ENGR R140: MATERIALS SCIENCE AND ENGINEERING

Originator
jwmiller

College
Oxnard College

Discipline (CB01A)
ENGR - Engineering

Course Number (CB01B)
R140

Course Title (CB02)
Materials Science and Engineering

Banner/Short Title
Materials Science

Credit Type
Credit

Start Term
Fall 2021

Catalog Course Description
An introduction to atomic bonding, crystalline structure and microstructure, and how these structures determine the physical, mechanical, electrical and thermal properties of materials. The course covers metals, ceramics, polymers, composites and semiconductors. Topics include material imperfections, diffusion, mechanical properties, phase diagrams, material selection, processing, heat treatment and strengthening mechanisms. Corrosion phenomena, electrical properties and thermal properties are also covered.

Taxonomy of Programs (TOP) Code (CB03)
0901.00 - Engineering, General (requires Calculus) (Transfer)

Course Credit Status (CB04)
D (Credit - Degree Applicable)

Course Transfer Status (CB05) (select one only)
A (Transferable to both UC and CSU)

Course Basic Skills Status (CB08)
N - The Course is Not a Basic Skills Course

SAM Priority Code (CB09)
E - Non-Occupational

Course Cooperative Work Experience Education Status (CB10)
N - Is Not Part of a Cooperative Work Experience Education Program

Course Classification Status (CB11)
Y - Credit Course

Educational Assistance Class Instruction (Approved Special Class) (CB13)
N - The Course is Not an Approved Special Class

Course Prior to Transfer Level (CB21)
Y - Not Applicable

Course Noncredit Category (CB22)
Y - Credit Course

Funding Agency Category (CB23)
Y - Not Applicable (Funding Not Used)

Course Program Status (CB24)
1 - Program Applicable

General Education Status (CB25)
Y - Not Applicable

Support Course Status (CB26)
N - Course is not a support course

Field trips
Will not be required

Grading method
Letter Graded

Does this course require an instructional materials fee?
No

Repeatable for Credit
No

Is this course part of a family?
No

Units and Hours

Carnegie Unit Override
No

In-Class

Lecture
Minimum Contact/In-Class Lecture Hours
52.5
Maximum Contact/In-Class Lecture Hours
52.5

Activity

Laboratory

Total in-Class

Total in-Class
Total Minimum Contact/In-Class Hours
52.5
Total Maximum Contact/In-Class Hours
52.5

Outside-of-Class

Internship/Cooperative Work Experience

Paid

Unpaid

Total Outside-of-Class

Total Outside-of-Class
Minimum Outside-of-Class Hours
105
Maximum Outside-of-Class Hours
105

Total Student Learning

Total Student Learning
Total Minimum Student Learning Hours
157.5
Total Maximum Student Learning Hours
157.5

Minimum Units (CB07)
3
Maximum Units (CB06)
3

Prerequisites
PHYS R131 and CHEM R120

Requisite Justification

Requisite Type
Prerequisite

Requisite
PHYS R131

Requisite Description
Course not in a sequence

Level of Scrutiny/Justification
Required by 4 year institution

Requisite Type
Prerequisite

Requisite
CHEM R120

Requisite Description
Course not in a sequence

Level of Scrutiny/Justification
Required by 4 year institution

Student Learning Outcomes (CSLOs)

	Upon satisfactory completion of the course, students will be able to:
1	Distinguish between the various types of atomic bonds.
2	Associate mechanical properties of metals with their structure, defects, as well as mechanical and thermal processing.
3	Use phase diagrams to determine composition.

Course Objectives

	Upon satisfactory completion of the course, students will be able to:
1	Explain the relationship between the internal structure of materials and their macroscopic properties.
2	Explain methods (intentional or unintentional) of altering the structure of materials by mechanical, chemical, or thermal means in order to change material properties.
3	Illustrate the various systems for classifying materials, and compare differences in properties among material classes that derive from differences in structure.
4	Gather data from reference sources regarding the properties, processing, and performance characteristics of materials, and use it as a basis to recommend appropriate material(s) to meet engineering design criteria.

Course Content

Lecture/Course Content

1. Atomic structure and bonding
    a. Electrons in atoms
    b. The periodic table
    c. Bonding forces and energies
    d. Primary interatomic bonding
    e. Secondary bonding or Van Der Waals bonding
    f. Mixed bonding
    g. Molecules
    h. Bonding type-materials classification
2. Crystal structures and crystallography
    a. Unit cells
    b. Metallic crystal structures
    c. Density computations
    d. Polymorphism and allotropy
    e. Crystal systems
    f. Point coordinates
    g. Crystallographic directions
    h. Crystallographic planes
    i. Linear and plane densities
    j. Close-packed crystal structures
    k. Single crystals
    l. Polycrystalline materials
    m. Anisotropy
    n. X-ray diffraction and the determination of crystalline structure
    o. Noncrystalline structure
3. Imperfections in crystals, including polycrystalline, semi-crystalline, and amorphous solids
    a. Vacancies and self-interstitials
    b. Impurities in solids
    c. Specification of composition
    d. Dislocations: Linear defects
    e. Interfacial defects
    f. Materials of importance: Catalysts and surface defects
    g. Bulk or volume defects
    h. Atomic vibration

   i. Microscopic examination and techniques
   j. Grain-size determination
4. Diffusion
   a. Diffusion mechanics
   b. Fick's first law
   c. Fick's second law: Nonsteady-state diffusion
   d. Factors of influence
   e. Diffusion in semiconducting materials
   f. Materials of importance
   g. Diffusion paths
5. Elastic and plastic deformation in metals
   a. Concepts of stress and strain
   b. Stress and strain behaviors
   c. Anelasticity
   d. Elastic properties of materials
   e. Plastic deformation
   f. Tensile properties
   g. True stress and strain
   h. Elastic recovery after plastic deformation
   i. Comprehensive, shear, and torsional deformations
   j. Hardness
   k. Variability of material properties
   l. Design and safety factors
   m. Mechanical properties and testing
   n. Stress-Strain analysis
6. Dislocations and strengthening mechanisms
   a. Dislocations and plastic deformations
   b. Characteristics of dislocations
   c. Slip systems
   d. Slip in single crystals
   e. Plastic deformation of polycrystalline materials
   f. Deformation by twinning
   g. Strengthening by grain size reduction
   h. Solid solution strengthening
   i. Strain Hardening
   j. Recovery
   k. Recrystallization
   l. Grain growth
7. Mechanical failure: fracture, fatigue, creep
   a. Fundamentals of fracture
      i. Ductile fracture
      ii. Brittle fracture
      iii. Principles of fracture mechanics
      iv. Fracture toughness testing
   b. Fatigue
      i. Cyclic stresses
      ii. The S-N curve
      iii. Crack initiation and propagation
      iv. Factors that affect fatigue life
      v. Environmental effects
   c. Creep
      i. Stress and temperature Effects
      ii. Data extrapolation methods
      iii. Alloys for high-temperature use
8. Phase diagrams
   a. Solubility limits
   b. Phases
   c. Microstructure

   d. Phase equilibria
   e. One-component phase diagrams
   f. Binary phase diagrams
   g. Binary Isomorphous systems
   h. Interpretation of phase diagrams
   i. Development of microstructure in isomorphous alloys
   j. Binary Eutectic systems
   k. Development of microstructure in Eutectic alloys
   l. Materials of importance
   m. Equilibrium diagrams having intermediate phases or compounds
   n. Eutectoid and peritectic reactions
   o. Congruent phase transformations
   p. Ceramic and ternary phase diagrams
   q. The Gibbs phase rule
   r. The Iron-Carbon system
9. Phase transformations
   a. The kinetics of phase transformations
   b. Meta versus equilibrium states
   c. Microstructural and property changes in Iron-Carbon alloys
   d. Isothermal transformation diagrams
   e. Continuous-cooling transformation diagrams
   f. Mechanical behavior of Iron-Carbon alloys
   g. Tempered martensite
   h. Shape memory alloys
10. Metals and Metal Alloys
   a. Types of metal alloys
   b. Ferrous alloys
   c. Nonferrous alloys
   d. Fabrication of metals
   e. Forming operations
   f. Casting
   g. Thermal processing of metals
   h. Annealing processes
   i. Heat treatment of steels
   j. Precipitation hardening
11. Structures and properties of ceramics
   a. Ceramic structures
      i. Crystal structures
      ii. Silicate ceramics
      iii. Carbon
      iv. Imperfections in ceramics
      v. Diffusion in ionic materials
      vi. Ceramic phase diagrams
   b. Mechanical properties
      i. Brittle fracture ceramics
      ii. Stress and strain behavior
      iii. Mechanisms of plastic deformation
      iv. Other mechanical considerations
12. Processing of ceramics
   a. Types and application of ceramics
      i. Glasses
      ii. Glass-ceramics
      iii. Clay products
      iv. Refractories
      v. Abrasives
      vi. Cements
      vii. Carbons
      viii. Advanced ceramics

b. Fabrication and processing
   i. Fabrication and processing of glasses and glass-ceramics
   ii. Fabrication and processing of clay products
   iii. Powder pressing
   iv. Tape casting

13. Polymer structures
    a. Hydrocarbon molecules
    b. polymer molecules
    c. Molecular weight, shape, structure, andconfigurations
    d. Thermoplastic and thermosetting polymers
    e. Copolymers
    f. Polymer crystallinity
    g. Defects in polymers
    h. Diffusion in polymeric materials
14. Characteristics, applications, and processing of polymers
    a. Mechanical behavior of polymers
       i. Stress and strain behavior
       ii. Macroscopic deformation
       iii. Viscoelastic deformation
       iv. Fracture of polymers
       v. Other mechanical characteristics
    b. Mechanisms of deformation and strengthening of polymers
       i. Deformation of semicrystalline polymers
       ii. Factors that influence mechanical properties
       iii. Materials of importance
       iv. Deformation of elastomers
    c. Crystallization, melting, and glass-transition phenomena in polymers
       i. Crystallization
       ii. Melting
       iii. The glass transition
       iv. Melting and glass transition temperatures
    d. Polymer types
       i. Plastics
       ii. Materials of importance
       iii. Elastomers
       iv. Fibers
       v. Applications
       vi. Advanced polymeric materials
    e. Polymer synthesis and processing
       i. Polymerization
       ii. Polymer additives
       iii. Forming techniques for plastics
       iv. Fabrication of elastomers, fibers, and films
15. Composites
    a. Particle reinforces composites
       i. Large-particle composites
       ii. Dispersion-strengthened composites
    b. Fiber-reinforced composites
       i. Influence of fiber length
       ii. Fiber orientation and concentration
       iii. Fiber phase
       iv. Matrix phase
       v. Polymer-matrix composites
       vi. Metal-matrix composites
       vii. Ceramic-matrix composites
       viii. Carbon-Carbon composites
       ix. Hybrid composites
       x. Processing of fiber-reinforced composites
    c. Structural composites

        i. Laminar composites
        ii. Sandwich panels
        iii. Nanocomposites
16. Corrosion and degradation of materials
    a. Electrochemical considerations
    b. Corrosion rates
    c. Prediction of corrosion rates
    d. Swelling and dissolution
    e. Bond rapture
    f. Weathering
17. Electrical properties
    a. Electrical conduction
        i. Ohm's law
        ii. Electrical conductivity
        iii. electric and ionic conduction
        iv. Energy band structures in solids
        v. Conduction in terms of band and atomic models
        vi. Electron mobility
        vii. Electrical resistivity of metals
        viii. Electrical characteristics of commercial alloys
        ix. Material importance
    b. Semiconductivity
        i. Intrinsic semiconductivity
        ii. Extrinsic semiconductivity
        iii. Temperature dependence of carrier concentration
        iv. The Hall effect
        v. semiconductor devices
    c. Electrical conduction in ionic ceramics and polymers
        i. Conduction in ionic materials
        ii. Electrical properties of polymers
        iii. Capacitance and polarization
        iv. Dielectric materials, strength, and constants
18. Thermal Properties
    a. Heat capacity
    b. Thermal expansion
    c. Thermal conductivity
    d. Thermal stresses
19. Magnetic properties
    a. Diamagnetism and paramagnetism
    b. Ferromagnetism
    c. Antiferromagnetism
    d. Temperature and magnetic behavior
    e. Domains and Hysterias
    f. Magnetic anisotropy
    g. Soft magnetic materials
    h. Hard magnetic materials
    i. Magnetic storage
    j. Superconductivity
20. Structure and properties of composites, including wood and concrete (optional)
21. Selection of materials in engineering design (optional)

Laboratory or Activity Content

None

Methods of Evaluation

Which of these methods will students use to demonstrate proficiency in the subject matter of this course? (Check all that apply):

Problem solving exercises

Written expression

Methods of Evaluation may include, but are not limited to, the following typical classroom assessment techniques/required assignments (check as many as are deemed appropriate):

Computational homework
Objective exams
Other (specify)
Problem-Solving Assignments
Problem-solving exams
Quizzes

Other

Essays

Instructional Methodology

Specify the methods of instruction that may be employed in this course

Computer-aided presentations
Distance Education
Demonstrations
Instructor-guided interpretation and analysis
Lecture
Small group activities

Describe specific examples of the methods the instructor will use:

1. Computer aided presentation: The instructor may employ the computer to aid in the presentation of course materials which would include simulations of specific phenomena lattice structures in crystals.
2. Demonstrations: The instructor will demonstrate physical engineering principals by employing equipment and other items such as a Charpy impact test apparatus.
3. Distance Education: When applicable, recordings of lectures will be used to convey subject matter. Also, the use of discussion boards and virtual meetings will be used to allow students to ask questions regarding the course and its material.
4. Instructor guided analysis: The instructor will work through engineering problems during lecture that investigate a given system in which the students will follow along, answering questions posed by the instructor. This will also serve as a forum for students to ask particular questions regarding the logic and methods employed to come to certain conclusions regarding said problem/system.
5. Lecture: The instructor will deliver the course subject matter via in person lectures to the students. For example, a lecture on material deformations.
6. Small group activities: These may be employed in the form of group quizzes where students work together in small groups to solve some engineering problems regarding current material.

Representative Course Assignments

Writing Assignments

1. Answers to short explanatory (conceptual) questions from the textbook, often assigned from among those at the end of each chapter or posed by the instructor, typically assigned weekly. A typical question might be that regarding material properties and reasons why, or why not, the particular material should be used in a given application.

Critical Thinking Assignments

1. Answering a wide array of homework, quiz, and exam questions requiring the analysis of a given physical system or circumstance in order to come to the correct conclusion and/or answer regarding the question and/or desired outcome.

Reading Assignments

1. Regular textbook readings that reinforce the concepts discussed or demonstrated during the class meetings. These readings typically include theory and principles, descriptions of important advances in material production, data tables, definitions, problem-solving examples, and practical applications of material use in engineering.

Skills Demonstrations

None

Other assignments (if applicable)

None

Outside Assignments

Representative Outside Assignments

1. Assigned reading from the textbook typically amounting to 1 chapter a week. This will amount to 1.5 hours per week of reading.
2. Assigned conceptual and problem solving based homework that further investigates and explores the notions and theories discussed throughout the course. Typically, homework sets will require 4.5 hours to fully complete and will be due on a weekly basis.
3. Studying and preparing for quizzes and exams.

District General Education

A. Natural Sciences

B. Social and Behavioral Sciences

C. Humanities

D. Language and Rationality

E. Health and Physical Education/Kinesiology

F. Ethnic Studies/Gender Studies

CSU GE-Breadth

Area A: English Language Communication and Critical Thinking

Area B: Scientific Inquiry and Quantitative Reasoning

Area C: Arts and Humanities

Area D: Social Sciences

Area E: Lifelong Learning and Self-Development

CSU Graduation Requirement in U.S. History, Constitution and American Ideals:

IGETC

Area 1: English Communication

Area 2A: Mathematical Concepts & Quantitative Reasoning

Area 3: Arts and Humanities

Area 4: Social and Behavioral Sciences

Area 5: Physical and Biological Sciences

Area 6: Languages Other than English (LOTE)

Textbooks and Lab Manuals

Resource Type

Textbook

Description

Callister, W. D. Jr., & Rethwisch, D. G. (2018). *Materials Science and Engineering: An Introduction* (10th). Hoboken, Wiley and Sons.

Distance Education Addendum

Definitions

Distance Education Modalities

Hybrid (51%–99% online)
Hybrid (1%–50% online)
100% online

Faculty Certifications

Faculty assigned to teach Hybrid or Fully Online sections of this course will receive training in how to satisfy the Federal and state regulations governing regular effective/substantive contact for distance education. The training will include common elements in the district-supported learning management system (LMS), online teaching methods, regular effective/substantive contact, and best practices.

Yes

Faculty assigned to teach Hybrid or Fully Online sections of this course will meet with the EAC Alternate Media Specialist to ensure that the course content meets the required Federal and state accessibility standards for access by students with disabilities. Common areas for discussion include accessibility of PDF files, images, captioning of videos, Power Point presentations, math and scientific notation, and ensuring the use of style mark-up in Word documents.

Yes

Regular Effective/Substantive Contact

Hybrid (1%–50% online) Modality:

Method of Instruction	Document typical activities or assignments for each method of instruction
Other DE (e.g., recorded lectures)	The students will watch recorded lecture videos that go over the pertinent subject matter of the course.
Synchronous Dialog (e.g., online chat)	The students will join live, online meetings in which they will receive instruction, be reminded of all upcoming assignments/events, and be allowed to ask questions pertaining to the lecture and lab material. Recordings will be made available of all live meetings. Students may also be put into small groups to discuss a given class problem.
Asynchronous Dialog (e.g., discussion board)	The Students will have access to a discussion board in which they can ask questions regarding the course material.
Face to Face (by student request; cannot be required)	Face to face meetings can be arranged when needed.

Hybrid (51%–99% online) Modality:

Method of Instruction	Document typical activities or assignments for each method of instruction
Other DE (e.g., recorded lectures)	The students will watch recorded lecture videos that go over the pertinent subject matter of the course.
Synchronous Dialog (e.g., online chat)	The students will join live, online meetings in which they will receive instruction, be reminded of all upcoming assignments/events, and be allowed to ask questions pertaining to the lecture and lab material. Recordings will be made available of all live meetings. Students may also be put into small groups to discuss a given class problem.
Asynchronous Dialog (e.g., discussion board)	The Students will have access to a discussion board in which they can ask questions regarding the course material.
Face to Face (by student request; cannot be required)	Face to face meetings can be arranged when needed.

100% online Modality:

Method of Instruction	Document typical activities or assignments for each method of instruction
Other DE (e.g., recorded lectures)	The students will watch recorded lecture videos that go over the pertinent subject matter of the course.

Synchronous Dialog (e.g., online chat)	TThe students will join live, online meetings in which they will receive instruction, be reminded of all upcoming assignments/events, and be allowed to ask questions pertaining to the lecture and lab material. Recordings will be made available of all live meetings. Students may also be put into small groups to discuss a given class problem.
Asynchronous Dialog (e.g., discussion board)	The Students will have access to a discussion board in which they can ask questions regarding the course material.

Examinations

Hybrid (1%–50% online) Modality

Online
On campus

Hybrid (51%–99% online) Modality

Online
On campus

Primary Minimum Qualification
ENGINEERING

Review and Approval Dates

Department Chair
09/11/2020

Dean
09/11/2020

Technical Review
09/23/2020

Curriculum Committee
09/23/2020

Curriculum Committee
11/25/2020

CCCCO
MM/DD/YYYY

Control Number
CCC000599713

DOE/accreditation approval date
MM/DD/YYYY