SYLLABUS

Manufacturing and Process Engineering

(Dept. Metallurgy & Materials Engg& Dept. of Production Engg)

1st Year

FIRST SEMESTER				SECOND SEMESTER			
Theory		Contact Hrs.	CR	Theory		Contact Hrs.	CR
Course Code	Subject	L-T-P		Course Code	Subject	L-T-P	
	Engineering Mathematics -1	3-1-0	4		Engineering Mathematics -2	3-1-0	4
	Engineering Physics	3-1-0	4		**Heat Treatment of Metals**	3-1-0	4
	Engineering Chemistry	3-1-0	4		**Metallurgical Thermodynamics and Kinetics**	3-1-0	4
	Physical Metallurgy	3-1-0	4		Engineering Economics& Costing	3-1-0	4
	Fuels Furnaces& Refractories	3-1-0	4		**Mineral Processing**	3-1-0	4
			20				**20**
	Sessional				**Sessional**		
	Fuel Testing Lab.	0-0-3	2		**Mineral Processing Lab.**	0-0-3	2
	Mechanics of Materials Lab.	0-0-3	2		**Metallurgical Thermodynamics and Kinetics Lab.**	0-0-3	2
	Physical Metallurgy Lab.	0-0-3	2		Manufacturing Lab.	0-0-3	2
		15-5-9	**26**			**15-5-9**	**26**

2nd Year

THIRD SEMESTER				FOURTH SEMESTER			
Theory		Contact Hrs.	CR	Theory		Contact Hrs.	CR
Course Code	Subject	L-T-P		Course Code	Subject	L-T-P	
	Basic Machining Processes	3-1-0	4		Theory of Metal forming	3-1-0	4
	Principles of Extractive Metallurgy	3-1-0	4		**Nonferrous Extractive Metallurgy**	3-1-0	4
	Iron & Steel Making	3-1-0	4		Organizational Behaviour	3-1-0	4
	Phase Transformations in Metals & Alloys	3-1-0	4		**Materials Characterization**	3-1-0	4
			16				**16**
	Sessional				**Sessional**		
	Process Metallurgy Lab.	0-0-3	2		**Materials Characterizations Lab.**	0-0-3	2
	Phase Transformations & Heat treatment Lab.	0-0-3	2		Communication skills	0-0-3	2
	Metal Cutting Lab.	0-0-3	2		Metal Forming Lab.	0-0-3	2
		12-4-9	**22**			**12-4-9**	**22**

3rd Year

FIFTH SEMESTER				SIXTH SEMESTER			
Theory		Contact Hrs.	CR	Theory		Contact Hrs.	CR
Course Code	**Subject**	**L-T-P**		**Course Code**	**Subject**	**L-T-P**	
	Hydro & Electro Metallurgy	3-1-0	4		**Testing of Materials**	3-1-0	4
	Deformation Theory of Metals	3-1-0	4		**Aluminium: Physical metallurgy**	3-1-0	4
	Transport Phenomenon	3-1-0	4		**Corrosion and Degradation of Materials**	3-1-0	4
	Non-Conventional Machining	3-1-0	4		Production & Operation Management	3-1-0	4
			16				**16**
	Sessional				**Sessional**		
	Materials Processing lab	0-0-3	2		**Materials Testing Lab.**	0-0-3	2
	Computer Applications in Metallurgical Engg. Lab	0-0-3	2		**Electro metallurgy &Corrosion Lab.**	0-0-3	2
	Transport phenomena Lab.	0-0-3	2		**Seminar - I**	0-0-3	2
		12-4-9	**22**			**12-4-9**	**22**

4th Year

SEVENTH SEMESTER				EIGHTH SEMESTER			
Theory		Contact Hrs.	CR	Theory		Contact Hrs.	CR
Course Code	**Subject**	**L-T-P**		**Course Code**	**Subject**	**L-T-P**	
	Computer Integrated Manufacturing	3-1-0	4		Strength of Materials	3-1-0	4
	Powder Metallurgy& Composite materials	3-1-0	4		Automation in Manufacturing	3-1-0	4
	Surface engineering	3-1-0	4		**Advanced Materials**	3-1-0	4
	Casting & Solidification of Materials	3-1-0	4		CAD - CAM	3-1-0	4
			16				**16**
	Sessional				**Sessional**		
	Minor Project	0-0-3	2		Major Project	0-0-6	4
	Comprehensive Viva	0-0-3	2				
	Seminar – II	0-0-3	2		Grand Viva	0-0-3	2
		12-4-9	**22**			**12-4-9**	**22**

DETAILED SYLLYABUS

ENGINEERING MATHEMATICS I *(First Semester)*

(Calculus, Linear Algebra and Numerical Method)

Module I (10 Hours)

Open sets, closed sets, Limit points of a set, Limits, Continuous functions, the derivative, Increasing and decreasing functions, Darboux's theorem, Rolle's theorem, Lagrange's mean value theorem, Cauchy's mean value theorem, Extremum values; Riemann integral: Definition and existence of the integral, Integral as a limit of sums, some integrable functions, Fundamental theorem of calculus, Mean value theorems for integral calculus.

Module II (10 Hours)

Vectors: Addition and Scalar Multiplication, Matrix Multiplication, Linear Systems of Equations, Gauss Elimination, Linear Independence, Rank of a Matrix, Vector Space, Solutions of Linear Systems: Existence, Uniqueness, Determinants, Cramer's Rule, Gauss-Jordan Elimination, Vector Spaces, Inner Product Spaces,

Module III (10 Hours)

Eigenvalues, Eigenvectors, Some Applications of Eigenvalue Problems, Symmetric, Skew-Symmetric, and Orthogonal Matrices, Eigenbases, Diagonalization, Quadratic Forms, Complex Matrices and Forms, IncIusion of Matrix Eigenvalues, Power Method for Eigenvalues

Module IV (10 Hours)

Numerical methods in general, Introduction, Solution of Equations by Iteration, Interpolation, Numerical Integration and Differentiation

Text Books:

1. S.C. Malik and S. Arora, Mathematical Analysis, New Age International
2. Erwin Kreyszig, Advanced Engineering Mathematics, Wiley India Pvt. Ltd

Chapters: S.C. Malik - 2(2.1- 2.3), 5(5.1-5.3), 6(6.1, 6.3-6.7), 7(7.1), 9(9.1, 9.6, 9.7, 9.9,9.10)

E. Kreyszig - 7(7.1-7.5, 7.7, 7.8, 7.9), 8, 20 (20.7, 20.8), 19(19.1, 19.2, 19.3, 19.5)

Reference Books:

1. George B. Thomas, Jr. and Ross L. Finney, Calculus and Analytic Geometry, Addison Wesley Publishing Company
2. R.K. Jain and S.R.K. Iyengar, Advanced Engineering Mathematics, Taylor & Francis
3. K.A. Stroud, Advanced Engineering Mathematics, Industrial Press

ENGINEERING PHYSICS *(First Semester)*

Module I (10 Hours)

Waves and acoustics:

Waves: Elementary idea, Wave equation, Progressive and stationary waves.

Oscillations: Equation of motion of Simple harmonic oscillations, Damped Harmonic oscillations, Forced Oscillation, Resonance.

Acoustics: Introduction, Classification of sound, Characteristics of Musical Sounds, Weber-Fechner Law, Reverberation, Sabines's formula, Absorption coefficient and measurement, Acoustic quieting and some common methods of quieting

Module II (12 Hours)

Electromagnetism: Introduction to Vector Products, Gradient, Divergence, Curl of Vector fields, Gauss divergence theorem. Stoke's theorem, Green's theorem (statement only), Maxwell's electromagnetic equations in differential form and in integral form.

Quantum mechanics: Need for Quantum Physics, Basic postulates of quantum mechanics, Wave function properties, Probability density, Normalization of the wave function, Operators, eigenfunction and eigenvalue, expectation value, Schrödinger wave equation (time dependent and time independent), Application of Schrodingers equation (particle in one dimensional box)

Module II (10 Hours)

Dielectric Properties: Introduction, Dielectric constant, Dielectric Polarization (Polarizability), Different types of Polarizations in Dielectrics (Electronic, Ionic, Orientational and space charge polarization, Internal fields (no derivation), Clausius-Mosotti equation, Dielectric Loss, Break down and Strength, Applications of Dielectric materials

Magnetic Properties: Introduction, Basic definitions, Bohr magneton, Classification of magnetic materials- Dia, Para, Ferro, Anti-ferro and Ferri magnetism, Hysteresis curve- Soft and Hard magnetic materials, Applications of magnetic materials

Superconductivity: General Properties, Meisener effect, isotope effect, Energy gap in superconductors, Coherence length, Critical magnetic field, Flux quantization Penetration depth, DC and AC Josephson effects Type-I and Type-II superconductors, BCS Theory, Londons equations, Applications of superconductors

Module IV (8 Hours)

Lasers: Introduction, Characteristics of lasers, Einstein's coefficients & Relation between them, Principle of Laser, Population inversion, Three and Four level pumping schemes, Components of LASER, Different types of Lasers (Ruby Laser, He-Ne Laser), Applications of LASER (elementary ideas). **Nanomaterials** Introduction, Classification, Physical characteristics and applications (fundamental)

Books Recommended:

1. Fundamental of Physics: Jearl Walker, David Halliday, Robert Resnick
2. Optics – Ajoy Ghatak
3. Concepts of Modern Physics – A. Beiser
4. Electricty & Magnetism – D. Griffiths
5. Quantum Mechanics – M. Das and P.K Jena

ENGINEERING CHEMISTRY *(First Semester)*

Module I (10 Hours)

Water Treatment: Hardness, Scale & Sludge, Caustic embrittlement, Priming & Foaming, softening methods, Drinking water, Desalination of Brackish water, Chemical analysis of water.

Module II (10 Hours)

General Metallurgy*: Ores & minerals****,*** *Ore dressing, Extraction and purification of metals*

Corrosion and its control: Introduction, Types of corrosion, Prevention methods,
Metallic Coatings, Electro plating, paints and varnishes

Module III (10 Hours)

Thermodynamics of Chemical Processes: Concept of Entropy, Chemical Potential, Equilibrium Conditions for Closed Systems, Phase and Reaction Equilibria, Maxwell Relations

Phase Rule: Definition of Terms: Phase, Components, Degree of Freedom, Phase Rule Equation. Phase Diagrams: One Component Systems – Water and Sulphur, Two Component System – Lead-Silver, Cooling Curves, Iron-Carbon Phase Diagram

Module IV (10 Hours)

Electrochemistry: Electrode Potentials and its Relevance to Oxidation and Reduction, Measurement of EMF, Determination of pH, Hydrogen, Glass, Quinhydrone Electrodes, Dry Cells, Fuel Cells and Storage Battery

Engineering application of materials: Nanomaterials

Reference Books:

1. P. W. Atkins, Elements of Physical Chemistry, 4th Edition, Oxford University Press
2. P. K. Kar, S. Dash and B. Mishra, B.Tech. Chemistry Vol. I & Vol.II, Kalyani Publications
3. Jain & Jain, Engineering Chemistry, Dhanpat Rai Publication

PHYSICAL METALLURGY *(First 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 supercooling, 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; Hotworking. 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 nonferrous alloys Cu-Al, Bronze, Brass.

Text Books:

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

FUEL, FURNACEs AND REFRACTORIES *(First 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.

ENGINEERING MATHEMATICS II *(Second Semester)*

(Multivariable Calculus and Special Functions)

Module I (10 Hours)

Vector and Scalar Functions and Fields, Derivatives, Gradient of a Scalar Field, Directional Derivative, Divergence of a Vector Field, Curl of a Vector Field, Line Integrals, Path Independence of Line Integrals, Double Integrals, Green's Theorem in the Plane, Surface Integrals, Triple Integrals, Divergence Theorem of Gauss, Further Applications of the Divergence Theorem, Stokes's Theorem.

Module II (10 Hours)

Fourier series and integral, Even and odd function, Half range series, Dirichlet criterion, Parseval's identity, Functions with arbitrary period.

Module III (10 Hours)

Orthogonal curvilinear coordinates, Jacobians, gradient, divergence, curl and Laplacian in curvilinear coordinates, Special curvilinear coordinates.

Module IV (10 Hours)

Gama function, The Beta function – Dirichlet integral, Other special functions– Error function, exponential integral, Sine and cosine integrals, Bessel's Equation, Bessel Functions, Bessel Functions of the Second Kind, Legendre's Equation, Legendre Polynomials.

Text Books:

1. Erwin Kreyszig, Advanced Engineering Mathematics, Wiley India Pvt. Ltd

Chapters: 5(5.3, 5.5, 5.6), 9(9.4, 9.7, 9.8, 9.9), 10.1-10.4, 10.8, 11(11.1-11.3, 11.6, 11.7), A3.4, A3.1

Reference Books:

1. S.C. Mallik and S. Arora, Mathematical Analysis, New Age International
2. Milton Abramowitz and Irene A. Stegun, Handbook of Mathematical Functions, National Bureau of Standards, Applied Mathematics Series – 55
3. Yury A. Brychkov, Handbook of Special Functions: Derivatives, Integrals, Series and Other Formulas, CRC Press
4. R.K. Jain and S.R.K. Iyengar, Advanced Engineering Mathematics, Taylor & Francis
5. K.A. Stroud, Advanced Engineering Mathematics, Industrial Press

HEAT TREATMENT *(Second Semester)*

Module I (10 Hours)

Objective and variables of heat treatments, Classification of steels, Heat treatment of steel, Phase transformation mechanisms, Fe-Fe_3C, Fe-C phase diagrams, TTT, CCT diagrams, Microstructure evolution during austenite decomposition, Microstructure evolution during reheating, Strengthening mechanisms in steel.

Module II (10 Hours)

Effects of Alloying Elements on Heat Treatment Processing of Iron–Carbon Alloys, Effect of Alloying Elements on Austenite Transformations, Definition of Hardenability, Factors Influencing Depth of Hardening, Determination of Hardenability, Grossmann's Hardenability Concept, Jominy End-Quench Hardenability Test, Hardenability Bands, Application of Hardenability Concept for Prediction of Hardness after Quenching, Hardenability in Heat Treatment Practice

Module III (10 Hours)

Heat Treatment with Gaseous Atmospheres: Carburizing, Reactions with Hydrogen and with Oxygen, Nitriding and Nitro-carburizing, Quenching: Metallurgical Transformation Behavior during Quenching, Quenching Processes, Determination of Cooling Characteristics, quenching as a Heat Transfer Problem, Process Variables Affecting Cooling Behavior and Heat Transfer: Distortion of Heat-Treated Components: Basic Distortion Mechanisms, Residual Stresses, Distortion during Post Quench Processing

Module IV (10 Hours)

Heat treatments of general engineering steels: Spring, Bearing steels, Tool steels, HSLA steel and Maraging steels, Dual phase steels and Stainless steels, Heat treatment cast irons, Heat Treatments of Non-ferrous alloys: Al-alloys, Brass, Bronze, and Ti-alloys, Superalloys

Text Books:

1. R.C. Sharma, Principle of Heat Treatment of Steel, New Age Publishers
2. V. Singh, Heat Treatment of Metals, Standard Publishers

METALLURGICAL THERMODYNAMICS & KINETICS *(Second 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.

ENGINEERING ECONOMICS & COSTING *(Second Semester)*

Module I (10 Hours)

Theory of Demand: Modern Utility Theory, The Neumann-Morgenslern Approach, The Friedman-Savard Hypothesis, Uncertainty and Consumer Behaviour, Expectedvalue of Perfect Information, Revealed Preference Theory, Intertemporal Choice Slutsky Equation, Annual Economic Worth, Present Value, Discount Rate-IRR and NPV.

Module II (10 Hours)

Profit Maximization: Theory of Production-Laws of Production, Returnto Scale and Variable Proportions, Equilibriumof Firm, and Choice of Optimal Combination of Factors, Cost Minimization-Calculus Analysis of Cost Minimization, Average and Marginal Cost-The Short Run Cobb-Douglas Cost Function. Constant Returns to Scale and cost functions, long run and short run cost curves-factor prices and cost functions, the envelop Theorem for Constrained Optimization, Cost Control Techniques, Critique of The Principle of Profit Optimization and Modern Theories of Firms-Baumol's Sales Maximization Hypothesis, Monis Model of Managerial Enterprise, Hall and Hitch Report and Full-Cost Pricing Principle, Bain's Limit Pricing Theory.

Module III (10 Hours)

Analysis of Public Projects: Benefit-Cost Analysis, Public Goods, Private Goods, Common Property, Free Rider Problem, Market Failure and Externalities, Private And Social Cost,Social Welfare Functions- Welfare Maximization and Pareto Optimality, Market Responses to Externalities-Mergers, Social Conventions, Property Right And Bargaining Coase Theorem.

Module IV (10 Hours)

Linear Models: Simple Regression Model the Problem and Estimation, Classical Normal Linear Regression Model, Two Variable Regression-Interval Estimation and Hypothesis Testing; Multiple Regression Analysis-The Problem of Estimation, Dummy Variable Regression Models, Multiple Parameter Sensitivity Analysis, Linear Programming-Graphic and Simplex Method; Game Theory-The Pay-Off Matrix of Game, Nash Equilibrium, The Mixed Strategies and The Prisoner's Dilemma.

Text Books:

1. Varian,H.R.(1992). Introduction to Micro Economic analysis, Norton and Company, New York.
2. Wooldridge, J.M. (2009) Introductory Econometrics-A Modern Approach, South Western CENGAGE learning.
3. Pearce,D.W. and Turner(1990) Economics of Environment and Natural Resources, Harvester Wheatsheaf, New York.
4. Damodaran, S. (2012) Managerial Economics, Second Edition, OUP

MINERAL PROCESSING *(Second 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.

Module II (10 Hours)

Size separation: Sieving and screening, laboratory sizing and its importance, representation and interpretation of size analysis data, industrial screening. Classification: Movement of solids in fluids, free setting and hindered settling of particles, different types of classifiers, e.g. sizing and sorting classifiers used in mineral industry.

Module III (10 Hours)

Concentration: Gravity separation, concentration criteria, jigging, flowing film concentration and tabling, dense media separation. Froth flotation: Theory, reagents used in floatation processes, machines and practice. Magnetic and electrostatic separation: Theory and application of magnetic and electrostatic separation techniques in mineral industry. Dewatering and drying: Theory and practice of thickening; filtration and drying.

Module IV (10 Hours)

Agglomeration techniques: Sintering, palletizing, briquetting and their applications in ferrous and non-ferrous metal industries, testing of agglomerates. Important mineral deposits in India.

Text Books:

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

BASIC MANUFACTURING PROCESSES *(Third Semester)*

Module – I *(10 Hours)*

Manufacturing process: Definition, Classification of manufacturing process, Sand Casting: Pattern – materials, allowances, types, molding types, molding procedure, molding and properties, testing of molding sand, cores, core materials, properties of core making. Melting and founding of cast iron, degasification, design of casting and risering, pouring and feeding of casting, casting defects and inspection.

Module II *(10 Hours)*

Special casting: Shell mould casting, investment casting, permanent mould casting, Die casting, and centrifugal casting. Solid state welding process: Introduction, Cold welding, Ultrasonic welding, Friction welding, Resistance welding,

Module – III *(10 Hours)*

Fusion welding processes: Introduction, oxy-fuel gas welding, arc welding Processes-I (consumable electrode): principle, equipment, power sources, principle of metal transfer, Electrodes, Submerged arc welding, Gas Metal Arc Welding, arc welding processes-II (non-consumable electrode): Gas Tungsten Arc Welding, Plasma Arc Welding, Other welding processes: Thermit welding, Brazing, soldering, Laser beam welding, Gas and Arc cutting, Defects in welding.

Module – IV *(10 Hours)*

Metal Forming Process:
Extrusion: Classification, Advantages, Limitations and applications
Wire Drawing: Classification, Advantages, Limitations and applications
Rolling: Cold and Hot Rolling processes, Classification, Advantages, Limitations and applications
Sheet Metal Working: Deep drawing process

TEXT BOOK(S):

1. Manufacturing Technology (Foundation Forming & Welding)- P.N. Rao, Tata McGraw Hill.
2. Principles of manufacturing materials and processes- J.S.Campbell, Tata McGraw Hill.
3. Basic Manufacturing Process- D. Mishra IndiaTech Publisher, New Delhi.

REFERENCE(S):

1. Principles of manufacturing materials and processes- J.S.Campbell, Tata McGraw Hill.
2. Manufacturing Engineering and Technology, 4^{th} Edition- S.Kalpakjian and S.R. Scsimid, Pearson Education.
3. Materials and processes in manufacturing- DeGarmo, Black and Kohser, Prentice Hall of India.
4. Principle of Metal Casting- Heine, Loper and Rosenthal, Tata McGraw Hill.

PRINCIPLE OF EXTRACTIVE METALLURGY *(Third 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

IRON & STEEL MAKING *(Third Semester)*

Module I (8 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 (12 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

PHASE TRANSFORMATIONS IN METALS & ALLOYS *(Third Semester)*

Module I (12 Hours)

Classification of phase transformations. 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: Driving force for diffusion, atomic mechanisms of diffusion, interstitial diffusion: steady state diffusion, Non-steady state diffusion, Solutions to the diffusion equation substitutional diffusion, High diffusivity paths.

Module II (8 Hours)

Crystal interfaces: Interfacial free energy, Boundaries in single phase solids, Bond breaking model, Interphase interfaces in solids: interface coherency, interfacial energy effects, misfit strain effects.

Nucleation and growth: Homogeneous nucleation, homogeneous nucleation rate, Heterogeneous nucleation, Heterogeneous nucleation rate, Growth of a pure solid,

Module III (15 Hours)

Diffusional transformations in solids: Overall transformation kinetics: TTT diagrams, Precipitation in age hardening alloys, Particle coarsening, Spinodal decomposition, Ferrite: nucleation and growth, Pearlitic transformation: mechanism, nucleation and growth, Bainitic transformation: mechanism, nucleation and growth, Effect of alloying elements on hardenability, CCT diagrams, massive transformations, ordering transformations

Module IV (5 Hours)

Diffusionless transformations: Martensitic transformations: characteristics, crystallography, theories of Martensitic nucleation, martensite growth. 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. Phase transformation in materials by Romesh C Sharma, CBS publishers & Distributors

THEORY OF METAL FORMING *(Fourth Semester)*

Module I ***(10 Hours)***

Review of two dimensional stress and strain, state of stress in three dimensions, Stress tensor, Invariants, Mohr's circle for 3-dimensional state of stress, strain at a point- Mohr's circle for strain, Hydrostatic & Deviatory components of stress, Elastic stress-strain relations.

Module II ***(10 Hours)***

Elements of theory of plasticity; Flow curve, True stress & true strain, Yield criteria for ductile metals, Von Misses & Teresa yield criteria, combined stress tests. The yield locus, Anisotropy in yielding, Yield surface, levy-Misses, Prandtl-Reuss Stress-Strain relation, Classification of forming processes variables in metal forming and their optimization.

Module III ***(10 Hours)***

Analysis of deformation processes- Method based on homogeneous compression slip line field theory, Upper bounds and lower bounds, Slab method of analysis. Flow stress determination, Hot working, Cold working, Strain rate effect, Friction and lubrication, Deformation zone geometry, Workability, Residual stress.

Module IV ***(10 Hours)***

Analysis of metal forming processes (only limited portion), forging: Load calculation in plane strain forging, Rolling: Forces & geometrical relationship in rolling, Rolling load and torque in cold rolling, Von-Karman work equation,

Text Books:

1. Mechanical Metallurgy: By- Dieter, Mc Graw Hill Book Co.
2. Plasticity- Chakraborty- McGraw Hill.

NON-FERROUS EXTRACTIVE METALLURGY *(Fourth 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

ORGANISATIONAL BEHAVIOUR *(Fourth Semester)*

Module I (10 Hours)

OB: Learning objectives, Definition & Meaning, why to study OB, An OB model, New challenges for OB Manager

LEARNING: Nature of learning, how learning occurs, Learning & OB

Case Study Analysis

Module II (10 Hours)

PERSONALITY: Meaning & Definition, Determinants of Personality, Personality Traits, Personality & OB

PERCEPTION: Meaning & Definition, Perceptual process, Importance of Perception in OB

MOTIVATION: Nature & Importance, Herzberg's Two Factor theory, Maslow's Need Hierarchy theory, Alderfer's ERG theory

Case Study Analysis

Module III (10 Hours)

COMMUNICATION: Importance, Types, Barriers to communication, Communication as a tool for improving Interpersonal Effectiveness

GROUPS IN ORGANISATION: Nature, Types, why do people join groups, Group Cohesiveness & Group Decision Making- managerial Implications, Effective Team Building

LEADERSHIP: Leadership & management, Theories of leadership- Trait theory, Behavioural Theory, Contingency Theory, Leadership & Followership, how to be an Effective Leader

CONFLICT: Nature of Conflict & Conflict Resolution

TRANSACTIONALANALYSIS: An Introduction to Transactional Analysis

Case Study Analysis

Module IV (10 Hours)

ORGANISATIONAL CULTURE: Meaning & Definition, Culture &Organizational Effectiveness

HUMAN RESOURCE MANAGEMENT: Introduction to HRM, Selection, Orientation, Training& Development, Performance Appraisal, Incentives

ORGANISATIONAL CHANGE: Importance of Change, Planned Change & OB Techniques

INTERNATIONAL OB: An Introduction to Individual & Interpersonal Behavior in Global Perspectives

Case Study Analysis

MATERIALS CHARACTERIZATION *(Fourth 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

HYDRO AND ELECTRO METALLURGY *(Fifth 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.

DEFORMATION THEORY OF METALS *(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.

NON-CONVENTIONNAL MACHINING *(Fifth Semester)*

Module-I *(10 Hours)*

Introduction: Need for Non-traditional Machining, Classification, process selection. Ultrasonic machining: Principle, Transducer, Magnetostrictive material, Analysis for Material Removal Rate by Shaw, Effect of process parameters, Application.

Module-II *(10 Hours)*

Abrasive Jet Machining: Principle, Application, Advantages and disadvantages, Variables in AJM, Water Jet Machining- Jet Cutting equipment, Principle, advantages, Practical Application. Electrochemical Machining: Principle, Faraday's law, Material Removal Rate, Dynamics of ECM process, Tool design, Advantages, Application, Limitation, Electro –chemical grinding, Deburring and Honing.

Module-III *(10 Hours)*

Electro Discharge Machining: mechanism of material removal, Basic EDM circuitry and principles of operation, Analysis of relaxation circuits, Concepts of critical resistance, Machining accuracy and surface finish, Tool Material, Dielectric fluid, Application limitation. [06]

Laser Beam Machining: Lasing process and principle, population inversion, Principle of Ruby laser, Nd: YAG Laser and CO2 Laser, Power control of laser output, Application.

Module-IV *(10 Hours)*

Electron Beam Machining: Basic principle, Controlling parameters and focal distance, Application. Ion Beam Machining: Principle and Mechanism, Application. Plasma Arc Machining: generation of Plasma, Equipments, Torch, Classification, Direct and indirect torches and applications, parameters effecting cutting, Advantages.

Text Books:

1. Modern machines process- P.C.Pandey and H.S.Shan. TMH
2. Non Conventional Machining- P.K.Mishra,Narosa.

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

CORROSION AND DEGRADATION OF MATERIALS *(Sixth 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

PRODUCTION & OPERATION MANAGEMENT *(Sixth Semester)*

Module I *(10 Hours)*

Operations function in an organization, Manufacturing vs. Service operation. Design in products, services & processes, new product design, Product life cycle, Design for services, Services process technology. Value Engineering, Standardization, Make or buy Decision. Process technology: project, job shop, batch, assembly line, continuous manufacturing, Process technology life cycle, Process technology trends, CAD, CAM, GT, FMS and CIM.

Module II *(10 Hours)*

Job Design & work Measurement, Method study: Techniques of analysis, recording, improvement & standardization. Work measurement: work measurement principles using stop watch time study, predetermined motion time standard & work sampling, standard time estimation. Demand Forecasting: Principles & methods, moving average, double moving average exponential smoothing, double exponential smoothing, Forecasting error analysis.

Module III *(10 Hours)*

Facility location: Factor influencing plant & warehouse location, impact of location on cost & revenue. Facility location procedure & models; qualitative models, Breakeven analysis, Single facility location model, Multi facility location model, Minimax location, Total & partial covering model Plant Layout: layout types; Process layout, Product layout, Fixed position layout, planning, tools and techniques of plant layout, travel chart, Systematic layout planning, CORELAP, ALDEP and CRAFT.

Module IV *(10 Hours)*

Production control: Loading, Sequencing and Scheduling-Assignment model, Single machine scheduling: Basics and performance evaluation criteria, methods for minimizing mean flow time, parallel machines: minimization of makespan, flowshop sequencing: 2 and 3 machine cases: Johnson's rule and CDS heuristic. Jobshop scheduling: priority dispatching rules. Inventory control: types of inventory, objectives of inventory control, inventory costs and deterministic models, inventory control systems, safety stock.

Text Books:

1. Production systems: planning analysis and control- J.L. Riggs, John Wiley.
2. Production and Operations Management- R. Panneerselvam, PHI.

COMPUTER INTEGRATED MANUFACTURING *(Seventh Semester)*

Module-I *(10 Hours)*

Introduction: The meaning and origin of CIM, The changing manufacturing and management scenario, External communication, Islands of automation and software, Dedicated and open systems, Manufacturing automation protocol, Product related activities of a company, Marketing engineering, Production planning, Plant operations, Physical distribution, Business and financial management. Computer Aided Process planning: Role of process planning in CAD/CAM integration, Approaches to computer aided process planning- Variant approach and Generative approaches, CAPP and CMPP process planning systems.

Module-II *(10 Hours)*

Shop Floor Control and FMS: Shop floor control-phases, Factory data collection system, Automatic identification methods- Bar code technology, Automated data collection system, FMS-components of FMS - types -FMS workstation, Material handling and storage systems, FMS layout, Computer control systems-application and benefits.

Module-III *(10 Hours)*

CIM Implementation: CIM and company strategy, System modeling tools-IDEF models, Activity cycle diagram, CIM open system architecture (CIMOSA), Manufacturing enterprise wheel, CIM architecture, Product data management, CIM implementation software. Data Communication: Communication fundamentals, Local area networks, Topology, LAN implementations, Network management and installations.

Module-IV *(10 Hours)*

CIM System: Open System Open systems inter connection, Manufacturing automations protocol and technical office protocol (MAP /TOP). Database for CIM: Development of databases, Database terminology, Architecture of database systems, Data modeling and data associations, Relational data bases, Database operators, Advantages of data base.

Text Books:

1. Automation, Production Systems and Computer Integrated Manufacturing- M.P.Groover, Pearson Education.
2. Computer Integrated Manufacturing System- Y. Koren, McGraw-Hill.

POWDER METALLURGY AND COMPOSITE MATERIALS *(Seventh Semester)*

Module I (10 Hours)

Introduction to powder metallurgy, Metal and alloy powder production, chemical, physical and mechanical methods of production, metal powder characterization introduction, chemical composition, particle size, surface area, densit , compressibility, strength .

Module II (8 Hours)

Powder compaction, Sintering introduction, Introduction to Composites: Matrices, Reinforcements: galss fibre, carbon fibre, whiskers, Fundamental concept of reinforcement, review of current developments; Basic mechanics of reinforcement, stiffness of parallel arrays of fibers in a matrix,

Module III (12 Hours)

Polymer Matrix Composites (PMCs): processing of thermoplastic and thermoset matrix composite, structural defect and mechanical properties, application .Metal Matrix Composites (MMCs):Aluminum alloy, copper alloy, titanium alloys, solid state processing, in situ processing, high temperature properties and strength, applications .

Module IV (10 Hours)

Ceramic Matrix Composites (CMCs):cold pressing and sintering, hot pressing, self propagating high temperature synthesis, thermal shock resistance properties, crack deflection and toughness. Nano composites: polymer clay nano composite, self healing and self reinforced composite, bio composite, hybrid composite.

Text Books:

1 Powder metallurgy technology by G. S. Upadhyaya

2 Composite materials science and engineering by K. Chawla

SURFACE ENGINEERING *(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.

CASTING & SOLIDIFICATION OF MATERIALS *(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.

STRENGTH OF MATERIALS *(Eighth Semesters)*

Module-I *(10Hours)*

Analysis of axially loaded members: Composite bars in tension and compression-temperature stresses in composite rods-statically indeterminate problem. 2D Stress system, Principal Planes, Principal stress, Mohr's stress circle, Members in biaxial state of stress: Stresses in thin cylinders, thin spherical shells under internal pressure-wire winding of thin cylinders. Strain & deformation: Two dimensional state of strain, Principal Strains, Calculation of principal stresses from principal strains, Strain measurement.

Module-II *(10Hours)*

Shear force and bending moment diagrams for simple beams: Support reactions for statically determinate beams, relationship between bending moment and shear force, shear force and bending moment diagrams. Simple bending of beams: Theory of simple bending of initially straight beams, distribution of normal and shear stress, composite beams.

Module-III *(10Hours)*

Torsion in solid and hollow circular shafts, Twisting moment, strength of solid and hollow circular shafts, Strength of shafts in combined bending and twisting, Close-coiled helical springs. Deflection of Beams: Slope and deflection of beams by integration method and area-moment method.

Module-IV *(10Hours)*

Buckling of columns: Euler's theory for initially straight columns with various end conditions. Theories of failure: maximum principal stress theory, maximum shear stress theory, maximum principal strain theory, Maximum strain energy theory and maximum distortion energy theory.

Text Book(s):

1. Strength of Materials- G.H.Ryder, Macmillan India.
2. Mechanics of Materials- J.M.Gere and S.Timoshenko.

AUTOMATION AND NUMERICAL CONTROL MACHINES *(Eight Semester)*

Module-I *(10Hours)*

Introduction: Automation, types, Reasons for automation, Types of production, Functions in manufacturing, Automation Strategies, Costs in manufacturing. Flow Lines: Automated Flow lines, transfer mechanisms, Automation for machining operations, Line balancing- basic concepts, general procedure, rank positional weight method.computer aided line balancing (CALB), Manual & Flexible assembly line, Automated assembly systems-Types, Part feeding device.

Module-II *(10Hours)*

Fundamentals of CAD: The design process, Application of computer for design, automated drafting, creating manufacturing data base, benefits of CAD, Design workstation – graphic terminal, operator input and output devices, Software of graphic system- graphic package, Data Base Structure, Wireframe Model and Solid Model, Graphics standards.

Module-III *(10Hours)*

Numerical Control: Components of NC system, NC procedure, NC co-ordinate system, motion control, applications, NC part programming-manual part programming, computer assisted part programming, ATP language-macro statements, programming with interactive graphics, NC part programming using CAD/CAM. Writing simple part programme. Computer control in NC: Problems with conventional NC. Controller technology, CNC, DNC Adaptive Control

Module-IV *(10Hours)*

Automated material handling: Type of equipment, Principles of material handling, Conveyor system Group Technology cell formation: Part classification & coding, Computer Aided Process Planning (CAPP) - Retrieval & Generative type process planning system.

Text Books:

1. Automation, Production System and CIM- M.P.Groover, PHI.
2. CAD/CAM- Groover & Zimmers, PHI.

ADVANCED MATERIALS (*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