GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)
Semester-II

Course Title: Physical Metallurgy-I
(Course Code: 4322101)

Diploma Programme in which this course is offered	Semester in which offered
Metallurgy Engineering	2nd Semester

1. RATIONALE

This elementary course deals with the crystal structures and construction of phase diagram of metals and alloys. The objective of this subject is to understand about different structures of crystalline solids, types of imperfections in solids, effect of solidification on structure of solids, types of phase diagrams and tools of metallographic method for specimen preparation of metals and alloys.

2. COMPETENCY

The purpose of this course is to help the student to attain the following competency through various teaching learning experiences:

- Able to apply the acquired knowledge on crystallography and alloy systems.

3. COURSE OUTCOMES (COs)

At the end of the study of this course the student will be able to:

- Understand the different types of crystalline structure of solids.
- Identify about various crystal imperfection.
- Acquire broader ideas about construction of equilibrium diagrams.
- Understand the method for metallographic examination of metals and alloys.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
3	1	0	4	30*	70	--	--	100

(*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessing the attainment of the cognitive domain UOs required for the attainment of the COs.

***Legends: L**-Lecture; **T**– Tutorial/Teacher Guided Theory Practice; **P** -Practical; **C** – Credit,*

CA *- Continuous Assessment;* ***ESE*** *-End Semester Examination.*

5. SUGGESTED TUTORIAL EXERCISES

Sr. No.	TUTORIAL Outcomes	Unit No.	Approx. Hrs. Required
1	Recall and state terms involved in crystallography and physical metallurgy.	I	02
2	Calculate atomic packing factor for different crystal structures.	I	02
3	Assign directions and planes in simple cubic structures from the given data.	I	02
4	Understand the concept of cooling curve for a metal and binary alloy.	III	02
5	Understand the concept of equilibrium diagram of solid solution type from the given diagram. e.g. Cu-Ni system	IV	01
6	Understand the concept of equilibrium diagram for eutectic type from the given diagram.	IV	01
7	Understand the concept of equilibrium diagram for metals partially soluble in solid state from the given diagram.	IV	01
8	Identify and label various parts of metallurgical microscopes. Distinguish them.	V	02
9	State the steps involved in macro and micro-examination. Differentiate them.	V	01

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

These major equipment with broad specifications for the guide to procure them by the administrators to user in uniformity of practical's in all institutions across the state.

S. No.	Equipment Name with Broad Specifications	Tutorial No.
1	Metallurgical Microscope (Belt Grinder, Double Disc Polishing Machine)	8,9

7. AFFECTIVE DOMAIN OUTCOMES

The following sample Affective Domain Outcomes (ADOs) are embedded in many of the above-mentioned Cos. More could be added to fulfill the development of this course competency.

1. Work as a leader/a team member.
2. Follow ethical practices.

8. UNDERPINNING THEORY

The major underpinning theory is given below based on the higher level UOs of Revised Bloom's taxonomy that are formulated for development of the COs and competency. If required, more such UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Major Learning Outcomes	Topics and Sub-topics
UNIT – I Structure of Crystalline Solids	1.a. Explain the importance of physical metallurgy. 1.b. Explain atomic structure and interatomic bonding. 1.c. Discuss structure of metals – crystallography. Calculate atomic packing factor of Simple Cubic (SC), Base Centered Cubic (BCC), Face centered cubic (FCC) and Hexagonal Close Packed (HCP) unit cell. 1.d. Identify the directions and planes in simple cubic structure.	1.1. Definition of metallurgy, physical metallurgy, Various branches of metallurgy 1.2. Structure of atom, Interatomic bonding in solids, Primary and Secondary bonds, Difference between primary and secondary bonds. 1.3. Concept of crystal, Lattice point, Space lattice, Crystal, Unit cell, Lattice parameter, Crystal system, Bravais Lattice Crystal structures - SC, BCC, FCC and HCP. Atomic packing factor, co-ordination numbers. Stacking sequences in SC, BCC, FCC and HCP. 1.4. Crystal directions and planes in simple cubic (SC), Miller Indices.
UNIT – II Imperfection in Solids	2.a. Discuss various types of defects in solids.	2.1. Defects in solids: Point defects, Line defects - Edge dislocation and Screw dislocation, Surface defects, Volume defects
UNIT – III Solidification of Metals and Alloys	3.a. Explain the solidification mechanism of metals and alloys. 3.b. Discuss the rules for formation of solid solution.	3.1. Difference between Metals and Alloys, Nucleation and Growth of crystal, Cooling Curves for Pure Metal and Alloy, Allotropic transformation of metal. 3.2. Solid Solutions – types, Hume Rothery rule
UNIT – IV Equilibrium Diagrams	4.a. Discuss the importance of equilibrium diagrams diagram (or phase diagram) in binary alloy system. 4.b. Explain different types of	4.1. Basic terms: System, Phase, Number of components, Degrees of freedom or variance of the system,

	binary equilibrium diagrams with an alloy system.	phase rule, Lever rule. Equilibrium diagram– classification and its uses. 4.2. Equilibrium diagram reactions Types of Binary equilibrium diagrams- Isomorphous, eutectic, eutectoid, peritectic, peritectoid systems
UNIT – V Metallography	5.a. Discuss the importance of metallographic examination. 5.b. Explain the process of metallography technique.	5.1. Macro and Micro Examination Metallurgical microscope- Principle, Construction and Working Types of Metallurgical microscope- Upright and Inverted Microscope 5.2. Steps involved for metallographic specimen preparation

9. SUGGESTED SPECIFICATION TABLE FOR QUESTIONPAPER DESIGN

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Structure of Crystalline Solids	10	15	05	05	25
II	Imperfection in Solids	08	13	05	02	20
III	Solidification of Metals and Alloys	08	13	05	02	20
IV	Equilibrium Diagrams	10	15	05	05	25
V	Metallography	06	04	04	02	10
Total		**42**	**60**	**24**	**16**	**100**

Legends: R = Remember; U = Understand; A = Apply and above levels (Bloom's revised taxonomy)

Notes:

1. This specification table shall be treated as a general guideline for students and Teachers. The actual distribution of marks in the question paper may slightly vary from above Table.
2. Ask the questions from each topic as per marks weightage. Numerical questions are to be asked only if it is specified. Optional questions must be asked from the same topic.

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related co-curricular activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group

1. Make a model/chart on the basis of crystalline structure of solids.

2. Prepare charts for various cooling curves and equilibrium diagrams and analyze it.

3. Prepare a chart for metallurgical microscope and flowchart for steps of metallography.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

Sr. No.	Unit Title	Strategies
1	Structure of Crystalline Solids	Real life examples. Demonstration of real systems. Movies/Animations. Numerical.
2	Imperfection in Solids	
3	Solidification of Metals and Alloys	
4	Equilibrium Diagrams	
5	Metallography	

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be individually undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should not exceed three.

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than 16 (sixteen) student engagement hours during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

1. Prepare models of different crystal structures.
2. Prepare charts of summary of crystal structures.
3. Prepare charts of various phase diagram.
4. Understand the parts of metallurgical microscope and steps of metallography.

13. SUGGESTED LEARNING RESOURCES

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

14. SOFTWARE/LEARNING WEBSITES

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
7. https://www.youtube.com/watch?v=UuHofNW40Yw

15. PO-COMPETENCY-CO MAPPING

Semester II	Physical Metallurgy-I (Course Code:)						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/ develop-ment of solutions	PO 4 Engineering Tools, Experimen-tation& Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Manage-ment	PO 7 Life-long learning
Competency	**Prepare microspecimen of metals and alloys and identify its phases.**						
Course Outcomes CO 1) Understand the different types of crystalline structure of solids.	3	-	-	-	-	1	1
CO 2) Identify about various crystal imperfection.	3	2	1	-	-	1	1
CO 3) Acquire broader ideas about construction of equilibrium diagrams.	3	2	-	-	-	1	1
CO 4) Understand the method for metallographic examination of metals and alloys.	3	3	2	1	-	1	2

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

S. No.	Name and Designation	Institute	Contact No.	Email
1.	Shri. Bindu H. Goyal, HOD- Metallurgy Engineering	Dr. S & SS. Ghandhy College of Engineering and Technology, Surat	8320500467	bindugoyal07@gmail.com

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