GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering

Level: UG

Subject Code : BE03000221

Subject Name : Material Science and Metallurgy

w. e. f. Academic Year:	2024-25
Semester:	3
Category of the Course:	PCC

Prerequisite:	**Knowledge of basic science**
Rationale:	The course will provide an over view of the study of basic knowledge of various materials and their properties, commonly used for engineering applications applications. It also includes the various heat treatment processes and their practical applications. This course covers the importance of non-destructive testing methods to evaluate the properties and integrity of materials without causing any damage or altering their usefulness. It also involves the study of corrosion, including its principle, types and prevention techniques.

Course Outcomes:

Sr. No.	CO statement	Marks % Weightage
CO-1	Understand the different types of engineering materials and their structure –property relationships.	20
CO-2	Examine the microstructure of metallic materials through phase diagrams and alter their microstructure and properties by applying various heat treatments.	50
CO-3	Understand the scope of different non-destructive testing methods and powder metallurgy.	20
CO-4	Interpret the causes of metallic corrosion and identify the methods for its prevention.	10

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	**Introduction to Material Science and Metallurgy:** Basics of engineering materials, their classifications and application, Basics of advance engineering materials, Engineering requirements of materials, Properties of engineering materials, Criteria for selection of materials for engineering applications.	**4**	**9**
2	**Crystal Geometry and Crystal Imperfection:** Unit cell, Crystal structure, Bravise lattice, atomic packing factor, coordination number, Metallic crystal structures- SC, BCC, FCC and HCP, crystal directions and planes, Miller indices, Imperfections in crystals and their effect on properties, Solute strengthening.	**6**	**14**
3	**Solidification and Theory of Alloys:** Solidification of metals and an alloy, Crystallization: Mechanism of crystallization - nucleation and growth, factors influencing nucleation and growth, Solid solutions and compounds, Hume-Rothery rules; Cooling curves, lever-arm principle.	**4**	**9**
4	**Phase Diagrams:** Systems, phases and phase rule, structural constituents, Gibb's phase rule. Binary equilibrium phase diagrams, Allotropy of iron; Iron-iron carbide equilibrium diagram with different reactions like eutectic, eutectoid and peritectic. Constituents, microstructures and properties of plain carbon steels. Alloy groups (Pig Iron, Wrought Irons, Steels and Cast Irons) of Iron-Iron Carbide equilibrium system and their characteristics in general. Equilibrium cooling of eutectoid, hypoeutectoid and hypereutectoid steels, their resultant microstructures and hence correlated properties and applications. IS and ISO Codification, Different specifications and designations of steels.	**8**	**17**
5	**Non-ferrous Metal and Alloys:** Introduction, properties and application of aluminium, copper, magnesium, titanium, nickel and their alloys.	**4**	**9**
6	**TTT diagram and Heat Treatment of Steel:** Time-Temperature-Transformation Diagram, Isothermal and continuous transformations. Study of heat treatment processes such as annealing, normalizing, hardening, tempering, carburizing, nitriding, cyaniding, induction hardening and flame hardening. Hardenability of	**7**	**15**

	steel. Application of above processes to machine components and mechanical equipments such as gears, shaft bearings, turbine blades, crank shafts, pistons etc.		
7	**Powder Metallurgy:** Introduction, advantages, disadvantages and applications of powder metallurgy, production of powder, compacting, sintering.	**3**	**7**
8	**Non Destructive Testing:** Non Destructive testing of materials such as Visual inspection, Dye Penetration Testing, Magnetic Particle Testing, Ultrasonic Testing, Radiography Testing, Eddy current testing with their principles, relative merits, demerits and applications.	**4**	**9**
9	**Corrosion of Metal And Alloys:** Principle of corrosion, types of corrosion, corrosion prevention techniques.	**3**	**7**
10	**Metallography:** Structure of Metals, Macro-examination: Macro-etching; Microscopic examinations: Specimen Preparation, etching, Spark Test, Sculptures Print, Magnetic Testing, Chemical analysis of steel and iron for Carbon, Sulphur & Phosphorous.	*	**4**
	Total	**42**	**100**

* Topic should be cover during laboratory session only.

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
Recall	**Comprehension**	**Application**	**Analysis**	**Evaluate**	**Create**
30	**30**	**25**	**10**	**05**	**00**

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

References:

1. Materials Science and Engineering: An Introduction: William D Callister and David G. Rethwisch, 10th edition, 2020.
2. Elements of Material Science and Engineering, Lawrence H. Van Vlack, Pearson Education.

3. The Science and Engineering of Materials Donald R. Askeland and Pradeep P. Phule, Cengage Learning.
4. Material Science and Metallurgy by G. H. Upadhyay, Atul Prakashan.
5. Introduction to Physical Metallurgy, Sydney H. Avner, Tata McGraw-Hill.
6. Practical Non-Destructive Testing, Baldev Raj, T. Jayakumar and M. Thavasimuthu, Narosa Pub. House.
7. Corrosion Engineering, Mars G. Fontana, McGraw Hill Education India.
8. ASM Handbook Vol. 9: Metallography and Microstructure, Ed. George F. Vander Voort, ASM International 2004.

List of Experiments:

1. To understand the concept of crystal planes and directions: a) To determine the coordination number (CN), Atomic Packing Factor (APF) and Effective number of atoms per unit cell for SC, BCC, FCC, and HCP structures.

   b) To draw the crystal planes and directions in a unit cell.
2. To get acquainted with the operation, construction, use and capabilities of a metallurgical microscope.
3. To perform specimen preparation for microscopic examination and gain a deeper understanding of the specimen preparation process.
4. To examine different ferrous microstructures and identify the micro-constituents and phase present in a specimen.
5. To examine different non-ferrous microstructures and identify the micro-constituents and phase present in a specimen.
6. To learn different heat treatment processes- annealing, normalizing, hardening and tempering to improve properties of steel during processes and applications.
7. To observe the effect of different quenching media (Oil, Water and Brine) on the hardness of medium/high carbon steel specimen.
8. To determine the effect of varying section size on hardenability of steel and obtain hardness distribution curves of hardened steel cross-section.
9. To understand the procedure of testing, nature of indication, the capability and sensitivity of the liquid penetrant test.
10. To understand the procedure of testing, nature of indication, the capability and sensitivity of the magnetic particle test.

11. To understand the procedure of testing, nature of indication, the capability and sensitivity of Ultrasound test.
12. To identify the different types of material through spark test.

Major Equipment:

Metallurgical microscope with computerized image analysis system, Standard specimen set of steel, cast iron and non- ferrous metals and alloys, Muffle furnace, Hardness tester, Jominy-end quench set-up.

List of Open Source Software/learning website:

https://archive.nptel.ac.in/courses/113/106/113106032/
https://archive.nptel.ac.in/courses/113/102/113102080/
https://archive.nptel.ac.in/courses/113/107/113107078/

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