Course code	Course Name	L-T-P - Credits	Year of Introduction
MT202	**PHYSICAL METALLURGY**	**3-1-0-4**	**2016**

Prerequisite : Nil

Course Objectives

- To develop an understanding of the basic principles of physical metallurgy and apply those principles to engineering applications.

Syllabus

Atomic Structure, Bonding & Crystal Structure - Braggs law - Problems related to crystal structure - Crystal Defects and Diffusion - Kirkendall effect- Plastic Deformation of Metal - Theoretical strength of ideal crystal - Critical resolved shear stress - Schmid's law - Solidification of Metals and Alloys - Cooling curve - Nucleation & Growth - Hume Rothery rules – Phases - Gibb’s phase rule - Binary Phase Diagram - Isomorphous alloy systems - The Lever rule, Common types of phase diagrams - The iron-carbon system - Structure Insensitive and Physical Properties of Materials - Anelasticity and internal friction - Long range and short range ordering in alloys – Annealing – Recovery – Recrystallisation - ASTM grain size.

Expected Outcome.

Upon completion of this course, students are expected to

i. Understand the geometry and crystallography of crystalline materials using Bravais lattices and Miller Indices.
ii. Differentiate the major families of materials and write the electron configuration for most elements.
iii. Describe the basic crystal structures (BCC, FCC, and HCP), recognize other crystal structures, various defects in crystals and diffusion in metals.
iv. Understand plastic deformation of single and polycrystalline materials, various strengthening mechanisms.
v. Understand solidification process in metals and alloys, Laws governing solid solution formation, Phase rules, phase diagrams, solid state reactions analyze the microstructure of iron and steels using phase diagram and how to modify the microstructure and properties using different heat treatments
vi. Understand structure insensitive and physical properties of materials, recovery, recrystallization and grain growth phenomenon in metals and alloys.

References/Textbooks

1. Reed-Hill R.E, Physical Metallurgy Principles, Affliated East
2. Reza Abbaschian, Lara Abbaschian, Robert E. Reed-Hill, Physical Metallurgy Principles, Cengage Learning
3. Bruce Chalmers. Physical Metallurgy, John Wiley
4. William D. Callister, David G. Rethwisch, Fundamentals of Materials Science and Engineering, John Wiley
5. Bishop R.J and Smallman. R.E, Modern Physical Metallurgy and Materials Engineering, Butterworth-Heinemann
6. Guy A.G, Elements of Physical Metallurgy, Addison Wesley.
7. Abhijit Mallick Principles of Physical Metallurgy,Viva Books Private Limited
8. Raghavan V., ‘Physical Metallurgy - Principles and Practice, Prentice - Hall of India

Course Plan			
Module	**Contents**	**Hours**	**Sem. Exam Marks**
I	**Atomic Structure, Bonding & Crystal Structure** 1.1Electronic structure of atoms, 1.2 Atomic Bonding- Ionic, Covalent, Metallic bonds, Stability of the structure, Hydrogen bonding, Vander waal's forces, 1.3 Crystal structure of metals, Unit cells, Crystal systems, 1.4 Bravis lattices, SC, BCC,FCC,HCP structures, Coordination number, Atomic packing factor, 1.5 Miller indices-directions and planes, Interplaner spacing, Braggs law (basic only), 1.6 Problems related to crystal structure.	10	15%
II	**Crystal Defects and Diffusion** **2.1Crystal defects in metals:** Point defects, one, two and three dimensional defects, 2.2 Dislocation: Edge, screw and mixed, partial dislocations, forest dislocations, stacking faults, 2.3 Dislocation interactions: Jogs and kinks, dislocation-precipitate interactions, 2.4 Frank-Read Sources and dislocation multiplication, 2.5 Deformation by slip of dislocation and by twinning, 2.6 Dislocation pile up, Hall-Petch relation, Grain boundary structure. 2.7 **Diffusion: Fick's first law,** Diffusion coefficient, Fick's second law, Determination of diffusivities, 2.8 Kirkendall effect, Self diffusion, Temperature dependence of diffusion coefficient, Factors influencing diffusion	10	15%
FIRST INTERNAL EXAMINATION			
III	**Plastic Deformation of Metal:** 3.1 Theoretical strength of ideal crystal, 3.2 Critical resolved shear stress, Schmid's law, 3.3 Dislocation and plastic deformation, Lattice resistance to dislocation motion 3.4 Single crystal tensile test (fcc), 3.5 Strengthening by grain boundaries, Hall-Petch relation, 3.6 Yield point phenomenon, Strain ageing, 3.7 Solid solution strengthening, Strengthening by second phase particles.	8	15%
IV	**Solidification of Metals and Alloys** **4.1. Solidification of pure metal: Cooling curve,** 4.2 Under cooling, Nucleation & Growth, Homogeneous & heterogeneous nucleation, directional solidification, Dendritic growth, 4.3 Intertstitial and substitutional solid solutions,4.4 Limits of solubility, Hume Rothery rules, 4.5 Phases:-Basic definitions, Physical nature of phase mixtures, Number of phases in an alloy system-single, and two components systems, 4.6 Gibb's phase rule	8	15%
SECOND INTERNAL EXAMINATION			
V	**Binary Phase Diagram** 5.1 Binary phase Diagrams and Gibbs free energy curves, 5.2 Importance of phase diagrams, 5.3 Thermodynamic concepts, Gibbs phase rule, 5.4 Axes of phase diagrams, 5.5 Isomorphous alloy systems, The Lever rule, Relative proportion of phases (tie lines and the lever principle), 5.6 Common types of phase diagrams, Binary solutions with unlimited solubility, Binary eutectic systems (limited solid solubility), Solid state reactions (eutectoid, peritectoid reactions), Binary systems with intermediate phases/compounds, 5.7 The iron-carbon system (steel and cast	10	20%

	iron), 5.8 Development of microstructure in isomorphous alloys, 5.9 Temperature dependence of solubility, 5.10 Multi-component (ternary) phase diagrams		
VI	**Structure Insensitive and Physical Properties of Materials** 6.1 Anelasticity and internal friction, 6.2 Long range and short range ordering in alloys, detection of ordering, influence of ordering on properties, 6.3 Annealing:-Stored energy of cold work, Relationship of free energy to strain energy, Release of stored energy, 6.4 Recovery, Polygonisation, Dislocation movement in polygonisation, Recocery at low and high temperatures, Dynamic recovery, 6.5 Recrystallisation, Recrystallisation temperature, Effect of strain on recrystallisation, Recrystallised grain size, 6.6 ASTM grain size, Limiting grain size, Secondary recrystallisation	8	20%
END SEMESTER EXAM			

QUESTION PAPER PATTERN:

Maximum Marks : 100 Exam Duration: 3 hours

PART A: 8 Questions from Module 1&2 (4+4). 6 questions to be answered. 6x5=30 Marks
PART B: 8 Questions from Module 3&4 (4+4). 6 questions to be answered. 6x5= 30 Marks
PART C: 6 Questions from Module 5&6 (3+3). 4 questions to be answered. 4x10=40 Marks