GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3142109
Semester – IV
Subject Name: Physical Metallurgy

Type of course: Science & Engineering

Prerequisite: Knowledge of Materials Thermodynamics, Transport Phenomena & Phase Transformations

Rationale: This subject is intended to focus on alloy design, phase diagram and strengthening mechanisms in different metals and alloys. The fundamental aspect of heat treatment and its influence in properties and application enhance capability of one's in the field of heat treatment. Moreover knowledge about the physical metallurgy of specific and important engineering materials such as ferrous and non-ferrous alloys can be implemented by students in various metallurgical industries.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	4	5	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	**Module 1**: Concepts of alloy system and explanation of terms like system, component, phase, micro constituent and degree of freedom, structural constituent of an alloy, phase rule and phase equilibria, equilibrium diagrams and their classification based on solubility of components in liquid and solid states, cooling curves, morphology and distribution of phases, effect of nonequilibrium cooling on morphology. Eutectic, peritectic, monotectic, eutectoid and peritectoid reactions, binary equilibrium diagrams involving isomorphous systems and various reactions, common binary systems viz. Cu-Ni, Al-Si, Cu-Sn, Al-Cu, Pb-Sn, Cu-Zn. Lever rule. Ternary diagrams of simple systems, Strengthening mechanisms – solid solution, work hardening, precipitation hardening, dispersion strengthening, Analytical problems for this unit	**15**	30
2	**Module 2:** Iron carbon diagram, isothermal and continuous cooling transformation diagrams; influence of alloying elements on transformation characteristics.	**10**	25
3	**Module 3**: Heat treatment - annealing, normalizing, hardening and tempering of steels, hardenability	**08**	25
4	**Module 4**: Introduction to important ferrous alloys (stainless and special steels, cast irons), aluminium alloys, titanium alloys, copper base alloys	**05**	10

5	**Module 5:** Superalloys, shape memory alloys – classification, heat treatment, properties and applications	**04**	10
	Total	**42**	100

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10	**30**	**35**	**10**	**10**	**05**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

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.

Reference Books:

1. Physical Metallurgy: Principles and Practice, V. Raghavan, PHI Learning, Delhi, 2008.
2. Heat Treatment Principles and Techniques - T. V. Rajan, C. P. Sharma and A. Sharma[Prentice Hall]
3. Introduction to Physical Metallurgy, Sidney H. Avner, McGraw Hill Book Co. 11.
4. Physical Metallurgy Principles, R. Abbaschian, R. E. Reed-Hill, Cengage Learning, 2009
5. Physical Metallurgy Vols. I, II, III, R.W. Cahn and P. Haasen, North Holland, 1996.
6. Light Metals, I.J. Polmear, Elsevier, 2005
7. Principles of Metallographic Laboratory Practice - G.E. Kehl and H. Davis [Mc.Hill]
8. Engineering Physical Metallurgy - Y. Lakhtin[MIR Publications]
9. Physical Metallurgy Vol I- I. A.Gulyaev [MIR Publications]
10. Physical Metallurgy for Engineers-D.S. Clark and W.R. Varney[CBS]
11. Modern Physical Metallurgy - R.E. Smallman[ELBS]

Course Outcomes:

Sr. No.	**CO statement**	**Marks % Weightage**
CO-1	Understand the heat treatment processes.	30
CO-2	Identification of phases in microstructure of ferrous metals.	35
CO-3	Construct the phase diagrams	35

List of Experiments:

1. To explore the metallurgical microscope and their various part dissections.
2. Hands on practice on metallography sample preparation steps and to develop microstructure.
3. To study about Iron-Iron Carbide phase diagram.
4. Demonstration of standard metallographic specimen of steels, cast Iron and non-ferrous metals.

5. Microstructural analysis by Photo metallography and Image Analyzer.
6. Construct phase diagram for given data and apply Tie line and Lever Rule.
7. For given metallographic specimen measure grain size and identify Inclusions as per standard.
8. To examine the effect of quenching media on hardening of steel.
9. To measure hardenability of given materials with Jominy End Quenched test.
10. To study heat treatment and microstructure of En: 8, 24, 31 steels.

Major Equipment: High Resolution Microscopes, Advanced Metallography Equipment, Muffle furnace

List of Open Source Software/learning website:

1. https://nptel.ac.in/courses/113105024/
2. https://ocw.mit.edu/courses/materials-science-and-engineering/3-40j-physical-metallurgy-fall-2009/lecture-notes/