# Course Catalog

**3 Credit hours**. All engineering structures and devices utilize materials which have been selected based on their properties. These properties along with design considerations enable a desired performance level. Therefore, engineers of every type are well served in their careers by an understanding of the scientific foundations of materials that govern these properties. Accordingly: This course is designed to provide an introduction to engineering materials with an emphasis on how atomic and molecular bonding, structure, composition and processing influence material properties.

## Instructor

<table>
<thead>
<tr>
<th>Instructor</th>
<th>Dr. Yousef Mubarak</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-mail</td>
<td><a href="mailto:ymubarak@ju.edu.jo">ymubarak@ju.edu.jo</a></td>
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<tr>
<td>Office</td>
<td>CHE 3rd Floor Office 315</td>
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<tr>
<td>Tel</td>
<td>22891</td>
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## Prerequisites

<table>
<thead>
<tr>
<th>Prerequisites by topic</th>
<th>Principles II</th>
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<tr>
<td>Prerequisites by course</td>
<td>0905212</td>
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## Textbook

<table>
<thead>
<tr>
<th>Title</th>
<th>Materials Science and Engineering</th>
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<tbody>
<tr>
<td>Author(s)</td>
<td>William D. Callister</td>
</tr>
<tr>
<td>Publisher</td>
<td>John Wiley &amp; Sons</td>
</tr>
<tr>
<td>Year</td>
<td>2010</td>
</tr>
<tr>
<td>Edition</td>
<td>8th Edition</td>
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## References

Objectives and Outcomes

<table>
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<tr>
<th>Objectives</th>
<th>Outcomes</th>
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<tr>
<td>1) To provide an understanding of the influence of bonding, nano- and microstructure, composition and processing on the properties of materials. [a, h]</td>
<td>Upon successful completion of the Introduction to Engineering Materials Science course, students should be able to:</td>
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<tr>
<td>2) To provide students with an understanding of various types of materials, their ranges of properties, and how their properties can be tailored for engineering purposes. [a, h]</td>
<td>1. Distinguish the different classes of engineering materials. [a, e]</td>
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<td>3) To provide the students with an understanding of the various advantages and disadvantages offered by specific classes of materials, and an awareness of the possible tradeoffs associated with optimization of a specific material's properties. [a, c, e]</td>
<td>2. Describe and comment on structure, processing and properties of the main classes of materials and the relationships between them. [a, h]</td>
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<tr>
<td>4) To provide students with an understanding of various types of materials, their ranges of properties, and how their properties can be tailored for engineering purposes. [a, h]</td>
<td>3. Describe the structure and properties of a range of advanced materials. [a]</td>
</tr>
<tr>
<td>5) To provide students with an understanding of the various advantages and disadvantages offered by specific classes of materials, and an awareness of the possible tradeoffs associated with optimization of a specific material's properties. [a, c, e]</td>
<td>4. Describe processing-microstructure-property relationships. [a, c, e]</td>
</tr>
<tr>
<td>6) To provide students with an understanding of various types of materials, their ranges of properties, and how their properties can be tailored for engineering purposes. [a, h]</td>
<td>5. Support their understanding of the above areas with quantitative analyses where appropriate. [a]</td>
</tr>
<tr>
<td>7) To provide students with an understanding of various types of materials, their ranges of properties, and how their properties can be tailored for engineering purposes. [a, h]</td>
<td>6. Demonstrate an awareness of the principles underpinning engineering design. [c, e]</td>
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**Course Assessment:** The assessment of objectives will be achieved through homework assignments, quizzes, and common examinations with common grading.

**Evaluation**

<table>
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<tr>
<th>Assessment Tool</th>
<th>Expected Due Date</th>
<th>Weight</th>
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<tr>
<td>Homework &amp; Quizzes</td>
<td>One week after homework problems are assigned and there will be a quiz every week.</td>
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<td>First Exam</td>
<td>Thursday 16/3/2017</td>
<td>20 %</td>
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<tr>
<td>Second Exam</td>
<td>Thursday 13/4/2017</td>
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<tr>
<td>Final Exam</td>
<td>According to the University final examination schedule</td>
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**Topics Covered**

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<tr>
<th>Week</th>
<th>Topics</th>
<th>Chapters in Text</th>
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| 1    | Introduction  
   - Historical Perspective  
   - Materials Science and Engineering  
   - Why Study Materials Science and Engineering  
   - Classification of Materials  
   - Advanced Materials  
   - Modern Materials Needs | Chapter 1 |
| 2-3  | Atomic Structure and Interatomic Bonding  
   - Introduction  
   - Atomic Structure  
     - Fundamental Concepts  
     - Electrons in Atoms  
     - The Periodic Table  
   - Atomic Bonding in Solids  
     - Bonding Forces and Energies  
     - Primary Interatomic Bonds  
     - Secondary Bonding or van der Waals Bonding  
     - Molecules | Chapter 2 |
| 4-6  | The Structure of Crystalline Solids  
   - Introduction  
   - Crystal Structure  
     - Fundamental Concepts  
     - Unit Cells  
     - Metallic Crystal Structures | Chapter 3 |
<table>
<thead>
<tr>
<th>Chapter</th>
<th>Topic</th>
<th>Subtopics</th>
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| 7       | Imperfections in Solids | o Introduction  
|         |         | o Point Defects  
|         |         | o Vacancies and Self-Interstitals  
|         |         | o Impurities in Solids  
|         |         | o Discrepancy Imperfections  
|         |         | o Dislocations—Linear Defects  
|         |         | o Interfacial Defects  
|         |         | o Bulk or Volume Defects  
|         |         | o Atomic Vibrations  
|         |         | o Microscopic Examination  
|         |         | o General  
|         |         | o Microscopy  
|         |         | o Grain Size Determination  
| 8-9     | Mechanical Properties of Metals | o Introduction  
|         |         | o Concepts of Stress and Strain  
|         |         | o Elastic Deformation  
|         |         | o Stress—Strain Behavior  
|         |         | o Anelasticity  
|         |         | o Elastic Properties of Materials  
|         |         | o Plastic Deformation  
|         |         | o Tensile Properties  
|         |         | o True Stress and Strain  
|         |         | o Elastic Recovery During Plastic Deformation  
|         |         | o Compressive, Shear, and Torsional Deformation  
|         |         | o Hardness  
|         |         | o Property Variability and Design Safety Factors  
|         |         | o Variability of Material Properties  
|         |         | o Design/Safety Factors  
| 10      | Failure | o Introduction  
|         |         | o Fracture  
|         |         | o Fundamentals of Fracture  
|         |         | o Ductile Fracture  
|         |         | o Brittle Fracture  
|         |         | o Principles of Fracture Mechanics  
|         |         | o Impact Fracture Testing  
|         |         | o Fatigue  
|         |         | o Cyclic Stresses  
|         |         | o The S—N Curve  
|         |         | o Crack Initiation and Propagation  
|         |         | o Crack Propagation Rate  
|         |         | o Factors That Affect Fatigue Life  
|         |         | o Environmental Effects  
|         |         | o Creep  
|         |         | o Generalized Creep Behavior  
|         |         | o Stress and Temperature Effects  

*Submission*: Chapter4, Chapter6, Chapter8
<table>
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<tr>
<th>Pages</th>
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| 11-12 | **Phase Diagrams**  
|       | - Introduction  
|       | - Definitions and Basic Concepts  
|       |   - Solubility Limit  
|       |   - Phases  
|       |   - Microstructure  
|       |   - Phase Equilibria  
|       |   - One-Component Phase Diagram  
|       | - Binary Phase Diagrams  
|       |   - Binary Isomorphous Systems  
|       |   - Binary Eutectic Systems  
|       |   - Equilibrium Diagrams Having Intermediate Phases or Compounds  
|       |     - Eutectoid and Peritectic Reactions  
|       |     - Congruent Phase Transformations  
|       |     - Ceramic and Ternary Phase Diagrams  
|       |     - The Gibbs Phase Rule  
|       | - The Iron-Carbon System  
|       |   - The Iron—Iron Carbide (Fe—Fe3C) Phase Diagram  
|       |   - Development of Microstructures in Iron—Carbon Alloys  
|       |   - The Influence of Other Alloying Elements  
| 13    | **Phase Transformations in Metals:**  
|       | - Introduction  
|       | - Phase Transformation  
|       |   - Basic Concepts  
|       |   - The Kinetics of Solid-State Reactions  
|       |   - Multiphase Transformations  
|       | - Microstructural and Property Changes in Iron-Carbon Alloys  
|       |   - Isothermal Transformation Diagrams  
|       |   - Continuous Cooling Transformation Diagrams  
|       |   - Mechanical Behavior of Iron—Carbon Alloys  
|       |   - Tempered Martensite  
|       |   - Review of Phase Transformations for Iron—Carbon Alloys  
| 14    | **Thermal Processing of Metal Alloys**  
|       | - Introduction  
|       | - Process Annealing  
|       | - Stress Relief  
|       | - Annealing of Ferrous Alloys  
|       | - Hardenability  
|       | - Influence of Quenching Medium, Specimen Size, and Geometry  
|       | - Heat Treatments  
|       | - Mechanism of Hardening  
|       | - Miscellaneous Considerations  
| 15    | **Structures and Properties of Ceramics**  
|       | - Introduction  
|       | - Ceramic Structure  
|       |   - Crystal Structures  
|       |   - Silicate Ceramics  
|       |   - Carbon  
|       |   - Imperfections in Ceramics  
|       |   - Ceramic Phase Diagrams  
|       | - Mechanical Properties  
|       |   - Brittle Fracture of Ceramics  
|       |   - Stress-Strain Behavior  
|       | - Types and Applications of Ceramics  
|       |   - Glasses  
|       |   - Glass-Ceramics  
|       |   - Clay Products  
|       |   - Refractories  
|       |   - Abrasives  

Chapter 9  
Chapter 10  
Chapter 11  
Chapter 12
### Relationship to Program Outcomes (%)

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### Relationship to Chemical Engineering Program Objectives

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<tr>
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<th>PEO1</th>
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### Document control

<table>
<thead>
<tr>
<th>Prepared by</th>
<th>Dr. Yousef Mubarak</th>
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<tbody>
<tr>
<td>Last Modified</td>
<td>January 23, 2017</td>
</tr>
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