Course Title: ENS 205 Introduction to Materials Science

Intended Audience: An introductory undergraduate level course for all interested FENS students.

Scope: This course is an introductory undergraduate level course that covers the fundamental principles and concepts of Materials Science. The course will cover the basic properties and behavior of materials, including metals, ceramics, polymers, and composites. It will also introduce the structure of materials, microstructure, and properties. The course aims to provide a foundation for understanding the structure and properties of materials, and how they can be designed and engineered for various applications. Students planning to study BIO, MAT, ME, and MS programs will especially benefit from this course.

Course Objectives:

1. To equip the students with a basic understanding of “materials science”.
2. To help students relate the atomic scale interactions to the structure of the material observed at the macroscopic scale.
3. To interrelate the mechanical, thermal, electrical, magnetic and optical properties of materials.
4. To explain the phase behavior and how thermodynamics and kinetics may be used to manipulate the observed phases.
5. To differentiate between novel materials such as polymers, ceramics, composites based on their properties.

Course Format: The course will be delivered through lectures, quizzes, homework assignments, and exams.

Grading Policy:
- Midterm Exam 1: 40%, Fourth week, 3\textsuperscript{rd} of August
- Final Exam: 40%
- Quizzes and Homework Assignments: 20%


Supplementary books:

Course Instructor: Mustafa Baysal, mustafa.baysal@sabanciuniv.edu

Office Hours: by appointment

Course Schedule: Wednesday: 11:40 am - 2:30 pm, Room: FENS L065 Thursday: 11:40 am - 2:30 pm Room: FENS L063
ENS 205 Introduction to Materials Science (Summer 2022-2023)

Course Outline:

Week 1:
- Introduction to Materials Science
- Atomic Structure and Interatomic Bonding
- Types of Bonds and Comparison
- Crystal Structure and Symmetry
- 3D Lattice and Miller Indices
- Types of Cubic Structures

Week 2:
- Defects in Materials
  - Point Defects and Thermodynamics of Defect Formation
    - Types of Point Defects
  - Line Defects and Dislocations
    - Edge and Screw Dislocations
    - Burgers Vector and Dislocation Slip
  - Planar Defects
    - Grain Boundaries
    - Types of Grain Boundaries
- Diffusion
  - Thermal activation of processes.
  - Time dependent changes.
  - Arrhenius plot, Activation energy, Fick's Law
- Sintering

Week 3:
- Mechanical Properties of Materials
  - Elastic and Plastic Deformation
  - Mechanical Testing and Stress-Strain Curves,
  - Measurements by creep and stress relaxation experiments.
  - Failure analysis.

Week 4:
- Thermal Properties of Materials
  - Thermal Expansion and Conductivity
  - Specific Heat Capacity and Heat Transfer
- Phase Diagrams
  - Binary and Ternary Phase Diagrams
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Lever Rule and Phase Equilibria
Eutectic diagrams.
Development of microstructure during slow cooling.

**Week 5:**

- Kinetics, Heat treatment
  - Time-dependent phase transformations, Transformation on a temperature-versus-time plot (TTT diagram)
  - Nucleation, Grain growth
  - Development of microstructure during slow cooling

**Week 6:**

- Strengthening Mechanisms
  - Phase transformations
  - Precipitation hardening
  - Strain hardening (recovery and recrystallization)
  - Toughening mechanisms (in ceramics and polymers)
  - A brief introduction to fiber reinforced materials

- Electrical and Magnetic Properties of Materials
  - Conductivity and Resistivity
  - Semiconductor types
  - Magnetic Properties

**Week 7:**

- Different types of Materials
  - Polymeric materials
    - Types
    - Properties
    - Processing
  - Ceramics
    - Types
    - Properties
    - Processing
  - Composites
  - Nanomaterials (Fabrication methods)

Note: This syllabus is tentative and subject to change at the discretion of the instructor.