

SEMESTER-III

NUMERICAL ANALYSIS AND PROGRAMMING (MA 3103)

Numerical computation and error, solution of algebraic and transcendental equations-Bisection method, Regula-Falsi method and Newton-Raphson method and their order of convergence. Iterative methods for system of non-linear equations. Linear system of equations: Gauss elimination method, Crout's method, Jacobi's method, Gauss-Seidel method. Computer programming of above methods.

Finite differences, difference operators and symbolic relations, difference of a polynomial, Interpolation ,error in interpolation, Newton's forward and backward formulae, Lagrange's interpolation formula, Newton general interpolation formula, Numerical differentiation, error in numerical differentiation. Numerical integration: Newton's cote's formula, Trapezoidal rule, Simpson 1/3 rule, Simpson 3/8 rule and their error estimation. Computer programming of above methods.

Ordinary differential equations: Taylor's series method, Euler's method, Euler's modified method, Runge-Kutta method, Boundary value problem-linear and non-linear equations. Computer programming of above methods.

MATERIAL SCIENCE (A) (ML 3101)

1. Atomic Bonding:- Classification of Engineering Materials, Ionic, Covalent, Metallic and Vander Walls Bonding. Effect of types of Bonding on properties of materials.
2. Structure of Solids:- Crystalline Solids, Crystal System, Unit Cells, Space Lattice, Miller Notations, Structure in Metallic Elements, Ionic and Molecular Crystals, Imperfection in Crystals.
3. Introduction to Iron Carbon Diagram and Principles of Heat Treatment. Annealing, Normalizing, Hardening, Tempering, T-T-T Diagram etc. recovery, recrystallisation and grain growth. White Caste Iron, Grey, Spheroidal Graphite, Malleable Caste Iron, their properties and applications.
4. Brief Introduction to Polymer, Ceramics, Composite Materials and Their Application as Engineering Materials.

MATHEMATICS – III (MA 3104)

LAPLACE TRANSFORMATION :- Definition of Laplace transform and linearity and shifting property, Laplace transform of elementary functions, Inverse Laplace transform, Laplace transform of derivative and integration, convolution theorem, Solution of differential equation by Laplace transform, Unit Step function, Unit impulse function.

VECTOR CALCULUS :- Differentiation of vector function, gradient, divergence, curl and their geometrical or physical interpretation, Line, Surface and Volume integrals, Statement of Green's Theorem, divergence theorem and Stoke's theorem and their applications. Curvilinear co-ordinates.

FOURIER SERIES :- Fourier series, Dirichlet's conditions, Half Range series.

FOURIER TRANSFORM :- Definition of Fourier Transform, linearity, shifting, frequency theorem, Fourier transform of derivatives and Dirac-delta function, Inverse Fourier transform, Fourier Sine and Cosine transform, Solution of simple differential equation by Fourier transform method.

Z- TRANSFORMATION :- Definition, Z-transformation of standard sequences, linearity property, Shifting theorem, inverse of Z-transformations, Scaling property of Z-transformation, differentiation of Z-transformation, convolution of sequences, solution of difference equations by Z-transformation.

MECHANICS OF SOLIDS – I (ME 3103)

Introduction and fundamental concepts: Introduction purpose and scope of the subject. Generalized procedure, Basic assumption, Types of forces (External and Internal forces), method of sections, constitutive laws, Elastic material, principle of superposition, St. Venant's Principle, Tensile test, Generalized Hook's law for isotropic and linear elastic material.

Simple stress and strain : Uniaxial tension or compression of a bar (prismatic and non prismatic) Cases of simple shear, shear strain components in terms of shear stress. Bi-axial and tri-axial tension or compression. Thermal stress and strain. Statically determinate system of bars in tension (or compression), thin walled pressure vessels. Cylindrical and spherical shells.

Shearing force and Bending moment : Use of singularity functions in drawing B.M.D. and S.F.D.

Stress due to bending : Pure bending of beams. Normal stress and shear stress distribution in a beam subjected to both B.M. and S.F.

Deflection due to bending, Double integration method, Moment area method.

Torsion : Torsion of solid and hollow circular shaft. Torsion of hollow thin walled shaft. Closed coiled spring Flanged coupling.

Two-dimensional stress analysis : Plane stress, stress components on a general plane at a point. Mohr's circle of stress.

Cases of combined loading : Bending with tension (or compression). Eccentrically loaded member ; Core of section, Torsion and shear. Torsion and bending. Cases of Transmission shafts subjected to bending tension or axial thrust.

Elastic strain energy and its application. Elastic strain energy of a rod under various kinds of loading. Elastic strain energy for various states of stress. Simple application. Castigliano's theorem.

GEO SCIENCE (GE 3102)

Introduction – Geoscience and its branches. Application of Geoscience in Metallurgy, An elementary idea of important Stratigraphic horizons of India.

Crystallography : Growth and development of crystals. Concept of symmetry in crystals, Space lattice, Normal classes of Isometric, Tetragonal, Hexagonal, Orthorhombic, Monoclinic and Triclinic crystal systems

Mineralogy – Chemical composition, Physical & Optical properties of Minerals, Structure of silicates, Mineral Groups : Olivine, Pyroxene, Amphibole, Feldspar and Silica

Petrology – General introduction of Igneous, Sedimentary and Metamorphic rocks and Petrographic studies of important rock types such as, Pegmatite, Granite, Granodiorite, Diorite, Syenite, Gabbro, Dolerite, Basalt, Anorthosite, Dunite, Peridotite, Rhyolite, Trachyte, Shale, Sandstone, Arkose, Limestone, Conglomerate, Breccia, Marble, Quartzite, Slate, Phyllite, Schist, Gneiss and Charnockite

Economic Geology - Introduction to Economic Geology, Ore, Gangue, Tenors of Ores, Grade, Assay value, Cut Off grade, Elementary idea of Processes of formation of Mineral deposits.

Distribution, mode of occurrence and uses of the following mineral deposits :

Iron, Copper, Aluminum, Manganese, Lead & Zinc and Radio active Minerals

Mica, Asbestos, Kyanite, Limestone and Gypsum

METALLURGICAL ANALYSIS (ML 3102)

Importance of Metallurgical Analysis in Metallurgical Industries. Important methods for the preparation of Standard Samples. Qualitative Analysis of Metallurgical Samples. Elementary discussion on the basic principles involved in Metallurgical Analysis.

Introduction to Instrumental methods of Analysis. i.e. XRF, EDS, EDAX etc.

Colorimetric and Spectro photometric methods of Analysis.

Emission Spectroscopy and its use in Metallurgical Analysis. Atomic Absorption Spectro photometric method of Analysis. Conductimetric, Potentiometric titration Polarographic and Electro Gravimetric methods of analysis.

Quantitative Estimation of Important Constitutes of the following items:

Iron Ore, Iron & Steel, Brass and Bronze, Lime Stone and Dolomite and Blast Furnace Slag.

SEMESTER-IV

MATHEMATICS – IV (MA 4105)

SPECIAL FUNCTIONS :- Series solution of differential equations, Bessel and Legendre's equations and their series solution, elementary properties of Bessel's function and Legendre's polynomial.

COMPLEX VARIABLE:- Analytic function, Cauchy- Riemann equation. Complex Integration, Cauchy's theorem and Cauchy Integral formula. Taylor and Laurent's expansion. Poles and Residue, Residue theorem. Conformal transformation, Bilinear and Schwartz's transformations.

PARTIAL DIFFERENTIAL EQUATION :- Formulation of partial differential equation, Linear and non-linear partial differential equations of the first order, Lagrange's method and Charpit's method. Higher order Partial Linear differential equations with constant coefficients. Method of separation of variables. Equation of vibrating strings, heat flow, Laplace's two dimensional equation and simple problems.

PROBABILITY AND STATISTICS (MA 4106)

Probability: classical and axiomatic definitions, addition law, conditional probability, multiplication law, total probability, Baye's theorem and independence of events.

Random variables: Discrete and continuous random variables, probability mass, probability density and commutative distribution functions. Mathematical expectation, variance, moment and moment generating function, Chebyshev 's inequality.

Regression Analysis: Linear regression, principle of least square, non-linear regression, correlation, coefficient of correlation, Rank correlation.

Distributions: Binomial, Hypergeometric, Geometric, Poisson and Normal distributions.

Sampling Distribution: Population samples, sampling distribution, estimate for population mean and variance, point of estimation, confidence interval for mean and variance of normal population, Testing of hypothesis, the critical and acceptance region, two type of errors, Chi-square, t-student and F distributions.

Analysis of Variance: completely randomize design and randomized block design, Quality control, control charts(X-chart, R-chart, P-chart and C-chart).

MINERAL ENGINEERING (ML 4103)

Introduction – Present status and future scope of Mineral Beneficiation. Mineral resources of India, Mechanism and Kinetics of Size Reduction.

Crushing And Grinding – Laws of Crushing & Grinding, Mechanism & Kinetics of size reduction. Principles and construction of Jaw Crusher, Gyratory Crusher, Cone Crusher, Roll Crusher, Rod Mill and Ball Mill. Laws of Crushing and Grinding

Sizing and Classification – Sieving and representation of sizing data. Hydrodynamics of movement of solids in fluid. Classification and important classifier like Cyclones and Hydrocyclones.

Concentration techniques, gravity separation methods, Heavy Media Separation, Jigging and Tabling, Magnetic Separation, Electrostatic Separation and Froth Flotation.

Dewatering – Qualitative discussion of Filtration and Drying. Mill Calculations and Selectivity Index, Simplified Flow Sheets for the beneficiation of the Ores of Iron, Cu, Zn, Mn and Beach Sand.

REFRACTORIES AND ITS APPLICATIONS(ML 4104)

Introduction : Definition, properties of a good refractory material and factors affecting selection of refractories, Classification of refractories and a general description of the manufacture of refractories, Equipments used.

Alumino-Silicate Refractories : Types of Clay, Weathering, Use of Grog and Its Advantages, manufacture, Properties & Application of Fireclay refractories, High Alumina Refractories.

Silica Refractories : Raw Materials, Bonding Agents & Mineralizers used, Manufacture, Properties & Applications, Semi-Silica refractories.

Dolomite Refractories : Raw Materials, Calcination, Slaking of Dolomite and Its Control, Bonding Agents, Manufacture, Properties and Applications of Dolomite Refractories.

Magnesite And Chromite Base Refractories : Preparation of Magnesite, Bonding Agents and Mineralizers, Composition, Magnesite, Chromite, Chrome-Magnesite & Magchrome Refractories, their properties and applications, Metalcase Refractories.

Carbon Refractories : Characteristics of Carbon as refractory material, Manufacture, properties and applications, graphitized Clay & its use as a refractory material, Standard Sizes of graphite Crucibles, Ceramic-Graphite Refractories, Magnesia-Graphite & Alumina-Graphite.

Insulating Refractories : Raw Materials used, Porosity and Its Control, Properties and Uses, Insulating Inserts, Artifacts and Insulating Wool.

Testing of Refractories : Importance of Felt, Fibre and Matting, Insulating Cements. Testing, Sampling, Standard Tests for various Refractory Properties- Pyrometric Cone equivalent, Refractoriness Under Load, Spalling resistance, Resistance to Thermal Attack, Cold Crushing strength, Apparent Porosity, Permeability, true Specific Gravity, bulk Density, Modulus of Rupture, Permanent Linear Change and Warpage.

Refractory Shapes : Standard and special Refractory Shapes, Standardization and Rationalization of Refractories, Some Special refractory Shapes used for iron Blast Furnace, Blast Furnace Stoves, Ladles, Stoppers, Electric and O.H. Furnaces, Cupola and Rotary Kilns

INTRODUCTION TO METALLURGY (ML 4105)

Importance of Metallurgy and Metallurgical Industries especially Iron & Steel Industries, Copper, Lead, Zinc and Aluminium Industries. Theories of Plant Location, Indian Mineral resources, Their Present Status and Future Prospects.

Mineral, Ores, Fluxes, Gangue etc. Brief Introduction of Mineral Beneficiation. Extraction Processes and Pre-Treatment of Ores for Smelting, refining of Metals, Introduction to Extraction of Non-Ferrous Metals like Copper, Aluminium, Zinc and Lead.

Introduction to Iron and Steel Making e.g. Blast Furnace Process, Acid and Base Converter (Thomas Process), E.O.F. and L.D. Converter.

Introduction to Metallurgical Fuels and Refractories, Metallurgical Furnaces.

Introduction to Pyrometry : Principles of temperature measurement, Thermoelectric Effect and Thermocouples, Resistance, Radiation and Optical Pyrometer. Construction, Calibration and Operation of Indicating and Recording Pyrometer.

Optical Microscope : Principle of Microscope, Objective, Chromatic and Spherical Aberration, types of Objectives and Eye pieces. Properties of objectives, Bright and Dark Field Illumination

Principles and construction of Transmission Microscope

METALLURGICAL THERMODYNAMICS AND KINETICS (ML 4106)

Basic scope and Concept of Thermodynamics, Thermodynamics terminology and definition, Concept of Heat, Work and Energy. Discussion of First and Second Law of Thermodynamics, their development, formulation and application.

The concept of Entropy and Free Energy, their importance, important consequence of these laws and their application, standard Free Energy & Temperature Effect. Thermodynamic analysis of Process and State of Equilibrium involving reactions in solutions and multiprocess system, Phase Equilibrium, illustration from Metallurgical System, Third Law of Thermodynamics.

Thermodynamics of Solutions, Ideal Solution, Raoult's Law, their deviation. Partial Molar quantities. Integral Quantities, Gibb's Duhem Equations, Heterogeneous Equilibria. Ellingham Diagram of Metal Oxide and Metal Sulphide Systems.

Kinetics – Kinetic reactions, Activated Complex Theory, Heterogeneous Reaction and importance of rate controlling Steps, Adsorption and Reactions on Surfaces, Reaction Rule. Thermodynamics of Electrolytes Concentration Cells.

SEMESTER-V

PRINCIPLES OF PHYSICAL METALLURGY(ML 5107)

Interstitial and Substitutional Solid Solutions, Hume Rothery's Rule, Equilibrium diagrams, Complete and Partial Solubilities, Intermediate Phase. Relation between Equilibrium Diagrams, Micro-Structure and Physical Properties of Alloy System, Specific Examples of Equilibrium Diagrams Fe-C, Cu-Ni, Cu-Sn, Pb-Sn, Al-Cu, Al-Si and other Alloys. Systems of Industrial Importance.

Effect of alloying elements on the structure and properties of Steel, Binary and Ternary systems.

Introduction of High Temperature Alloys, Super Plastic materials, Memory Alloys, Magnetic Alloys, Tool Steel, Maraging Steel, HSLA Steels.

Strengthening Mechanism, Conductive Materials, Transformer Steels, Materials for Solar Energy, Cryogenic Materials. Classification, Strengthening properties of Matrix, Strengthening Mechanism & Fracture Behavior of Monolithics & Composite Materials.

IRON MAKING (ML 5108)

Status of iron and steel industries in India & World. Quality of Indian Iron Ores and its effect on Iron Production, Beneficiation of iron ores. Other important raw materials for Iron Production.

Agglomeration of Iron Ores: Sintering, Pelletizing, their quality testing and use in blast furnace. Construction of Iron Blast Furnace, its profile and refractory lining for Hearth, Shaft, Bosh etc. Handling equipment and Charging System and accessories to blast furnace.

Reduction of Iron Oxide by Carbon, Carbon monoxide and hydrogen in blast furnace conditions. Counter current principles and thermal equilibrium and Critical Hearth Temperature.

Reduction of impurities in blast furnace charge materials like Mn, Bi, P, S and Ti.

Principle of Burdening and Metallurgical control of the slag and grade of Iron produced. Irregularities in the furnace and their control.

Influence of preheating of blast, Oxygen Enrichment, Humidified Blast, High Top Pressure, Injection through Tuyers etc on productivity and Coke Rate of Blast Furnace.

Blast furnace Slag formation, Influence of hearth temperature upon the physico-chemical properties of slag and slag/metal equilibria with particular reference to desulphurization and effect of Silica, MnO, Al₂O₃, FeO etc in general and particularly under Indian conditions.

A brief description of the manufacture of Ferro Alloys like Ferro Manganese, Ferro Silicon and Ferro-Chrome.

PHASE TRANSFORMATION (ML 5109)

Fick's Law of Diffusion, Darken's Equation, variation of Diffusion Coefficient with Temperature and Concentration, Self Diffusion, Determination of Diffusion Coefficient, Mechanism of Diffusion.

Classification of Phase Transformation Processes.

Solidification of Metals & Alloys : Types of Solidification, factor affecting solidification, Homogeneous and Heterogeneous nucleation.. Theory of Nucleation and Growth, Role of Under Cooling and Super Cooling Equiaxed, Dendritic and Columnar Grains. Thermodynamics and Kinetics constraints during nucleation. Interface and diffusion controlled growth processes.

Thermodynamics, kinetics and crystallography of Eutectoid Bainitic and Martensitic transformations, Precipitation Reaction and Spinodal Transformation, Order-Disorder reactions.

Segregation : Gravity, Normal and Inverse Segregation, Zone Refining, Growth of Single Crystals.

Methods of Detection of Phase Change and Construction of Equilibrium Diagrams – Dilation, Magnetic, Microscopic, X-Ray, Electrical Resistivity Methods.

TESTING OF MATERIALS (ML 5110)

INTRODUCTION: The role of testing, objective of testing of materials, significance of tests. Specification of materials. Standardizing agencies I.S.S. & I.S.O.

Mechanical properties of metals and alloys, their standard specifications with particular emphasis on I.S.S.

Standard Mechanical Tests, their purposes, types, test conditions design of test, test specimens, selection of testing apparatus, measurements, conducting tests, Tensile Tests – requirement of the relevant I.S.S. stress determination.

Compression Test: Specimen, apparatus, procedure, effect of variables, behavior of a typical ductile and a typical brittle material in a compression testing machine. Relevant I.S.S. requirement.

Hardness Test: Concept of hardness, scope and applicability, standard hardness test, Brinell, Rockwell, Vickers & effect of variables. Scleroscope tests micro hardness test, Relevant I.S.S. requirement of test.

Impact Test: concept of Impact, scope and applicability of test, principle, apparatus, specimen, procedure, effect of variable. Transition temperature effect of variables. Transition temperature effect of variables on Transition Temperature. Relevant I.S.S. requirement of test.

Fatigue Test: Concept, scope and applicability, specimens, apparatus, procedure. Effect of specimen variable test variables, Goodman's & Gerber's Formula, Mechanics of Fracture by Fatigue.

Creep Test: Concept of Creep metals at elevated temperature, scope and applicability of laboratory test for determining the Creep Properties, various Creep Curves and their interpretations.

Concept of Fracture & Failure of Metals and Alloys in brief.

Non-Destructive Testing: Dye Penetrant, Radiographic Method, Electromagnetic Method, Magnetic Particle Method, Electrical Method, Ultrasonic Method etc.

Relevant I.S.S. requirements of each method. Inspection of Cast & Wrought Products, Proof Test etc.

MECHANICAL ENGINEERING (ME 5111)

1. Boiler : Classification, description of important types, mounting accessories, types of draught, Calculation of chimney height.
2. Steam Engine : Introduction to properties of steam, Use of steam tables and charts, simple steam engine, indicator diagrams, I.H.P., B.H.P., M.E.P., efficiencies of steam engine.
3. Steam Turbine : Flow of steam through nozzle(elementary) simple impulse turbine velocity diagram and efficiency.
4. Compressor : Simple and multistage reciprocating air compressor (elementary).
5. I.C. Engine : Elementary principle of S.I. and C.I. engine, Air standard efficiencies of Otto Diesel cycles. Thermal and relative efficiencies of actual engines. I.H.P., B.H.P., M.E.P. of I.C. Engine.
6. Pump : Elementary principle of reciprocating and centrifugal pumps.
7. Lubrication : Simple idea of lubricated bearings pressure.
8. Power drives : Belt and Rope Drivers, Initial and centrifugal tensions, friction Clutch, Principles of Spur, Bevel and worm gearings, simple and compound Gear Trains.
9. Governors : Elementary analysis of Watt porter and spring loaded governors.
10. Balancing : Balancing of Rotating masses.

SEMESTER-VI

PRINCIPLES OF EXTRACTIVE METALLURGY (ML 6111)

Process flowsheets, process aims, characteristics and costs, Material sources and products.

General characteristics of Pyrometallurgical process – Separation, Vapour Phase Separation, Liquid-liquid separation, chemical change in solid state.

Compound Formation – Metal Products from Oxides, Sulphides and Halides.

Metal Purification – Liquation, removal of impurities by compound formation, Vacuum Refining, Zone Refining,

Reactor Characteristics – Design, Energy Sources and reactor materials.

Environmental problems associated with Pyrometallurgical Process, Treatment of Gases and effluents, environmental regulation.

Economic characteristics of Pyrometallurgical Process: Solid/Gas, Solid/Solid, and Liquid/Liquid Reactions.

Hydrometallurgy: General characteristics process aimed at Leaching, leaching conditions and techniques, impurities separation, Selective Precipitation, Ion-exchange, Solvent extraction.

Compound Formation: Crystallization and Chemical precipitation of Metal Compounds.

Metal Production: Cementation, Gaseous Reduction and Chemical Precipitation. Metal Purification

Environmental effects of Hydrometallurgical Process.

Electrometallurgy: General characteristics, factor affecting design of electro-chemical reaction.

Process Aims: Compound formation, Metal production, Metal Purification, Economic characteristics of Electrometallurgical Processes.

STEEL MAKING –I (ML 6112)

Physico-chemical principles of various systems pertaining to steel making. Systems like Acid Bessemer, Basic Bessemer (Shames Process). Factors for setting up of greater field Iron & Steel plants. Slag/Metal equilibria involved in Steel Making. Reactions involved in these processes. Slag-Metal equilibria involved in Steel making.

Introduction to Twin Hearth Steel Making and Improvement in the practice.

Detail discussion regarding oxygen steel making process. Physico-chemical principles and processes. Principles and Operation of EOF Process.

Deoxidation of Steels – killed, semi-killed and rimming steels. Teeming, casting and pit practice. Degasification, pattern of solidification, segregation, continuous casting.

Scope, merits and economics of different methods like Arc and induction (Electric Steel Making Process). Construction and operation of electric Arc Furnace. Recent Trends in Electric Arc Furnace.

NON FERROUS EXTRACTIVE METALLURGY(ML 6113)

Scope of Non-Ferrous Metallurgy in India.

Extraction of metals by Pyro, Hydro and Electro Metallurgical techniques with emphasis on the physico-chemical principles involved.

Refining and typical flowsheet of plants in production of Copper, Aluminium, Zinc, Tin, Lead and Nickel.

Simplified flowsheet for extraction of metals Ti, Mg, U and Th. Recovery of meals from by-products and industrial wastes. Ion Exchange and Solvant Extraction.

Consideration of environment, safety, energy optimization and productivity associated with above mentioned processes.

Electroplating : Principles of Electrode – Position of Metals and Alloys, Throwing Power, Electroless Plating, Electroforming, Anodizing.

Electro-Wining and Electro-Refining, Special features and electrometallurgy of important metals like Cu, Zn and Al, Metal Extraction from Sea Noodles.

DEGRADATION OF MATERIALS (ML 6114)

Technological importance of corrosion study, corrosion as non-equilibrium process, corrosion rate, expansion, electrochemical principle of corrosion-cell analogy, concept of single electrode potential, reference electrodes, emf and galvanic series – their use in corrosion study, polarization, passivity, different forms of corrosion – uniform attack, galvanic, crevice, pitting, intergranular, selective leaching, erosion, stress corrosion, cracking and their characteristics, causes and remedial measures.

Principles of corrosion prevention, material selection control of environment including inhibitors, cathodic and anodic protection, coatings and design considerations, corrosion testing methods.

Introduction to high temperature corrosion, oxidation kinetics, oxide defect structure. Wagner – Hauffe valance approaching alloy oxidation, catastrophic oxidation, internal oxidation, considerations in high temperature alloy design, prevention of high temperature corrosion – use of coatings. Liquid metal attack – liquid metal embrittlement, preventive measures, chemical degradation of non-metallic materials like rubber, plastics, ceramics etc, hydrogen damage types, characteristics, mechanism and preventive measures.

FUELS AND FURNACES (ML 6115)

FUELS: Classification of Fuels, Indian Resources.

SOLID FUELS: Coal Preparation, Coal Washing, Carbonization of Coal, Brief description of the manufacture of Coke and recovery of products, specifications and testing of Coal and Coke. Indian standard specification of Metallurgical Coke to be used in the Blast Furnace. Pre-Carbonisation of Coal, Different methods of precarbonisation.

LIQUID FUELS: Advantages of liquids fuels, liquid fuel furnaces, storage and handling of liquid fuels.

GASEOUS FUELS: Advantages of Gaseous Fuels, specification and analysis of gaseous fuels, Testing of gaseous fuels, Manufacture of Producer Gas, Water Gas, By Products of Gaseous Fuels – Blast Furnace Gas, Coke Oven Gas.

COMBUSTION: Chemistry of Combustion Reaction, Air required for Combustion, Excess Air, Control of Combustion, Complete Combustion. Numerical examples based on Combustion Problems.

FURNACES: Classification, Principles of Working and application of Industrial Furnace, brief description of the construction of different parts of furnaces e.g. Hearth, Roof, Tempers etc. Heat Economy. Newer Heat Insulating Materials.

Heat recovery by Regenerators, Recuperators and Waste Heat Boilers. Design and Calculation of furnaces.

SEMESTER VII

PHYSICS OF METALS (ML 7116)

Concept of Modern Physics – Introduction of Crystalline Solids, Electron Theory of Metals. Schrodinger's Wave Equation, Concept of Brillouin Zone, Electrical and Thermal Conductivities, Semi Conductivity, Super Conductivity.

Theory of dislocation, Plastic Deformation of Single Crystal and Polycrystalline aggregates. Solute dislocation interalli, Cottrell atmosphere. Formation of Slip and Twin. Dislocation Reaction in F.C.C. Theory of Work Hardening. Dynamic and Metadynamic recrystallisation process. X-Ray Crystallography, Stereographic Projection, X-Rays Generation and properties. Principles of X-Ray Diffraction, various diffraction methods. Indexing of diffraction pattern. Magnetic Properties of Materials.

Fracture – Types of Fracture, Theory of Brittle Fracture. Fracture of Crystalline Solids. Mechanism of Cleavage Crack, Nucleation in Crystalline Solid and Its propagation. The effect of Grain Boundary and the state of stress on cleavage fracture. Intercrystalline Brittle Fracture. Temper Brittleness.

Creep – Mechanism of Creep, stages of creep. Design and development of creep resistant alloys. Metallurgical factors affecting creep.

Fatigue – Theory of Fatigue, structural features of fatigue. S-N Curve, Effect of metallurgical variables on fatigue properties.

FOUNDRY TECHNOLOGY (ML 7117)

Introduction of Indian Foundries. Advantages of Metal Casting Process. Various pattern materials, allowances, types of patterns etc.

Technology of Moulding and Core Making: Principle ingredients of moulding and core sand, their characteristics.

Various types of Binders and additives to moulding, Sand Conditioning, preparation and core making sand and related equipments. Various sand control tests.

Machine Moulding, high pressure moulding. Core making machine, sand moulding processes based on Sodium Silicate, Organic Binders and other special moulding processes

Design of Gating and risering of casting pertaining to iron and steel and Non-Ferrous casting.

Different methods of casting such as die casting. Centrifugal casting Rheo Casting, Spray Casting. Shell moulding and its full details.

Various types of melting furnaces used in foundries such as Cupola, Electric Furnace, Induction furnace, Melting of Cast Iron, Steel, Non-Ferrous Metals and Alloys.

Casting defects, their causes and remedies. Metallurgical inspection and quality control and foundries. Modernization and mechanism of foundries I.S.S.

Consideration of environment, safety, energy optimization, and productivity associated with above mentioned process.

HEAT TREATMENT OF METALS AND ALLOYS (ML 7118)

Basic principles of Heat Treatments, determination of T-T-T and C-C-T diagram of Eutectoid Steel, effects of alloying elements on T-T-T and C-C-T diagram.

Solid state transformation, Austenite-Pearlite , Austenite-Banite and Austenite-Martensite transformation. Tempering of steel, Sub-Zero treatment. Principle of selective hardening of steel.

Case carburizing, Nitriding, Cyaniding, Induction and Flame hardening of steel.

Special methods of heat treatment such as Austempering, Martempering, Ausforming and Maraging of Steel.

Hardenability of Steel. Methods for hardenability determination, effects of alloying elements on hardenability.

Heat Treatment of Stainless Steel, Maraging Steel, Die Steel, Hadfield Steel.

Heat treatment of High Speed Steel. H.S.L.A., Steel, Shape Memory Alloy, Super Plastic Materials, TRIP Steel. Heat treatment of Transformer Steel.

Age Hardening of Al alloys. Al & Cu base alloys.

ELECTIVE I & II

ALTERNATIVE METHOD OF IRON AND STEEL (ML 7119)

Alternative route for Iron Production, their technology and present status in India & World at large.

Electrical Reduction Furnace in which Coke merely the reducing agent, Low Shaft Furnace, The Small Shaft Blast Furnace, Sponge Iron Production (DR). The physical chemistry of DR processes, HyL Process, Midrex Process, Fluidised Bed Process, rotary kiln Process, Krupp–Renn process, SL/RN Process, New Technology for Iron Production as SKF Plasma Smelt Process, ELRED Process and INRED Process.

Strategic consideration in direct and continuous steel making. Elimination of Processing steps, Direct use of Coal and Ore Fines. Optimum of Direct Steel Making Process like WORCRA, SPRAY Steel Making etc.

PHYSICAL CHEMISTRY OF IRON AND STEEL MAKING (ML 7120)

Liquid Properties: Surface Tension, Viscosities of liquid metals, Diffusion in Metals and Alloys, Physico-chemical properties of Molten glasses, Slag and Matte., Surface Tension and Transport Properties.

Rate Phenomenon: Salient features of kinetics of interfacial reactions, Nucleation and Growth, Heat and Mass transfer in Fluid Films, Nature of Reaction Product layers. Reaction of gases in porous media. Mass transfer across stirred liquid surfaces, Gas bubbles in liquids.

Reactions in Iron Making, Kinetics of reduction of ores, Pellets and Sinters. Slag-Metal reaction of S-Si in Blast Furnace.

Reactions in Steel Making – Slag-Metal reaction in Hearth Process. Gas/Slag/Metal reactions in Pneumatic and Oxygen steel Making process..

Discussions of Phosphorus and Carbon reactions and their interdependence.

Deoxidation Theory and Practice:- Ladle Treatment of Steel, like gas purging, vacuum treatment and Ladle Furnace etc.

Reaction during Solidification of Steel in Moulds and/or during continuous casting.

NUCLEAR METALLURGY (ML 7121)

Review of nuclear physics: Nuclear structure, binding energy, fission and fusion reactions, neutron cross-sections, moderation of neutrons, energy release from fission & fusion reactions.

Materials for reactors: Classification of nuclear reactors viz., fuels, moderators, control rods, coolants, reflectors and structural materials. Fabrication of fuel and cladding materials.

Radiation effects: Interaction of radiations with solids, concepts of radiation damage. Influence of radiation on structural and fuel materials. Radiation health hazards, safety and shielding. Disposal of radioactive wastes. Uses of radioactive isotopes, International safety regulations and Indian nuclear establishments.

Production of nuclear metals: Atomic minerals and their general methods of processing.

Production metallurgy of nuclear uranium: The fuel cycle, extraction of uranium and enrichment of uranium. Extraction of thorium, beryllium and zirconium. Processing of spent fuel and extraction of plutonium.

Indian status: Atomic energy programme in India and Indian Reactors.

METAL FORMING TECHNOLOGY (ML 7122)

Plastic deformation of Metals: Stress-Strain curve for metals, yield point phenomenon, yielding criteria, Bauschinger's Effect, strain ageing.

Hot working and Cold working of metals, Annealing of cold worked materials.

Rolling: Classification of Rolling mills, Forces and geometrical relationship in rolling, main variables in rolling. Roll pass, design and rolling equipments. Defects in rolling products.

Forging: Classification of Forging Processes. Forging processes, forging equipments, forging defects, residual stresses in forgings.

Extrusion: Classification of extrusion processes, extrusion equipments, variables of extrusion. Flow of metals in extrusion, extrusion defects, extrusion of tubes, production of seamless pipes and tubing.

Drawing: Wire drawing, wire drawing without friction, wire drawing with friction, defects in wire drawn products, variables in wire drawing.

Super Plastic Forming, High Energy Forming.

SEMESTER-VIII

STEEL MAKING II (ML 8123)

Secondary Steel Making Process: Introduction, Process, variation, Stirring techniques, Synthetic Slag refining with Stirring and Perrin Process.

Classification and properties of alloy steel, raw materials, raw materials for alloy steel making.

Manufacture of alloy steel like Stainless Steel, Hadfield Steel and High Speed Steel.

Design of Electric Furnace and Induction Furnace for Steel Making. Manufacture and testing of Graphite Electrodes. Physical chemistry of alloy steel making.

Development in Stainless Steel Making. Other recent process of steel making e.g. Ajax Process, Tandem Furnace Process, Continuous Steel Making Process, Spray Steel Making Process, IRSID Process, SIP Process, EOF Process and Dual Hearth Furnace Process.

Decarburization Techniques: AOD process, VOD Process, CLU Process and MRP Process.

Injection Metallurgy: Plunging technique, Powder Injection, Wire Feeding, Their Economic Analysis.

Remelting Process : Vacuum Arc Remelting & Electro Slag Remelting Process

Teeming Methods: Direct Pouring, Tundish Teeming and Bottom Teeming.

Vacuum Treatment of Liquid Steel: Principles, vacuum raising equipments, Degassing Process e.g. Ladle Degassing & Stream Degassing.

ENGINEERING ECONOMICS AND MANAGEMENT (ME 5115)

ENGINEERING ECONOMY:

(a) Simple and compound interest, annuities (b) depreciation: cause and methods (c) comparison of alternative and replacement studies: (i) equivalent annual cost method, (ii) present worth method, (iii) rate of return method.

ACCOUNTING :

(a) Double entry book keeping, (b) journal, (c) ledgers, (d) manufacturing account: profit and loss accounts, (e) balance sheet.

COSTING:

(a) cost and cost accounting, elements, (b) break even analysis, determining selling price and profitability, (c) over-head cost allocation, (d) costing system, job costing, unit costing, process costing, operating cost, departmental cost, (e) cost control : actual and standard cost, budget and budgetary control.

ENTREPRENEURSHIP DEVELOPMENT :

(a) Introduction to entrepreneurship, (b) motivation, (c) psychological factors, risk taking behavior, (d) rural entrepreneurship, (e) self employment.

MANAGEMENT AND ORGANIZATION :

(a) Principle of management, (b) elements of management, planning, organizing direction and control, (c) organization structure and charts, line, staff functional and committee organization.

INDUSTRIAL MANAGEMENT :

(a) Industrial ownership LP proprietorship, partnership, Joint Stock Company and cooperative societies, (b) site selection, (c) plant layout: process oriented product oriented layouts, line balancing.

PRODUCTION MATERIALS MANAGEMENT :

(a) Production types: job order, batch and mass production, (b) inspection and quality control, (c) inventory control, economic order quality.

OPTIMIZATION TECHNIQUES :

(a) Linear programming: graphical method, analytical method of solution (two variables), (b) CPM & PERT.

PERSONAL MANAGEMENT :

(a) Functions: manpower planning, recruitment, selection, training, promotion, discipline, welfare, (b) job evaluation, (c) merit rating, (d) wages and incentives

MARKETING MANAGEMENT :

(a) Market research and sales forecasting, (b) sales management, (c) advertisement and sales promotion

ELECTIVES III, IV & V

POWDER METALLURGY (ML 8124)

Advances in Metal Powder Production. Methods, characterization of metal powders. Chemical composition and micro-structure, particle size, shape and their determination. Powder flow, compressibility and porosity measurements. Treatment of metal powders. Behavior of powder during compaction, Die Compaction.

Types of Presses – Tooling and Design. Modern methods of Powder consolidation, Isotactic Pressing. Roll compaction, powder extrusion and forging, slip casting, evaluation of Sintered Products.

Shaping Process – Casting, Forging and Machining.

Products of Metal Powders – Chemical Methods, Electro-Chemical Methods and atomization.

Recent development in Powder Production, Mechanical Alloying, Rapid Solidification. Processing of Nano-Sized Powders.

Compaction – Basic fundamentals, parametric relations, effect of particle characteristics on compaction, lubrication, pressure and density distribution during compaction.

Sintering – Effects of Process Variables and Powder characterization on Sintering. Mechanism of Mass Flow during solid state sintering, liquid phase sintering, Hot Pressing.

Applications – Sap, Connected Composite tools, Nickel and Tungsten filaments, contact materials and structural parts.

METAL JOINING TECHNOLOGY (ML 8125)

Introduction, classification of Joining Processes. Principles of Brazing and Soldering.

Basic Welding Principles – Physics of Arc, Welding equipments. Fusion welding processes – Principles of operation parameters, Shielded Metal Arc Welding, Gas Metal Arc welding. Tungsten Inert Gas Welding, Submerged Arc Welding, Electro-Slag Welding, Electro-Gas Welding. Electron Beam Welding, Laser Welding, Flash Butt Welding, Flux Core Arc Welding, Co₂ Welding, Gas Welding – Thermit Welding.

Solid State Welding – Forge Welding, Roll Welding, Friction Welding, Ultrasonic Welding, Resistance Welding Processes.

Weldability of Carbon Steels, Low Alloy Steels, Stainless Steels, Nickel Steel, Al and Al-Alloys, Copper and Copper Alloys; Welding Problems and their remedies. Welding of Cast Iron. Weld defects, Causes and Thermal Cycles in Welding.

COMPOSITE MATERIALS(ML 8126)

Classification of Composite Materials, Dispersion, Strengthened, Particle-reinforced and fiber-reinforced composites. Laminates, properties of Matrix and reinforcement materials. Micro-mechanics and principle of Strengthening, Elastic properties, Stress-Strain Relations, Fracture Behavior, Fabrication Methods and Structural Applications of different types of Composite Materials.

ELECTRO-CHEMICAL TECHNOLOGY IN MATERIAL PROCESSING (ML 8127)

Thermodynamics of Electrolyte, Electro Chemical Potential, Conduction of ions in Solution, Over Potential, Desorption, Phase Formation, Economics of Electrolytic Process, Principles of Cell Deposition, Electro-Chemical Technology, Electro-Winning, Electro-Refining and Electroforming. Electro-Chemical machining, Electro Plating, Anodizing, Pickling, Electrophoretic Painting, Electro-Chemical Treatment of minerals, Batteries and Fuel Cells, Water Treatment and Environmental Protection.

ENGINEERING APPLICATIONS OF METALLURGICAL MATERIALS (ML 8128)

Effects of modification in Composition, structure and Processing on properties, Underlying Metallurgical Principles, Microstructure property Correlation, Criterion in material selection. Material property charts, processing maps, concept of Strain Ratio, Forming Limit Diagram. Transformation induced Plasticity and Super Plasticity.

Strengthening Mechanism, thermo mechanical processing, Controlled Cooling. Inclusion type/shape control, Grain Boundary Engineering, Single Grain Processing directionally Solidified materials, Texture Effects.

Important groups of Metallic Materials – Carbon Alloys and Stainless Steel, Electrical and Magnetic Steels and Alloys, Coated Sheets, Cast Iron, Light Metal and Alloys, Copper and its Alloys, Nickel, Iron Cobalt based Super Alloys, Titanium, Zirconium, Alloys.

Applications to focus on transport, energy and chemical plant sectors highlighting criteria for material selection.

NDT OF METALS AND ALLOYS (ML 8129)

Physical Principles and application of NDT Techniques. General Introduction applications and Classification of NDT.

Visual Inspection: Simple aids detectable limits and analysis.

Liquid Penetrant Inspection: Steps for liquid penetrant inspection, properties of chemicals, Principles of Fluorescence, common applications.

Magnetic Particles Inspection: Magnetic Materials, Ferro-magnetism, Hysteresis loop, magnetisation methods, Testing with use of dye and Fluorescent particles.

Eddy Current Testing.

Ultra Sonic Testing: Theory and Application.

Radiographic Testing: Theory and Application.

Theory and Application of Acoustic Emission, Thermography,

In-situ and replica Metallography and Residual Stress Measurement Analysis.