ENGR A210: ENGINEERING MATERIALS

Item	Value
Curriculum Committee Approval Date	12/08/2021
Top Code	090100 - Engineering, General (requires Calculus) (Transfer)
Units	3 Total Units
Hours	54 Total Hours (Lecture Hours 54)
Total Outside of Class Hours	0
Course Credit Status	Credit: Degree Applicable (D)
Material Fee	No
Basic Skills	Not Basic Skills (N)
Repeatable	No
Grading Policy	Standard Letter (S)

Course Description

This is an introductory course emphasizing the understanding of the structure and properties of the materials, and the design and selection of materials for engineering applications. Studies include analysis of ferrous and non-ferrous metals, ceramics, polymers, composites and semiconductors. Emphasis is on micro and macro structure, relationship between the structure and properties of materials, and effect of heat, stress, imperfections and chemical environments on material structure, properties and performance. Topics also include mechanical, thermal, electrical (including semiconductors), magnetic and optical properties and also corrosion and degradation of materials. PREREQUISITE: CHEM A180 and PHYS A185 or PHYS A185H. Transfer Credit: CSU; UC. C-ID: ENGR 140.**C-ID:** ENGR 140.

Course Level Student Learning Outcome(s)

1. Explain the internal structure (macro- and micro-) of materials and its effect on the material properties.
2. Explain the methods (intentional or unintentional) to modify the properties of the material by altering its structure by mechanical mechanisms, and altering the composition (i.e. chemically), and by thermal means.
3. Recommend a suitable material or materials for specific applications and to meet the design criteria based upon the data of the properties, processing and the performance of materials of all classes.

Course Objectives

- 1. Describe the primary and secondary bonding, and crystal structure for metals, determine the crystallographic points, directions and planes, determine miller indices, and explain the material microscopic visualization techniques and determine the grain size.
- 2. Explain types of imperfections in materials, their effect on properties of materials, and how to alter the properties using defects. Also determine the solid state diffusion and it effects on the properties, especially surface properties on the materials.
- 3. Explain the stress-strain behavior and determine the mechanical properties of the different types of materials, including changes in structure. Determine the effect of temperature and strengthening mechanisms. Explain different failure modes for various types of materials under different loading conditions and their role in selection and performance of materials.
- 4. Use the equilibrium and non-equilibrium phase diagrams to control the microstructure and the properties of materials and design the materials using variation in composition and thermal processes.
- 5. Select and recommend material/materials for specific use, utilizing the collection of data on mechanical and other properties. Selection of metallic and non-metallic materials based on their physical properties and typical applications.
- 6. Explain and select the joining, forming, fabrication and machining and/or other processes to manufacture the components. Use metallic, ceramic, polymeric and composite materials. Explain the processes to design the particle- and fiber-reinforced composite materials.
- 7. Identify ceramic structures and types and processing of ceramic materials and identify polymer structure, and characteristics and processing of polymeric materials.
- 8. Identify the electrical properties of materials and explain the process of conduction, semiconductivity and dielectric behavior. Explain the mechanisms of thermal, magnetic and optical properties of materials.
- 9. Explain various corrosion and degradation processes and their effects on the properties of materials.

Lecture Content

Atomic Structure and Bonding: Fundamental Concepts (Particles, Isotopes, Mass and Charge) Bohrs Model and Wave – Mechanical Model Quantum Numbers and Electron Configurations Bonding Forces and Energies Primary and Secondary Bonds (including the Hydrogen and Dipole Bonds) Crystal Structure and Crystallography: Unit Cells, Atomic Packing and Mass Density Primitive Lattice Structures Crystallographic Points, Directions, Planes Miller Indices Linear and Planar Densities Imperfections and Defects: Point Defects Vacancies and Self-interstitials Solid Solutions (Substitutional and Interstitial) Dislocations Interfacial Defects External surfaces Grain boundaries Twin boundaries Microstructure Visualization: Optical Microscope Electron Microscope Transmission Electron Microscope Scanning Electron Microscope Diffusion: Solid State Diffusion Mechanisms Ficks First and Second Laws Effect of Temperature and Species on Diffusion Mechanical Properties of Materials and Testing Normal and Shearing Stresses and Strains Tensile, Compression, Shearing and Torsional Tests Stress-Strain Analysis (Elastic and Plastic) Moduli and Poissons ratio Tensile Properties, Ductility, Resilience, Toughness True Stress and Strain Hardness, Hardness Tests Strengthening Mechanisms: strong> Plastic Deformation and Dislocations Slip Systems and Slip in Single Crystals, Critical Resolved Shear Stress Deformation and Slip in Polycrystalline Materials Strengthening in Metals (Grain Size, Solid-Solution, Strain-Hardening) Recovery and Recrystallization Processes in Cold-Worked Metals Phenomenon and Effect of Grain Growth Mechanical Failure: Ductile and Brittle Fractures Fracture Mechanism Stress Concentration Fracture Toughness, Plane Strain, Fracture Toughness Fracture and Design Impact Fracture and Techniques Fatigue Cyclic Stresses S-N Curve Crack Initiation and Propagation Fatigue Life and the Factors Affecting Fatigue Life ll;"> Creep Creep Mechanisms Effect of Stress and Temperature on Creep Equilibrium Phase Diagrams: Basic Concepts and Definitions Components, Systems, Solubility Limits, Phases, Phase Equilibrium, Metastable State Chemical Composition, Phase Composition, Tie Line, Lever Rule Equilibrium Phase Diagrams Binary Isomorphous System Microstructure

in Isomorphous System Equilibrium Cooling Non-Equilibrium Cooling Eutectic Systems and Microstructure of Eutectic Alloys Systems with Intermediate Phases Eutectoid and Peritectic Reactions nt-size: small;"> Iron-Carbon System Phase Diagram Phases (Ferrites, Cementite, Austenite, Pearlite, Proeutectoid Ferrite) Hypoeutectoid, Hypereutectoid Alloys Effect of Alloying Elements on Eutectoid Temperature and Composition Phase Transformation and Heat Treatments of steels: Kinetics of Solid-State Reactions Multiphase Transformations Non-Equilibrium Structure and Properties of Iron-Carbon Alloys Isothermal Transformation Diagrams Pearlite (Coarse and Fine) Bainite Spheroidite Martensite Continuous Cooling Transformation Diagram Austempering, Annealing, Marquenching and Normalizing Compositions, Properties and Applications of Ferrous and Non-Ferrous Alloys: rong> Steels (Plain-Carbon Steels, Alloy Steels) Low-Carbon, Medium-Carbon, High-Carbon Steels, Stainless Steels Cast Irons Gray Cast, Nodular, White and Malleable IronsCopper and its AlloysAluminum and its AlloysMagnesium and its AlloysTitanium and its AlloysThermal Processing of Metals:Annealing ProcessesHardenability and Jominy End-Quench TestPrecipitation Hardening Structures and Properties of Ceramic Materials: Crystal Structures Coordination Number Silicate Ceramics Graphite, Diamond, Fullerenes and Carbon Nanotubes Equilibrium Phase Diagrams of Various Ceramic Systems Stress-Strain Behavior and Flexural Strength Fracture in Ceramics Plastic Behavior of Crystalline and Non-Crystalline Ceramics Hardness and Creep Glasses Refractories and Clay Products Cements and Concrete Structure and Properties of Polymers: Polymer Molecules and Formation of Polymeric Structures Bond Strength Defects and Diffusion in Polymers Variations in Thermoplastic Polymer Structures Properties of Thermoplastic Polymers, and Effect of Time, Temperature and Strain Rate. Thermosetting Polymers, Plastics, Elastomers, Fibers Mechanical Behavior of Polymers Deformation Mechanisms and Strengthening Fabrication and Forming: Metallic Casting Machining, Hole Making and Surface Finish Welding and Soldering Powder Metallurgy Ceramics Fabrication and Processing of Glasses Fabrication and Processing of Clay Products Sintering Tape Casting Polymers Polymerization Polymer Additives Forming Techniques for Plastics and Elastomers Composite Materials: Synthetic Macroscopic Composite Materials Particle- and Fiber-Reinforced Composite Materials Properties and Designing Composite Materials for Applications Concrete Components and Properties of Concrete Concre tes for Specific Applications Reinforces and Pre-Stressed Concrete Wood Macro- and Microstructures of Wood Properties of Wood Defects in Wood Corrosion and Degradation of Materials Corrosion in Metals and Oxidation Reaction Galvanic Series Corrosion Rates Types of Corrosion (Galvanic, Crevice, Intergranular, Selective Leaching, Stress, Hydrogen Embrittlement) Corrosion Prevention Oxidation in Metals Corrosion of Ceramics and Polymenrs Radiation Damage Properties of Materials Electrical Properti es Conduction and Conductivity in Metals Superconductivity Semiconductors Extrinsic and Intrinsic Semiconductors Application of Semiconductors (Rectification, Amplification, Solar Cells, Hall Effect) Dielectric Properties Optical Properties Emission, Absorption, Reflection, Refraction and Transmission Phenomenon Optical Application of Materials Magnetic Properties Structure and Properties of Metallic and Ceramic Magnetic Materials Hysteresis Loop Magnetic Permeability

Method(s) of Instruction

- Lecture (02)
- DE Live Online Lecture (02S)
- DE Online Lecture (02X)

Instructional Techniques

Mode of instruction is lecture and demonstration.

Reading Assignments

2 hrs./week of readings form the textbook and articles.

Writing Assignments

0.75 hrs./week of written discussion of results and findings, related to problem solving, open-ended problems, and material research/design projects.

Out-of-class Assignments

4 hrs./week of practice problems, open-ended problems, and material research/design projects.

Demonstration of Critical Thinking

Solving problems involving the evaluation and design of materials through altering and controlling their structure and properties using various methods.

Required Writing, Problem Solving, Skills Demonstration

Problem-solving exercises, open-ended, scientific and engineering judgment problems assigned as homework , exams, quizzes, and term paper/project.

Eligible Disciplines

Engineering: Masters degree in any field of engineering OR bachelors degree in any of the above AND masters degree in mathematics, physics, computer science, chemistry, or geology OR the equivalent. (NOTE: A bachelors degree in any field of engineering with a professional engineers license is an alternative qualification for this discipline.) Masters degree required. Title 5, section 53410.1

Textbooks Resources

1. Required Callister, W.D., Rethwisch, D.G.. Materials Science and Engineering, An Introduction, 10th edition ed. Wiley, 2018 2. Required Shackelford, J.F.. Introduction to Materials Science for Engineers, 8th ed. Prentice Hall, 2015