GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: Diploma

Branch: Metallurgy Engineering

Course / Subject Code : DI03021031

Course / Subject Name : Physical Metallurgy-I

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

Prerequisite:	The prerequisites for this course include a fundamental understanding of general chemistry, with an emphasis on atomic structure and bonding, as well as basic physics, particularly thermodynamics, to understand phase diagrams and solidification. A foundational knowledge of materials science, especially the properties and structures of metals, is also helpful. Additionally, a basic proficiency in mathematics, including algebra and calculus, will support the analysis of phase diagrams and solidification processes.
Rationale:	This introductory course focuses on the crystal structures and phase diagrams of metals and alloys. The objective is to gain an understanding of the various types of crystalline solid structures, the different types of imperfections in solids, and the impact of solidification on the structure of metals and alloys. It also covers the principles of phase diagrams and introduces metallographic techniques for preparing specimens of metals and alloys for analysis.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT Level
01	Gain an understanding of the various types of crystalline structures in solids.	R
02	Identify the different types of crystal imperfections.	U
03	Develop a comprehensive understanding of the construction and interpretation of equilibrium phase diagrams.	A
04	Acquire knowledge of the techniques used in the metallographic examination of metals and alloys.	A

**Revised Bloom's Taxonomy (RBT)*

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Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE (E)	PA(M)	PA(I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	1.1. Definition of metallurgy, Various branches of metallurgy, physical metallurgy 1.2. Structure of atom, Interatomic bonding in solids, Primary and Secondary bonds, Difference between primary and secondary bonds 1.3 Crystalline Solids, Non Crystalline Solids 1.4. Concept of crystal, Lattice point, Space lattice, Crystal, Unit cell, Lattice parameter, Crystal system, Bravais Lattice 1.5 Atomic packing factor, Co-ordination numbers, Stacking sequence of SC, BCC, FCC and HCP crystal structure 1.6. Crystal directions and planes in simple cubic (SC), Miller Indices.	15	40
2.	2.1 Point defects- Vacancies, Schottky defect, Interstitials, Frenkel defect, Impurities 2.2 Line defects - Edge dislocation and Screw dislocation, 2.3 Surface defects- External Surface, Grain boundary, Twin boundary, Tilt boundary, Stacking fault 2.4 Volume defects- Voids, Inclusion, Crack, Precipitate	10	15
3.	3.1 Alloys, Cooling Curves for Pure Metal and Alloy, Allotropic transformation 3.2. Solid Solutions – types, Hume Rothery rule 3.3. Basic terms: System, Phase, Number of components, Degrees of freedom or variance of the system 3.4 Gibbs phase rule, Lever rule 3.5 Phase diagram– classification and its uses. 3.6 Isomorphous, eutectic, partial eutectic phase diagrams- Cu-Ni, Bi-Cd, Pb-Sn phase diagram	12	30
4.	4.1. Macro and Micro Examination	08	15

	4.2 Metallurgical microscope- Principle, Construction and Working 4.3 Types of Metallurgical microscope- Upright and Inverted Microscope 4.4. Steps involved for metallographic specimen preparation		
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
50	**30**	**20**	-	-	-

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:
(a) Books:

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
1	Introduction to Physical Metallurgy	Sidney H. Avner	Tata McGraw-Hill Education Pvt.Ltd, New Delhi, 2012 ISBN: 0-07-002499-5 ISBN-13: 978-0-07-463006-8 ISBN-10: 0-07-463006-5
2	Engineering Physical Metallurgy	Y. Lakhtin	Mir Publishers - Moscow & CBS, New Delhi, 2005 ISBN: 978-93-895-6570-6
3	Materials Science and Engineering- A First Course	V. Raghavan	PHI Learning Pvt. Ltd, New Delhi, 2015 ISBN: 978-81-203-5092-2
4	Material Science and Metallurgy for Engineers	V. D. Kodgire, S. V. Kodgire	Everest Publishing House, Pune, 2008 ISBN: 81-86314-00-8

(b) Open source software and website:

1. https://study.com/academy/lesson/crystal-definition-types-structure-properties.html
2. https://nptel.ac.in/content/storage2/courses/112108150/pdf/PPTs/MTS_07_m.pdf
3. https://www.eng.uc.edu/~beaucag/Classes/Properties%20of%20Materials/MetalPhaseDiagramUVa.pdf
4. https://www.youtube.com/watch?v=BJrTZ07bHm4&list=PLfIFNJ1DPG4lENg4VUTWyKxxB911aHuJz
5. https://www.youtube.com/watch?v=IPjM4UGumT4
6. https://www.youtube.com/watch?v=fc8zrgYJCJw

Suggested Course Practical List:

Sr. No.	TUTORIAL Outcomes	Unit No.	Approx. Hrs. Required
1	Calculate Atomic Packing Factor (APF) for SC, BCC, FCC, and HCP Crystal Structures.	I	04
2	Assign Directions and Planes in Simple Cubic Crystal Structures Using Miller Indices.	I	04
3	Investigate and Analyze Point, Line, Surface, and Volume Defects in Materials.	II	02
4	Plot Cooling Curves for Pure Metal, Eutectic, and Off-Eutectic Alloys.	III	02
5	Construct and Analyze the Isomorphous Phase Diagram: Cu-Ni System.	III	02
6	Construct and Interpret the Eutectic Phase Diagram: Bi-Cd System.	III	02
7	Draw and Analyze the Partial Eutectic Phase Diagram: Pb-Sn System.	III	02
8	Solve Problems Involving Gibbs Phase Rule and Lever Rule for Binary Phase Diagrams.	III	02
9	Demonstrate the Design, Operation, and Key Components of the Metallurgical Microscope.	IV	04
10	Prepare Micro Specimens for Metallographic Examination: Techniques and Procedures.	IV	06
	Total		30

List of Laboratory/Learning Resources Required:

- Metallurgical Microscope
- Standard specimens Set

- Belt grinding machine
- Polishing disc machine
- Consumables- Emery papers, Chemical reagent for etching, Test Sample (Metal/Alloy)

Suggested Project List:

- Construct 3D Models of Different Crystal Structures: SC, BCC, FCC, and HCP.
- Create Comprehensive Charts Summarizing Crystal Structures and Their Properties.
- Design and Interpret Various Phase Diagrams for Materials (Isomorphous, Eutectic, Partial Eutectic).
- Explore and Identify the Components of the Metallurgical Microscope and Demonstrate Metallographic Techniques.

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