INTRODUCTION TO PHYSICAL METALLURGY *(Third Semester)*

Module I (10 Hours)

Introduction, Atomic structure of materials, Symmetry aspects in crystals, Crystal systems, crystal planes and directions, atomic packing efficiency, voids in common crystal systems, Solidification of pure metal, Homogeneous and heterogeneous nucleation processes, cooling curve, concept of super cooling, microstructures of pure metals, solidification of metal in ingot mould. Crystal imperfections,

Module II (10 Hours)

Mechanical properties of metals, concept of plastic deformation of metals, CRSS, Slip and twinning Concept of cold working : Recovery ; Recrystallization and grain growth; Hot working. Concept of equilibrium, Concept of alloy formation, types of alloys, solid solutions, factors governing solid solubility; **U**nary phase diagram, phase rule, binary phase diagrams : Isomorphous, Eutectic, Peritectic, Eutectoid, Peritectoid, Monotectic and Monotectoid system.

Module III (10 Hours)

Lever rule and its application, interpretation of solidification behavior and microstructure of different alloys belonging to those systems, effect of non equilibrium cooling, coring and homogenization. Allotropic transformations, order disorder transformations, Iron cementite and iron- graphite phase diagrams, microstructure and properties of different alloys (both steels and cast irons),

Module IV (10 Hours)

Concept of heat treatment of steels i.e., annealing, normalizing, hardening and tempering; Microstructural effects brought about by these processes and their influences on mechanical properties. Effect of common alloying elements on the Fe-Fe_3C and Fe-C diagrams, concept to hardenability, factors affecting hardenability. Alloy steels- Stainless steels. Physical metallurgy of non ferrous alloys Cu-Al, Bronze, Brass.

Text Books:

1. Introduction to physical metallurgy – Sydney Avner
2. Fundamentals of materials science and engineering W. Callister

METALLURGICAL THERMODYNAMICS & KINETICS *(Third Semester)*

Module I (10 Hours)

Importance of Thermodynamics, Definition of Thermodynamics ; concept of state and path functions, Equation of states, thermodynamic processes, first law of thermodynamics, Phase diagram of a single component system, Internal energy, heat capacity, enthalpy. Second law of thermodynamics, entropy, and entropy changes for various processes.

Module II (10 Hours)

Free energy and its significance, free energy change as a function of temperature, reversible and irreversible process, criteria of equilibrium, auxiliary functions, combined statements, Maxwell's relations, transformation formula, Gibbs-Helmoltz equation, Concept of standard state.

Module III (10 Hours)

Fugacity, activity, equilibrium constant, Concept of Third law of thermodynamics, temperature dependence of entropy, statistical interpretation of entropy, relation between C_p and $C_{v,}$ consequences of third law, Ellingham – Richardson diagrams. Solutions: partial molal quantities, ideal and non-ideal solutions, Roult's law; Henry's law, Gibbs – Duhem equation, regular solution, Chemical potential.

Module IV (10 Hours)

Free energy – composition diagrams for binary alloy systems, determination of liquidus, solidus and solvus lines, Thermodynamics of electrochemical cells, solid electrolytes.

Introduction of metallurgical kinetics: heterogeneous reaction kinetics: gas-solid, solid-liquid, liquid-liquid and solid-solid systems. Concept of Johnson-Mehl equation, thermal analysis.

Text Books:

1. Introduction to the Thermodynamics of Materials by D.R.Gaskell; Taylor and Francis.
2. Textbook of Materials and Metallurgical Thermodynamics by A. Ghosh; Prentice Hall of India Pvt. Ltd.

MECHANICS OF MATERIALS LABORTAORY *(Third Semester)*

1. Determination of rigidity modulus of a given wire
2. Determination of M.I of a fly wheel
3. Study of Epicyclic gear train
4. Determination of mechanical advantage & velocity ratio of various lifting machines
5. Ericson cupping test and impact test for 3different specimen
6. Fatigue Test of a given specimen

PHYSICAL METALLURGY LABORATORY *(Third Semester)*

1. To make the crystal structures and study these systems, with the help of ball models.
2. To study the principles and operation of metallurgical microscope
3. To prepare specimen of some metals and alloys for microstructural examination
4. To study the Fe-Fe_3C phase diagram.
5. To study the microstructure, grain size of the carbon steels.
6. To study the microstructure, of the given cast iron samples
7. To study the microstructure, grain size of the selected non ferrous alloys.
8. To find out the grain size/number of the given metals and alloys

MINERAL PROCESSING & FUEL TECHNOLOGY *(Fourth Semester)*

Module I (10 Hours)

Introduction to mineral beneficiation, sampling, liberation studies and its importance, Comminution: Fundamentals of comminution, crushing-construction and operational features of jaw, gyratory, cone and roll crushers. Grinding: Theory of ball mill, rod mill, critical speed of the mill, open circuit and closed circuit, circulating load. Size separation: Sieving and screening, laboratory sizing and its importance, representation and interpretation of size analysis data, industrial screening. Concept of average size Classification: Movement of solids in fluids, terminal velocity, stokes law, free settling and hindered settling of particles, different types of classifiers, e.g. sizing and sorting classifiers used in mineral industry.

Module II (12 Hours)

Concentration: Gravity separation, concentration criteria jigging, flowing film concentration, Wilfley table, dense media separation. Froth floatation: Theory, reagents used in floatation processes machines and practices Magnetic and electrostatic separation: Theory and application of magnetic separation with emphasis on field strength. Principle and application of electrostatic separation, Flow sheets: Typical flow sheets for beneficiation of iron, gold, copper, lead-zinc sulphide ores, rock phosphate, beach sand, uranium and other industrial minerals.

Module III (8 Hours)

Agglomeration techniques: Sintering – acid sinter, flux sinter, super flux sinter, palletizing, briquetting and their applications in ferrous and non-ferrous metal industries, testing of agglomerates.

Module IV (10 Hours)

Fuels: Definition and classification of fuels, comparative study of solid, liquid and gaseous fuels. Coal beneficiation, Fundamentals of coal carbonization, Selection of coal and coke for metallurgical uses, Gaseous fuels, Water gas, Producer gas, Blast furnace gas:- their production details and process parameters. Fuel calorimetry, testing of fuels. Definition and principle of combustion of fuels, Energy resources in India.

Text Books:

1. Principle of Mineral Dressing by A. M. Gaudin
2. Mineral Processing Technology by Berry A. Willis

MINERAL PROCESSING LABORATORY *(Fourth Semester)*

1. Physical examination and identification of minerals
2. To determine and analyze the size distribution of a fixed granular solid by using a test sieve stack and a vibratory shaker.
3. Crushing of ore/coal in the jaw crusher. Determination of average size by sieving
4. To study the jaw crusher and determine the actual capacity and reduction ratio
5. Verification of Rittinger's law of crushing in a jaw crusher
6. Crushing of ore/coal in a roll crusher. Determination of average size.
7. To study the effect of grinding with grinding time in ball mill.
8. To separate a mixture of two minerals of different densities by gravity concentration using Wilfley Table and determine the weight and density of each fraction of the products

FUEL TESTING LABORATORY *(Fourth Semester)*

1. To determine the calorific value of coal and coke using bomb calorimeter
2. Proximate analysis of coal and coke
3. To determine flash point and fire point of a given sample such as kerosene oil. Diesel, petrol, by pensky-martins /or other apparatus apparatus
4. To determine effect of temperature on kinematic viscosity of glycerin by redwood viscometer
5. To determine the bulk and true density of coal sample
6. Determine the flow rate of oil

PRINCIPLE OF EXTRACXTIVE METALLURGY *(Fifth Semester)*

Module I (10 hours)

Overview of Extractive Metallurgy processes; Pyro-metallurgy, Hydrometallurgy and Electrometallurgy; Thermodynamic and Kinetic Principles of metal extraction; Ellingham diagrams, Calcinations; Roasting; Predominance Area Diagram, Roasting Practices, Smelting, Formation and function of slag and their calculations ,Metallo-thremic reduction of oxides, Smelting Furnaces, Matte Smelting, Pyro metallurgical processes using vacuum

Module II (12 hours)

Hydrometallurgy: Leaching; Theory of Leaching; Role of oxygen in leaching operation; Bacterial and microbial leaching; Contact reduction of metals in aqueous solutions; Gaseous reduction of metals in aqueous solutions; Ion exchange, Solvent Extraction and Electrolysis

Module III (8 hours)

Electrometallurgy: laws of electrolysis, electrolyte Structure of solvent media; Electrolysis of aqueous solution; Electrolysis of fused salts; Cell design; Electro-plating.

Module IV (10 hours)

Halide Metallurgy and Halogenisation.,Basic approaches of refining, preparation of pure compounds; Purification of crude metals produced in bulk; Numerical problems relevant to Pyro, Hydro and Electrometallurgical processes

Text Books:

1. Principles of Extractive Metallurgy: A. Ghosh & H.S. Ray, IIN Publications, Kolkata 1984.
2. Principles of Extractive Metallurgy: Rosenquist, T., McGrawhill-Kogakusha International – 1983

DEFORMATION BEHAVIOR OF MATERIALS *(Fifth Semester)*

Module I (10 Hours)

Introduction: Scope of the subject, elastic, plastic and visco-elastic deformation. Deformation behavior: Tensile and compression testing, effect of temperature and strain rate Continuum mechanics: Concepts of stress and strain in 3D stress and strain tensor, principal stresses and strains and principal axes, mean stress, stress deviator, maximum shear, equilibrium of stresses, equations of compatibility.

Module II (10 Hours)

Elastic behavior of materials: Constitutive equations in elasticity for isotropic and anisotropic materials, strain energy, elastic stiffness and compliance tensor, effect of crystal structure on elastic constants. Plastic response of materials-a continuum approach: classification of stress-strain curves, yield criteria.

Module III (10 Hours)

Microscopic basis of plastic deformation: Elements of dislocation theory, movement of dislocation, elastic properties of dislocation, intersection of dislocation, dislocation reactions in different crystal structures, origin and multiplication of dislocations. Plastic deformation of single crystals: Critical resolved shear stress, deformation by twinning, deformation band and kink band, strain hardening of single crystal; stress-strain curves of fcc, bcc and hcp materials

Module IV (10 Hours)

Plastic deformation of polycrystalline materials: Role of grain boundaries in deformation, strengthening by grain boundaries, yield point phenomenon, strain ageing, strengthening by solutes, precipitates, dispersoids and fibres. Deformation in non-metallic materials: structure and deformation of polymers, concept Super lattice dislocations in inter metallics, and concept of charge associated with dislocations in ceramics.

Text Books:

1. Mechanical Metallurgy, 3rd Ed., McGraw Hill Book Company, New Delhi, 1986 - G.E. Dieter
2. Mechanical Behavior of Materials, McGraw Hill Book Company, New Delhi, 1990 - T.H. Courtney

TRANSPORT PHENOMENA *(Fifth Semester)*

Module I (10 Hours)

Fluid Flow: Classification of fluids, Energy balance, Laminar and Turbulent flows. Flow through pipes and ducts. Flow measurement, Application of dimensional analysis of fluid flow. Concept of boundary layer. molecular of Knudsen flow, etc. as in problems and exercises.

Module II (10 Hours)

Heat Transfer I: Steady state and Transient conduction in solids. One dimensional steady state problems of heat flow through composite walls, Cylinder and Spheres. Unsteady conduction in one dimensional system.Use of Heisler charts and applications. Convective heat transfer, equation of energy, free and forced convections.

Module III (10 Hours)

Heat Transfer II: Radiation, Nature of thermal radiation, Black and Grey bodies, Stefan and Boltzmann law, Kirchhoff's laws, Intensity of radiation, lamberts law, View factor. Heat transfer between two black walls in an enclosure. Combined effect of convection, conduction and radiation. Overall heat transfer coefficient. Example problems and exercises on systems of steady heat flow important in Metallurgy.

Module IV (10 Hours)

Mass Transfer and Kinetics: Importance in Heterogeneous metallurgical systems of reactions. Steady state one dimensional mass diffusion of component through stationary media. Convective mass transfer in fluids, concept of concentration boundary layer, Mass transfer coefficient.Heterogeneous reactions of metallurgical importance, their rate controlling steps. Discussion of the following examples from metallurgical systems: Nucleation and growth and bubble formation phenomenon, Interfacial reaction, Carbon gasification by CO_2, slag-metal reaction at the interface, Topo-chemical model of gas-solid reaction

Text Books:

1. F.P. Incropera, D. P. Dewitt, T. L. Bergman and A. S. Lavine, Fundamentals of Heat and Mass Transfer, Wiley.
2. H.S. Ray, Kinetics of Metallurgical Reactions.

FABRICATION OF MATERIALS *(Fifth Semester)*

Module I (10 Hours)

Foundry : Introduction to patterns and foundry process, Sand binders and different additives, Sand testing and melting furnaces for ferrous and non-ferrous metals such as cupola, Induction furnace, Arc furnace & Resistance furnace. Solid fiction of castings, Continuous casting process: Precision investment casting, centrifugal casting, Die casting, Casting defects.

Module II (10 Hours)

Continuous casting process: Precision investment casting, centrifugal casting, Die casting, Casting defects. Solid fiction of castings, Continuous casting process: Precision investment casting, centrifugal casting, Die casting, Casting defects. Principles of Gating and Risering: Feeding characteristics of alloys, Types of Gates and Risers.

Module III (10 Hours)

Welding and cutting: Introduction to gas welding, cutting, Arc welding and equipment's. TIG (GTAW) and MIG (GMAW) welding, resistance welding and thermit welding. Weldability, Newer Welding methods like plasma Arc, Laser Beam, Electron Beam, Ultrasonic, Explosive and friction welding. Brazing and soldering, welding defects. Destructive and non-destructive testing of castings and weldings

Module IV (10 Hours)

Brief introduction to powder metallurgy processes.; Plastic deformation of metals: Variables in metal forming and their optimization. Dependence of stress strain diagram on Strain rate and temperature. Hot and cold working of metals.; Rolling: Pressure and Forces in rolling, types of rolling mills, Rolling defects.

Text Books:

1. P. D. Webster, Fundamentals of Foundry Technology, Portwillis press, Red hill, 1980.
2. Kalpakjian, S., & Schmid, S. R. 2008. Manufacturing processes for engineering materials: Pearson Education.

MATERIALS PROCESSING LABORATORY *(Fifth Semester)*

1. To study the structure property correlation of metals after cold rolling
2. To study the structure property correlation of metals after hot rolling
3. Determination of tensile properties of different classes of materials
4. To determine the compressive strength of the given samples
5. To determine the coefficient of elasticity for given materials
6. Observation of dislocations by using the etch pitting technique
7. Effect of Work-Hardening on Tensile Properties of Metals
8. Study of nucleation and growth in eutectoid steel

PROCESS METALLURGY LABORATORY *(Fifth Semester)*

1. Calcination of ore
2. Carbo-thermic reduction of oxide ore
3. Leaching of ore
4. Study of alloy Chemistry
5. Distillation
6. Electro refining of metals
7. Liquid metal and alloy production with casting facility
8. Solvent extraction

IRON MAKING *(Sixth Semester)*

Module I (10 Hours)

History of Iron making in India, Indian and other resources of raw materials required for iron making. coke making. Blast furnace plant and -Modern blast furnace, plant layout, Details of construction of blast furnace and its main accessories; gas cleaning system, hot blast generation. Blast furnace refractories and blast furnace cooling system

Module II (10 Hours)

Agglomeration of iron ore fines, sintering and pelletision, evaluation of properties of blast furnace, burden materials and application to blast furnace performance. Blast furnace plant operation, blowing in, blowing out and banking of blast furnace, role of burden charging and distribution in iron extraction, irregularities in Blast furnace operation and their remedies. Blast furnace products their quality control and disposal, coke rate and fuel efficiency of B.F. operations.

Module III (10 Hours)

Modern trends in Blast furnace practice-Production of super flux sinter, pellets, super flux and cold bonded pellets. Auxiliary fuel injection in the blast furnace. High temp.blast, humidified and oxy generated blast, high top pressure, Desulphurization of hot metal. Chemical processes in Blast Furnace, Reactions in Tuyere, hearth and bosh zone. Reduction and coke gasification, Reactions in stack and exit gases. Thermodynamics of Blast furnace process requirement in Blast furnace, temp. profile in the furnace. Free energy and equilibrium consideration in Blast furnace a brief discussion on blast furnace stoichiometry and enthalpy balance

Module IV (10 Hours)

Alternate route for iron making charcoal blast furnace, low shaft furnace and electro thermal processes of iron making. Direct reduction processes, their classification, choice of DR process. Introduction to Production of Ferro-alloys. Production of various ferro-alloys Fe-Mn, Fe-V, Fe-Cr etc. uses of ferro-alloys in iron and steel industry

Text Books:

1. Modern Iron Making - Dr. R.H. Tupkary
2. Principles of Blast Furnace iron making - Dr. A K Biswas

REFRACTORIES AND FURNACE *(Sixth Semester)*

Module I (10 Hours)

Introduction of fossil fuels and their world wide reserves; Primary and secondary fuels, Coking and non-coking coals, Characterization of coal properties (caking and swelling indices, calorific value, proximate and ultimate analyses, etc.); Coal carbonization and effects of different parameters; Properties of coke, char and graphite. Selection of coal for sponge iron making and thermal power plants. Alternative sources of energy (viz. ferro-coke, formed coke, charcoal, solar, wind, tidal, etc.) and their suitability for metallurgical and power industries.

Module II (10 Hours)

Classification of refractories, raw materials, manufacture, testing and properties of heavy and special refractories, silica, silicousaluminosilicate, high alumina, magnetisite, chrome, chrome-magnesite, dolomite, forsterite, chemically bonded basic, carbon and insulating refractories and special purpose oxides, carbide nitride refratories. Binary phase diagrams of Al_2O_3-SiO_2, CaO - MgO,Cr_2O_3-MgO and MgO - SiO_2 systems. Refractory mortars and cements, Refractory castables, selection of refractories for coke oven ,ironblast furnace, copper convertor ,soaking reheating furnaces and heat treatment furnaces, electric arc furnaces.

Module III (7 Hours)

Classification of furnaces: basis and uses. Mechanism of combustion, ignition temperature. Flames: Flame propagation, flame speed and inflammability limits, types of flames; premixed and diffusion flames and their characteristics.

Module IV (13 Hours)

Combustion control; variables of control, viz.: temperature, pressure and gas ratio control, modes or combustion control. Theoretical, adiabatic & true flame temperature.Available heat and factors affecting it. Heat losses in furnaces: Heat balance and furnace efficiency. Liquid and gaseous fuel burners: methods of atomization, types of liquid fuel burners and principle of design. Low pressure, high pressure and injection type gaseous fuel burners and principles of their design.

Text Books:

1. Fuels,Furnaces and Refractories by J.D. Gilchrist.
2. Fuels,Furnaces and Refractories by O. P. Gupta.

PHASE TRANSFORMATIONS & HEAT TREATMENT *(Sixth Semester)*

Module I (10 Hours)

Thermodynamics and Kinetics: Introduction, Equilibrium, Gibbs free energy change with single component system, Thermodynamic parameters in binary system, Binary phase diagrams, Free energy Vs Composition phase diagrams.Diffusion in solids: phenomenological approach and atomistic approach

Module II (10 Hours)

Nucleation and growth: Homogeneous nucleation, homogeneous nucleation rate, Heterogeneous nucleation, Heterogeneous nucleation rate, Strain energy effects. interface-controlled growth and diffusion controlled growth; overall transformation kinetics.

Module III (10 Hours)

Precipitation in age hardening alloys, Particle coarsening, Spinodal decomposition.Iron-carbon alloy system: iron-carbon diagram, nucleation and growth of pearlite, cooling of hypo-eutectoid, eutectoid, and hyper-eutectoid steels, development of microstructures in cast irons.

Module IV (10 Hours)

Heat treatment of steels: TTT and CCT diagrams, bainitic transformation, martensitic transformation, hardenability, role of alloying elements in steels, conventional heat treatment of steels. Massive transformation.Order-disorder transformation.Recovery, Recrystallization and grain growth.

Text Books:

1. Phase transformations in metals and alloys by D.A.Porter, K.E.Easterling and Sharif, CRC press
2. Heat treatment –Principles & Techniques by T.V.Rajan,C.P.Sharma and A.Sharma, PHI publishers

NON-FERROUS EXTRACTIVE METALLURGY *(Sixth Semester)*

Module I (10 Hours)

General principles of extraction of metals from oxides and sulphides; Mineral resources of non – ferrous metals in India; their production, consumption and demand; Future of non – ferrous metal industries in India; Thermodynamic considerations and process selection in pyro-metallurgical extraction of metals. Aluminium: Bayer's process and factors affecting its operation; Hall – Heroult process: principle & practices, use of electrodes, anode effect; Refining of Aluminium; Alternative methods of Alumina and Aluminium production.

Module II (12 Hours)

extraction of metals from Sulphide ores (Cu, Ni, Pb and Zn) Matte smelting; Converting; Refining; by-products recovery; recent developments; Continues copper production processes, hydrometallurgy of copper.

Module III (8 Hours)

Extraction of metals from oxide ores (Sn, Mg), and extraction of metals through halide route (Ti and Zr).

Extraction of metals like (U,Nb, etc)

Module IV (10 Hours)

Electro winning and Electro refining of metals:

a) From aqueous salts (Cu, Ni, Au, and Ag)

b) From fused salts (Al and Mg)

Environmental pollution and its address related to various metal extraction processes in general.

Text Books:

1. Extraction of Non Ferrous Metals by H.S.Ray, R.Sridhar&K.P.Abraham, Affiliated EastWest Press, New Delhi
2. Principles of Extractive Metallurgy, by T. Rosenquist, McGraw hill, 1974

TESTING OF MATERIALS *(Sixth Semester)*

Module I (10 Hours)

Engineering materials and their applications, testing of materials: Types of testing systems, significance of measurement of properties and test conditions, interpretation of test results, Tensile Testing: significance of measured parameters, necking, stress distribution, ductility measurement,

Module II (10 Hours)

Effect of gauge length, effect of strain rate and temperature on flow properties, Machine stiffness in tensile testing system, measuring instrument computerization, Torsion Test: Mechanical properties in torsion. torsion vs tension test.

Module III (10 Hours)

Hardness Test: Rockwell, Brinell, Vickers and micro-hardness, elastic and plastic behavior during hardness testing, Special hardness tests: superficial, micro and shore. Fracture Mechanics: Introduction, Strain-Energy Release Rate, Stress Intensity Factor, Fracture Toughness and Design, KI_c Plane-Strain Toughness Testing Ductile, brittle fracture, Griffith theory, Ductile to brittle transition, Notch effect in fracture,

Module IV (10 Hours)

Fatigue Tests: Stress cycles, SN curve, effect of stress concentration, size and surface conditions on fatigue, Creep, Stress rupture tests, Creep curve and its analysis, Non-destructive Testing: Visual, magnetic, radiographic, ultrasonic, electromagnetic, penetrant tests, their applications in quality control and inspection.

Text Books:

1. Mechanical Metallurgy George E. Dieter
2. Materials Testing by S. Bhargava

PHASE TRANSFORMATIONS & HEAT TREATMENT LABORATORY *(Sixth Semester)*

1. To study the microstructure, grain size and hardness of Annealed plain carbon steel having ≤0.2%C and ≤0.4%C
2. To study the microstructure, grain size and hardness of Normalized plain carbon steel having ≤0.2%C and ≤0.4%C
3. To study the microstructure, grain size and hardness of Hardened plain carbon steel having ≤0.2%C and ≤0.4%C
4. To study the microstructure, grain size and hardness of Tempered plain carbon steel having ≤0.2%C and ≤0.4%C
5. To study the microstructure, grain size and hardness of spheroidized annealing of ≤1.2%C steel
6. To Study the effect of recovery, recrystallization and grain growth (annealing) in a plastically deformed metal on its microstructure (grain structure) and mechanical properties
7. To Study the effect of precipitation hardening treatment on Al-4%Cu alloy on isothermal ageing
8. To Study hardness and microstructure as a function of quench rate, and investigate the hardenability of steels by the Jominey tesT
9. To measure cooling curve of a Pb-Sn alloy using thermocouple and draw the equilibrium diagrams with these cooling curves
10. To develop carburized layer on low carbon steels and study the hardness of that steel

TESTING OF MATERIALS LABORATORY *(Sixth Semester)*

1. To learn the how to use Rockwell hardness tester and understand the effect on hardness values
2. To learn the how to use Vickers hardness tester and understand the effect on hardness values
3. To study the principal of creep testing and determine the creep strength of the given sample
4. To study the principle of fatigue testing and required to construct an S-N curve (stress level - number of cycles to failure) of the test samples provided.
5. To determine the Impact strength of materials using Charpy (I-noch and V-noch) test methods
6. Ericson Cupping Test
7. Friction and Wear test
8. Creep Testing of Materials

COMPUTER APPLICATIONS IN METALLURGICAL ENGINEERING LABORATORY *((Sixth Semester)*

1. To draw various graphs using in Origin.
2. To draw a circle using MATLAB; To solve a system of linear equations using MATLAB;
3. To solve an ODE using MATLAB;
4. To find out the standard deviation of a given set of values using MATLAB; Curve fitting techniques using regression and interpolation. Using MATLAB fit a linear curve for given set of data;
5. To draw a sphere using MATLAB and extend the program to draw FCC and BCC crystal structures;
6. To find out the lattice parameter from the XRD data of an element belonging to the cubic system using MATLAB.
7. To draw a sphere using MATLAB and extend the program to draw FCC and BCC crystal structures
8. To find out the lattice parameter from the XRD data of an element belonging to the cubic system using MATLAB

STEEL MAKING *(Seventh Semester)*

Module I (10 Hours)

Introduction: Principles of steel making reactions, Viz. Decarburisation, dephosphorisation, desulphurisation, silicon and manganese reaction. Slag Theories: Molecular and Ionic theories; Interpretation of the above reactions in terms of ionic theory of slag, LD Process: Design of converter & lance, Quality of raw materials charged, Operation of the converter and control of bath and slag composition,Some characteristics of L. D. blow Viz. Emulsion formation, lance height for dephosphorisation and decarbonisation

Module II (10 Hours)

Recovery of waste heat, OBM/Q-BOP, Process, Concept and operation of the process, Mixed/Combined blowing Processes, Oxygen top blowing with inert gas purging at bottom, Oxygen top blowing with inert and oxidizing gases at bottom, Oxygen top and bottom blowing. Open Hearth Furnace: Its modification into Twin Hearth, Operational principle, Advantages. Electric Arc Furnace: Advantages; Charging, Melting and refining practices for plain carbon and alloy steels, Use of DRI in arc furnace and its effect on performance,

Module III (8 Hours)

Duplex processes of stainless steel making using VOD, AOD. Induction Furnace: Advantages, principle of induction melting, Its use in steel industry. Deoxidation of liquid steel: Requirements of deoxidisers, deoxidationpractice,Use of complex deoxidisers, Inclusions and their influence on quality of steel, Killed, Semi-killed and Rimming steel

Module IV (12 Hours)

Secondary refining of steel: Objectives, Principle of degassing, Different industrial processes such as DH, RH, VAD, SD. LF, and ESR, Limitations and specific applications. Continuous Casting of Steel: Advantages, types of machines, Mould lubrication and reciprocation, Developments in technology with respect to productivity, quality and energy conservation, Near-net-shape casting, Strip casting

Text Books:

1. Iron and steel making theory and practiced - Ahindra Ghosh, Amit Chatterjee
2. Introduction to Modern Steel Making, Khanna Publishers, Delhi - R.H. Tupkary

CHARACTERIZATION OF MATERIALS *(Seventh Semester)*

Module I (10 Hours)

Introduction to materials characterization & its importance, Fundamentals of Crystallography, levels of characterization (macro, meso and micro), Resolution, depth of field/focus, aberrations (spherical, chromatic and astigmatism) and its remedial measures. Optical microscopy (OM) – Microscope construction and working, reflected/transmitted light microscope, theoretical and practical resolution of optical microscope, numerical aperture, principle of image formation, , effective/empty magnification, Types of illumination - bright field, dark field, polarized light and phase contrast, applications of each type of illumination. Sample preparation for optical microscopy, features of an image

Module II (12 Hours)

Introduction to scanning electron microscope (SEM), working and construction, advantages/disadvantages as compared to OM, types of electron gun and comparison between them. Electron - specimen interaction, imaging modes (secondary and backscattered), effect of spot size, apertures, accelerating voltage on SEM image, Everhart-Thornley detector, Robinson detector, solid state segmented detector, atomic number and topological contrast. Chemical analysis using SEM, EDS/WDS working principle, construction, resolution of EDS/WDS detector, advantages/disadvantages.

Module III (8 Hours)

X-ray diffraction: Generation of X-rays, characteristic X-ray spectrum, Bragg's Law, Diffraction methods: Laue method, rotating crystal method, powder method, structural factor, applications of X-ray diffraction in materials characterization: determination of crystal structure, lattice parameter.

Module IV (10 Hours)

Thermal analysis techniques & its Importance, principles and applications of differential thermal analysis (DSC), differential scanning calorimetry (DSC) and thermogravimetric analysis (TGA). Brief idea of TEM: principle of operation, application. Introduction to advanced microscopic techniques

Text Books:

1. Elements of X-Ray Diffraction, B.D. Cullity, Prentice Hall (2001)
2. Electron Microscopy and Microanalysis, Goodhew, Humphreys and Beanland, Taylor and Francis, New York, 2001

MECHANICAL WORKING OF METALLIC MATERIALS *(Seventh Semester)*

Module I (10 Hours)

Fundamentals of Metal Working: Classification of forming processes; Temperature in Metal– working, Hot working, Cold working and Warm working of metals, Heating of metals and alloys for hot working, Friction in Metal working, Lubrication, concept of yield criteria.

Module II (10 Hours)

Rolling of Metals: Classification of Rolled products, Types of rolling mills, terminology used in rolling; Forces and Geometrical relationships in rolling, Rolling variables, Theories of rolling, Rolling Torque and HP calculations. Roll-pass Design: Fundamentals of Roll-pass-design; Mill type, Layout and rolling practice adopted for some common products such as Slabs, Blooms, Billets, Plates, Sheets etc. Rolling defects and their control

Module III (10 Hours)

Forging of Metals: Forging principles, types of forging and equipments needed, calculation of forging load under sticking and slipping friction conditions, Forging defects and their control, Manufacture of rail wheels and tyres. Extrusion: Types, Principles and Equipments. Variables in extrusion, deformations in extrusion, calculation of extrusion pressure under plane strain conditions; extrusion defects; production of tubes and seamless pipes.

Module IV (10 Hours)

Wire Drawing**:** Drawing of Rods, Wires and Tubes, calculation of drawing load; drawing defects. Sheet Metal Forming**:** Forming methods such as bending stretch forming, shearing and blanking, deep drawing, and redrawing. Defects in formed products, Special forming methods such as explosive forming (elementary ideas excluding mathematical treatment)

Text Books:

1. G. W. Rowe, Principles of Industrial Metal Working processes, Crane Russak, 1977.
2. Amitabh Ghosh, Asok Kumar Mallick, Manufacturing sciences, East-west press private ltd; latest reprint-1991.

MATERIALS CHARACTERIZATION LABORATORY *(Seventh Semester)*

1. Micro structural analysis of a given (Ferrous & Nonferrous) sample using Optical Microscope
2. Study of electron microscope (SEM &TEM)
3. Determination of interlamellar spacing of pearlite using SEM
4. Study of precipitation hardening of Al-Cu alloy using SEM
5. Compositional Analysis of a unknown sample using EDX
6. Determination of Phase Transformation temperature of given sample using DSC
7. Determination of Melting Temperature of a unknown metal using DTA
8. Indexing of XRD Pattern of a given sample
9. Determination of lattice parameter of a given sample
10. Determination of crystallite size of a powdered sample using XRD
11. Determination of lattice strain of a deformed sample using XRD

CORROSION AND DEGRADATION OF MATERIALS *(Eighth Semester)*

Module I (10 Hours)

Introduction, importance of corrosion study, corrosion as non equilibrium process, corrosion rate expressions, electrochemical principles of corrosion-cell analogy, concept of single electrode potential, reference electrodes, e.m.f. and galvanic series-their uses in corrosion studies, polarization, passivity.

Module II (10 Hours)

Different forms of corrosion-uniform attack, galvanic, crevice, pitting, intergranular, stress corrosion cracking - their characteristic features, causes and remedial measures. Principles of corrosion prevention-material selection control of environment including inhibitors

Module III (10 Hours)

Cathodic and anodic protection, coatings and design considerations. Corrosion testing methods. Introduction to high temperature corrosion, Pilling- Bedworth ratio, oxidation kinetics, oxide defect structures.

Module IV (10 Hours)

Considerations in high temperature alloy design, prevention of high temperature corrosion -use of coatings. Hydrogen Damage-Sources, Types of damage, Mechanisms and preventive methods, Liquid metal attack - liquid metal embrittlement, preventive measures.

Text Books:

1. M. G. Fontana : Corrosion Engineering , 3rd edition, Mc Graw Hill International, 1987.
2. U. K. Chatterjee, S. K. Bose and S. K. Roy: Environmental Degradation of Metals, Marcel Dekker, 2001

COMPOSITE MATERIALS *(Eighth Semester)*

Module I (10 Hours)

Introduction to Composites, Matrices, Reinforcements, Classifications, Applications, Advantages, Fundamental concept of reinforcement, review of current developments; design & fabrication and economic considerations. Basic mechanics of reinforcement, Stiffness of parallel arrays of fibres in a matrix. Discontinuous and particulate reinforcement.

Module I (10 Hours)

Fibres and resin materials. Rule of Mixtures, Critical Fiber Length, Short and Continuous Fibers, Fiber Orientation Matrix and Reinforcement Materials, Polymeric Matrices, Metallic Matrices, Ceramic Matrices, Particulates, Flakes, Whiskers, Fibers: C, B, Glass, Aramid, Al2O3, SiC, Nature and manufacture of glass, carbon and aramid fibres. Review of the principal thermosetting and thermoplastic polymer matrix systems for composites. Polymer Matrix Composites (PMCs), Metal Matrix Composites (MMCs), Ceramic Matrix Composites (CMCs), CFRP & Carbon/Carbon Composites (CCCs).

Module I (10 Hours)

Types of Manufacturing, Processing methods, Interfaces, Properties, Applications, Toughening Mechanisms, Fiber Forms, Prepregs, Molding Compounds-Processes, Lay-Ups, Filament Winding, Pultrusion, Recycling. Matrix– Reinforcement Interface, Wettability, Interactions at Interface, Interfacial Bonding Types, Interfacial Strength Tests, The role of the interface. The nature of fiber surfaces, wetting and adhesion.

Module I (10 Hours)

Strength, Stiffness, Fracture, Toughness and toughening mechanisms of composites. Strengths of unidirectional composites. Multiple fracture in laminates. Macroscopic fracture and energy dissipating processes. Application of fracture mechanics to composite materials. Fracture Mechanics and Fracture Toughness in Composites, Linear Elastic fracture mechanics, Toughness, Fiber matrix de-bonding, FiberPullout Buckling and Post-Buckling. Failure criteria, Fatigue and Creep in composites, Environmental effects in Composites, Green composites. Synthesis and Properties of Nanocomposites.

Text books:

1. Composite materials science and engineering by Krishna K chawla

JOINING OF MATERIALS *(Elective – I, Seventh Semester)*

Module I (10 Hours)

Introduction: Principle, Theory and Classification of welding and other joining processes. Manual metal arc (MMA): Equipment requirement, electrodes for welding of structural steels, coating constituents and their functions, types of coatings, current and voltage selection for electrodes, Arc welding power sources; Conventional welding transformers, rectifiers and current and voltage.

Module II (10 Hours)

The influence of these power sources on welding, metal transfer. Submerged arc welding (SAW): Process details, consumables such as fluxes and wires for welding mild steel, Variations in submerged arc welding process. Gas metal arc welding (GMAW) or MIG/ MAG welding: Process details, shielding gases, electrode wires, their sizes, and welding current ranges.

Module III (10 Hours)

TIG welding: Process details, power sources requirements, electrode sizes and materials, current carrying capacities of different electrodes, shielding gases, application of process. Resistance welding: General principle of heat generation in resistance welding, application of resistance welding processes. Process details and working principle of spot, seam, and. projection welding, electrode materials, shapes of electrodes, electrode cooling, selection of welding currents, voltages.

Module IV (10 Hours)

Welding metallurgy of carbon and alloy steels, Cast irons, Stainless steels, Al- and Cu-based alloys. Weldability and Heat affected zones (HAZ). Welding defects and detection techniques. Soldering and brazing: Difference between both the processes, consumables used, methods of brazing, fluxes used, their purposes and flux residue treatment.

Text Books:

1. J F Lancaster, Allen and Unwin, Metallurgy of Welding
2. Welding Technology by O.P.Khanna

ADVANCED CASTING PROCESSES *(Elective – I, Seventh Semester)*

Module I (10 Hours)

Introduction: Casting as a process of Manufacturing. Moulding Processes, Equipments and Mechanization: Different types of Moulds, Moulding Materials and Moulding processes, Pattern and other mould making equipments, Different types of binders and their uses in mould and core makings

Module II (10Hours)

Melting of Metals and Alloys for casting: Brief mention of various melting units, melting and post melting treatments, melting practices as adopted for a few metals and alloys such as CI, Al, Cu, steels, cast irons.

Module III (10Hours)

Solidification of Metals and Alloys: Nucleation, Growth, Role of alloy constitution, Thermal conditions and inherent nucleation and growth conditions in the liquid melt, Time of solidification and Chowrinov rule, concept of directionality in solidification Significance and practical control of cast structure Principles of Gating and Risering: Feeding characteristics of alloys, Types of Gates and Risers, gating ratio.

Module IV (10Hours)

Special casting Methods: Investment casting, Die casting, Centrifugal casting, Full mould casting, Vacuum sealed casting. Casting Defects: A detailed analysis of casting defects Their causes and prescription of remedial measures

Text Books:

1. P. R. Beeley, Foundry Technology, Newnes-Buttterworths, 2001

2. P. D. Webster, Fundamentals of Foundry Technology, Portwillis press, Red hill, 1980.

SURFACE ENGINEERING *(Elective – I, Seventh Semester)*

Module I (10 Hours)

Introduction, Surface dependent engineering properties, viz., Friction and wear, corrosion, fatigue, etc.; common surface initiated engineering failures; mechanism of surface degradation; importance and necessity of surface engineering; classification and scope of surface engineering in metals, ceramics, polymers and composites, tailoring of surfaces of advanced materials.

Module II (10 Hours)

Surface protection (Physical); surface modification (Chemical) techniques: classification, principles, methods, and technology. Conventional surface engineering methods: carburising, nitriding, cyaniding, diffusion coating, hot dipping, galvanizing etc.

Module III (8 Hours)

Electrochemistry and electro-deposition; scope and application of conventional surface engineering techniques in engineering materials; advantages and limitations of conventional processes

Module IV (12 Hours)

Recent trend in surface engineering: physical/chemical vapor deposition; plasma spray coating; plasma assisted ion implantation. Surface modification by directed energy beams like ion, electron and laser beams; energy transfer, novelty of the directed energy beams assisted surface modification techniques.

Text Books:

1. K. G. Budinski (Ed.): Surface Engineering for Wear Resistance, Prentice Hall, New Jersey 1988.
2. J. R. Davis (Ed.): Surface Engineering for Corrosion and Wear Resistance, ASM International, Materials Park, Ohio, 2001.

NANO MATERIALS *(Elective – II, Seventh Semester)*

Module I (10 Hours)

Introduction: Types of nanomaterials, Emergence and challenges in nanotechnology. Synthesis routes for nanomaterials: Bottom-up and top-down approaches

Module II (10 Hours)

Solid, Liquid, Gas phase synthesis, Hybrid Phase synthesis, Synthesis of bulk Nanostructured materials: Approaches and challenges. Properties of nanomaterials: Stability of nanomaterials,

Module III (10 Hours)

Mechanical properties, Optical, Electrical and Magnetic properties, nano-diffusion, Characterization of nanomaterials: Structural characterization by XRD, SEM, TEM, SPM, Chemical characterization by spectroscopy techniques, Characterization of mechanical properties by nanoindentation,

Module IV (10 Hours)

Hot compression testing, Fracture analysis. Application of nanomaterials: Electronics and optoelectronics applications, Nanobots, Biological applications, Catalytic applications, Quantum devices, Application of carbon nanotubes, Nanofluids. Future of Nanotechnology

Text Books:

- Yuri Gagotsi (Ed.), Taylor and Francis, Nanomaterails Handbook, 2006
- G. Cao, Nanostructures and Nanomaterials, Imperial College Press, 2006

BIO MATERIALS *(Elective – II, Seventh Semester)*

Module I (10 Hours)

Introduction: Biomaterials, bio-inert, bioactive, property requirement of biomaterials. Biocompatibility: tissue response to biomaterials; corrosion. Assessment of biocompatibility of biomaterials: in vitro and in vivo testing of biomaterials.

Module II (10 Hours)

Metallic materials in medical application: Stainless steel, cobalt based alloys, titanium based alloys (including shape memory alloys).

Module III (10 Hours)

Ceramics and polymer based implant material. Processing and properties of different bio-ceramics materials

Module IV (10 Hours)

Surface modification of implant material, mechanical, Physical, chemical and high energy based surface modification. Design concept of developing new materials for bio-implant application.

Text Books:

1. J.B. ParkandJ. D. Boonzino, Biomaterials: Principles and Application, CRC Press, 2002.
2. R E Smallman, A. H. W., Butterworth-Heinemann, Physical Metallurgy and Advanced Materials, Seventh Edition, 2007, ISBN: 0750669063.

ENGINEERING POLYMERS *(Elective – II, Seventh Semester)*

Module I (10 Hours)

Basic concepts on polymers, Polymer raw materials, Polymerization principles and processes (step, chain and other polymerizations, polymer kinetics), Polymerization techniques

Module II (10 Hours)

Polymer manufacture (unit operations, polymer reactors, polymer isolation, handling and storage), Polymer structure and property, Polymer characterization

Module III (10 Hours)

Polymer modification, Multicomponent polymeric materials (polymer miscibility, polymer blends and alloys, filled plastics, polymer composites)

Module IV (10 Hours)

Polymer compounding and fabrication (polymer additives, Compounding processes, fabrication techniques, post fabrication operations), Polymer testing (sample preparation, testing standards and methods, analysis of polymer and additives), Polymer applications: Biodegradable polymers, biomedical polymers, conducting polymers, Problems with polymers (thermo oxidative degradation, fire hazards, toxicity, effluent disposal, feedstock scarcity).

Text Books:

1. Fred W. Billmeyer, Jr., Textbook of Polymer Science, 3rd Edition, John Wiley & Sons, Singapore, 1994
2. George Odian, Principles of Polymerization, Second Edition, John Wiley & Sons, New York, 1981

ALTERNATIVE ROUTES OF IRON MAKING *(Elective – III, Eighth Semester)*

Module I (12 Hours)

Introduction: Present and future of sponge iron industries in India; Classification of DR processes; Characteristics of raw materials and their preparation. Thermodynamics and Kinetics aspects. Direct Reduction Processes: Reduction of Iron bearing materials in shaft furnace, rotary kiln.

Module II (8 Hours)

Retort and fluidized bed with special reference to reductant, energy consumption and operational problems. Salient features of coal- based (rotary kilns) DR processes; Salient features of gas-based DR processes.

Module III (10 Hours)

Commercially available processes like SL/RN, ACCAR, Krup-CODIR, Kinglon Meter, MIDREX, HyL, Purofer, Iron Carbide, etc. Uses of DRI in steel making, iron making and foundries; effect on DRI on EAF performance and product characteristics.

Module IV (10 Hours)

Smelting Reduction Processes: COREX, ROMELT, Fluidized bed reactors, Hismelt etc. Strengths and weaknesses of different DR processes particularly in context to India; Properties and usage of DRI; Pollution issues in the Indian DR industries. Present status of alternative methods of iron making in India.

Text Books:

1. Alternative Routes of Iron Making by Amit Chatterjee, PHI
2. Beyond the Blast Furnace by Amit Chatterjee

FERRO ALLOYS TECHNOLOGY *(Elective – III, Eighth Semester)*

Module I (10 Hours)

Survey of Ferro-alloy industries in India and their future prospects, Physico-chemical principles of ferro-alloy making, principles of carbothermic and metallothermic reduction.

Module II (10 Hours)

Ferro-alloy furnaces: Submerged arc furnaces, selection for transformer capacity, secondary voltage and current, furnace dimensions, size and spacing of electrodes, mechanical equipments, charging devices and dust collection system.

Module III (10 Hours)

Electrodes used in ferro-alloy furnaces: graphitised and self baking electrodes, properties and uses. Production of ferro-manganese, ferrochrome, ferrosilicon and silico-calcium by carbothermy, production of FeCr, FeTi, FeB, FeNb, FeMo, and FeV by metallothermy. Recovery of vanadium from ores and production of FeV.

Module IV (10 Hours)

Charge calculations in production of ferro-alloys, Use of plasma arc for production of ferro-alloys. Use of ferro-alloys in Iron and Steel industries (deoxidation and alloy making).

Text Books:

1. Riss and Khodorovasky, Production of Ferro-Alloys
2. Elyutin V.P., Production of Ferro-Alloys

ELECTRO METALLURGY *(Elective – III, Eighth Semester)*

Module I (10 Hours)

Introduction**:** Justification of Hydrometallurgical selection of solvent processing, Eh-Pt diagrams Principles underlying hydrometallurgical processes, various commercial hydrometallurgical processes. Criteria for selection of solvents, Types of Solvents.

Module II (10 Hours)

Thermodynamics & kinetics of hydrometallurgical processes, Unit operations in hydrometallurgical processing, Thickness & filters, counter current decantation. Applications of hydrometallurgy to Copper, Zinc, Precious metals etc.

Module III (10 Hours)

Solvent Extraction & Ion Exchange, Purification methods of leach solutions, Recovery of metal values from solution, Precipitation methods Thermodynamics & Kinetics of concentration.

Module IV (10 Hours)

Electrolytic Recovery: Electrowining of methods from Aq. Solutions Electro Refining, Fused Salt Electrolysis – Extraction of Aluminum& Magnesium from their ores, Mass balance calculations.

Text Books:

1. H. S. Ray, K. P. Abraham and R. Sridhar, Extraction of Non-Ferrous Metals, Affliated East- West Press.
2. E. Jackson, Hydrometallurgical Processing & Reclaimation, John Wicky & Sons.

FRACTURE MECHANICS AND FAILURE ANALYSIS *(Elective – IV, Eighth Semester)*

Module I (10 Hours)

Griffith's crack theory, Strain energy release rate, Stress analysis of cracks and linear elastic fracture mechanics (LEFM), Crack tip plastic zone, Fracture mode transition: plane strain and plane stress fracture toughness, Plane strain fracture toughness determination, Plane stress fracture toughness determination,

Module II (10 Hours)

Fracture toughness determination using ***J***-integral approach. Microstructural aspect of fracture toughness, Optimizing microstructure and alloy cleanliness to enhance fracture toughness. Causes & Sources of Failures, Methodology, Art of Questioning, Fractography: ductile versus brittle,

Module III (10 Hours)

Fractography: Fatigue, Creep, Stress Calculations, Fatigue Design Fractography: overload Calculations. Case studies related this topic. Fracture Toughness, Creep, Wear, Rolling Contact Fatigue, Advanced Fractography, Case studies related this topic. Non Destructive Evaluation (NDE) Metallography,

Module 1V (10 Hours)

Introduction to Corrosion, Forms of Corrosion, Galvanic, Pitting, crevice corrosion etc. Polymer Failures Ceramics and Glass Liquid Metal Embrittlement, Case studies related this topic. Failures related to Casting, Welding, Metal working, Fasteners (screws bolts, rivets), Shafts and Gears, Sequencing, Case studies related this topic.

Text Books:

1. ASM Handbook, Vol. 11, Failure Analysis and Prevention," edited by R.J. Shipley and W.T. Becker,
2. Mechanical Metallurgy, 3rd Ed., McGraw Hill Book Company, New Delhi, 1986 - G.E. Dieter

MATERIALS FOR ADVANCED APPLICATIONS *(Elective – IV, Eighth Semester)*

Module I (10 Hours)

Electronic Polymers, Organic electronics, Melanin, Organic semiconductor, Printed electronics, Organic LED. Nanostructures, Nanomaterials, Nanocomposites. Biomaterials: Metallic biomaterials like 316L stainless steel, Co-Cr Alloys, Titanium Ti6Al4V,.

Module II (10 Hours)

Ceramic biomaterials like Alumina, Zirconia, Carbon Hydroxy-apatite, Polymeric biomaterials like Ultra high molecular weight polyethylene, Polyurethane Smart Materials: Piezoelectric materials, Shape memory alloys and shape memory polymers.

Module III (10 Hours)

High Performance Alloys: Nickel super alloys, Ti alloys, Al-Li alloys, Hastelloy, Inconel, Monel, Nitronic, Cobalt based alloys and commercially available pure nickel alloys. Functional and Engineering Ceramics: diverse applications as cutting tools, mobile phone microwave devices, polycrystalline diamond and fuel cells.

Module IV (10 Hours)

Hybrid Materials: Design, Synthesis and Properties of hybrid materials created by blending disparate materials such as plastics with metals. Processing of Advanced Materials: Superplastic, spray forming, rapid solidification. Materials selection and design.

Text Books:

1. Mark J. Hampden-Smith Wiley-VCH, Chemistry of Advanced Materials: An Overview Leonard V. Interrante, 1st edition (1997) ISBN-10: 0471185906 ISBN-13: 978-0471185901.
2. R E Smallman, A. H. W., Butterworth-Heinemann, Physical Metallurgy and Advanced Materials, Seventh Edition, 2007, ISBN: 0750669063

PHYSICS OF MATERIALS *(Elective – IV, Eighth Semester)*

Module I (10 Hours)

Crystallography: Crystalline and amorphous structures, Elements of Crystal Symmetry, Symmetry elements and axes, two, three, four and six fold Symmetry, Review of atomic bonding. Order-Disorder Transformation: Ordering Degrees of long range and short range ordering, Anti phase Domain,

Module II (10 Hours)

Super lattice, Elements of Super lattice Theories, Properties and Applications. Electron Theory of Materials: Heisenberg's uncertainty Principle, Schrodinger's equation. Free Electron Theory, Zone Theory, Density of States, Fermi Energy Level, Application of Zone Theory to Alloy Phases;

Module III (10 Hours)

Conductors and Insulators, Semiconductors, P & N – Type Semiconductors Magnetic Properties: Dia, Para and Ferro-magnetism, Domain Theory of Ferromagnetism Antiferromagnetism and Ferrites, Hysteris loop, Soft Magnetic Materials, Hard Magnetic Materials, Super Conductivity

Module IV (10 Hours)

BCS Theory, Type-I & Type-II Super Conductors. Elements of X-ray Diffraction: X-ray, Bragg's Law, Laue, Rotating Crystal and Powder Methods, Structure Determination with the help of X-ray.

Text Books:

1. R. E. Reid – Hill, Physical Metallurgy Principles, East – West Press Pvt. Ltd., (New Delhi), (2004)
2. W. Hume Rothery and B. R. Coles – Atomic Theory for Students of Metallurgy, The Institute of Metals (London) (1988)