, fatigue, and creep.
4) Relate macroscopic properties of materials such as melting temperature, modulus of elasticity, strength, electrical and thermal conductivities to the type and characteristics of their interatomic/intermolecular bonds.