

Material Science and Engineering

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Course Objectives

- To teach the principles of physical metallurgy, i.e. crystallography of metals, constitution of alloys, phase diagrams and heat treatment of steels.
- Explain the methods to change the properties of materials through heat treatment processes.
- Expose commercially important metals and alloys (both ferrous and nonferrous) with engineering constraints.
- Familiarize properties and applications of ceramics, polymers and composite materials.
- Demonstrate the fundamental properties of nano-materials and their applications.

UNIT I:

10 Hours

Structure of Metals: Crystal Structures: Unit cells, Metallic crystal structures, Imperfection in solids: Point, Line, interstitial and volume defects; dislocation strengthening mechanisms and slip systems, critically resolved shear stress.

Constitution of Alloys: Necessity of Alloying, substitutional and interstitial solid solutions – Phasediagrams: Interpretation of binary phase diagrams and microstructure development; eutectic, peritectic, peritectoid and monotectic reactions. Iron – Iron – carbidediagram and microstructural aspects of ferrite, cementite, austenite, ledeburite, and cast iron.

Learning Outcomes:

At the end of this unit the student will be able to

- Explain the importance of material science in engineering.(L2)
- Recall the definitions and terminology of crystallography. (L1)
- Distinguish metals and alloys. (L4)
- Make use of the principles of construction of binary phase diagrams. (L3)
- Identify various invariant reactions in binary phase diagrams. (L3)
- Explain the concept of metallography in studying the microstructures of metals and alloys. (L2)

UNIT II:

8 Hours

Heat Treatment of Steels: Annealing, tempering, normalizing and spheroidizing, isothermal transformation diagrams for Fe-Fe₃Calloys and microstructure development. Continious cooling curves and interpretation of final microstructures and properties- austempering, martempering, case hardening, carburizing, nitriding, cyaniding, carbo-nitriding, flame and induction hardening, and vacuum and plasma hardening

Learning Outcomes:

At the end of this unit the student will be able to

- Understand the importance of steel and iron - iron carbide phase diagram. (L2)
- Explain the influence of heat treatment in modification of properties of steels. (L2)
- Develop a heat treatment cycle based on properties required. (L3)
- Explain the principles of surface hardening methods. (L2)

UNIT III:**8 Hours**

Steels: Plain carbon steels, use and limitations of plain carbon steels. AISI& BIS classification of steels. Classification of alloys steels. Micro structure, properties and applications of alloy steels-stainless steels and tool steels.

Cast irons: Micro structure, properties and applications of white cast iron, malleable cast iron, grey cast iron, nodular cast iron and alloy cast irons.

Learning Outcomes:

At the end of this unit the student will be able to

- Classify various types of steels, their properties and applications. (L2)
- Identify various types of cast irons, their properties and applications. (L3)
- Compare steels and cast irons and their limitations in applications. (L3)

UNIT IV:**8 Hours**

Non-ferrous Metals and Alloys: Micro structure, properties and applications of copper and its alloys, aluminium and its alloys. Study of Al – Cu phase diagram, precipitation hardening. Micro structure, properties and applications of titanium and its alloys.

Learning Outcomes:

At the end of this unit the student will be able to

- Explain the importance of non-ferrous metals and alloys in engineering applications. (L2)
- Demonstrate various properties and applications of non-ferrous alloys. (L4)
- Differentiate between hardening of ferrous and non-ferrous alloys. (L4)

UNIT V:**8 Hours**

Ceramics, Polymers and Composites: Structure, properties and applications of ceramics, polymers and composites. Introduction to super alloys and nanomaterial's.

Learning Outcomes:

At the end of this unit the student will be able to

- Explain the properties of ceramics and their applications. (L2)
- Summarize the properties of polymers and composites and their use. (L2)
- Interpret the properties of Nano materials and their applications. (L2)
- Identify the difference between the micro and Nano scale materials and their uses. (L3)

Course Outcomes:

After completing the course, the student will be able to

- Explain the principles of binary phases. (L2)
- Apply heat treatment to different applications. (L3)
- Select steels and cast irons for a given application. (L3)
- Utilize nonferrous metals and alloys in engineering. (L3)
- Choose composites for various applications. (L3)
- Assess the properties of Nano-scale materials and their applications. (L2)

TextBook:

1. V.Raghavan, Material Science and Engineering, 5/e, Prentice Hall of India, 2004.
2. William D. Callister Jr. Materials Science and Engineering: An Introduction, 8/e, John Wiley and Sons, 2009.

References:

1. Y. Lakhtin, Engineering Physical Metallurgy, University Press of the Pacific, 2000.
2. S.H. Avner, Introduction to Physical Metallurgy, 2/e, Tata McGraw-Hill, 1997.
3. L.H. VanVlack, Elements of Material Science and Engineering, 6/e, Pearson Education, 2008.
4. George E. Dieter, Mechanical Metallurgy, 3/e, McGraw-Hill, 2013.