Course Type	Course Code	Name of Course	L	T	P	Credit
DC	NFMC517	Advanced Physical Metallurgy	3	1	0	4

Course Objective

- Equip students with the fundamental theories of physical metallurgy
- Equip students with advanced concept of phase transformation
- Developing understanding for processing-structure-property correlation
- Building a sound understanding for ferrous and non-ferrous alloy development.

Learning Outcomes

- Students will learn solution thermodynamics
- Students will learn kinetic approach of alloy development
- Students will learn the role of materials defect
- Students will learn different phase transformations
- Students will learn processing-structure-property correlation during alloy development

Unit No.	Topics to be Covered	Lecture Hours	Tutorial Hours	Learning Outcome
1	Introduction to physical metallurgy: Structure of metals, different types of bonds, concept of crystal structure and its attributes, structure of alloys, concept of solid solution	2	0	Students will be able to understand the structural aspects of metallic and alloys systems.
2	Thermodynamics and Phase diagrams: Equilibrium, Single Component Systems, Binary Solutions, Equilibrium in Heterogeneous Systems, Binary Phase Diagrams, Influence of Interfaces, Ternary Diagrams, Kinetics of Phase Transformation.	4	2	Students will be able to understand the solution thermodynamics related to phase transformation
3	Diffusion: Atomic Mechanisms of Diffusion, Interstitial Diffusion, Substitutional Diffusion, Concept of Atomic Mobility, High Diffusivity Paths, Case Studies	4	2	Students will know the concept of atomic movement and mass transfer during phase transformation.
4	Solidification: Nucleation in Pure Metals, Growth in Pure Solid, Alloy Solidification, Solidifications of Ingots and Castings, Case Studies.	6	1	Students will know about the steps of solidification process in metals and alloys, practical casting methods.
5	Defects in crystals: Point, line, surface and volume defects, role of defects in microstructure evolution, Deformed state and annealing phenomena: Stored strain energy, deformation modes, recovery, recrystallization and grain growth	8	3	Students will know about crystal imperfections and their role in microstructure evolution, deformation microstructure and annealing phenomena.
6	Diffusional Transformation in Solids: Homogeneous Nucleation, Heterogeneous Nucleation, Precipitate Growth, Overall Transformation Kinetics, Transformation Diagrams, Precipitation, Precipitation of Ferrite from Austenite, Cellular Precipitation, Eutectoid Transformation, Massive Transformation, Ordering Transformation, Case Studies.	5	2	Students will know about the phase transformations that are driven by the change in temperature in single to multiphase alloy systems. .

7	Diffusionless Transformations: Characteristics of Diffusionless Transformations, Martensitic transformation: Nucleation & Growth, Tempering of Martensite, Case Studies.	5	1	Students will learn about some important aspects of a thermal transformation with respect to important engineering alloys.
8	Engineering Alloy systems: Heat Treatment of ferrous and non-ferrous alloys-Annealing, Normalising, tempering, case hardening, age hardening Selective ferrous and non-ferrous alloys, their microstructure, properties and applications	8	3	Students will know about different heat treatment techniques and their role in microstructural engineering the physical metallurgy of different alloys for various engineering applications.
	Total	**42**	**14**	

Text Books:

1. Robert E. Reed Hill, Reza Abbaschian, *Physical Metallurgy Principles*, 4th Edition, Stamford: Cengage Learning, 2009.
2. Vijendra Singh, *Physical metallurgy*. Standard Publisher, 2005.

Reference Books:

1. David A Porter, Kenneth E Easterling, *Phase Transformations in Metals and Alloys*, 3rd Edition, CRC Press, 2009.
2. F. J. Humphreys, M. Hatherly, *Recrystallization and Related Annealing Phenomena*, 2nd Edition, Elsevier, 2004.
3. E. J. Mittemeijer. *Fundamentals of materials science- The Microstructure–Property Relationship Using Metals as Model Systems*, 2nd Edition, Berlin: Springer, 2010.