

**C U R R I C U L U M**

**A N D**

**S Y L L A B U S**

FOR

**BACHELOR OF TECHNOLOGY (B. Tech.)**

IN

**METALLURGY & MATERIALS ENGINEERING**

**(Operative from Session)**

**(2019-2020)**



**DEPARTMENT**

**OF**

**MATERIALS AND METALLURGICAL ENGINEERING**

**NATIONAL INSTITUTE OF FOUNDRY & FORGE**

**TECHNOLOGY HATIA, RANCHI - 834 003**

**National Institute of Foundry and Forge Technology, Hatia, Ranchi-834003**

**Department of Materials and Metallurgical Engineering**

S#	Category	Letter	No. of Subject	No. of Credits
1	Basic Science	BSC	07	22.5
2	Mathematics	MA	01	3
3	Engineering Science	ESC	06	16
4	Humanities and Social Sciences including Management	HSC	01	03
5	Extra Activities	EA	02	02
6	Programme Core	MF	30	80.5
7	Programme Electives (PE)	MF	08	24
8	Open Electives	MF	03	9
<b>Total</b>			<b>58</b>	<b>160</b>

\*3<sup>rd</sup> semester onwards the codes of the subjects contain the following:

The first, second and last two numbers denote year, semester and course codes, respectively.

**Course structure for B. Tech. (Metallurgy and Materials Engineering)**

Year	Semester	Code	Subject	L - T - P - C	
I (41.5)	I (17.5)	BSC-101	Physics-I (Introduction to Mechanics)	3 - 1 - 0 - 4	
		BSC-103	Mathematics I	3 - 1 - 0 - 4	
		ESC-101	Basic Electrical Engineering	3 - 1 - 0 - 4	
		ESC-102	Engineering Graphics and Design	1 - 0 - 4 - 3	
		BSC-101P	Physics Laboratory	0 - 0 - 3 - 1.5	
		ESC-101P	Basic Electrical Engineering Laboratory	0 - 0 - 2 - 1	
	II (24)		BSC-102	Chemistry-I	3 - 1 - 0 - 4
			BSC-104	Mathematics II	3 - 1 - 0 - 4
			BSC-105	Physics-II (Mechanics of Solid)	3 - 1 - 0 - 4
			HSM-101	English	3 - 1 - 0 - 4
			ESC-103	Programming for Problem Solving	2 - 0 - 2 - 3
			BSC-102P	Chemistry Laboratory	1 - 0 - 4 - 3
			ESC-104	Workshop/Manufacturing Practices	0 - 0 - 2 - 1
			ESC-103P	Programming for Problem Solving Laboratory	0 - 0 - 2 - 1
II (42)	I (21)	MA-2101	Mathematics III	3 - 0 - 0 - 3	
		MT-2101	Fluid Mechanics	3 - 0 - 0 - 3	
		MT-2102	Mineral Dressing	2 - 0 - 0 - 2	
		MT-2103	Fuels, Furnaces and Refractories	2 - 0 - 0 - 2	
		MT-2104	Metallurgical Thermodynamics and Kinetics	3 - 1 - 0 - 4	
		MT-2105	Principles of Extractive Metallurgy	3 - 0 - 0 - 3	

		MT-2111	Fluid Mechanics Laboratory	0 - 0 - 2 - 1	
		MT-2112	Mineral Dressing Laboratory	0 - 0 - 2 - 1	
		MT-2113	Fuels, Furnaces and Refractories Laboratory	0 - 0 - 2 - 1	
		EA-2121	Extra Activities (NSO/NCC/YOGA/CREATIVE ARTS/ MINI PROJECT)	0 - 0 - 2 - 1	
	II (21)	MT-2201	Numerical Methods and its applications	2 - 0 - 0 - 2	
		MT-2202	Heat and Mass Transfer	3 - 0 - 0 - 3	
		MT-2203	Phase equilibria in Materials system	3 - 0 - 0 - 3	
		MT-2204	Iron Making	3 - 0 - 0 - 3	
		MT-2205	Physical Metallurgy-I	3 - 0 - 0 - 3	
		MT-2206	Mechanical behavior of Materials	3 - 1 - 0 - 4	
		MT-2211	Numerical Methods and its applications Laboratory	0 - 0 - 2 - 1	
		MTD-2212	Physical Metallurgy-I	0 - 0 - 2 - 1	
		EA-2221	Extra Activities (NSO/NCC/YOGA/CREATIVE ARTS/ MINI PROJECT)	0 - 0 - 2 - 1	
III (42)		I (21)	MT-3101	Steel Making	3 - 0 - 0 - 3
	MT-3102		Physical Met-II	3 - 1 - 0 - 4	
	MT-3103		Welding Metallurgy	2 - 0 - 0 - 2	
	MT-3104		Foundry Technology	3 - 0 - 0 - 3	
	MT-3105		Powder Metallurgy	2 - 0 - 0 - 2	
	MT-3106		Mechanical Properties of Materials and its Evaluation	3 - 0 - 0 - 3	
		MT-3113	Welding Metallurgy Laboratory	0 - 0 - 2 - 1	
		MT-3114	Foundry Technology Laboratory	0 - 0 - 2 - 1	
		MT-3115	Powder Metallurgy Laboratory	0 - 0 - 2 - 1	
		MT-3116	Mechanical Properties of Materials and Evaluation	0 - 0 - 2 - 1	
		II (21)	MT-3201	Metal Forming Technology	2 - 0 - 0 - 2
			MT-3202	Corrosion Science and Engineering	3 - 0 - 0 - 3
			MT-3203	Extraction of Non ferrous Metals	3 - 0 - 0 - 3
			MT-3204	Heat treatment Technology	3 - 0 - 0 - 3
			MT-3205	Characterization of Materials	3 - 0 - 0 - 3
			MT-323*	Elective -I	3 - 0 - 0 - 3
	MT-3211	Metal Forming Technology Laboratory	0 - 0 - 2 - 1		
	MT-3212	Corrosion Science and Engineering Laboratory	0 - 0 - 2 - 1		
	MT-3214	Heat treatment Technology Laboratory	0 - 0 - 2 - 1		
	MT-3215	Characterization of Materials Laboratory	0 - 0 - 2 - 1		
IV (34.5)	I (18)	MT-4101	Composite materials	3 - 0 - 0 - 3	
		MT-4102	Environment and Pollution Control in iron and steel industry (Audit)	2 - 0 - 0 - 0	
		MT-4103	Industrial Engineering and Management	2 - 0 - 0 - 2	
		MT-4104	Engineering Economics	2 - 0 - 0 - 2	
		MT-414*	Elective -II	2 - 0 - 0 - 2	
		MT-415*	Elective -III	3 - 0 - 0 - 3	
		MT-4120	Environment and Pollution Control in iron and	0 - 0 - 2 - 0	

		steel industry (Audit)	
	MT-411*	Elective –II Laboratory	0 - 0 - 2 - 1
	MT-4122	Industrial /R&D Lab Training and Report Evaluations	0 - 0 - 0- 2
	MT-4121	Project-I	0 - 0 - 0- 3
Minimum Four weeks of industrial Training if possible, Mini projects to be carried out in the industry/R&D lab itself.			
II (16.5)	MT-4201	Org. Behavior and Industrial Psychology	3 - 0 - 0 - 3
	MT-426*	Elective -IV	3 - 0 - 0 - 3
	MT-4223	Seminar presentation	0 - 0 - 0 - 2
	MT-4224	Comprehensive Viva-voce	0 - 0 - 0 - 2.5
	MT-4225	Project Work-II and Viva -voce	0 - 0 - 0 - 6

### Elective –I

**(3-0-0-3)**

MT-3231: Methoding of Castings  
 MT-3232: Materials handling  
 MT-3233: Failure Analysis  
 MT-3234: Advanced Materials  
 MT-3235: Surface Engineering  
 MT-3236: Non metallic materials

### Elective – II

**(2-0-2-3)**

MT-4141: Modern NDT  
 MT-4142: Instrumentation and Control  
 MT-4143: Computer applications in Metallurgy  
 MT-4144: Physics of metals  
 MT-4145: Fracture Mechanics  
 MT-4146: Modeling and Simulation in Metallurgy

### Elective – III

**(3-0-0-3)**

MT-4151: Secondary Steel Making  
 MT-4152: X-Ray crystallography  
 MT-4153: **Wear, Friction & Lubrication**  
 MT-4154: Nano Materials and Applications  
 MT-4155: Bio materials  
 MT-4156: Functional materials

### Elective-IV

**(3-0-0-3)**

MT-4261: Electronic, Optical & Magnetic Properties of Materials  
 MT-4262: Forging Die Design and Manufacturing  
 MT-4263: Light Metals and Alloys  
 MT-4264: Aerospace Materials  
 MT-4265: High Temperature Materials  
 MT-4266: Automotive Materials

**Syllabus, B. Tech. Metallurgy & Materials Engineering**  
**2<sup>nd</sup> Year, Third Semester onwards**

**SEMESTER- III**

**MA- 2101 Mathematics- III**

**L-T-P-C (3-0-0-3)**

Differential Equations: Definitions, Differential equation of first order, of first degree and higher, Singular solutions, Geometrical interpretations of differential equations, Linear equations of higher order with: constant coefficients and variable coefficients (Second order and homogeneous equations), Simultaneous differential equations of one or more variable, partial differential equations, total differential equations, geometrical interpretations, solution of Laplace equation, Heat conduction equation and wave equations by separation of variables in Cartesian, cylindrical and spherical polar co ordinate systems. Special Functions: Solution of Legendre and Bessel differential equations, Different kinds of associated functions, Orthogonality conditions, Expansion of functions in terms of Legendre polynomials and Bessel functions. Integral Transforms: Definitions, Laplace transforms, Inverse Laplace transforms, Fourier series- Expansion, Conversion into different intervals, Fourier integral formula, Fourier Mellin theorem, Infinite and Finite Fourier Transforms and Hankel transforms. Definite integrals with the help of Transforms, Application of Transforms to the solution of boundary value problems. Heat and wave equations.

**MT- 2101 Fluid Mechanics:**

**L-T-P-C (3-0-2-4)**

Introduction: Definitions, Fluid properties, classification of fluids and flow regimes, Fluid statics: Stationary fluids and liquids subjected to constant linear acceleration and to constant rotation. Fluid kinematics: Lagrangian and Eulerian descriptions, Pathlines, Streaklines and streamlines, acceleration. Integral flow analysis: Reynolds transport theorem, conservation of mass/ continuity equation and conservation of linear and angular momentum for a control volume in inertial and accelerating reference frames, energy equation, Bernoulli's equation. Engineering applications, Differential analysis of flow: Continuity and Navier- Stokes equations. Dimensional analysis, Similitude theory. Inviscid flows: Irrotational flow, circulation, velocity potential and applications. Viscous 12 flows in pipes and ducts, External viscous flows: Concepts of boundary layer, Momentum integral equation, drag and lift, separation.

Reference Books: 1. Szekley J.S. & Themlis N.J., Rate Phenomena in Process metallurgy

2. Bird R.B., Stewart W.E. & Lightfoot J.F., Transport Phenomena.

3. Geiger G.H. & Priorer D.R., Transport Phenomena in Materials Processing, Addison Wesley.

**MT-2102 Mineral Dressing:**

**L-T-P-C (2-0-2-3)**

Ores and Minerals: Rocks, Minerals, Ores and Gangue, Elementary ideas of formation of rocks and mineral deposits and their mode of occurrence associations. Scope of mineral processing. Comminution and Liberation: Concept and importance of liberation. Theory and practice of crushing and grinding. Sizing and classification: Laboratory sizing techniques, Interpretation and plotting of sizing data. Industrial screens and classifiers. Concentration: Principles and applications of heavy media separation, Jigging, Flowing film concentration and equipments used. Physico chemical

principles of Flotation, Flotation reagents, Machines and circuits, Electrostatic and magnetic separation. Pre concentration techniques. Dewatering and Drying: Principles and practice of thickening, Filtration and Drying. Flow sheets: Typical flow sheets for the beneficiation of Coal and ores of Cu, Pb, Zn, Iron, Al and Mn with special reference to Indian deposits.

Reference Books:

1. Wills B.A., Mineral Processing Technology, Pergamon.
2. Gaudin A.M., Principles of Mineral Dressing, Tata McGraw-Hill.
3. Pryor E.J. Mineral Processing, Allied Science.
4. Jain S.K., Ore Processing, Oxford & IBH.

**MT-2103 Fuels, Furnaces and Refractories:**

**L-T-P-C (2-0-2-3)**

Fuels: Classification, Their merits and limitations Solid Fuels- Origin of coal, its types, properties, proximate and ultimate analysis, Storage and reserve in India. Coal Washing, Preparation and blending methods, application of coal. Coke making by beehive and byproduct ovens. Modern practices of coke making, Characterization of coke and coal. Selection of reductant fuel for BF, DRI, COREX, Cupola and Pit furnaces. Liquid and gaseous fuels- Types and uses of liquid and gaseous fuels. Flame characteristics. Burners for liquid, gas and pulverized coal. Synthesis and reformation of gas for direct reduction. Producer and water gas. Furnaces: Classification of Furnaces, Basic working principles of fuel fired, resistance, induction and arc furnaces. Energy conservation measures in furnaces. Advantages and disadvantages of various kind of furnaces. Refractories: Classification of refractories, Properties and application of fireclay, silica, chromite, graphite, magnesite, dolomite, zirconia, silicon carbide, silimanite and kyanite refractories.

Reference Books: 1. Gupta O.P., Elements of Fuels, Furnaces and Refractories, Khanna Publishers.

2. Gilchrist J.D., Fuels, Furnaces and Refractories, Pregamon.
3. Nandi D.N., Handbook of Refractories, Tata McGraw-Hill.
4. Norton F.H., Refractories, McGraw-Hill.

**MT-2104 Thermodynamics and Kinetics:**

**L-T-P-C (3-1-0-4)**

Basic concepts: Thermodynamic systems and processes, state and path functions, Extensive and Intensive properties, Internal Energy, First Law of Thermodynamics and 13 its applications in various metallurgical processes. Enthalpy, Heat capacity, Hess's Law, Kirchoff's Law, Second Law of Thermodynamics and Entropy. Entropy changes for various processes, Significance of sign change of entropy. Trouton's and Richard rules. Driving force of a chemical reaction, Combined statement of First and Second Law of Thermodynamics. Statistical concept of entropy. Free Energy and its Significance: Helmholtz and Gibbs free energy, Free energy change as a function of temperature. Concepts of standard state, Fugacity, Activity and Equilibrium constants. Gibbs- Helmholtz equation, Van't Hoff equation, Le Chatelier principle, Clausius- Clapeyron equation, Maxwell equation. Ellingham Diagram and its significance in metallurgical engineering., Third Law of Thermodynamics. Solution Thermodynamics: Solution, Mixture and Compounds, Raoult's Law, Ideal, Non ideal and Regular solutions and their thermodynamic properties, Free energy of mixing, excess and integral

quantities, Alpha function, Gibb's– Duhem equation and its integration. Dilute solutions, Henry's Law and Sivert's Law, Alternate standard states, Interaction coefficients. Kinetics: Basic concepts of reaction steps, rate of reactions, Order of reaction, Determination of order of reactions. Arrhenius equation in reaction kinetics, Mechanism of reaction and rate controlling steps, Activated complex and its thermodynamic and kinetic aspects, Effect of concentration and temperature on reaction kinetics. Kinetics of heterogeneous reactions.

- Reference Books: 1. Gaskell D.R., Introduction to Metallurgical Thermodynamics, McGraw-Hill.  
2. Darken L.S. and Gurry R.W., Physical Chemistry of Metals, McGraw-Hill.  
3. Upadhyaya G.S. and Dube R.K., Problems in Metallurgical Thermodynamics and Kinetics, Pergamon.  
4. Szekely J and Themelis N.J., Rate Phenomena in Process Metallurgy, Addison Wesley.  
5. Mohanty A.K., Rate Processes in Extractive Metallurgy, PHI.

**MT-2105 Principles of Extractive Metallurgy:**

**L-T-P-C (3-0-0-3)**

Introduction: Scope of extractive Metallurgy, Occurrence of Metals in Nature, Minerals and Ores, Elementary concepts of extraction of Metals from their ores. Ellingham diagrams for oxides and sulphides. Pyrometallurgy: Ore preparation, Calcination, Roasting, Predominance area diagram, Roasting practice, Reduction smelting, Matte smelting, Converting, Role of Slags. Refining Methods: Fire refining, Liquation, Poling, Cupellation, Vacuum distillation, Zone refining, Electrolytic refining. Hydrometallurgy: Ore preparation, Leaching practice, Bio leaching, Kinetics of leaching, Role of oxygen in leaching, Recovery of metals from leach liquor by solvent extraction, ion exchange, precipitation, cementation and electro winning methods. Electrometallurgy: Theory of electrodeposition, Faraday's Laws, Electrode potential, EMF series, Nernst equation, Hydrogen over voltage, Electro winning, Pourbaix diagram. Calculation of material and heat balances pertaining to some important metal extraction process.

- Reference Books: 1. Newton J., Extractive Metallurgy, Wiley.  
2. Gilchrist J.D., Extraction Metallurgy, Pergamon.  
3. Rosenqvist T., Principles of Extractive Metallurgy, McGraw Hill.  
4. Ray H.S. and Ghosh A., Principles of Extractive Metallurgy, New Age International

**SEMESTER IV**

**MT-2201 Numerical methods and its applications:**

**L-T-P-C (2-0-2-3)**

Errors in computation, instability, Non linear equation in one variable: Direct and Iterative methods, order of convergence, Iterative methods for systems of non linear equations. Linear system of equations, direct and iterative methods, rate of convergence of iterative methods, ill conditionedness of systems and condition numbers. Interpolation: Lagrange, Newton divided difference formula, Newton's interpolations, errors in interpolation, Gauss, Stirling, Bassels, Splines. Approximation: Least square and uniform approximations differentiation –differentiation using interpolation formulas Integration: Integration using interpolation, Newton-cotes formulas, Gauss quadrature

rules. . Ordinary Differential Equation: Taylor, Euler and Runge- kutta formula, Multi step methods. Computer implementation of various methods.

Reference Books: 1. Sastry S.S. Introductory Methods of Numerical Analysis.

2. Chapra S.C. and Canale R.P., Numerical Methods for Engineers, Tata McGraw Hill.

3. Hildebrand F.B., Introduction to Numerical Analysis, Tata McGraw Hill.

**MT-2202 Heat and Mass Transfer:**

**L-T-P-C (3-0-0-3)**

Conduction: Mechanism, Fourier's general conduction equation in 3D; 1D Steady state conduction with heat generation, Composite plane wall and cylinders, thermal resistance network, Critical thickness of insulation; extended surface heat transfer, 2D Steady state conduction , Solution for simple boundary condition, Unsteady heat conduction: lumped parameter system, semi infinite wall with convection boundary condition, Use of Heisler charts. Convection: Review of hydrodynamics equation of boundary layer theory .Convection boundary layers: Velocity and thermal boundary layers. Laminar boundary layer analysis on flat plate. Fully developed heat transfer through smooth pipe, Relation between fluid friction and heat transfer .Turbulent boundary layer, Forced convection correlations. free convection, laminar free convection on a vertical flat plate, empirical correlations. Boiling and Condensation: Mechanism, different regimes of boiling, boiling curves and correlation, laminar film condensation on a vertical plate. Heat exchangers: types, analysis, LMTD, effectiveness-NTU method. Radiation: Physical mechanism, Radiation properties, Black body radiation, Gray body, Special dependence of radiation properties, Kirchoff's Law, Wein's displacement Law. View factor; Radiation exchange between infiniteplanes and between gray bodies; Radiation shielding; re-radiating surface and 3- surface enclosures, network representation. Mass transfer: Fick's Law, Similarity with convection and correlations.

Reference Books: 1. Holman J.P., Heat Transfer.

2. Geankopolis C.J., Transport Process: Heat Mass & Momentum.

3. Welty J.R., Wicks C.E. & Wilson R.E., Fundamentals of Momentum, Heat & Mass Transfer.

**MT- 2203 Phase Equilibria in Materials system:**

**L-T-P-C (3-0-0-3)**

Introduction to thermodynamics of phase change: Equilibrium, phase stability ,evolution of phase diagrams, chemical potential gradient , Atomic model of diffusion, solid solution , Theories of alloying, Hume- Rothery rules, Single component systems, P-T diagrams, Allotropy. Free energy-composition diagram, Binary equilibrium diagrams, Gibbs phase rule , Tie line, Lever rule, Isomorphous , eutectic, eutectoid, monotectic, peritectic, peritectoid, Syntectic systems. Common alloy systems, Ceramic systems. Microstructure of plain carbon steels and cast irons. Complex phase diagram: Rule for construction of phase diagrams for complex system. Metastability, computation of phase diagrams. Ternary system: Ternary phase diagrams, representation, isothermal and vertical sections, Ternary isomorphous and eutectic systems, Tie lines, Gibb's triangle representation, Two phase, Three phase and four phase equilibrium, Experimental determination of phase diagrams. Microscopy, X-ray diffraction technique, Thermal analysis, Dilatometry, Electrical resistivity, Diffusion couples and Magnetic methods.



Reference Books:

1. Gordon P., Principles of Phase Diagrams in Materials Systems, McGraw Hill.
2. Prince A., Alloy Phase Equilibria, Elsevier.
3. Rhines F.N., Phase Diagrams in Metallurgy, McGraw Hill.
4. Hume- Rothery W., Christian J.W. and Pearson W.B., Metallurgical Equilibrium Diagrams, The Institute of Physics (London).

**MT-2204 Iron Making:**

**L-T-P-C (3-0-0-3)**

Raw Materials and their properties: Iron ore, flux , Agglomerates and coke. Preparation of ore: Sintering and palletizing, blast furnace burdening and distribution, testing of raw materials for B.F Design: B.F profile , Stove and gas cleaning units, instrumentation , refractory used in B.F and stove Reactions: Fe-C-O, Fe-O-H phase equilibrium, Reaction in stack, bosh and hearth, formation of primary slag , bosh slag and hearth slag . Slag composition and its control, Metal –slag reactions, control of hot metal composition Process Control: Factors affective fuel consumption and productivity, Recent development in B.F Operations like, Bell-less top charging system, High top pressure, Humified and oxygen enrichment of B.F and auxilliary fuel injections through tuyers. Irregularities in B.F Operations and their remedies. B.F Stoichiometry, mass and enthalpy balance, problems based on charge calculations. Alternate routes of Iron Making: Processes of sponge iron production. Coal based and gas based. Smelting reduction processes.

Reference Books: 1. Biswas A.K., Principles of Blast Furnace Iron Making, SBA.

2. Tupkary R.H., Introduction to Modern Iron Making, Khanna Publishers
3. Gupta S.S. and Chatterjee A., Blast Furnace Iron Making, SBA New Delhi.
4. Chatterjee A., Singh R. and Pandey B., Metallics for Steel Making- Production and Use, Allied Publishers.

**MT-2205 Physical Metallurgy- I:**

**L-T-P-C (3-0-2-4)**

Introduction, Crystal structure and crystal defects. Metallography: Metallurgical microscope, Specimen preparation, Techniques for microscopic observation. High temperature microscopy, Quantitative metallography. X- Ray crystallography: Fundamentals of crystallography, Reciprocal lattice, X- Ray diffraction, Bragg's Law. Lau, Powder and rotating crystal methods, Intensity calculations, Lorentz polarization, absorption, temperature, multiplicity factors. Application of x-ray diffraction to identification of Bravais lattices, calculation of lattice parameters, residual stresses and orientation determination. 17 Diffusion: Fick's first law of diffusion, self diffusion and interstitial diffusion in alloys, diffusion mechanisms, activation energy. Fick's second law of diffusion & its solution. Applications. Boltzman- Matano analysis, kirkendall effect. Darken analysis.

Reference Books: 1. Reed Hill R.E., Physical Metallurgy Principles, Affiliated East West Press.

2. Azaroff L.A., Introduction to Solids, Tata McGraw Hill.
3. Barret C.S. & Massalski T.B., Structure of Metals, Pergamon.
4. Cullity B.D. Elements of X-Ray Diffraction, Addition-Wesley.
5. Smallman R.E. & Ashbee K.H.G., Modern Metallography, Pergamon.

6. Gifkins R.C., Optical Microscopy of Metals, Pitman.

**MT-2206: Mechanical behavior of Materials:**

**L-T-P-C (3-1-0-4)**

Theory of elasticity and plasticity, Generalised Hooke's law, stress-strain relationship. Mechanism and crystallography of slip and twinning. Concept of critical resolved shear stress. Deformation of single crystals and polycrystals. Hall –Petch relationship. Dislocation Theory: Type of dislocations, Their geometrical and elastic properties, Movement and multiplication of dislocations, Dislocation intersection and reactions. Partial dislocations and stacking faults. Application of dislocation theory to strengthening mechanism and yield point. Strain ageing and work hardening phenomena. Effect of strain rate and temperature on flow properties. Creep: Generation and analysis of creep and rupture data. Dislocation and diffusion mechanisms of creep. Grain boundary sliding and migration. Deformation mechanism maps. Effect of metallurgical and test variation on creep and fracture. Superplasticity. Parametric methods for prediction of long time properties. Fatigue :Fatigue testing methods and machines. Stress controlled and strain controlled fatigue. Analysis of cyclic stress – strain data. Mechanism of fatigue crack, nucleation and propagation. Fracture: Mode and mechanism of fracture, Griffith's theory, Ductile to brittle transition. Transition temperature phenomena, Factors affecting transition temperature, Fracture mechanism, strain energy release rate, stress intensity factor, plane strain fracture, toughness, Design approach. Fracture and fatigue of composites. Fractographic aspects of failure. Environment assisted fracture.

Reference Books: 1. Dieter G.E., Mechanical Metallurgy, McGraw Hill.

2. Hertzberg R.W., Deformation and Fracture Mechanics of Engineering Materials, John Wiley.

3. Hull D., Introduction to Dislocations, Pergamon.

4. Meyers M.A. and Chawla K.K., Mechanical Behaviour of Materials, PHI.

**SEMESTER V**

**MT-3101 Steel Making:**

**L-T-P-C (3-0-0-3)**

Introduction: Principles of steel making reactions, viz decarburization, dephosphorization, desulphurization, silicon & manganese reaction. Slag Theories: Molecular & 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. Chemical reactions involved, Temperature and residual bath oxygen control. Use of oxygen sensor, some characteristics of L.D blow viz emulsion formation, slopping, maneuvering lance height for dephosphorisation and decarburisation. Catch carbon technique, Recovery of waste heat, OBM/Q-BOP process, Concept and operation of the process. Mixed/ Combined blowing process. Oxygen top blowing with inert gas purging at bottom, Oxygen top blowing with inert and oxidizing gases at bottom, Oxygen top and bottom blowing, Steel making Scenario in India. Open hearth Furnace: 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 furnaces and its effect on performance. UHP electric arc furnace with DC supply. Duplex processes of stainless steel making using VOD, AOD and CLU. Induction Furnace: Advantages,

Principles of induction heating, Use in steel industry. Deoxidation of liquid steel: Requirement of deoxidizers, deoxidation practice, Stoke's law, use of complex deoxidizers, Inclusions and their influence on quality of steel. Killed, semi killed and rimming steels. Secondary refining of steels: Objectives, principles 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.

Reference Books: 1. Tupkary R.H., An Introduction to Modern Steel Making, Khanna Publishers.

2. G.R. Bashforth, The Manufacture of Iron and Steel, Chapman & Hall.

3. Schrewe H.F. Continuous Casting of Steel, Stahl-eisen.

4. Edneral F.P., Electrometallurgy of Steel and Ferroalloys, Vol. 1&2, Mir.

### **MT-3102 Physical Metallurgy- II:**

**L-T-P-C (3-1-0-4)**

Theory of solidification: Nucleation and growth, mechanism of nucleation and driving force for growth. Morphology, Zone refining, crystal growth, crystallography, stabilization, Recovery, recrystallisation and grain growth. Annihilation of point imperfections, order disorder transformation, eutectoidal reaction, cellular reaction. Strengthening mechanisms, massive and spinodal decomposition. Mechanism and kinetics of precipitation of age hardenable alloys. Fe- C system: Effects of alloying elements, Formation of Austenite, Decomposition of Austenite, Pearlitic, Bainitic and Martensitic phase transformations, TTT and CCT diagrams, Hardenability, Critical diameter, Jominy end quench Test, Tempering of steel, Temper brittleness, Thermomechanical Treatment, , Ausforming, Maraging steels, Processing- structure property relationship in multiphase alloys, Rapid solidification processing, Metallic Glasses, Single crystal processing. Nano crystalline materials.

Reference Books: 1. Reedhill R.E., Physical Metallurgy Principles, Affiliated East West Press.

2. Avner S.H., Introduction to Physical Metallurgy, Tata McGraw Hill.

3. Porter D.A. & Easterling K.E., Phase Transformations in Metals and Alloys.

4. Clarke & Varney, Introduction to Physical Metallurgy.

### **MT-3103 Welding Metallurgy**

**L-T-P-C (2-0-2-3)**

Welding Metallurgy: Introduction to various welding processes (in brief) Chemical reactions in welding: Gas- Metal reactions, Slag- Metal reactions, Effect of gaseous inclusions in weld metal. Fusion Zone: Basic solidification concepts, Weld metal solidification, Post solidification phase transformations, Weld metal chemical inhomogeneity. Partially melted zone: Formation of partially melted zone, Difficulty associated with the partially melted zone. Heat affected zone: Recrystallisation and grain growth in welding, Effect of welding parameters and process. Weldability of common engineering materials like carbon and alloy steels, cast irons, stainless steels, Al- and Cu-based alloys, Welding defects and its remedies.

Reference Books: 1. Lancaster, J.F, Metallurgy of welding, Allen and Unwin.

**MT-3104 Foundry Technology:****L-T-P-C (3-0-2-4)**

Design and process selection in metal casting, Foundry processes 20 Patterns: materials and design, features of moulding processes, equipments, mechanizations, forces acting on moulds, mould factors in metal flow, molding factors in casting design. Different types of binders and their uses in mould and core makings. Melting of metals and alloys for castings: Brief mention of various melting units, melting & post melting treatments, melting practices as adopted for a few metals and alloys such as Cu, Al, Steel, Cast irons. Solidification of metals and alloys: Nucleation, growth, role of alloy constitutions, thermal conditions and inherent nucleation and growth conditions in the liquid melt, significance & practical control of cast structure. Principles of Gating and Riser: Feeding characteristics of alloys, types of gates and risers. Time of solidification and Chvorinov rule, wlodawer system for feeder head calculations, gating ratio, concept of directionality in solidification. Yield of casting and prescription for its augmentation. Special casting methods: Investment casting, Die casting, centrifugal casting, Full mold casting, vacuum sealed casting. Thixo and Rheo casting, strip casting, near net shape casting. Development in modern casting processes. Casting defects: A detailed analysis of casting defects, their causes and prescription of remedial measures.

Reference Books: 1. Heine R.W., Lopper C.R. & Rosenthal P.C., Principles of Metal Casting, McGraw Hill.

2. Davis, G.J., Solidification in Casting, Applied Sciences.

3. Beeley P.R., Foundry Technology, Butterworth.

4. Kondic V., Metallurgical Principles of Foundry, Edward Arnold.

**MT-3105 Powder Metallurgy****L-T-P-C (2-0-2-3)**

Introduction, Metal powder production methods. Characterization of Powders: Composition & their structure, particle size & shape determination, treatment of metal powders. Powder flow, Compressibility and porosity measurements. Behavior of powder during compaction, Die compaction, Types of presses, Tooling & Design. Modern methods of powder consolidation, Isostatic pressing, Roll compaction, powder extrusion & forging, slip casting. Sintering of powders & evaluation of sintered products. Sintering theories, solid and liquid phase sintering, applications of sintered products.

Reference Books: 1. Randal G., Powder Metallurgy, John Wiley.

2. Metal Powder Handbook, ASM.

**MT- 3106 Mechanical properties of materials & its evaluation:****L-T-P-C (3-0-2-4)**

Principles involved in: Hardness Test: Types of Hardness Test, Brinell hardness, Analysis of indentation, Relationship between Hardness and the Flow Curve; Vicker's Hardness, Rockwell Hardness, Micro and Nano hardness tests, Hardness Conversion Relationship; Hardness at elevated Temperature. Tensile Test: Specimen Geometry, Engineering and True Stress-Strain Curves, Evaluation of Tensile Properties, Strain Hardening and Plastic Instability. Testing Machines, Strain

and Load Measuring Devices, Temperature and Strain Rate Effects. Torsion Test: Mechanical Properties in Torsion, Torsional Stresses for Large Plastic Strains, Types of Torsion Failure, Tension Test Vs. Torsion Test, Hot Torsion Testing. Impact Test: Notched Bar Impact Tests, Instrumented Charpy Test, Significance of Transition Temperature Curve, Metallurgical Factors affecting Transition Temperature Fracture Toughness Test: Strain Energy Release Rate, Stress Intensity Factor, Fracture Toughness and Design, KIC Plane Strain Toughness Testing, Plasticity Corrections. Creep Test: Creep Curve, Stress Rupture Test, Structural Changes During Creep, Mechanism of Creep, Fracture at Elevated Temperatures, Prediction of Long Time Properties. Fatigue Test: S-N Curve, Cyclic stress strain Curve, Low Cycle Fatigue, Effect of Stress concentration on Fatigue, Effect of Metallurgical Variables on Fatigue. Unusual properties of ceramics, testing of ceramics. Non destructive testing of materials.

- Reference Books: 1. Dieter G.E., Mechanical Metallurgy, Tata McGraw Hill.  
2. Patratia Han (ed), Tensile Testing, ASM.  
3. Boyer H.E. (ed), Hardness Testing, ASM.  
4. Metals Handbook, 9th edition Vol. 8, Mechanical Testing, ASM.  
5. Halmsaw R., Non Destructive Testing, Gordon & Breach

#### **SEMESTER VI**

##### **MT-3201 Metal Forming Technology:**

**L-T-P-C (2-0-2-3)**

Classification of metal forming processes, hot, cold and warm working. Flow curve for materials, effect of temperature, Strain rate and microstructural variables, residual stresses, experimental techniques, yielding theories, processing maps. Friction in metal working, Lubrication. Rolling of Metals: Classification of rolled products, Types of rolling mills, Terminology used; Forces and Geometrical relationships in rolling, Rolling variables, Theories of design, Mill type, Lay out and rolling practice, adopted for some common products such as slabs, blooms, billets, plates, sheets etc., Rolling defects and their control. Forging of Metals: Forging principles, Type of Forgings and equipment needed; Calculation of Forging load under sticking and slipping Plain strain forging analysis, friction conditions. Manufacture of rail wheels and tyres. Forging defects and their control. Extrusion: Types, Principles and equipments, Variables in extrusion, deformation in extrusion, Calculation of extrusion pressure under plain strain conditions, extrusion defects, production of tubes and seamless pipes. Wire drawing: Drawing of rods, wire and tubes, Calculation of drawing loads, drawing defects. Sheet metal forming: Forming methods such as bending, stretch forming, shearing, blanking, deep drawing and redrawing. Formability diagrams, Defects in formed products. Special forming methods such as high energy forming: explosive forming, electrohydraulic and magnetic forming processes.

- Reference Books: 1. Dieter G.E., Mechanical Metallurgy, McGraw Hill.  
2. Harris J.N., Mechanical Working of Metals- Theory and Practice, Pergamon.  
3. Kalpakjian S. and Schmid S.R., Manufacturing Processes for Engineering Materials, Pearson.

##### **MT-3202 Corrosion Science and Engineering:**

**L-T-P-C (3-0-2-4)**

Introduction, Importance of Corrosion, Economics of corrosion. Electrochemical and thermodynamic principles, Nernst equation and electrode potentials of metals. EMF and Galvanic series, Merits and demerits; Origin of Pourbaix diagram and its importance. Exchange current density, Polarisation, Concentration, Activation and Resistance, Tafel equation; Passivity, Electrochemical behaviour of active/ passive metals, Flade potential, Theories of passivity. Atmospheric, Pitting, Dealloying, Stress corrosion cracking, intergranular corrosion, Corrosion fatigue, Fretting corrosion and high temperature oxidation, Causes and remedial measures. Purpose of testing, laboratory, semi plant and field tests, susceptibility tests for IGC, stress corrosion cracking and pitting, sequential procedure for laboratory and onsite corrosion investigations, corrosion auditing and corrosion map of India. Corrosion prevention by design improvements, anodic and cathodic protection, metallic, non metallic and inorganic coatings, Mechanical and chemical methods, Various corrosion inhibitors.

Reference Books:

1. Fontana M.C., Corrosion Engineering, McGraw Hill.
2. Glasstone S., An Introduction to Electrochemistry, Van Nostrand.
3. Narain S. and Saran R., An Introduction to Electrometallurgy, Standard Publishers.
4. Scully J.C., The Fundamentals of Corrosion, Pergamon.

**MT-3203 Extraction of Non Ferrous Metals:**

**L-T-P-C (3-0-0-3)**

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. Aluminum: Bayer's process and factors affecting its operation, Hall- Heroult process: Principle and practices, anode effect, refining of aluminum. Alternate methods of production of alumina and aluminum. Copper: Roasting of sulphides, Matte smelting, Converting; Refining, Byproducts recovery; Recent developments, Continuous copper production processes, Hydrometallurgy of Copper. Zinc: Pyrometallurgy of Zinc; Principle and practices of roasting; sintering and smelting; Hydrometallurgy of Zinc. Lead: Agglomeration of galena concentrates and roasting, blast furnace smelting, refining of lead bullion. 24 Uranium: Process for the digestion of uranium ores; Purification of crude salts; Production of reactor grade UO<sub>2</sub>. Titanium: Methods of upgrading Ilmenite; Chlorination of Titania, Kroll and Hunter processes; Consolidation and refining. Other Metals: Simplified flow sheets and relevant chemical principles of extraction of Ni, Mg, Au, Ag, Sn, Zr.

Reference Books:

1. Ray H.S., Sridhar R. & Abraham K.P., Extraction of Non Ferrous Metals, Affiliated East West.
2. Biswas A.K. & Davenport W.G., Extractive Metallurgy of Copper, Pergamon.
3. Zelikman A.N., Krein O.E. & Samsonov G.V., Metallurgy of Rare Metals, Israel Program for Scientific Translation.
4. Burkhin A.R. (ed), Production of Al & Al<sub>2</sub>O<sub>3</sub>, Wiley.

**MT-3204 Heat treatment Technology:****L-T-P-C (3-0-2-4)**

Objectives and variables involved in heat treatment. Role of alloying elements including microalloying. Decomposition of Austenite, Pearlitic, Bainitic and Martensitic transformations. Limitations of Fe- C diagram. TTT and CCT diagrams. Annealing: (Full, Homogenising, spheroidisation and stress relieving), Normalising, Comparison of annealing and normalizing. Hardening: Objectives, Volume and surface hardening, Austenitising temperature and internal stresses, Quenching medium and methods, Retained austenite and defects in hardening. Tempering of steels, Aims and stages of tempering, Tempering of alloy steels and multiple tempering. Thermomechanical treatment of steels, Principles and practices. Ausforming and isoforming; Heat treatment of alloy steel castings and forgings. Heat treatment of cast iron, malleable cast iron and S.G iron. Heat treatment of general engineering steels: Stainless steel, Hadfield steel, Spring steels, Bearing steels, Tool steels, HSLA steels, Maraging steels and dual phase steels. Heat treatment of Non ferrous metals and alloys, Brasses, Bronzes, Al and Mg - alloys. Heat treatment defects and their rectification. Advances in heat treatment technology.

Reference Books: 1. Reed Hill R.E., Physical Metallurgy Principles, Affiliated East West.

2. Sharma R.C., Principles of Heat Treatment of Steels, New Age International.

3. Sinha A.K., Physical Metallurgy Handbook, McGraw Hill.

4. Singh V., Heat Treatment of Metals, Standard Publishers.

5. Brooks C.R., Heat Treatment, Structure and Properties of Non Ferrous Alloys, ASM. 25

**MT-3205 Characterization of Materials:****L-T-P-C (3-0-2-4)**

Scanning electron microscope, Modes of operation, Study of surface topography and elemental composition analysis, Electron probe analysis (EPMA/ EDX) and Auger spectroscopy. Transmission electron microscopy, Imaging and different modes, bright and dark field imaging, selected area diffraction, specimen preparation techniques. Advanced microscopic techniques: AFM Thermal characterization techniques: Theory, TGA, Instrumentation, applications. DTA, Apparatus, methodology, applications; DSC, applications, Dilatometer. Chemical characterization techniques: Principle underlying techniques, Infrared spectroscopy, Emission spectroscopy, Chromatography techniques. Resistivity and Magnetic measurements. Structure- Property co-relationship.

Reference Books: 1. Cullity B.D., Elements of X-Ray Diffraction, Addition Wesley.

2. Shridhar G., Ghosh C.S. and Goswami N.G., Materials Characterization Techniques. (ed), NML Jamshedpur.

3. Williams, D.B. & Carter C.B. , Transmission Electron Microscopy: A Text Book of Materials science.

4. Krishna, R., Ananthraman T.R., Pande C.S., Arora, O.P., Advanced Techniques for Microstructural Characterization (ed), Trans Tech Publication

## **SEMESTER VII**

### **MT-4101 Composite Materials:**

**L-T-P-C (3-0-0-3)**

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 fibers in a matrix. Discontinuous and particulate reinforcement. Fibers and Resin materials. Rule of mixtures, critical fiber length, Short and continuous fibers, Fiber orientations; Matrix and reinforcement materials, Polymeric matrices, Metallic matrices, Ceramic matrices, Particulates, flakes, whiskers, Fibers: Glass, aramid, alumina, silicon carbide. Nature and Manufacture of Glass, Carbon and aramid fibers. Review of the principal thermosetting and thermoplastic polymer matrix systems for composites. Polymer matrix composites, CFRP and carbon- carbon composites; Types, Manufacturing, processing methods, Interfaces, Properties, Applications. Toughening mechanisms, Fiber forms, Prepregs, The role of interface. The nature of fiber surfaces, Wetting and adhesion, Strength, stiffness, fracture toughness and toughening mechanism of composites, strength of unidirectional composites. Application of fracture mechanics to composite materials. Synthesis and properties of nano composites.

Reference Books:

1. Chawla, Composite Materials Science and Engineering, Springer.
2. Hull, An Introduction to Composite Materials, Cambridge.
3. Mathews and Rawlings, Composite Materials: Engineering and Science, Chapman and Hall.

### **MT-4102 Environment & Pollution Control in Iron & Steel Industry:**

**L-T-P-C(2-0-2-0)**

Various types of solid, liquid and gaseous pollutants and their harmful effects; Environmental impact assessment in metallurgical Industries; Pollutant emissions from integrated iron and steel plants, Sponge iron plants, coal washeries. Environmental aspects of coal and metal mines; Management of solid, liquid and gas wastes generated during iron and steel making operations; Environmental audit; Preventive measures to reduce atmospheric pollution from these industries; scope of alternative energy sources to combat pollution from metallurgical industries. Environmental legislation related to metallurgical industries.

Reference Books:

1. Pandey, G.N, A Text book for energy system engineering, Vikas publishing
2. Rao, C.S, Environmental pollution control Engineering, Wiley Eastern Limited
3. Ray, H.S et al (ed), Energy and the mineral and metallurgical industries, Allied publishers
4. Nathanson, J.A, Basic environmental Technology, Prentice Hall 27

### **MT-4103 Industrial Engineering and Management:**

**L-T-P-C (2-0-0-2)**

Factory Planning: Types of industrial organizations, organizational structures. Management functions and concepts. Plant location and layout. Financial Management: Functions, Relevance of fixed and working capital, Elements of cost, Depreciation, Break even analysis, Budget and budgetary control. Production Management: Production and productivity, productions, planning & control, sales fare



casting, Inventory control. Project Management: Elementary concepts of operation research, networking, CPM & PERT. Concepts of quality control, statistical quality control, quality circles and total quality management, ISO standards. Personnel Management: Leadership & motivation work study, time and motion, wages and incentives. Management information system: Aims, Characteristics, Designs and implementation. Entrepreneurship: Relevance and benefit, Essential qualities of Entrepreneur, preparation of prefect report, feasibility study, Market survey, Agencies available for financial and technical assistance.

Reference Books: 1. Bangra T.R. & Sharma S.C., Industrial Organization and Engineering Economics, Khanna Publishers.

2. Khanna O.P. Industrial engineering and Management, Dhanpat Rai & Sons.

3. Gupta C.B. & Shrinivasan N.P., Entrepreneurial Development, S.Chand & Sons.

4. Shrinath L.S. PERT and CPM- Principles and Application, Affiliated East West.

### **MT-4104 Engineering Economics**

**L-T-P-C (2-0-0-2)**

Definition, nature and scope of the subject, central problems of economic science, micro economics. Theory of production: law of returns, marginal productivity theory, determination of optimum input levels under cost or output restriction, expansion path, long run and short run function, supply functions and elasticity of supply. Theory of consumer behaviour: Determination of optimum levels of consumption. Income- consumption curve, derivation of demand function, elasticity of demand and slutsky's equation. Perfect competition and pricing of output. Market imperfections and the determination of equilibrium price and output. Classical and Keynesian theories of income employment and output. Multiplier and accelerator. Consumption function, capital budgeting. Theories of inflation, methods of credit control, fiscal policy and full employment. Cyclical fluctuations.

Reference Books: 1. Banga, T.R and Sharma, S.C, Industrial organization and Engineering Economics, Khanna Publishers.

2. Khanna, O.P, Industrial Engineering and Management, Dhanpat Rai and Sons

### **SEMESTER -VIII**

#### **MT-4201 Organisational behavior and Industrial Psychology:**

**L-T-P-C (3-0-0-3)**

Scope of scientific psychology & industrial psychology, Basis process, perception. Training & Learning: Human variables, selection and placement: Intelligence, MA & IQ measurement. Personality: Development, Approaches, Assessment, tests, selection and placement, job analysis, interviewing, psychological test, decision making process, motivation and work; Needs: Hierarchy of needs, leadership, supervision. 28 Ergonomics: Three process, work space & human factors in job design. Working environment, noise, atmospheric conditions and illumination.

Reference Books: 1. Parrek U., Understanding Organizational Behavior.

2. Robbins S., Organizational Behavior.

3. Luthans F., Organizational Behavior.

4. Prasad L.M., Organizational Behavior, S. Chand.

**MT-3232 Methoding of Castings:**

Principles of casting design, pattern design considerations, pattern allowances, pattern design and construction. Design of different types of cores and core prints Fundamentals of fluid flow, design of gating system, slag traps and filters etc. Directional and progressive solidification, differential methods of feeder design, feeding distance, feeding efficiency, feeder aids.

Reference Books: 1. Heine R.W., Lopper C.R. & Rosenthal P.C., Principles of Metal Casting, McGraw Hill.

2. Davis, G.J., Solidification in Casting, Applied Sciences.
3. Beeley P.R., Foundry Technology, Butterworth.
4. Kondic V., Metallurgical Principles of Foundry, Edward Arnold.

**MT- 3232 Materials Handling:**

Objectives of material handling systems, material handling engineering survey, basic features of handling, types of material handling systems, various material handling considerations including combined handling, space for movements, analysis of handling methods, economical and technical considerations of handling equipments, cost analysis of material handling systems. Material handling equipments, types of material handling equipment; selection and maintenance of material handling equipments used in foundries, forging machinery and assembly shops. Lifting and lowering devices, Conveying devices; Design of belt conveyers, Use of limit switches and Micro processors, Programmable logic controllers; Automation in Foundries; Use of robots; Kinematics of industrial robots. Amount of equipments required and predicting in process inventory by graphical technique. Procedures for travel charting, numerical problems in optimum arrangement of various departments and shops under given constraints and to check their effectiveness.

Reference Books: 1. Plant Layout and design, Moore

2. Plant Layout and Material handling, Apple
3. Plant Layout, Shubhin
4. Construction management, Verma, M.

**MT-3233 Failure Analysis:**

Types of failure and techniques for failure analysis Failure data retrieval, Procedure steps for investigation of a failure for failure analysis. Failure analysis methodology, Tools and Techniques of Failure analysis. . Reliability concept and hazard function, life prediction, condition monitoring, application of Poisson, Exponential and Weibull distributions for reliability, bath tub curve, parallel and series system, mean time between failures & life testing. Some case studies of failure analysis. Introduction to quality management, concept of ISO 9000, ISO 14000, QS 9000; Inspection; Inspection by sampling.

Reference Books: 1. Metals Handbook, Failure Analysis and Prevention, Vol.10 ASM.

2. Colangelo V.J. & Heiser F.A., Analysis of Metallurgical Failures, John Wiley.

### **MT-3234 Advanced Materials:**

Processing of Advanced materials: Super plastic, spray forming, rapid solidification. Materials selection and design Nanostructures, Nano materials, Nano composites. Bio materials: Metallic bio materials like 316L stainless steel, Co-Cr alloys, Ti6 Al4V, ceramic bio materials like Alumina, Zirconia, carbon hydroxyapatite, polymeric bio materials like ultra high molecular weight polyethylene, polyurethane. Smart Materials: Piezo electric materials, shape memory alloys and shape memory polymers. High performance alloys: Nickel super alloys, Ti-alloys, Al-Li alloys, Haste alloy, Inconel, Monel, Nitronic, Co-based alloys and commercially available pure Ni-alloys. Nuclear Materials: Materials for nuclear reactors such as fuels, moderators, control rods, coolants, reflectors and structural materials. Fabrication of fuel and cladding materials.

Reference Books: 1. Gandhi M.V., Thompson B.S., Smart Materials and Structures, Chapman and Hall.

2. Ray A.K. (ed), Advanced Materials, Allied Publishers.

3. Rama Rao P. (ed), Advances in Materials and Their Applications, Wiley Eastern Ltd. 4. Bhushan B., Nano Technology (ed), Springer

### **MT-3235 Surface Engineering:**

Introduction: Material surfaces and their importance in tribology. Surface modification processes: Case hardening, Shot peening, Chemical vapor deposition, Physical vapor deposition, Thermal barrier coatings, Plasma deposition, Sputter coating, Laser processing, Ion implantation, Electro and electroless plating processes, Surface cleaning and finishing processes, Testing and evaluation of surface coatings. Friction: Fundamentals, Types and measurement of solid, liquid and gaseous friction. Friction heat and calculation. Wear: Modes of adhesive, abrasive, erosive, fretting, Corrosive, erosive- corrosive, sliding, rolling, impact and lamination wear, Worn surface topography, debris analysis and wear mechanism maps. Lubrication: Lubricants and additives, mechanism of solid, liquid and gaseous lubricants. Mode of friction and wear: Al- Si, Ti- alloys, Cemented carbides and metal, polymer and ceramic matrix composites. Friction and wear: Sliding bearings, Pistons, Cylinders, Brakes, Cutting Tools, Dies, Electrical contacts.

Reference Books: 1. Sarkar, A.D., Wear of Metals, Pergamon

2. Rabinowicz, E., Friction and Wear of Materials, Wiley

3. Hand book, Friction, Lubrication and Wear Technology, Vol. 18, ASM

4. Surface treatments for protection, Series3, No. 10, , The institute of metallurgist series.

### **MT-3236 Non Metallic Materials**

Introduction: Definition and classification of materials, comparison of properties of metals and nonmetallic materials. Nature of bonding. Ceramics : Structure, defects. Ionic and semiconducting behavior. Processing techniques. Glasses and glass-ceramics, glass fibres. Structural ceramics: fracture toughness, toughening mechanisms. Special ceramics: Electro-optic, dielectric, ferroelectric,

piezoelectric, magnetic, superconducting, laser and dilute magnetic and bio-ceramics. Polymers : Structure, properties and applications of thermoplastics and thermosets. Conducting and biopolymers. Biomaterials: Introduction to biomaterials, Structure and properties of biomaterials. Different types of biomaterials. Preparation methods. Physical Characterization. Cell biomaterial interactions. Applications.

READINGS 4.1 TEXTBOOKS:: 1. W.D.S. Kingrey: Introduction to Ceramics, John Wiley.

2. W.S. Smith: Principles of Materials Science and Engineering, McGraw-Hill.

3. V. Raghavan: Materials Science and Engineering, Prentice-Hall.

4. Robert J. Young, Peter A. Lovell: Introduction to Polymers, Third Edition

5. Biomaterials: A Nano Approach, S. Ramakrishna, M. Ramalingam, T.S.S. Kumar, W. O. Soboyejo, CRC Press, Taylor and Francis Group, 2010.

## **Elective – II**

L-T-P-C (2-0-2-3)

### **MT-4141 Modern NDT:**

Review of conventional methods of non destructive testing. Acoustic emission inspection: Types, basic concepts, instrumentation and read out, signal description, background noise, inspection of pressure vessels, flaw location, inspection of wire ropes, welds, ceramic materials, composite materials. Leak Testing: Visible indications, electronic indications, basic methods of leakage measurements, characteristics of gaseous tracers in leak testing, reference standards. Calibration of standard reference leaks, safety aspects of leak testing. Thermography: Contact and non contact inspection methods, heat sensitive paints and papers; thermally quenched phosphors liquid crystals, techniques for applying liquid crystals, calibration and sensitivity; other temperature sensitive coatings; non- contact thermographic inspection- advantages and limitations, infrared radiation and infrared detectors. Instrumentation and methods, applications. Optical holography: Laser fundamentals, holography, recording and reconstruction, holographic interferometry, real time, double exposure and time averaged techniques, holographic NDT, methods of stressing and fringe analysis, typical applications, advantages and limitations. Acoustical holography: Liquid surface acoustical holography, optical system, object size and shape, sensitivity and resolution, commercial liquid surface equipment; scanning acoustical holography, reconstruction, object size, sensitivity and resolution, commercial scanning equipment, read out methods, calibration, interpretation of results, applications, inspection of welds in thick materials. Stress analysis: Polariscope, calibration of photoelastic materials, isochromatic and isoclinical fringes, stress determination, time edge effects, Moire fringes techniques, photo elasticity, strain gauges, X- ray residual stress analysis. Magnetic resonance imaging: Magnetic resonance phenomena, chemical shift, relaxation phenomena, back projection imaging, practical consideration of experimental set up, magnetic resonance imaging systems, applications. Acceptance standards.

Reference Books: 1. Miller, R and Paul, M; Non destructive testing handbook; Acoustic emission testing, Vol 5, American society for non destructive testing, 1987.

2. Spanner, J.C; Acoustic emission techniques and applications., Latex publishing, 1974

3. American Society for Metals, Non destructive inspection and quality control; Metals handbook, Vol 11, 8th edition.

4. ASM handbook, Non destructive testing and quality control, Vol. 17.

**MT-4142 Instrumentation and Control:**

**L-T-P-C (2-0-0-2)**

Generalized measurement systems. Basic standards; static and dynamic measurements; measurement of temperature, pressure, velocity, force strain, vibration and acceleration by transducers. Role of transducers in automatic control systems, Feed back systems and their characteristics. P.I.D. controllers; Response characteristics and compensation of electrical, hydraulic and pneumatic systems.

**MT-4143 Computer applications in Metallurgy**

Numerical methods for solution of ordinary differential equations. Application of regression analysis and curve fitting techniques.

Calculation of phase diagrams, stereographic projections. Computer applications for energy & material balance in B.F. and BOF Steel making processes.

Numerical solution of partial differential equations pertinent to heat, mass & momentum transfer. Computer applications in solidification, potential energy diagrams and experiments in metallurgy. Analysis of test data using softwares.

Reference Books:

1. Chapra S.C. and Canale S.C., Numerical Methods for Engineers, Tata McGraw Hill.

2. Szekley J.S., Evans J.W. and Brimakombe J.K., The Mathematical and Physical Modeling of Primary Metals Processing Operations, Wiley.

**MT-4144 Physics of Metals:**

**L-T-P-C**

**(2-0-0-2)**

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 transformations: Ordering, Degrees of long range and short range ordering, Anti phase domain, super lattice, Elements of super lattice theories, properties and applications.

alloy phases; Conductors and insulators, semi conductors, P- and N- type semi conductors.

Magnetic Properties: Dia, Para and Ferro- magnetism, Domain theory of Ferro magnetism, Anti ferromagnetism and Ferrites, Hysteresis loop, soft magnetic materials, Hard magnetic Materials, Super conductivity, BCS theory, Type- I and Type- II super conductors.

Elements of X-ray diffraction: X- Ray, Bragg's Law, Lau, Rotating crystal and powder methods, structure determinations with the help of X-Ray. Stereographic Projections.

Reference Books:

1. Reed Hill R.E., Physical Metallurgy Principles, Affiliated East West.

2. Kakani S.L. and Kakani A., Materials Science, New Age International.

3. Higgins R.A., Engineering Metallurgy, Standard Publishers.

4. Raghavan V., Materials Science and Engineering, PHI.

### **MT-4145 Fracture Mechanics**

Griffith's crack theory, stress intensity factor, stress analysis of cracks, strain energy release rate, Derivation of relationship between strain energy release rate and stress intensity factor, crack tip plastic zone, Dugdale's plastic strip model. Fracture mode transition: Plane stress vs. plane strain, crack opening displacement, plane strain fracture toughness (K<sub>IC</sub>) testing, Fracture toughness determination with elastic plastic analysis (JIC), concept of R-curve and Fracture toughness measurement using it, Microstructural aspect of fracture toughness, optimizing microstructure and alloy cleanliness to enhance fracture toughness. Fatigue stress life approach, Basquin's equation, Fatigue strain life approach, Low cycle fatigue, Coffin-Manson's equation, Fatigue total strain life relation, Fatigue life prediction, Neuber's analysis for notched specimens, Fatigue crack growth rate, Paris law, fatigue life calculation using this approach. Mechanism of fatigue crack nucleation and propagation, factors affecting fatigue crack growth rate, influence of load interaction, short fatigue crack; stress corrosion cracking and K<sub>Isc</sub> determination. Corrosion fatigue, temper embrittlement, hydrogen embrittlement, liquid metal embrittlement, neutron embrittlement

Reference Books: 1. Hertzberg, R.W., Deformation and fracture mechanics of engineering materials, John Wiley.

2. Dieter, G.E., Mechanical Metallurgy, McGraw Hill

3. Metal Hand book, Failure analysis and prevention (Volume- XI), ASM Pub.

4. Metal Hand book, Fractography (Volume- XII), ASM Pub

### **MT-4146 Modelling and Simulation In Metallurgy**

Modelling: Classification, functions, limitations and interrelationship of different types of models. Types and development of mathematical models. Development of rigorous and semirigorous physical models. Multi-scale modelling of materials. Phase-field methods for modelling solidification microstructures of metals and alloys.

Simulation: Survey of simulation techniques. Molecular dynamics and Monte-Carlo simulations. Fuzzy logic, neural networks and genetic algorithms.

Applications: Computation of phase diagrams using solution models and Monte-Carlo simulations. Modelling of blast furnace operations, steel making processes and materials processing.

#### **READINGS 4.1 TEXTBOOKS::**

1. J.S. Szekely, J.W. Evans and J.K. Brimacombe: The Mathematical and Physical Modelling of Primary Metals Processing Operations, Wiley.

2. D. Mazumdar and J.W. Evans: Modelling of Steel Making Processes, CRC.

3. N. Provatas and K. Elder: Phase-field Methods in Materials Science and Engineering, Wiley-VCH.

4. S. Rajasekaran, G.A.V. Pai: Neural networks, Fuzzy Logic and Genetic Algorithms Synthesis and Applications, Prentice-Hall of India

**MT-4151 Secondary steel making:**

Objectives and techniques adopted in secondary steel making. Vacuum degassing processes: ladle degassing processes (VOD, VAD), Steam degassing processes, circulation degassing processes (RH, DH), Inert gas purging, ladle furnace etc. Role of slag and powders in inclusion control: Desulphurization, Dephosphorisation. Modification of inclusion morphologies, production of ultra low carbon, ultra low sulphur, ultra low phosphorus and inclusion free steels. Powder injection systems. Production of alloy steel through post solidification treatments (VAR, ESR); Refractories used in secondary steel making furnaces, their properties and selection criteria. Process selection in secondary steel making.

- Reference Books: 1. Ghosh A., Secondary Steelmaking- principle & Applications, CRC Press.  
 2. Ghosh A., Principles of Secondary Steelmaking Processing and Casting of Liquid Steel, Oxford & IBH Publication.  
 3. Ghosh Ahindra, Chatterjee A., Ironmaking and Steelmaking Theory and Practices, PHI Pvt. Ltd.

**MT-4152 X-Ray crystallography:**

L-T-P-C (3-0-0-3)

Use of X-Rays, electrons and neutrons for diffraction studies Fundamentals of crystallography, Reciprocal lattice. X-ray diffraction, Bragg's law, Factors affecting intensities of diffracted beams. Atomic scattering factor, structure factor, integrated intensity of diffracted beam, temperature factor, line broadening, Lorentz polarization factor. Powder diffraction methods: Lau patterns and orientation of single crystals. Lau, powder & rotating crystal method. Electron diffraction: selected area diffractions, convergent beams, electron diffraction and micro diffraction, Analysis of diffraction patterns. Stereographic projections. Techniques for studying bent crystals, textures, order-disorder transformations.

- Reference Books: 1. Cullity B.D., Element of X-Ray Diffraction, Addison Wesley.  
 2. Barret C.S. and Massalki T.B., Structure of Metals, McGraw Hill.  
 3. Chaterjee S.K., X-Ray Diffraction, its theory and applications.  
 4. Goodhow P.J., J. Humhreys, R. Beanland, Electron Microscopy & Analysis Taylor and Fransis publication.

**MT-4153 Wear, Friction & Lubrication**

Importance of wear, friction & Lubrication Friction Solid friction; Fundamentals, basic theories and mechanism; types of friction: sliding and rolling; friction in metals, alloys and composites; effect of parameters affecting friction; measurement of friction; frictional heating and calculations.

Wear Introduction to wear; surface damage; types of wear: solid-solid, solid-liquid and solid gas such as adhesion, abrasion, slurry erosion, cavitation erosion, liquid impingement erosion, fretting,

erosion-corrosion, types of contacts: sliding, rolling; worn surface topography, debris analysis and wear mechanism mechanisms; parameters affecting wear.

Lubrication Lubricants & additives, mechanism of solid, liquid and gaseous lubricants. Friction and wear of different components Solid and rolling contact bearings, gears, seals, dynamic pistons, cylinders, connecting rods, push rods, drive shafts, brakes, IC engine parts, drive chains, cutting tools, dies and electrical contacts. Materials for friction and wear applications

Cast irons, carbon and alloy steels, stainless steels, bearing steels, tool steels, hardfacing alloys, aluminium alloys, intermetallics, and composites.

READING TEXTBOOK:: 1. Wear of metals by A.D.Sarkar, Pergamon Press, Oxford

2. Engineering Tribology by Prasanta Sahoo, PHI Learning Pvt Ltd, New Delhi

3. Principles and Applications of Tribology by Bhushan B, John Wiley and Sons, New York

4. Friction and Wear of Materials by Rabinowicz.E, John Wiley and Sons, New York

5. Engineering Tribology by Williams. J.A, Oxford University Press, New York.

### **MT-4154 Nano Materials and its applications:**

Introduction: Types of nano materials, emergence and challenges in Nano Technology.

Synthesis routes for nano materials.

Bottom up and top down approaches; solid, liquid and gas phase synthesis, hybrid phase synthesis.

Synthesis of bulk nano structured materials: Approaches & challenges.

Properties of nano materials: Stability of nano materials, mechanical properties, optical, electrical and magnetic properties, Nano-diffusion.

Characterization of nano materials: Structural characterization by XRD, SEM, TEM, SPM.

Chemical characterization by spectroscopy techniques, characterization of mechanical properties by nano indentation, hot compression testing, Fracture analysis.

Application of nano materials: Electronics and optoelectronic applications, nano dots, biological applications, catalytic applications, quantum devices, application of carbon nano tubes, nano fluids, Future of Nano Technology.

Reference Books:

1. Pradeep T. Nano: The Essentials, McGraw Hill Publishing Co Ltd.

2. Mick Wilson et al, Nanotechnology, Overseas Press India Pvt. Ltd.

3. Charles P. Poole, Jr. Frank J. Owens, Introduction to Nano Technology, Wiley.

4. Gunter Schmid, Nanoparticles: From Theory to applications, Wiley-VCH Verlag GmbH & Co.

### **MT-4155 Biomaterials**

Overview: Historical development; Materials in Medical Applications; Materials Properties for Bio-applications Biomaterials Classification and Synthesis: Metallic materials; Ceramic and glass implant materials; Polymeric implant materials; Collagen; Thin films; Grafts and coatings; Biological functional materials

Cell Structure: Bone structure; Bone properties; Proteins; Bacteria structure; Antibacterial assay

Cell-material Interaction: In vivo testing; Cell-material interaction; Cell-signalling; in vitro testing; Cytotoxicity; Clinical trials

Tissue Engineering: Scaffolds, cellular materials, stem cells, regeneration engineering

#### **Readings**

1. Buddy D. Ratner: Bio Material Science- An introduction to Materials in Medicine, Elsevier, 2013.



2. B. Basu, D. Katti and Ashok Kumar; Advanced Biomaterials: Fundamentals, Processing and Applications; John Wiley & Sons, Inc., USA, 2009.
3. S. V. Bhat ,Biomaterials; 2nd Ed., Narosa Publishing House, 2006.
4. J. Park, R.S. Lakes , Biomaterials an introduction; 3rd Ed., Springer, 2007

#### **4156 Functional Materials**

The Origin of Functional Materials (FMs), Potential Applications of FMs, Classification of FMs, Processing Techniques: Powder Metallurgy Route, Melt-processing Route, Vacuum arc melting, Vacuum induction melting, Vapor deposition and types

Specific properties of functional materials: Magnetic materials, Electronic Materials and Sensors, Electric Contact Materials, Conducting Thermoplastics and polymer composites, Surface coatings for functional applications, Biomaterials and Shape memory metals, Invar alloys

Batteries and fuel cells, solar energy harvesting, Reflective and antireflective layers, Waste heat recovery materials

Microstructure-property correlations, characteristic dimensions and spatial variations, volume fraction, rules of mixture and effective field parameters; characterization of properties of FMs, macrostructural thermomechanical properties, effective material properties for ceramic-metal FMs, basic mathematical modeling.

#### **Reading:**

1. D.D.L. Chung: Engineering Materials for Technological Needs, Vol. 2- Functional Materials: Electrical, Dielectric, Electromagnetic, Optical and Magnetic Applications, World Scientific Publishing,2010.
2. D.D.L. Chung: Composite Materials- Functional Materials for Modern Technologies, Springer, 2002.
3. Hui-Shen Shen: Functionally Graded Materials - Nonlinear Analysis of Plates and Shells, CRC Press,2009.
4. Y. Miyamoto, W.A. Kaysser, B.H. Rabin, A. Kawasaki, R.G. Ford (Eds): Functionally Graded Materials- Design, Processing and Applications, Springer,1999.

#### **Elective-IV**

**L-T-P-C (3-0-0)**

#### **MT-4261 Electronic, optical and magnetic properties of Materials:**

Review of free electron and band theories of solids, electrical conduction in metals and semiconductors, Hall effect, Temperature dependence of electrical conductivity, Thermal conductivity. Thermoelectric properties of metals and semiconductors.

Ionic conductivity, Super conductivity, Piezoelectric and ferroelectric properties of dielectric materials.

Introduction to magnetism; Diamagnetism, paramagnetism, ferromagnetism, antiferromagnetism and ferrimagnetism. Calculation of magnetic moment, Soft and hard magnetic materials.

Optical properties, Refraction, Absorption, Absorption in dielectrics, photographic images, Luminescence, Lasers. 33

Classification, methods of manufacture and fabrication techniques. Applications of these properties in optical fibers, magnetic data storage, solar cells, transistors and other devices. Experimental determination of the electronic, optical and magnetic properties of materials.

Reference Books:

1. Hummel, R.E, Electronic properties of Materials, Springer
2. Raghavan, V, Materials Science and Engineering, Prentice Hall
3. Azaroff, L.I, Magnetic Materials
4. Kasap, S.O, Principles of electronic materials and devices, Tata McGraw Hill

### **MT-4262 Forging Die Design and Manufacturing**

Job analysis, designer's drawing, standards for forging tolerances and allowances, forging drawing, preliminary die design considerations like parting line position, rib and web dimensions, draft angle, filler and corner radii etc.

Design of flash and gutter, preform design, insert design, finishers, blockers, design consideration.

Design of upsetter and piercing tools, Design of trimming and punching die and tools. Estimation of forging load and energy. Computer aided design of forging dies. Automation in forge shops. Materials and properties of forging dies. Heat treatment of dies and tools. Problems of die wear estimation and remedial measures. Role of lubricants in hot and cold forgings of ferrous, non ferrous metal and alloys.

Noise and vibration control in forge shops. Recent developments in technology of die forging. Economics of die design.

Reference Books:

1. Thomas, A. Forging Die design
2. Thomas, A. Forging Methods
3. Alton, Forging Die design and Practice
4. Cold and Hot Forging, Fundamentals and applications, ASM

### **MT-4265 High Temperature Materials**

Introduction to high temperature Materials, Characteristics of engineering materials at high temperature, oxidation, high temperature corrosion, Creep, thermal fatigue, erosion, aging, structural changes, material damage, crack propagation, damage mechanics, life time analysis.

High temperature materials- Carbon alloy steels, Stainless steels, super alloys and titanium and its alloys, ceramics, composites, Refractory metals, alloys and Structural inter-metallic and high temperature polymers.

Coatings: Thermal barrier coatings, Oxidation resistant coatings.

**Reading:**

1. G. W. Meetham and M. H. Van de Voorde, Materials for High Temperature Engineering Applications (Engineering Materials) Springer; 1 edition (May 19, 2000)
2. J. R. Davis: ASM specialty Hand book: Heat-Resistant materials, ASM, 1997
3. Neil Birks, Gerald H. Meier, and Frederick S. Pettit, Introduction to the High Temperature Oxidation of Metals by Cambridge University Press; 2 edition (July 23, 2009)
4. Sudhansu Bose, High Temperature Coatings, Butterworth-Heinemann; 1 edition (February 6, 2007)
5. K. L. Mittal, Polyimides and Other High Temperature Polymers: Synthesis, Characterization and Applications, Brill Academic Publications, 2009
6. R.W. Evans, and B. Wilshire, Creep of metals and alloys, Institute of Metals, London, 1985.
7. Krishan Kumar Chawla, Composite Materials- Science and Engineering, Springer, 2012.

## MT-4264 Aerospace Materials

Introduction to aerospace engineering and aerospace materials, Requirements of aerospace materials, Identification of components of aero planes, space vehicles and missiles, Materials usage in each sections and criticality of the components and their materials selection; Materials for Gas turbines, and Aero engines; Super alloys – Iron, Nickel and cobalt base super alloys; Aluminium alloys for aerospace applications, Cast Aluminium alloys – Designation, properties and applications, Wrought Aluminium alloys for aerospace applications; Titanium alloys for aerospace applications-Introduction, Alpha Titanium alloys – microstructure, properties and applications, Alpha-Beta Titanium alloys – microstructure, properties and applications, Beta Titanium alloys – microstructure, properties and applications; Introduction to steels-Special steels for aerospace applications; Intermetallics – Introduction; Ceramics in aerospace applications; Composites for aerospace applications; New high strength materials; Advanced Materials for aerospace applications.

### Readings:

1. Balaram Gupta: Aerospace Materials with Material Technology for Engineers, Vol. 1-4, S. Chand & Co. New Delhi, 1996 and 2002
2. I.J.Polmear, Light Alloys - From Traditional alloys to nanocrystals, Fourth Edition, Butterworth Heinemann, 2005
3. G. Lutjering, J.C. Williams, Titanium, Springer, 2007
4. George F. Titterton: Aircraft Materials and Processes, Himalayan Books, New Delhi, 1998
5. Michael F. Ashby: Materials Selection in Mechanical Design, Butterworth-Heinemann, 2005
6. F. C. Campbell: Manufacturing Technology for Aerospace Structural Materials, Elsevier, UK, 2006

## MT-4263 Light Metals and Alloys

General introduction - strengthening by solid solution, precipitation, dispersion of second phase particles, grain refinement and work hardening.

Aluminum and its alloys: Production of Aluminum, Designation, temper and characteristics of cast and wrought alloys. Heat treatment of Aluminum alloys – Al-Si, Al-Cu, Al-Mg & Al-Zn-Mg systems. Development of high strength Aluminum alloys by non-equilibrium processing routes such as rapid solidification and powder metallurgy. Applications in consumer, automotive and aerospace industry.

Magnesium and its alloys: Production of Magnesium, Designation, temper and characteristics. Heat treatment of Magnesium alloys – Mg-Sn, Mg-Zn, Mg-Gd, Mg-Li systems. Development of high strength magnesium alloys. Applications in consumer, automotive and aerospace industry.

Titanium and its alloys: Production of titanium. Heat treatment of Titanium and its alloys - alpha alloys, alpha - beta alloys, beta alloys. Applications in sports, automotive, aerospace and strategic industries.

### Reading:

1. I.J.Polmear, Light Alloys - From Traditional alloys to nanocrystals, Fourth Edition, Butterworth Heinemann, 2005
2. R.W.Heine, C.R.Loper, P.C.Rosenthal, Principles of Metal Casting ,Tata McGraw Hill, 1976.
3. D.H. Kirkwood, M. Surey, P. Kapranos, H.V. Atkinson, K.P. Young, Semisolid Processing of Alloys, Springer Series in materials Science, 2010.
4. M. Gupta, N.M.L. Sharon, Magnesium, Magnesium Alloys, and Magnesium Composites, Wiley, 2011
5. G. Lutjering, J.C. Williams, Titanium, Springer, 2007

6. T.W. Clyne, P.J. Withers, An introduction to metal-matrix composites, Cambridge University Press, 1993.

### **MT-4266 Automotive Materials**

Classes of materials and its properties: metals, alloys, polymers, ceramics, composites, body materials: aluminium alloys, steels, special steels, magnesium materials sandwich materials, engine materials: cylinder, piston, cam shaft, valve materials, plastic materials, functional materials, electronic materials , smart materials advanced materials, light weighting automobiles, future vehicles and materials, materials selection in design.

### **Readings**

1. Brain Cantor, Patrick Grant, Colin Johnston, Automotive Engineering:Lightweight, Functional, and Novel Materials, Taylor& Francis, 2008
2. Hiroshi Yamagata, The science and technology of materials inautomotive engines, Woodhead Publishing, 2005
3. Jason Rowe, Advanced materials in automotive engineering, Wood head Publishing, 2012
4. Sobey, A field guide to automotive technology, Chicago Review Press,2008