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ENS 205 Introduction to Materials Science (Fall 20-21)

Intended Audience:

An introductory undergraduate level course for all interested FENS students especially for MAT, BIO, ME, and IE programs.

Scope:

To provide fundamentals of how interactions and structure at atomic scale lead to macroscopic properties and to introduce the fundamental thermodynamic/kinetic concepts operating on the structure for the design and implementation of materials with novel functions. The class will also give insight to what MAT Engineers do in industry.

Schedule:

Week 1 / 3 hours

General concepts and definitions

Understanding interactions in materials at the atomic scale

Functional Materials, How to make functional materials

Why nanomaterials are important

Broader / Social Impact of Materials Science

Atomic bonding, Crystals, Classification of crystals

Week 2 / 3 hours

Engineering Materials

Crystals, Bonding, Failures, Primary bonding

Symmetry

Lattice positions, directions and planes; fundamentals of x-ray diffraction

Week 3 / 3 hours

Secondary bonding (Hydrogen bonds, Van der Waals bond)

Electronegativity, Polar crystals

Lattice, Unit cell, Atomic packaging factors

Arrangement of particles inside crystals

Week 4 / 3 hours

Lattice positions, directions, and planes; fundamentals of x-ray diffraction

Miller indices

Week 5 / 3 hours

Defects, Dislocations

Diffusion, Thermal activation of processes; time-dependent changes

Arrhenius plot, Activation energy, Fick's Law

Week 6 / 3 hours

Mechanical properties of materials

The response of materials to mechanical changes: Stress-strain curves, Tensile test

Elastic and plastic deformation; measurements by creep and stress relaxation

Week 7 / 3 hours

Thermal properties of materials

The response of materials to heat: Heat capacity, thermal expansion, thermal conductivity

Debye Model, Dulong-Petit

Failure analysis and Prevention, Ductile-to-Brittle transition, Experiments; failure analysis

Week 8 / 3 hours

Phase diagrams

The lever rule, stability. Eutectic diagrams.

Development of microstructure during slow cooling

Week 9 / 3 hours

Kinetics, Heat treatment

Time-dependent phase transformations, Transformation on a temperature-versus-time plot (TTT diagram)

Nucleation

Development of microstructure during slow cooling

Ferrous and non-ferrous materials

Types of steel (stainless, cast, low carbon, mild etc..)

Week 10 / 3 hours

Structural properties of polymers

Thermoset and thermoplastic materials

Additives, Metal Matrix Composites

Electrical properties of materials

Week 11 / 3 hours

Charge carriers, Hund rules

Energy levels, Doping in semiconductors

Electronic properties of Engineering materials

Optical and magnetic properties

Week 12 / 3 hours

Applications in Materials Engineering