

MATSE 201: INTRODUCTION TO MATERIAL SCIENCE

- Course Designation:** This is a required course in all options in Materials Science and Engineering. There is a requirement of a C-grade for MATSE graduates.
- Catalog Description:** Concepts of relationships between structure and thermal, optical, magnetic, electrical, and mechanical properties of metals, ceramics, glasses, and polymers.
- Course Description:** Modern science and technology is highly dependent on materials whose properties can be controlled to accommodate a wide range of applications. The multidisciplinary field of materials science and engineering outlines approaches to enhance the synthesis of new materials, understand their properties, and specifically tailor characteristics for needs. The purpose of this course is to present to students the basic principles necessary to understand structure-property relations in engineering materials. The course assumes a basic knowledge in general physics, general chemistry, and mathematics. With these tools and the subject matter outlined in this course, students obtain a wide knowledge of modern challenges to the application of modern materials. Where appropriate, state-of-the-art problems are discussed in the form of examples. The student grasps concepts of structure from bonding through to microstructure, and then learns to consider the interrelationships between structure and property. The properties ranging from structural, electrical, optical to thermal in nature are all considered. Further, examples are given to discuss the manipulation of these structure-property relationships in terms of the engineering of materials.
- Prerequisites:** CHEM 013, MATH 231
- Textbook:** Introduction to Materials Science and Engineering, J.F. Shackelford

Course Objectives:

1. To provide students with a broad appreciation of the diverse activities with material science.
2. Teach basic concepts regarding structure-property-processing relations across all material classes.
3. Establish an understanding that structure dimensions range from bonds lengths to mesoscopic (defect scales) through to microstructure and device scale.
4. Instruct students on the importance of quantification and characterization of properties and phenomena.
5. Teach the students that there are many factors that ultimately determine a material selection for a given application.

Topics Covered:

- I. Structure of Materials
Atomic bonding and bonding types, Crystallography and x-ray diffraction, Defect structures, Amorphous structures in metals, ceramics, and polymers
- II. Kinetics
Diffusion and Diffusion Pathways, Fick's 1st and 2nd law, Avrami-rate equation, T.T.T. diagrams, specific attention shown to Fe-Fe₃C system
- III. Phase Equilibria
Unary and binary phase diagrams, Gibb's phase rule, Cooling curves and determination, Solid solution, eutectics, peritectics, eutectoids, peritectoid reactions
- IV. Mechanical Properties
Elastic and plastic behavior is contrasted in ceramics, metals, and polymers, Stress-strain curves, Hardening mechanisms in polymers and metals, Time dependent mechanical properties, creep mechanisms, Fracture toughness
- V. Composite Materials

- Designing composite materials, Average property description, Connectivity
- VI. Electrical Properties
 Conductivity (metals), Semiconductors, intrinsic versus extrinsic, Insulators, Superconductors, Magnetic materials, Optical materials, refractive indices, and color

Class Schedule: 3-credit course offered annually, meeting 3 times per week for 50 minutes.

Course Outcomes:

1. Student should understand why the design of structure has profound impact on observed properties.
2. Students should be able to identify different types of structure in all classes of materials.
3. Students are familiar with interpreting binary and unary phase diagrams, understand concepts of solid solution and solubility limits, and are able to predict microstructures.
4. Basic ideas for defining crystal structure and identifying phases with x-ray diffraction is established.
5. Student should understand basic diffusion laws and have the ability to model simple transformations with the Avrami equation and T.T.T. diagrams.
6. Student understands important mechanical properties.
7. Microscopic mechanisms that control deformation in ceramics, metals, and polymers, such as elastic, plastic deformation, and creep, should be understood.
8. Understanding electronic properties and mechanisms in conductors, semiconductors, and insulators.
9. Student should have a basic understanding of composite materials, their typical design criteria, and property averaging for properties such as elastic modulus and resistivity.

Assessment Tools:

Six homeworks are given, with three closed book examinations.

Professional Component: The course topics introduce the basic principles of materials science which utilize the interrelationships between structure, properties, and performance of materials. Structure is introduced on a number of scales, properties are linked to mechanisms on these various length scales.

Honors Option:

1. Oral presentation on a topical aspect in materials.
2. Laboratory and company visit.

Prepared by: Clive A. Randall, February 2002

| MAP TO DEPARTMENTAL OUTCOMES (For further detail, see coursebook) | | | | | | | | | | | |
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| MAP TO DEPARTMENTAL OBJECTIVES (For further detail, see coursebook) | | | | | | |
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