# ENGI-240: PROPERTIES OF MATERIALS

Engineering Courses Updates Fall 2023

Course

- ENGI-110: Introduction to Engineering
- ENGI-240: Properties of Materials
- ENGI-241: Engineering Mechanics: Statics
- ENGI-242: Circuits 1

**Effective Term**

Fall 2024

**CC Approval**

10/6/2023

**AS Approval**

10/10/2023

**BOT Approval**

10/19/2023

## SECTION A - Course Data Elements

**Send Workflow to Initiator**

No

**CB04 Credit Status**

Credit - Degree Applicable

**Discipline**

| Minimum Qualifications | And/Or |
|---|---|
| Engineering (Master's Degree) | |

**Subject Code**

ENGI - Engineering

**Course Number**

240

**Department**

Engineering (ENGI)

**Division**

Science and Engineering (SE)

**Full Course Title**

Properties of Materials

**Short Title**

Properties of Materials

**CB03 TOP Code**

0901.00 - Engineering, General (requires Calculus) (Transfer)

**CB08 Basic Skills Status**

NBS - Not Basic Skills

**CB09 SAM Code**

E - Non-Occupational

**Rationale**

Last update was longer than 6 years. Update to SLOs, content and textbooks.

## SECTION B - Course Description

**Catalog Course Description**

This is an introductory course on the properties of engineering materials and how their overall properties relate to internal structure. Topics include: atomic structure and bonding; crystal structure; phases and phase diagrams; properties (mechanical, electrical, magnetic, optical) and structure of metals, polymers, ceramics and composites; mechanical deformation and fracture; taxonomy systems; corrosion and processing methods.

## SECTION C - Conditions on Enrollment

**Open Entry/Open Exit**

No

**Repeatability**

Not Repeatable

**Grading Options**

Letter Grade Only

**Allow Audit**

Yes

## Requisites

**Prerequisite(s)**

Completion of CHEM-120 and PHYS-140 with a minimum grade of C.

## Requisite Justification

**Requisite Description**

Course Not in a Sequence

**Subject**

CHEM

**Course #**

120

**Level of Scrutiny**

Required by 4-Year Institution

**Explanation**

1 semester college-level general chemistry (e.g., CHEM 110 General Chemistry for Science Majors I, with Lab) listed in C-ID descriptor for Materials Science and Engineering (ENGI 140)

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**Requisite Description**

Course Not in a Sequence

**Subject**

PHYS

**Course #**

140

**Level of Scrutiny**

Required by 4-Year Institution

**Explanation**

1 semester calculus-based physics (e.g., PHYS 205 Calculus-Based Physics for Scientists and Engineers: A) listed in C-ID descriptor for Materials Science and Engineering (ENGI 140)

## SECTION D - Course Standards

**Is this course variable unit?**
No

**Units**
4.00000

**Lecture Hours**
54.00

**Lab Hours**
54.00

**Outside of Class Hours**
108

**Total Contact Hours**
108

**Total Student Hours**
216

## Distance Education Approval

**Is this course offered through Distance Education?**
Yes

**Online Delivery Methods**

| DE Modalities | Permanent or Emergency Only? |
|---|---|
| Entirely Online | Permanent |
| Hybrid | Permanent |
| Online with Proctored Exams | Permanent |

## SECTION E - Course Content

**Student Learning Outcomes**

| | Upon satisfactory completion of the course, students will be able to: |
|---|---|
| 1. | Know and understand the types of atomic bonding and crystal structures; and how diffusion operates and relates to defects and vacancies in material structures. |
| 2. | Know and understand the importance of engineering properties (mechanical, electrical, optical) of materials (metal, ceramics/glasses, polymers, and composites), how they relate to internal structure, and the cause and underling mechanisms of the failure modes of fatigue, fracture, and creep. |
| 3. | Demonstrate knowledge and understanding of common thermal processing methods for alloys, their underlying mechanisms, their effect on material processes, and be able to interpret and use phase diagrams. |

**Course Objectives**

| | Upon satisfactory completion of the course, students will be able to: |
|---|---|
| 1. | Fundamentally explain material (metals, ceramic/glasses, polymers, composites, and semiconductors) properties, atomic structure and their relationship. |
| 2. | Fundamentally explain the material behavior in response to stimuli (load, temperature, chemistry). |
| 3. | Understand and explain failure mechanisms of materials. |
| 4. | Understand and explain mechanism of diffusion and its role in material behavior. |
| 5. | Understand the role of phase and ITT diagrams in thermal processing of alloys. |
| 6. | Understand the role of material selection in engineering design. |
| 7. | Have the ability to make appropriate selections of material for an application. |

| | |
|---|---|
| 8. | Solve problems involving properties of materials including crystallography, Arrhenius type equations, property averaging of composite materials, and intrinsic and extrinsic semiconductors. |
| 9. | Write formal lab reports. |

**Course Content**

1. Materials for Engineering
   a. The Material World
   b. Materials Science and Engineering
   c. Six Materials That Changed Your World
   d. Processing and Selecting Materials
   e. Looking at Materials by Powers of Ten
2. Atomic Bonding
   a. Atomic Structure
   b. The Ionic Bond
   c. The Covalent Bond
   d. The Metallic Bond
   e. The Secondary, or van der Waals, Bond
   f. Materials–The Bonding Classification
3. Crystalline Structure–Perfection
   a. Seven Systems and Fourteen Lattices
   b. Metal Structures
   c. Ceramic Structures
   d. Polymeric Structures
   e. Semiconductor Structures
   f. Lattice Positions, Directions, and Planes
   g. X-Ray Diffraction
4. Crystal Defects and Noncrystalline Structure Imperfection
   a. The Solid Solution–Chemical Imperfection
   b. Point Defects–Zero-Dimensional Imperfections
   c. Linear Defects, or Dislocations–One-Dimensional Imperfections
   d. Planar Defects–Two-Dimensional Imperfections
   e. Noncrystalline Solids–Three-Dimensional Imperfections
5. Diffusion
   a. Thermally Activated Processes
   b. Thermal Production of Point Defects
   c. Point Defects and Solid-State Diffusion
   d. Steady-State Diffusion
   e. Alternate Diffusion Paths
6. Mechanical Behavior
   a. Stress Versus Strain
   b. Elastic Deformation
   c. Plastic Deformation
   d. Hardness
   e. Creep and Stress Relaxation
   f. Viscoelastic Deformation
7. Thermal Behavior
   a. Heat Capacity
   b. Thermal Expansion
   c. Thermal Conductivity
   d. Thermal Shock
8. Failure Analysis and Prevention
   a. Impact Energy
   b. Fracture Toughness
   c. Fatigue
   d. Nondestructive Testing
   e. Failure Analysis an d Prevention
9. Phase Diagrams

  a. The Phase Rule
  b. The Phase Diagram
  c. The Lever Rule
  d. Microstructural Development During Slow Cooling
10. Kinetics–Heat Treatment
  a. Time–The Third Dimension
  b. The T T T Diagram
  c. Hardenability
  d. Precipitation Hardening
  e. Annealing
  f. The Kinetics of Phase Transformations for Nonmetals

PART II Materials and Their Applications

1. Structural Materials–Metals, Ceramics, and Glasses
  a. Metals
  b. Ceramics and Glasses
  c. Processing the Structural Materials
2. Structural Materials–Polymers and Composites
  a. Polymers
  b. Composites
  c. Processing the Structural Materials
3. Electronic Materials
  a. Charge Carriers and Conduction
  b. Energy Levels and Energy Bands
  c. Conductors
  d. Insulators
  e. Semiconductors
  f. Composites
  g. Electrical Classification of Materials
4. Materials in Engineering Design
  a. Material Properties–Engineering Design Parameters
  b. Selection of Structural Materials
  c. Selection of Electronic Materials
  d. Materials and Our Environment

Lab Content (Lab activities need to be detailed and compliment the lecture content of the course):

1. Lab activities include:
2. Experiments,
3. Simulations,
4. Investigations and Presentations, and Demonstrations.

The lab activity topics include:

1. Characterization of properties of materials
2. Measuring Stress and Strain
3. Thermal Expansion
4. Failure Analysis: Fatigue
5. Microstructural Development During Slow Cooling
6. Corrosion
7. Materials and Our Environment
8. Making a Conductor from a Non-conductor
9. Materials of the Future: Polymers and Composites
10. Properties of Materials in Engineering Design
11. Investigate and Present Results of Engineering Situations/Cases/Projects Involving Properties of Materials
12. Run simulations demonstrating material (metals, ceramic/glasses, polymers, composites, and semiconductors) properties, atomic structure and their relationship.

Write a laboratory report for each experiment that includes a discussion comparing experimental, theoretical, and/or simulated results.

## Methods of Instruction

**Methods of Instruction**

| Types | Examples of learning activities |
|---|---|
| Discussion | Applications of engineering materials, Ethics involving material selection, Processing of materials |
| Lecture | Lectures covering course content. |
| Other | Demonstrations. Computer simulations. Video presentations. |
| Lab | Density and Atomic Structure, Viscosity, Diffusion, Crystal Defects |

**Instructor-Initiated Online Contact Types**

Announcements/Bulletin Boards
Chat Rooms
Discussion Boards
E-mail Communication
Video or Teleconferencing

**Student-Initiated Online Contact Types**

Chat Rooms
Discussions
Group Work

**Course design is accessible**

Yes

## Methods of Evaluation

**Methods of Evaluation**

| Types | Examples of classroom assessments |
|---|---|
| Homework | Homework Assignments (End of the Chapter Problems, Problems from a Handout, Reading Assignments) |
| Exams/Tests | Midterm Exams<br>Final Exam |
| Lab Activities | Lab Participation and Reports<br>Examples:<br>1. Calculate the density of Schottky pairs (in m^-3) in MgO if the fraction of vacant lattice<br>sites is 5x10^-6. The density of MgO is<br>3.60 Mg/m^3.<br>2. A 10-mm diameter rod of 3003-H14 aluminum alloy is subjected to a 6-kN tensile load.<br>Calculate the resulting rod diameter. |
| Projects | Final Project (Case Studies, Applications of Six Engineering Materials) |

## Assignments

**Reading Assignments**

Read assignments from the text and class handouts.

Examples:

1. Read Section 3.3 on Ceramic Structures
2. Read Section 8.5 on Failure Analysis & Prevention

**Writing Assignments**

Complete all written and oral assignments, including homework assignments. Complete all laboratory reports. Complete circuit simulation assignments.

Examples:

1. Describe qualitatively the microstructural developmental during the slow cooling of a 30:70 brass (Cu with 30 wt % Zn).
2. A soda-lime-silica glass used to make lamp bulbs has an annealing point of 514 degrees C and a softening point of 696 degrees C. Calculate the working range and the melting range for this glass.

**Other Assignments**

Homework Problems (Sample Problems):

For a steel furnace, silica refractories have corrosion rates of $2.0 \times 10^{-7}$ m/s at 1345#C and $9.0 \times 10^{-7}$ m/s at 1510#C. Calculate the activation energy for the corrosion of these silica refractories.

Manufacturing traditional clayware ceramics typically involves driving off the water of hydration in the clay minerals. The rate constant for the dehydration of kaolinite, a common clay mineral, is $1.0 \times 10^{-4}$ $s^{-1}$ at 485#C and $1.0 \times 10^{-3}$ $s^{-1}$ at 525#C. Calculate (a) the activation energy for the dehydration of kaolinite, (b) the rate constant at 600#C.

## SECTION F - Textbooks and Instructional Materials

**Material Type**

Textbook

**Author**

James Shackelford

**Title**

Introduction to Materials Science for Engineers

**Edition/Version**

9th

**Publisher**

Pearson

**Year**

2021

**ISBN #**

9780135650127

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**Material Type**

Textbook

**Author**

William Smith and Javad Hashemi

**Title**

Foundations of Materials Science and Engineering

**Edition/Version**

7th

**Publisher**

McGraw Hill

**Year**

2023

**ISBN #**

9780135650127

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## Proposed General Education/Transfer Agreement

**Do you wish to propose this course for a UC Transferable Course Agreement (UC-TCA)?**

Yes

## Course Codes (Admin Only)

**ASSIST Update**

No

**C-ID Approval Dates**

| C-ID Descriptor | Approval Date |
|---|---|
| C-ID ENGR 140 B Materials Science and Engineering | 2/12/2016 |

**CB00 State ID**

CCC000337743

**CB10 Cooperative Work Experience Status**

N - Is Not Part of a Cooperative Work Experience Education Program

**CB11 Course Classification Status**

Y - Credit Course

**CB13 Special Class Status**

N - The Course is Not an Approved Special Class

**CB23 Funding Agency Category**

Y - Not Applicable (Funding Not Used)

**CB24 Program Course Status**

Program Applicable

**Allow Pass/No Pass**

No

**Only Pass/No Pass**

No

**Reviewer Comments**

**Stacey Howard (showard) (Thu, 28 Sep 2023 17:52:53 GMT):** Added anticipated Fall 2023 effective date as no rearticulation required.

**Stacey Howard (showard) (Thu, 28 Sep 2023 18:25:31 GMT):** Selected anticipated fall 2023 begin date as no rearticulation required for existing CSU/UC transferability. No matching C-ID descriptor currently.

**Stacey Howard (showard) (Thu, 28 Sep 2023 18:26:38 GMT):** Correction on last comment: Anticipated fall 2024 implementation.

**Stacey Howard (showard) (Thu, 28 Sep 2023 18:45:37 GMT):** ENGI 160 - Anticipated Fall 2024 begin date of COR update ok as no rearticulation for CSU/UC transferability required. Changed term from fall 2025 to 2024. Please add "group" to term or final project. Highly recommended to add this as UC Davis will not articulate this course for any applicable major agreement in ASSIST without inclusion of a group term project. Thank you!

**Stacey Howard (showard) (Thu, 28 Sep 2023 19:21:38 GMT):** ENGR 242 - Suggestion addition of Differential Equations (C-ID MATH 240) as co-requisite. Previous C-ID denial due to missing co-req as per C-ID ENGR 260 descriptor and reviewer.

**Stacey Howard (showard) (Thu, 28 Sep 2023 19:58:57 GMT):** ENGI 240 - Anticipated fall 2024 implementation ok as CSU/UC rearticulation is not required.

**Stacey Howard (showard) (Thu, 28 Sep 2023 20:10:50 GMT):** ENGR 241 - Anticipated begin date of fall 2024 ok as CSU/UC rearticulation not required. C-ID ENGR 130 submission expired. Resubmission required.