



The University of Jordan
School of Engineering
Chemical Engineering Department

0905351 *Engineering Materials Science*
Second Semester 2016/2017

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

Instructor	Dr. Yousef Mubarak E-mail: ymubarak@ju.edu.jo	Office: CHE 3 rd Floor Office 315 Tel: 22891 Web: http://eacademic.ju.edu.jo/ymubarak/default.aspx
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Prerequisites

Prerequisites by topic	<i>Principles II</i>
Prerequisites by course	0905212

Text book

Title	<i>Materials Science and Engineering</i>
Author(s)	William D. Callister
Publisher	John Wiley & Sons
Year	2010
Edition	8 th Edition

References

Books	<ol style="list-style-type: none">1. Ashby, M. F. and Jones, D. R. H., "<i>Engineering Materials: an Introduction to their Properties and Applications</i>", 1st Edn., Pergamon Press, 1980.2. Deighton, M., Mead, J. A., "<i>Introduction to Materials Science</i>", Oxford U. P., 1978.3. Brick, R. M., Pense, A. W., and Gordon, R. B., "<i>Structure and Properties of Engineering Materials</i>", 4th Edn., McGraw-Hill, 1977.4. Budworth, D. W., "<i>Intorudction to Ceramic Science</i>", Pergamon Press, 1970.5. Van, V. and Lawrence, H., "<i>Materials Science for Engineers</i>", Addison-Wesley, 1970.6. Raghavan, V., "<i>Materials Science and Engineering: a First Course</i>", 2nd Edn., Prentice-Hall, 1982.7. Van, V. and Lawrence, H., "<i>Elements of Materials Science and Engineering</i>", 6th Edn., Addison-Wesley, 1989.8. Shackelford, J. F., "<i>Introduction to Materials Science for Engineers</i>", 4th Edn., Prentice-Hall International, 1998.9. Smith, W. F., "<i>Principles of Materials Science and Engineering</i>", 2nd Edn., McGraw-Hill, 1990.10. Alper, Allen M., "<i>Phase Diagrams: Materials Science and Technology</i>", Academic Press, 1970.
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<i>Objectives and Outcomes</i>	
<i>Objectives</i>	<i>Outcomes</i>
<p>1) To provide an understanding of the influence of bonding, nano- and micro-structure, composition and processing on the properties of materials. [a, h]</p> <p>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]</p> <p>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]</p>	<p>Upon successful completion of the Introduction to Engineering Materials Science course, students should be able to:</p> <ol style="list-style-type: none"> 1. Distinguish the different classes of engineering materials. [a, e] 2. Describe and comment on structure, processing and properties of the main classes of materials and the relationships between them. [a, h] 3. Describe the structure and properties of a range of advanced materials. [a] 4. Describe processing-microstructure-property relationships. [a, c, e] 5. Support their understanding of the above areas with quantitative analyses where appropriate. [a] 6. Demonstrate an awareness of the principles underpinning engineering design. [c, e]

Course Assessment: The assessment of objectives will be achieved through homework assignments, quizzes, and common examinations with common grading.

<i>Evaluation</i>		
Assessment Tool	Expected Due Date	Weight
Homework & Quizzes	One week after homework problems are assigned and there will be a quiz every week.	10 %
First Exam	Thursday 16/3/2017	20 %
Second Exam	Thursday 13/4/2017	20%
Final Exam	According to the University final examination schedule	50 %

<i>Topics Covered</i>		
Week	Topics	Chepters in Text
1	<p>Introduction</p> <ul style="list-style-type: none"> ○ Historical Perspective ○ Materials Science and Engineering ○ Why Study Materials Science and Engineering ○ Classification of Materials ○ Advanced Materials ○ Modern Materials Needs 	Chapter 1
2-3	<p>Atomic Structure and Interatomic Bonding</p> <ul style="list-style-type: none"> ○ Introduction ○ Atomic Structure <ul style="list-style-type: none"> ▪ Fundamental Concepts ▪ Electrons in Atoms ▪ The Periodic Table ○ Atomic Bonding in Solids <ul style="list-style-type: none"> ▪ Bonding Forces and Energies ▪ Primary Interatomic Bonds ▪ Secondary Bonding or van der Waals Bonding ▪ Molecules 	Chapter 2
4-6	<p>The Structure of Crystalline Solids</p> <ul style="list-style-type: none"> ○ Introduction ○ Crystal Structure <ul style="list-style-type: none"> ▪ Fundamental Concepts ▪ Unit Cells ▪ Metallic Crystal Structures 	Chapter 3

	<ul style="list-style-type: none"> ▪ <i>Density Computations</i> ▪ <i>Polymorphism and Allotropy</i> ▪ <i>Crystal Systems</i> ○ <i>Crystallographic Points</i> <ul style="list-style-type: none"> ▪ <i>Crystallographic Directions</i> ▪ <i>Crystallographic Planes</i> ▪ <i>Linear and Planar Atomic Densities</i> ▪ <i>Close-Packed Crystal Structures</i> ○ <i>Crystalline and Noncrystalline Materials</i> <ul style="list-style-type: none"> ▪ <i>Single Crystals</i> ▪ <i>Polycrystalline Materials</i> ▪ <i>Anisotropy</i> ▪ <i>X-Ray Diffraction Determination of Crystalline Structure</i> ▪ <i>Noncrystalline Solids</i> 	
7	<p><i>Imperfections in Solids</i></p> <ul style="list-style-type: none"> ○ <i>Introduction</i> ○ <i>Point Defects</i> <ul style="list-style-type: none"> ▪ <i>Vacancies and Self-Interstitials</i> ▪ <i>Impurities in Solids</i> ○ <i>Discllanceous Imperfections</i> <ul style="list-style-type: none"> ▪ <i>Dislocations—Linear Defects</i> ▪ <i>Interfacial Defects</i> ▪ <i>Bulk or Volume Defects</i> ▪ <i>Atomic Vibrations</i> ○ <i>Microscopic Examination</i> <ul style="list-style-type: none"> ▪ <i>General</i> ▪ <i>Microscopy</i> ▪ <i>Grain Size Determination</i> 	Chapter4
8-9	<p><i>Mechanical Properties of Metals</i></p> <ul style="list-style-type: none"> ○ <i>Introduction</i> ○ <i>Concepts of Stress and Strain</i> ○ <i>Elastic Deformation</i> <ul style="list-style-type: none"> ▪ <i>Stress—Strain Behavior</i> ▪ <i>Anelasticity</i> ▪ <i>Elastic Properties of Materials</i> ○ <i>Plastic Deformation</i> <ul style="list-style-type: none"> ▪ <i>Tensile Properties</i> ▪ <i>True Stress and Strain</i> ▪ <i>Elastic Recovery During Plastic Deformation</i> ▪ <i>Compressive, Shear, and Torsional Deformation</i> ▪ <i>Hardness</i> ○ <i>Property Variablity and Design Safety Factors</i> <ul style="list-style-type: none"> ▪ <i>Variability of Material Properties</i> ▪ <i>Design/Safety Factors</i> 	Chapter6
10	<p><i>Failure</i></p> <ul style="list-style-type: none"> ○ <i>Introduction</i> ○ <i>Fracture</i> <ul style="list-style-type: none"> ▪ <i>Fundamentals of Fracture</i> ▪ <i>Ductile Fracture</i> ▪ <i>Brittle Fracture</i> ▪ <i>Principles of Fracture Mechanics</i> ▪ <i>Impact Fracture Testing</i> ○ <i>Fatigue</i> <ul style="list-style-type: none"> ▪ <i>Cyclic Stresses</i> ▪ <i>The S—N Curve</i> ▪ <i>Crack Initiation and Propagation</i> ▪ <i>Crack Propagation Rate</i> ▪ <i>Factors That Affect Fatigue Life</i> ▪ <i>Environmental Effects</i> ○ <i>Creep</i> <ul style="list-style-type: none"> ▪ <i>Generalized Creep Behavior</i> ▪ <i>Stress and Temperature Effects</i> 	Chapter 8

	<ul style="list-style-type: none"> ▪ <i>Data Extrapolation Methods</i> ▪ <i>Alloys for High-Temperature Use</i> 	
11-12	<p>Phase Diagrams</p> <ul style="list-style-type: none"> ○ <i>Introduction</i> ○ <i>Definitions and Basic Concepts</i> <ul style="list-style-type: none"> ▪ <i>Solubility Limit</i> ▪ <i>Phases</i> ▪ <i>Microstructure</i> ▪ <i>Phase Equilibria</i> ▪ <i>One-Component Phase Diagram</i> ○ <i>Binary Phase Diagrams</i> <ul style="list-style-type: none"> ▪ <i>Binary Isomorphous Systems</i> ▪ <i>Binary Eutectic Systems</i> ▪ <i>Equilibrium Diagrams Having Intermediate Phases or Compounds</i> <ul style="list-style-type: none"> ▪ <i>Eutectoid and Peritectic Reactions</i> ▪ <i>Congruent Phase Transformations</i> ▪ <i>Ceramic and Ternary Phase Diagrams</i> ▪ <i>The Gibbs Phase Rule</i> ○ <i>The Iron-Carbon System</i> <ul style="list-style-type: none"> ▪ <i>The Iron—Iron Carbide (Fe—Fe₃C) Phase Diagram</i> ▪ <i>Development of Microstructures in Iron—Carbon Alloys</i> ▪ <i>The Influence of Other Alloying Elements</i> 	Chapter 9
13	<p>Phase Transformations in Metals:</p> <ul style="list-style-type: none"> ○ <i>Introduction</i> ○ <i>Phase Transformation</i> <ul style="list-style-type: none"> ▪ <i>Basic Concepts</i> ▪ <i>The Kinetics of Solid-State Reactions</i> ▪ <i>Multiphase Transformations</i> ○ <i>Microstructural and Property Changes in Iron-Carbon Alloys</i> <ul style="list-style-type: none"> ▪ <i>Isothermal Transformation Diagrams</i> ▪ <i>Continuous Cooling Transformation Diagrams</i> ▪ <i>Mechanical Behavior of Iron—Carbon Alloys</i> ▪ <i>Tempered Martensite</i> ▪ <i>Review of Phase Transformations for Iron—Carbon Alloys</i> 	Chapter 10
14	<p>Thermal Processing of Metal Alloys</p> <ul style="list-style-type: none"> ○ <i>Introduction</i> ○ <i>Process Annealing</i> ○ <i>Stress Relief</i> ○ <i>Annealing of Ferrous Alloys</i> ○ <i>Hardenability</i> ○ <i>Influence of Quenching Medium, Specimen Size, and Geometry</i> ○ <i>Heat Treatments</i> ○ <i>Mechanism of Hardening</i> ○ <i>Miscellaneous Considerations</i> 	Chapter 11
15	<p>Structures and Properties of Ceramics</p> <ul style="list-style-type: none"> ○ <i>Introduction</i> ○ <i>Ceramic Structure</i> <ul style="list-style-type: none"> ▪ <i>Crystal Structures</i> ▪ <i>Silicate Ceramics</i> ▪ <i>Carbon</i> ▪ <i>Imperfections in Ceramics</i> ▪ <i>Ceramic Phase Diagrams</i> ○ <i>Mechanical Properties</i> <ul style="list-style-type: none"> ▪ <i>Brittle Fracture of Ceramics</i> ▪ <i>Stress-Strain Behavior</i> ○ <i>Types and Applications of Ceramics</i> <ul style="list-style-type: none"> ▪ <i>Glasses</i> ▪ <i>Glass-Ceramics</i> ▪ <i>Clay Products</i> ▪ <i>Refractories</i> ▪ <i>Abrasives</i> 	Chapter 12

<ul style="list-style-type: none"> ▪ Cements ▪ Advanced Ceramics ○ Fabrication and Processing of Ceramics <ul style="list-style-type: none"> ▪ Fabrication and Processing of Glasses and Glass-Ceramics ▪ Fabrication and Processing of Clay Products ▪ Powder Processing ○ Tape Casting 	
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Relationship to Program Outcomes (%)

A	B	C	D	E	F	G	H	I	J	K
70	0	10	-	10	-	-	10	-	-	-

Relationship to Chemical Engineering Program Objectives

PEO1	PEO2	PEO3	PEO 4	PEO 5	PEO 6
√	√	√	√	√	√

Document control

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Materials Science and Engineering A provides an international medium for the publication of theoretical and experimental studies and reviews of the properties and behaviour of a wide range of materials, related both to their structure and to their engineering application. The varied topics comprising materials science and engineering are viewed as appropriate for publication: these include, but are not limited to, the properties and structure of crystalline and non-crystalline metals and ceramics, polymers, and composite materials. RG Journal Impact: 2.13 *. *This value is calculated using Res