DETAILED SYLLABUS
METALLURGICAL AND MATERIAL ENGINEERING DEPARTMENT
JADAVPUR UNIVERSITY

First Year: First Semester

SUBJECT CODE	NAME OF THE SUBJECT	THEORETICAL/ SESSIONAL/ TUTORIAL	CREDIT HOURS PER WEEK
THEORETICAL SUBJECTS			
Met/Chem/T/111	Chemistry-I	Theoretical	300
Met/CSE/T/112	Computer Programming	Theoretical	300
Met/Math/T/113	Mathematics-IN	Theoretical	300
Met/AM/ME/T/1A/114	Engineering Mechanics	Theoretical	400
Met/Ph/T/1A/115	Physics-IA	Theoretical	300
Met/BED/ME/T/116	Basic Engineering Drawing	Theoretical	000
SESSIONAL SUBJECTS			
Met/Ph/S/1 /111	Physics Laboratory-I	Sessional	003
Met/BED/ME/S/1/112	Basic Engineering Drawing	Sessional	003
Met/WS/ME/S/9/113	Workshop Practice-IX (Pattern Making and Moulding)	Sessional	003
Met/CSE/ S/114	Computer Programming	Sessional	003
TOTAL CREDIT HOURS (16-0-15) : 16-0-0 (Theoretical); 0-0-12 (Sessional) **Marks: Theoretical: 600; Sessional: 400; Total: 1000**			

Met/Chem/T/111 : CHEMISTRY-I

Surface effects: Definition and concepts of surface/interfacial tensions, surface free energy, surface entropy and surface concentration. Thermodynamics of surfaces and interfaces - Gibbs Adsorption isotherm, Langmuir's isotherm, and other adsorption isotherms, curved interfaces.

Viscosity and its determination; effect of temperature on viscosity.
Catalysis and its mechanism and applications.

Theory of inorganic qualitative analysis; solubility product and its application in analysis; hydrolysis, ionic product of water, pH, buffer, common ion effect, and their applications.

Redox systems; red-ox potentials and their use in chemistry.

Environmental chemistry; pollution control in air, water; greenhouse gases, NOx, SOx, SPM, BOD, pH etc.
Colloidal systems; their classification and applications.
Nuclear chemistry, Photochemistry.

Met/CSE/T/112: COMPUTER PROGRAMMING

Writing flow chart, Fortran language, details of format , do loops subprogrammes, sub-routines , order of Fortan statement , etc, C-Programmes ,details of programmes , I/O files, C-Processor.

Met/Math/T/113: MATHEMATICS-IN

Real numbers, Functions of a single variable: Concept of limit, successive differentiation, Rolle's theorem, Mean value theorem, Taylor's series, Maclaurin's series, Maxima and minima.

Functions of several variables: Limit, continuity, Partial derivatives. Different partial derivatives of a composite function. Euler's theorem, Total derivatives and directional derivatives.

Properties of definite integrals. Fundamental theorem of integral calculus. Improper integrals. Beta and Gamma functions multiple integrals. Applications: Arc length and areas of plane curves. Volumes and surface areas of solids of revolution, Sequence and infinite series, Convergence and divergence of infinite series. Comparison test. D'Alembert's ratio test and Cauchy's root test.

Met/AM/ME/T/1A/114: ENGINEERING MECHANICS

Statics: Introduction, IdealizationsofMechanics,FundamentalsofVectorAlgebra,Application of Vectors in Mechanics, Equiv System, Equilibrium, FBD Concept, Fundamentals of Friction, Properties of surface, Centroid, Moment of Inertia Dynamics: Intro to vector calculus, Definition of vectors in Dynamics, Rectilinear Motion, Curvilinear motion of particle and description of different coordinate systems, Kinetics, Newton's Law and D' Alembert's principle and application to rectilinear and curvilinear motion, constrained motion, Energy and Momentum methods.

Met/Ph/T/1A/115: PHYSICS-IA

Use of vectors in particle mechanics, Unit vectors in spherical and cylindrical polar coordinates, Conservative vector fields and their potential functions - gravitational and electrostatic examples, Gradient of a scalar field, Equipotentials, States of equilibrium, Work and Energy, Conservation of energy, Motion in a central field and conservation of angular momentum.

Angular momentum of a system of particles, Torque, Moment of inertia , Parallel and Perpendicular axes theorem, Calculation of moment of inertia for (i) thin rod, (ii) disc, (iii) cylinder and (iv) sphere. Rotational dynamics of rigid body (simple cases).

Motion of fluids, Bernoulli's equation and its applications, motion of viscous fluids - Poiseuille's equation.

Simple harmonic motion, Composition of simple harmonic motion, Forced vibration and resonance, Wave equation in one dimension and travelling wave solution, Standing waves, Wave velocity and group velocity.

Assumption for the kinetic theory of gases, Expression for pressure, Significance of temperature, Deduction of gas laws, Qualitative idea of (i) Maxwell's velocity distribution. (ii) degrees of freedom and equipartition of energy, Specific heat of gases at constant volume and constant pressure.

Equation of state of a gas, Andrew's experiment, Qualitative discussion on van der Waal's equation of state, Critical constants, Law of corresponding states.

Macroscopic and microscopic description, Thermal equilibrium, Zeroth law of thermodynamics, Concept of international practical temperture scale, Heat and Work, First law of thermodymamics and some applications, Reversible and irreversible processes, Carnot cycle, Second law of thermodymamics, Concept of entropy, Thermodynamic relations.

Met/BED/ME/T/1/116: BASIC ENGINEERING DRAWING

(Only Semester Examination will be held)

Met/Ph/S/1 /111: PHYSICS LABORATORY-I

(Selected Experiments from the following)

1. Determination of Galvanometer resistance by half - deflection method.
2. Determination of Galvanometer resistance by Thomson's method.
3. To find high resistance by Galvanometer deflection method.
4. To measure mechanical equivalent of heat, J by electrical method (Joule's) using copper calorimeter (radiation correction to be done).
5. To compare to low resistance by drop of potential method.
6. To determine resistance per unit length of wire by using Carey Foster bridge.
7. To estimate strength of a current by using copper voltmeter.
8. a) To compare the EMF's of two cells by using a potentiometer
   b) To measure current by using a potentiometer
9. To measure the horizontal components of earth's magnetic field intensity using deflection and vibrating magnetometers.
10. Determination of co efficient of linear expansion by optical lever method.
11. Determination thermal conductivity of metal by Searle's method.
12. To determine co-efficient of viscosity by Capillary flow method.
13. Determination of Young's modulus by Flexure method.
14. To draw mutual and anode characteristics of triode and hence too fine Rp, μ, and gm
15. To draw the transistor characteristics (NPN / PNP) in the given configuration and hence to find hi, hf
16. Determination of refractive index of the material of the glass prism by prism spectrometer
17. Study of collisions in one dimension using a linear air track
18. Use of an air track for obtaining potential energy curves for magnetic interactions.
19. Study of oscillations under potential wells of various shapes using an air track.
20. Experiments on diffraction in single slit, double slit and plane grating using He- Ne laser a) To find the wavelength of a monochromatic light by single slit. b) To find slit separation of a double slit. c) To find number of rulings per cm of a plane grating
21. To find the wavelength of a monochromatic light by Newton rings.
22. Fabry-Perot interferometry: To find out separation of wavelength of sodium D1 & D2 lines.

Met/BED/ME/S/1/112: BASIC ENGINEERING DRAWING

Drawing primitives: instruments, letters, lines, title block, geometric curves & shapes, scale and dimension. Projection: orthographic and isometric, sectional views.

Met/WS/ME/S/9/113: WORKSHOP PRACTICE-IX (Pattern Making and Moulding)

Introduction to different phenomena arising out of shrinkage of castings and pattern maker's rule; making of wooden patterns from supplied drawings and samples of patterns; making of core boxes. Introduction to moulding practice- preparation of moulding sand and use of moulder's tools; making of moulds by using selected pattern's; introduction to melting and pouring practice; experiments sand testing like permeability, moisture content, shutter index, mould strength, grain fineness number etc.; demonstration of injection moulding machine.

Met/CSE/ S/114: COMPUTER PROGRAMMING

As per the theoretical paper Met**/CSE/T/112**.

First Year: Second Semester

SUBJECT CODE	NAME OF THE SUBJECT	THEORETICAL/ SESSIONAL/ TUTORIAL	CREDIT HOURS PER WEEK
THEORETICAL SUBJECTS			
Met/Chem/T/121	Chemistry-II	Theoretical	300
Met/Math/T/122	Mathematics-IIN	Theoretical	300
Met/AM/ME/T/3/123	Strength of Materials	Theoretical	400
Met/ME/T/124	Heat Engineering	Theoretical	300
Met/Ph/T/2A/125	Physics-IIA	Theoretical	300
Met/AED/ME/T/1/126	Advanced Engineering Drawing	Theoretical	000
SESSIONAL SUBJECTS			
Met/Chem/S/124	Qualitative Analysis	Sessional	003
Met/Ph/S/2/125	Physics laboratory-II	Sessional	003
Met/AED/ME/S/1/126	Advanced engineering drawing	Sessional	003
Met/WS/ME/S/11/127	WORKSHOP PRACTICE-XI (Fitter Shop and Machine Shop)	Sessional	003
TOTAL CREDIT HOURS (16-0-12) : 16-0-0 (Theoretical); 0-0-12 (Sessional) **Marks: Theoretical: 600; Sessional: 400; Total: 1000**			

Met/Chem/T/121: CHEMISTRY-II

Complexes. Perfect and imperfect, Werner;s theory of cordination compunds, chelates, stereochemistry, studies on complexes, nature of linkages in cordination compounds, organometallic complexes, nomenclature. Chemical equilibrium : Law of mass action, Le Chatelier's principle and its applications, problems. Chemical Kinetics : Order of reaction (Ist & 2nd order).
Polymer chemistry

Biochemistry

Met/Math/T/122: MATHEMATICS-IIN

Determinants and Matrices: Definition and properties. Product of two determinants. Solution of system of linear equations by Cramer's rule. Addition and multiplication of matrices. Adjoint and inverse of matrix. Hermitian and unitary matrices. Eigenvalues and eigen vectors.
Vectors: Vectors, position vectors, Addition of vectors, Multiplication of a vector by a scalar. Scalar and vector product of two vectors. Differentiation of a vector function, gradient, divergence and curl, Physical interpretation. Vector identities. Line and surface integrals. Green's, Gauss' and Stokes' theorems.

Tensors: Definition, covariant and contravariant, properties, Metric tensors.

Met/AM/ME/T/3/123: STRENGTH OF MATERIALS

Uniaxial stress field, Thin pressure vessels, Torsion (inclusive of Helical spring), shear force and Bending moment, Bending and shear stress in beams, Deflection beams, Energy methods in Strength of Materials, Problem of Plane stress and strain, Theories of failure, Buckling of columns.

Met/ME/T/124: HEAT ENGINEERING

Laws of thermodynamics, mechanical equivalent of heat, laws of perfect gases and their characteristics equation, Gas constants, specific heats, internal energy, expansion and compression of gases in general, carnot cycle, simple reciprocating air- compressor, properties of saturated and superheated steam, use of steam tables and charts. Boilers and their types, orifice and nozzles, impulse and reaction turbines, types of condensers, gas and oil engines, petrol engines working cycles, indicated and break horse power, mechanical and thermal efficiency.

Refrigeration, COP of refrigeration cycle, Vapour compression refrigeration system, refrigerants; applications.

Met/Ph/T/2A/125: PHYSICS-IIA

1. Electric potential and intensity, Flux of electric field, Gauss's law and its application to problems with spherical and cylindrical symmetry, Capacitance- parallel plate and spherical condensers, Energy of a capacitor, Energy density of an electric field, Potential and field due to a dipole, Dielectric polarisation, Electric displacement vector, dielectric susceptibility.

2. Biot-Savart law and Ampere's law in magnetostatics, Calculation of magnetic field in simple situations like (i) straight wire (ii) circular wire (at a point on the symmetry axis) and (iii) Solenoid.

3. Time-varying fields, Faraday's law of electromagnetic induction, Self and mutual inductance, Resonance and oscillation in electrical circuits.

4. Nature of light waves, Interference of light waves, Young's experiment, Spatial and temporal coherence, Fresnel bi-prism, Interference in thin film, Newton's rings, Measurement of film thickness and wavelength, Diffraction of light waves, Huygen's construction, Fresnel and Fraunhoffer diffraction, Fraunhoffer diffraction due to single slit and plane diffraction grating, Approximate rectilinear propagation of light, Zone plate, Polarisation of light waves, Polarisation by reflection, Brewster's law, Double refraction- ordinary extraordinary rays, Polaroid, Optical activity.

5. Energy levels of the hydrogen atom and the Bohr atom model, X-ray spectra, X-ray diffraction, Bragg's law, Compton effect. De-Broglie waves, Particle diffraction, Uncertainty principle and its application.

Met/AED/ME/T/1/126: ADVANCED ENGINEERING DRAWING

True length, development of surface of simple objects. Threaded joint & riveted joints, cotter / knuckle joint. Pulley, shaft coupling.

Met/Chem/S/124: QUALITATIVE ANALYSIS

As per the theoretical paper Met / Chem / T / 111.

Met/Ph/S/2 /125: PHYSICS LABORATORY-II

(Selected Experiments from the following)

1. Determination of Galvanometer resistance by half - deflection method.
2. Determination of Galvanometer resistance by Thomson's method.
3. To find high resistance by Galvanometer deflection method.

4. To measure mechanical equivalent of heat, J by electrical method (Joule's) using copper calorimeter (radiation correction to be done).
5. To compare to low resistance by drop of potential method.
6. To determine resistance per unit length of wire by using Carey Foster bridge.
7. To estimate strength of a current by using copper voltmeter.
8. a) To compare the EMF's of two cells by using a potentiometer
   b) To measure current by using a potentiometer
9. To measure the horizontal components of earth's magnetic field intensity using deflection and vibrating magnetometers.
10. Determination of co efficient of linear expansion by optical lever method.
11. Determination thermal conductivity of metal by Searle's method.
12. To determine co-efficient of viscosity by Capillary flow method.
13. Determination of Young's modulus by Flexure method.
14. To draw mutual and anode characteristics of triode and hence too fine Rp, μ, and gm
15. To draw the transistor characteristics (NPN / PNP) in the given configuration and hence to find hi, hf
16. Determination of refractive index of the material of the glass prism by prism spectrometer (for at least two ?s)
17. Study of collisions in one dimension using a linear air track
18. Use of an air track for obtaining potential energy curves for magnetic interactions.
19. Study of oscillations under potential wells of various shapes using an air track.
20. Experiments on diffraction in single slit, double slit and plane grating using He- Ne laser a) To find the wavelength of a monochromatic light by single slit. b) To find slit separation of a double slit. c) To find number of rulings per cm of a plane grating
21. To find the wavelength of a monochromatic light by Newton rings.
22. Fabry-Perot interferometry: To find out separation of wavelength of sodium D1 & D2 lines.

Met/AED/ME/S/1/126: ADVANCED ENGINEERING DRAWING

True length, development of surface of simple objects. Threaded joint & riveted joints, cotter / knuckle joint.

Pulley, shaft coupling.

Met/WS/ME/S/11/127: WORKSHOP PRACTICE-XI (Fitter Shop and Machine Shop)

Introduction to fitter’s tools, gauges, measuring instruments etc.; marking of jobs; fitter’s job involving chipping, filing, sawing, drilling; use of taps and dies; pipe fittings and plumbing. Introduction to machine tools - lathes, drilling machines, shaping machines, planning machines, slotting machines, milling machines, grinding machines; machine shop work involving different operations by using the above mentioned machines through making of jobs.

SECOND YEAR: FIRST SEMESTER

SUBJECT CODE	NAME OF THE SUBJECT	THEORETICAL/ SESSIONAL/ TUTORIAL	CREDIT HOURS PER WEEK
THEORETICAL SUBJECTS			
Met/ChE/T/211	Fluid Flow and Heat Transfer	Theoretical	300
Met/Geo/T/212	Geology and Minerals Beneficiation **(Geology offered by Geological Sciences Deptt.)**	Theoretical	400 (Geology: 200) (Min. Ben.: 200)
Met/ETech/EE/T/A/213	Electrical Technology-A	Theoretical	300
Met/Math/T/214	Mathematics-IIIN	Theoretical	300
Met/MDD/ME/T/1/215	Machine Design and Drawing	Theoretical	300
Met/Hum/T/A /216	Humanities-A	Theoretical	300
SESSIONAL SUBJECTS			
Met/Geo/S/211	Geology Laboratory (offered by Geology Dept.)	Sessional	003
Met / S /212	Minerals Beneficiation Laboratory (offered by Metallurgical and Material Engg. Dept.)	Sessional	003
Met/MDD/ME/S/1/213	Machine Design and Drawing	Sessional	003
TOTAL CREDIT HOURS: 19-0-0 (Theoretical); and 0-0-9 (Sessional) Marks: Theoretical: 600; Sessional: 300; Total: 900			

Met/ChE/T/211: FLUID FLOW AND HEAT TRANSFER

Fluid Flow

Newton's law of viscosity, Laminar flow. Fluid flow. between two flat parallel plates, Fluid flow down an inclined plane, Fluid flow in a cylindrical tube, Hagen- Poiseuille equation and Flowmeters. Navier Stokes equation. Fluid flow over a horizontal flat plate, Approximate integral method of obtaining boundary layer thickness.

Creepping flow past a sphere, Form drag and Friction drag, Stoke's law, Turbulent flow, Friction factor and Turbulent flow in cylindrical pipes. Flow through packed beds, Ergun's equation. Fluidized beds. Mechanical energy balance, Bernouli's equation, Friction loss, Influence of bends, Fitting and changes in the pipe radius.

Heat Transfer

Conduction: Fourier's law of steady state heat transfer for several bodies in series, Log mean area, use of Gurney Lurie chart.

Convection: Flim concept, Dettus-Bolter equation, Overall heat transfer coefficient, Heat exchangers. Dimensionless numbers. Heat Transfer by Forced Convection. Transient Heat Flow.

Radiation: Concept of black body, Kirchoff's law, Allowance for non- black and pre- radiating surfaces.

Met/Geo/T/212: GEOLOGY AND MINERALS BENEFICIATION

Geology (2-0-0)

Introduction to Geology and its relation to metallurgy
Introduction to crystallography: definition , common morphology, symmetry elements, point crystal, classes.
Physical properties of mineral colour, lustre, hardness, specific gravity electrical conductivity and thermal conductivity , magnetic properties .
Polarsied light microscopy-both transmitted and incident light types .Basic principles involved and the properties of minerals studied under microscope.
Ore textures, textural features and their interpretation; sheet structures and layer structures.

Nature and types of ore deposits. A short discourse on the types of ore deposits with emphasis on the chemical and mineralogical compositions
Different types of rocks and their basic characteristics. Major Indian ore deposits.
Resource potential of Indian and other countries with respect to important ore types and metallurgical coal.

Minerals Beneficiation (2-0-0)

Laws of comminution; Crushing and Grinding machines; Classification: free and hindered settling; Dry and wet sizing, tabling - Wilfley tables, Jigging and Jigging machines, surface chemistry of minerals; Floatation principles and froth floatation; dewatering, magnetic separators. Pollution in beneficiation plants & control steps.

Met/ETech/EE/T/A/213: ELECTRICAL TECHNOLOGY-A

DC Circuits: Kirchhoff's Laws. Maxwell's Loop Current Methods of Analysis. Star-Delta Conversion. Superposition Theorem. Thevenin's Theorem. Maximum Power Transfer.
Magnetic Circuit: MMF, Flux ,Reluctance. B-H Loop. Hysteresis and Eddy current loss. Magnetic circuit analysis with air gap.

AC 1 -phase: Periodic Waves and Sinusoids. Average and RMS Values, Form Factor, Peak. Factor. Phasor concept of Sinusoids. Impedance and Admittance. Power, Power Factor, V A, V AR. Series R-L-C Circuit ,Parallel R-L-C circuit. Resonance.

Balanced 3-phase: 3-phase AC balanced circuits. Phase-sequence. Star and Delta connections. Power, V A, V AR, Power Factor _or balanced 3-phase circuits. Power Measurement: Wattmeter circuit connection. Power Measurment by two wattmeter methods in 3phase system.

DC Machines: Construction and general priciple of operation. Generator EMF Equation. Field connection ,shunt series and compound. Generator characteristics.
Motor-equation and general operation. starting and speed control, torque -speed curve.

1-PhaseTransformer: Construction. EMF equation. Phasor diagram. Equivalent circuits. Losses and Efficiency. Open circuit and Short circuit test.
3-Phase Induction Machine: Types of induction machines. Rotating magnetic field, slip ,torque equation, torquespeed curve.DOL starting and reduced voltage starting.
3-Phase Synchronous Machines: Alternator, constructional features, EMF equation, synchronous reactance, power -angle characteristics.

Concept of synchronous motor.

Meters: DC and AC Ammeters and Voltmeters. Megger.Multiplier.

Met/Math/T/214: MATHEMATICS-IIIN

Complex numbers, De'Moivre's theorem, Exponential values of sines and cosines, Hyperbolic functions, Ordinary differential equations.

Linear exact and first order equations, Second and higher order equations with constant coefficients. Method of variation of parameters. Euler – Cauchy equation.

Laplace transform and its inverse. Solution of ordinary linear differential equations with constant coefficients. Series solution of Bessel and Legendre equations. Legendre polynomials and orthogonal properties. Fourier series. Solution of one dimensional wave and diffusion equations and two dimensional Laplace equations.

Met/MDD/ME/T/1/215: MACHINE DESIGN AND DRAWING

Basic idea of design, factor of safety, modes of failure, theories of failure, design under static and fatigue loading. Design of Cotter / knuckle Joint, threaded and riveted joint, eccentric loading. Shaft coupling (rigid / flexible). Belt-pulley drive. Pressure vessel.

Met/Hum/T/A /216: HUMANITIES-A

HUMANITIES

1.Basic writing skills
2.Report, Covering Letter & Curriculum-Vitae writing
3.Reading and Comprehension
4.Selected Short Stories

SOCIOLOGY

1.Sociology: Nature and scope of Sociology - Sociology and other Social Sciences - Sociological Perspectives and explanation of Social issues
2. Society and Technology: Impact of Technology on the Society - A case study
3. Social Stratification: Systems of Social Stratification - determinants of Social Stratification - Functionalist, Conflict and Elitist perspectives on Social Stratification
4.Work: Meaning and experience of work: Postindustrial society- Post-Fordism and the Flexible Firm
5.Development - Conceptions of and approaches to development - The Roles of State and the Market in the Development
6. Globalization: The concept of globalization - globalization and the nation state - Development and globalization in post colonial times.
7. Industrial Policy and Technological change in India - The nature and Role of the State in India
8. Technology Transfer: The Concept and Types of Technology Transfer-Dynamics of Technology Transfer
9. Technology Assessment: The Concept - Steps involved in Technology Assessment
10. Environment: Sociological Perspectives on Environment - Environmental Tradition and values in ancient India
11.The Development of Management: Scientific Management - Organic Organization - Net Work organization; Post modern Organization - Debureaucratization - Transformation of Management
12. Technological Problems and the Modern Society: Selected Case Studies - Electric Power Crisis, Industrial and / or Environmental Disaster, or Nuclear Accident.

Met/Geo/S/211: GEOLOGY AND MINERAL BENEFICIATION LABORATORY

Symmetry elements, Identification of minerals and as per the theory subject Met / Geo / T / 212 **(Geology Part)**

Met / S /212: MINERALS BENEFICIATION LABORATORY

As per theory subject Met / Geo / T / 212 (Minerals beneficiation part**)**

Met/MDD/ME/S/1/213: MACHINE DESIGN AND DRAWING

Basic idea of design, factor of safety, modes of failure, theories of failure, design under static and fatigue loading. Design of Cotter / knuckle Joint, threaded and riveted joint, eccentric loading. Shaft coupling (rigid / flexible). Belt-pulley drive. Pressure vessel.

SECOND YEAR:SECOND SEMESTER

SUBJECT CODE	NAME OF THE SUBJECT	THEORETICAL/ SESSIONAL/ TUTORIAL	CREDIT HOURS PER WEEK
THEORETICAL SUBJECTS			
Met/CSE/T/221	Numerical Analysis	Theoretical	300
Met/ET/T/222	Applied Electronics and Instrumentation	Theoretical	300
Met/ T/223	Matreials Science	Theoretical	300
Met /T / 224	Thermodynamics of Materials	Theoretical	310
Met/T/225	Testing of Materials	Theoretical	300
Met / ChE /T / 226	Fuels and Combustion	Theoretical	300
SESSIONAL SUBJECTS			
Met/EE/S/221	Electrical Technology	Sessional	003
Met/CSE/S/222	Numerical Analysis	Sessional	003
Met/Chem/S/223	Metallurgical Analysis	Sessional	003
TOTAL CREDIT HOURS (18-1-9) : 18-0-0 (Theoretical); 0-1-0 (Tutorial); 0-0-9 (Sessional) Marks: Theoretical: 600; Sessional: 300; Total: 900			

Met/CSE/T/221: NUMERICAL ANALYSIS

Solution of algebric and transcendental equations. Simultaneous linear algebraic equations. Interpolation. Approximation, boundary value problems, Eulers, Range-Kutte etc. methods. Two dimensional problems, elliptic and parabolic equations. Stiff differential equation. Finite difference and finite element methods for solution of differential equations.

Met/ET/T/222: APPLIED ELECTRONICS AND INSTRUMENTATION

Circuits: Response of resistance, inductance and capacitance to D.C. and A.C, voltage sources. Series and parallel resonance of LRC circuits.

Maximum power transfer theorem. Thevenin's and Norton's theorem.

Semiconductors : P and N type semiconductors, P.N. diodes- its operation and characteristics. P-N-P and N-P-N transistors and their operations & characteristics.
Semiconductors, diodes and transistor circuits: Single phase, half wave rectifier, full wave rectifier, bridge rectifiers and different types of filters. Transistor biasing and stabilisation. Hybrid equivalent circuit of for transistor. Transistor as an amplifier. Common emitter amplifier with a emitter resistance, the emitter follower. Cascaded resistance, capacitance- coupled amplifier.

Concept of feedback- Gain with feedback-positive and negative feedback, Negative feedback amplifier with its various advantages. The operational amplifier (TC). Use of operation of amplifier as inverter.
Adder, Integrator, Differentiator. Brief idea of Electronic analong computer. Simulation of a second order differential equation. A Wien bridge oscillator using I.C. Operational amplifier.

The Cathode ray oscilloscope.

Instrumentation: Transducers like strain gauge, LVDT etc. used in electronic instrumentation . Electronic instrumentation for the measurement of different physical parameters.

Met/ T/223: MATREIALS SCIENCE

Elements of crystallography, Bravais lattice & Miller indices, Atomic packing, Pauling's rule, crystal structure of oxides, nonoxides and metals. Defects, Phase rule.

Types and construction of phase diagrams; a few examples from oxide & metallic systems, Fe-C phase diagram, and annealed structures, Lever Rule, Introduction to ternary system.

Classification of refractory materials, their testing, properties and applications.

Elements of polymers.

Temperature measurements: Use of thermocouples and pyrometers.

Met /T/224: THERMODYNAMICS OF MATERIALS

Introduction; types of systems; state functions and path functions; extensive and intensive properties; reversible and irreversible processes.

1st law of thermodynamics; internal energy and enthalpy; heat capacities of gases, liquids and solids; application of the 1st law to isothermal, adiabatic, constant pressure and constant volume processes with ideal gas as system; thermochemistry; Kirchoff's equation; adiabatic flame temperature; H-T diagrams.

Carnot cycle; entropy; different statements of the 2nd law of thermodynamics; statistical interpretation of entropy; 3rd law of thermodynamics.

Gibbs and Helmholtz free energies; chemical potential; different forms of criteria of spontaneity and equilibrium; Maxwell relations; Joule-Thomson effect; fugacity; activity; concept of standard states; equilibrium constant; reactions involving gases and pure condensed phases; variations of standard free energy and equilibrium constant with temperature; Le Chatelier's principle; Ellingham diagram and relative stability of oxides; oxygen and carbon potential; carbothermic and metallothermic reductions.

Phase equilibrium; Clausius-Clapeyron equation; vapor pressure vs temperature relations; Trouton's and Richard's rules.

Ideal and nonideal solutions; Raoult's law and Henry's law; mixing and excess functions; relationship between integral molar and partial molar properties; Gibbs Duhem equation; integration of Gibbs Duhem equation; quadratic activity coefficient vs. composition relations; regular solution; reactions involving components in condensed solution.

Gibbs phase rule; alternative (Henrian) standard states; interaction coefficients; Sievert's law.

Met/T/225: TESTING OF MATERIALS

Introduction; objectives.
Indentation hardness testing: Brinell, Rockwell, Meyer, Vicker and Knoop hardness testing. Meyer's law.
Micro- and nano-hardness testing.
Tension, compression and torsion testing. Effects of specimen geometry and testing variables.
Impact testing with Charpy and Izod specimens. Ductile to brittle transition behavior. Drop weight testing.

Fatigue testing to determines S-N and □ -N curve. Ultra high cycle fatigue.
Applicable testing standards.
NDE Methods – Visual, liquid penetrant testing, magnetic particle testing, ultrasonic testing, radiography, acoustic emission testing. Eddy current testing, thermography.

Applicable Testing standards, Introduction of TQM in Material testing

Met/ChE /T / 226: FUELS AND COMBUSTION

Definition and classification of fuels; Solid fuels:
Original formation of coal, reserves of coal , composition and classification of coal, its chemical constitution and physical properties, commercial varieties of coal, caol washing, briquetes and powdered coal, spontaneous ignition of coal on storage.
Coke and coking:
N.T.C.& L.T.C. and products of carbonisation . Special forms of coal . Domestic and metallurgical coke properties, methods of improving coking quality of coal, other minor solid fuels, fire wood, charcoal, etc, gasification of solid fuels.
Liquid fuels:
Composition and character of fuel oil, petroleum, it occurrence and composition, properties and pro-commercial products of petroleum. System of burning fuel oil.
Gaseous fuels:
Composition, character and application, Nuclear fuels.
Energy utilisation:
Thermodynamic and economic aspect of utilisation in furnances.
Waste heat recovery
Analysis of waste heat system and efficient methods of heat recovery. Fuel testing.

Met/EE/S/221: ELECTRICAL TECHNOLOGY LABORATORY

Experiments in tune with the course on "Electrical Technology-A" (Met / ETech / EE / T / A / 213).

Met/CSE/S/222: NUMERICAL ANALYSIS LABORATORY

Experiments in tune with the course on "Numerical Analysis" (Met / CSE / T / 221).

Met/Chem/S/223: METALLURGICAL ANALYSIS

Experiments based on complete analysis of ores & concentrates, Estimation of iron in iron ore (total Fe_2O_3 amount of ferrous / ferric state)

1. Estimation of Cr, Mn, in steel, 2. Estimation of Ni in stainless steel, 3. Estimation of Cu & Sn in brass, 4. Estimation of C & S by Strolein's apparatus, 5. Slag analysis: CaO & alumina in slag , 6. Iron oxide in ore, 7. Silica in clay or fireclay.

THIRD YEAR : FIRST SEMESTER

SUBJECT CODE	NAME OF THE SUBJECT	THEORETICAL/ SESSIONAL/ TUTORIAL	CREDIT HOURS PER WEEK
THEORETICAL SUBJECTS			
Met / T / 311	Deformation and Fracture Behaviour of Materials	Theoretical	300
Met / T / 312	Physical Metallurgy - I	Theoretical	300
Met / T / 313	Iron Making	Theoretical	300
Met / T/ 314	Chemical Kinetics and Mass Transfer	Theoretical	310
Met / T/ 315	Electro-Chemistry and Corrosion	Theoretical	300
SESSIONAL SUBJECTS			
Met / S / 311	Viva - Voce - I	Sessional	003
Met / S / 312	Physical Metallurgy Laboratory	Sessional	006
Met / S / 313	Electrochemistry and Corrosion	Sessional	003
Met / S / 314	Mechanical Testing	Sessional	003
TOTAL CREDIT HOURS (15-1-15) : 15-0-0 (Theoretical); 0-1-0 (Tutorial); 0-0-15 (Sessional) Marks: Theoretical: 500; Sessional: 400; Total: 900			

Met / T / 311: DEFORMATION AND FRACTURE BEHAVIOUR OF MATERIALS

Introduction: Scope of the subject, elastic, plastic, and anelastic deformation. Constitutive equations in elasticity for isotropic and anisotropic materials, strain energy, elastic stiffness and compliance tensor, crystal structure and elastic constants.

Plastic response of materials - different types of uniaxial stress-strain curves. Equivalent stress and strain. Levy-Mises and Prandl-Reuss equations. Deformation theory of plasticity. Yield surface, Isotropic and kinematic hardening - Bauschinger effect. Elements of dislocation theory - crystallography, elastic properties, dislocations and their interactions in different crystal structures, origin and multiplication of dislocations, thermally activated dislocation motion.

Critical resolved shear stress in single crystals. Work hardening in single and polycrystals. Strengthening mechanisms in polycrystals –role of grain boundaries, solid solution, precipitates and dispersoids, order-disorder transformation, Mechanical properties of composites. Elevated termperature deformation mechanisms - cross slip, climb and grain boundary sliding. Deformation mechanism maps.

Fracture – mechanisms of ductile and brittle fracture; fracture in creep and stress corrosion conditions; fractograohy. Griffith theory of brittle fracture. Concepts of stress concentrations and stress intensity factors, rack tip plastic zone. J and CTOD parameters. Ductile to brittle transition behaviour.

Met / T / 312: PHYSICAL METALLURGY

Alloy theory-terminal solid solutions and intermediate phases, Fe-C system, steel and iron microstructures with phase relations, Free energy-composition diagrams. Ideal and non-ideal behaviour of alloy systems. Diffusion: Diffusion laws, Kirkendall effect, activation energy, uphill diffusion etc. Transformation in metals and alloys – solidification and solid-state transformation. Nucleation and growth reactions: Homogeneous & Heterogeneous nucleation. Dendritic solidification; Divorced eutectic, Super cooling, Interface calculation etc., Kinetics of solid-state transformation, C-curve etc. Segregation precipitation reaction. Diffusional phase transformation process: Short range difusional and long range diffusional process like polymorphic transformation, massive transformation, recrystallisation, precipitation transformation, order disorder, eutectoid and spinoidal transformations.

Optical microscopy: Construction, image formation and resolution.

Met / T / 313: IRON MAKING

World production of iron & steel, occurrence and distribution of iron, coal & limestone in India, Concept of integrated steel plant, different types of ironmaking processes, Agglomeration techniques, raw materials for iron making & their properties, Overview of Blast furnace, six internal zones of blast furnace, Blast furnace operation – Thermodynamic principles, refractories, temperature profile, aerodynamics, high top pressure, different factors, irregularities etc., Blast furnace reactions, thermodynamics of slag-metal reactions, oxygen enrichment, injection of steam, oil etc., Blast furnace products - pig iron, top gas, slag & their utilization, Blast furnace design & sizing, productivity, coke rate etc., Concept of alternative iron making processes, Idea about direct reduction process – DRI, HBI, Principles & technology of different coal based & gas based direct reduction processes like Rotary kiln, Rotary hearth, Midrex, HyL etc., Concept of other smelting reduction processes like Corex, Romelt, HiSmelt, Finex etc., Advances in iron making.

Met / T/ 314: CHEMICAL KINETICS AND MASS TRANSFER

Chemical Kinetics

Introduction; classification of reactions: homogeneous vs heterogeneous, single vs multiple; elementary vs nonelementary, reversible vs irreversible; molecularity and order of reactions; types of intermediates for nonelementary reactions; search for reaction mechanism.

Temperature dependence of reaction rate; Arrhenius equation; activation energy; activated complex theory; collision theory; rate controlling step.

Integral and differential method of analysis of batch reactor data; 1st-, 2nd-, and zero-order reaction kinetics; determination of order; series and parallel reaction kinetics; reversible reaction kinetics.

Design of plug flow and mixed flow continuous reactors.

Mass Transfer

Introduction; definition of fluxes; relation of fluxes relative to stationary coordinates and average velocities; Fick's 1st law of diffusion; analogy of momentum, heat and mass transfers; temperature and pressure dependence of mass diffusivity; theory of diffusion in gases and liquids.

Applications of shell mass balance and boundary conditions in solving diffusion problems: diffusion-controlled evaporation of a liquid through a stagnant gas film at steady state; mixed control oxidation of a metal plate; reduction of ferric oxide pellets by reducing gas mixtures and their control by interfacial reaction, gas film diffusion, and pore diffusion; diffusion-controlled vaporization of a liquid metal in a reactive atmosphere; mixed control dissolution of pure metal A in liquid B; reduced time plots for different kinetic models.

Three-dimensional equation of diffusion with convection in a binary mixture A-B: Fick's 2nd law of diffusion.

Mass transfer coefficient and concentration boundary layer on a flat plate: exact solution method and approximate integral method, Sherwood and Schmidt dimensionless numbers. One-dimensional unsteady-state diffusion in solids: carburization of iron.

MET / T/ 315: ELECTRO-CHEMISTRY AND CORROSION

Principles of Electro-Chemistry, Electrode Potential, Reference Electrode, Half-cell reaction, Nernst's equation, Application of Thermodynamics to Feasibility of corrosion of metals & alloys in various environments, Pourbaix diagram of common metals, Electrolytes , potentiometric and conductometric titration

Kinetics of Corrosion , Polarization: Activation, Concentration & Resistance Polarization, Overvoltage, Tafel's Equation, Corrosion rate determination by Tafel extrapolation & Linear polarization methods, Passivity & passivity breakdown, Cyclic polarization, Evan's diagram , Practical applications of polarization diagrams

Forms of Corrosion: Uniform attack, Galvanic , Crevice, pitting, Intergranular , Erosion corrosion, Stress induced Corrosion: SCC,CF,HIC, Testing slow strain rate & Fracture mechanics K_{1C}

Principle of prevention & protection of Corrosion, Anodic protection, Cathodic Protection, Application of Inhibitors, Organic coating & paints, Metallic coating, Anodizing , phosphating, Chromate coating,

Atmospheric corrosion & Oxidation at elevated temperature, Factors affecting atmospheric corrosion & remedy, doping of p & n type metallic oxide, various kinetic laws of Oxidation.

Microbial corrosion : Accelerated degradation of metals in presence of Aerobic & Anaerobic microorganisms

Corrosion for Beneficial purpose: Introduction to Fuel cell & Battery.

Met / S / 311: VIVA - VOCE – I

Based on all theoretical subjects of the current Semester.

Met / S / 312: PHYSICAL METALLURGY LABORATORY

1. Study and use of metallurgical microscope (Term Paper).
2. Metallographic specimen preparation, mechanical polishing, mounting, and etching.
3. Microstructure of annealed pure metals-iron, copper, lead, zinc alluminium and use of specific etchants.
4. Macro etching and sulphur printing.

5. Electro polishing.

6. Calibration of thermocouple.

7. Pyrometry (Term paper)

8. Comparative study of microstructure of annealed steel (Hypo eutectoid, Eutectoid, Hyper eutectoid) and variation of hardness.

9. Microstructure of Cast Iron (Gray, White, Nodular).

10. Microstructure of eutectic alloys Al-Si, Pb-Sn, and Pb-Sb.

11. Microstructure of wrought and annealed single-phase alpha brass & Aluminium.

12. Recovery, Recrystallisation and Grain growth of cold worked copper.

Met / S / 313: ELECTROCHEMISTRY AND CORROSION LABORATORY

1. Verification of Reversibility of Electrochemical cells.

2. Conductivity of electrolyte & Conductometric titration.

3. Potentiometric titration.

3. E-pH diagram

4. Electrode potential determination & Galvanic Series

6. Galvanostatic polarization & determination of corrosion rate by Tafel's Extrapolation

7. Potentiostatic Polarization, passivity & Passivity breakdown study

8. Oxidation kinetics.

9. Cathodic protection

10.Stress corrosion behaviour of metals & alloys.

Met / S / 314: MECHANICAL TESTING LABORATORY

Introduction; objectives
Indentation hardness testing: Brinell, Rockwell, Meyer, Vicker and Knoop hardness testing. Meyer's law.

Micro- and nano-hardness testing.

Tension, compression and torsion testing. Effects of specimen geometry and testing variables.

Impact testing with Charpy and Izod specimens. Ductile to brittle transition behavior. Drop weight testing.

Fatigue testing to determines S-N and □ -N curve. Ultra high cycle fatigue.

Applicable testing standards.

NDE Methods – Visual, liquid penetrant testing, magnetic particle testing, ultrasonic testing, radiography, acoustic emission testing. Eddy current testing, thermography.

Applicable Testing standards, Introduction of TQM in Material testing

THIRD YEAR : SECOND SEMESTER

SUBJECT CODE	NAME OF THE SUBJECT	THEORETICAL/ SESSIONAL/ TUTORIAL	CREDIT HOURS PER WEEK
THEORETICAL SUBJECTS			
Met / T / 321	Steel Making	Theoretical	300
Met / T / 322	Foundry Metallurgy	Theoretical	300
Met / T / 323	Extraction of Non-ferrous Metals	Theoretical	300
Met / T / 324	Solid state Phase Transformation Processes	Theoretical	300
Met / T / 325	Physics of Metals	Theoretical	300
SESSIONAL SUBJECTS			
Met / S / 321	Viva - Voce - II	Sessional	003
Met / S / 322	Foundry Metallurgy	Sessional	003
Met / S/ 323	Heattreatment Practice and Microstructure Analysis	Sessional	006
Met / S/ 324	Computer Application in Metallurgy	Sessional	003
TOTAL CREDIT HOURS (15-0-15): 15-0-0 (Theoretical), 0-0-15 (Sessional) Marks: Theoretical: 500; Sessional: 400; Total: 900			

Met / T / 321: STEEL MAKING

Introduction to basic principles of steelmaking; Physicochemical principles of steelmaking & its refining reactions; Application of alternative standard states & interaction co-efficient in steelmaking problems. Slag theories; Different pneumatic & hearth based steelmaking processes - Bessemer, LD, Kaldo & Rotor, LDAC, OBM, Combined blowing / bath agitated processes, Open hearth furnace, Electric arc furnace, Induction furnace etc.; Secondary steel making, deoxidation desulphurization & degassing Solidification of steel ingot, ingot defects (inclusions, blowholes, segregation etc) and their remedies Continuous casting of steel; Design & sizing of steel melt shop

Met / T / 322: FOUNDRY METALLURGY

Introduction to foundry, Casting production. Sand & Non-sand Casting processes, Special Casting processes- Full mold, Shell molding, CO_2 , Die, Investment, Centrifugal etc.Sand molding materials, their properties, selection & testing (Grading of sand, GCS, DCS, Permeability etc)Bonding & bond mechanisms (Clay-water, Hydraulic & Organic),

Selection of Foundry Clay (Bentonite Structure, Base exchange capacity & Acceptability Test,).Additives, Mechanization of Sand molding Process,Patterns- Allowances, Types, Selection etc.

Gating Design, Laws of fluid flow, Top & Gating Time, Aspiration correction, Design of gating for a plate casting. Riser Design(Modulus method, Geometry of risers, Directional solidification, Chill, Padding etc,) Complete Methoding Practice from Pattern to riser / gating design of individual castings.

Solidification of - Metals, Alloys & Eutectics, (Nucleation & Growth Process, Critical nucleus size, Supercooling, G/R ratio, Cell, Dendritic & Random dendritic structure, Segregation & Coring, Eutectics, Compositions in Cast Irons, FG & SG structures, Metallic Glass) . Mold dilation, Mold-metal reactions. Structure & Section sensitivity

Cast irons- family & microstructures, Alloying effects, Cupola & its operation, nodular iron and alloy cast irons. White (Malleable) Iron, ADI, Charge calculations.

Non-ferrous casting production (Silumin alloys, Liquid forging, Brass & Bronze casting)

Melting furnaces (Arc, Induction, Gas & Oil fired furnaces, Fluxes).
Fettling & finishing, Casting defects- Hot tears, Inclusions and porosities.

NDT testing & inspection,Casting design.

Met / T / 323: EXTRACTION OF NON-FERROUS METALS

1. Brief Introduction of Non Ferrous Ores ore & mineral
2. Thermodynamics & kinetics of metal extraction from oxides , sulphides & other forms
3. Unit processes in Pyrometallurgy: Classification and design aspects of roasting process and equipments , calcinations,different types of smelting, refining
4. Unit processes in Hydrometallurgy: E-pH diagram, Leaching, Solvent extraction, Ion Exchange, precipitation, cementation.
5. Unit processes in Electrometallurgy: Electrowining, Electrorefining, Cell potential, polarization, Electrolytic production of metals from aqueous & Fused salt electrolytes
6. Extraction of common metals, Cu, Ni, Zn, Pb, Al, Au & Ag, Cr,Ti, etc.
7. Secondary Metals extraction from waste products & slag.

Met / T / 324: SOLID STATE PHASE TRANSFORMATION PROCESSES

Phase transformation in steel, Kinetics of transformation, TTT&CCTcurves, pearlitic transformation with different factors, characteristic of baintic transformation, Diffusional phase transformation process: Dtiffusionless transformation; characteristics of martensitic transformation with stabilization and micro associated phenomena.

Role of alloying elements in Steel-Equilibrium diagrams etc. Structure and properties. Alloy classification and families- Stainless steel, High speed steel etc. Heat treatment of different alloy steels, special heat treatment processes, atmospheres etc. Tool steels, bearing steels.

Hardenability. Different heat treatments- Annealing, Normalizing, Hardening, Tempering surface treatment etc. Thermo mechanical treatments. Different heating atmospheres and salt baths. Carburizing, nitriding and its varieties, and induction hardening.

Met / T / 325: PHYSICS OF METALS

Crystal symmetry, symmetry groups, stereographic projection.

Free electron theory, density of states, Fermi level, electrical conductivity of metals,

Zone theory, Brillouin zones, conductors, semiconductors and insulators,

Zone theory of alloy phases.

Magnetic properties, dia-magnetism, para-magnetism, ferro magnetism, ferrimagnetism, anti-ferromagnetism ; bark Hausen noise etc. Bhor magneton, Domain theory, magnetic materials, B-H curves, superconductivity, dielectric properties.

Met / S / 321: VIVA - VOCE – II

Based on all theoretical subjects of current Semester

Met / S / 322: FOUNDRY METALLURGY LABORATORY

Sand Testing: Grading of Sand for foundry purpose, Determination of Optimum moisture content in Green Sand Practice, Determination of DCS of Core Sand, Determination of Permeability for molding sand mixtures, Sand Molding Practice for production of molds (Cope & Drag Pattern), Core- making Practice, Study of different types of Pattern.

Gating Design Calculations, Riser Design by Modulus method, Melting of metals & Production of Castings using sand molds / metal molds.

Identification of Casting Defects & Cast-metal Structures.

Met / S/ 323: Heattreatment Practice and Microstructure Analysis

1. Effect of carbon and cooling rate of annealing normalizing, oil quenching, water quenching on microstructure and hardness of stee, macro- & microhardness testing.
2. Hardenability
3. Tempering of hardened steel.
4. Overheated, burnt, Widmanstatten structures in steel.
5. Microstructure of heat-treated brasses. Stainless steel, High Speed steel.
6. Heat treatment practice of carbon tool steel.
7. Age hardening of Aluminium.
8. Quantitative Metallography.

Met / S/ 324: COMPUTER APPLICATION IN METALLURGY

All programs must be written in C / C++ and compiled in Borland C++ or Visual C++

1. Application of data input and output, functions in computing free energy of common metallurgical systems from enthalpy and entropy or heat capacity and determination of temperature of reduction of metal oxides.

2. Computation of % CO/CO_2 at different heights with a given function of temperature profile along the height of BF and Simulations of Blast furnace reduction reactions at various heights

3. Introduction to Object Oriented Programming with concept of class, private & public variables & functions; application of it with free energy as class, Tensile strength as class etc

4. Write a program to develop binary phase diagram , isomorphous systems from user input thermodynamic data.

5. Write a set of programs to design a reactor of continuous reduction of metal oxide moving downward at a speed and reducing gas moving up, assuming a diffusion controlled or chemical controlled mechanism.

6. Write a program to simulate mechanical properties of pure metal or simple binary isomorphous / eutectic system from given composition, heat treatment condition, % cold working etc.

7. Write a program to design sacrificial anode cathodic protection of underground pipe line with user given pipe dimension & electrochemical properties of soil & polarization characteristics of metal.

FOURTH YEAR : FIRST SEMESTER

SUBJECT CODE	NAME OF THE SUBJECT	THEORETICAL/ SESSIONAL/ TUTORIAL	CREDIT HOURS PER WEEK
THEORETICAL SUBJECTS			
Met / T/ 411	Alloy Steel Making and Ferroalloys	Theoretical	300
Met / T /412	Metal Working Processes	Theoretical	300
Met /T / 413	Material Engineering	Theoretical	300
Met / T /414	**Elective – I** a) Theory of Metallurgical Processes b) Light Metals and Alloys c) Composite Materials	Theoretical	300
SESSIONAL SUBJECTS			
Met / S /411	Viva-Voce - III	Sessional	003
Met / S/ 412	Materials Laboratory	Sessional	003
Met / S /413	Seminar	Sessional	003
Met / S/ 414	Project and Report	Sessional	006
TOTAL CREDIT HOURS (12-0-15): 12-0-0 (Theoretical), 0-0-15 (Sessional) **Marks: Theoretical: 400; Sessional: 400; Total: 800**			

Met / T/411: ALLOY STEEL MAKING AND FERROALLOYS

Alloy steel making processes – special reference to stainless steels, high speed steel, manganese steel and other special steels, Thermodynamics and kinetics of alloy steel making, Defects & remedies, Post solidification treatments, Secondary alloy steel making technologies. Problems.

Overview of Indian ferro alloy sector & alloy steel sector, Basics of ferro alloys production – concepts, thermodynamic principles & techniques, Existing production process of important ferro alloys , Fe-Cr, Fe-Mn, Fe-Si, Recent advances in ferro alloy technology, Production of other ferro alloys – Fe-V, Fe-Ti, Fe-W, Fe-Nb, Fe-Mo, Fe-Ni, Fe-Zr, Fe-B etc.

Met / T / 412: METAL WORKING PROCESSES

Concepts of stress & plastic state of deformation – principal stress, normal stress, hydrostatic stress, shear stress etc., Yield Criteria – Von Mises & Tresca.

Elements of metal deformation processes – Rolling: hot rolling & cold rolling; Forging: open die forging, closed die forging & press forging; Extrusion: direct, indirect & Aluminium extrusion; Wire drawing; Sheet metal working; Stretch forming for foils. Deformation load calculations. Defects & limitations, Comparison of metal working & shaping processes.

Met /T / 413: MATERIAL ENGINEERING

Basic understanding of Dielectric and Magnetic materials, concept of polarization and local field. Dielectric constant, loss and relaxation time – concept of complex permittivity. Ferro- electric ceramics and their temperature dependent response.

Origin of interaction in ferrimagnetic materials, Spinel ferrite, rare earth garnets and hexagonal ferrites. Structural ceramics- Silicon carbide, silicon nitride and transformation toughened based ceramics.

Tool & Die Materials [WC & Cermet] Forging & Drawing Dies, Steel & C. I. Rolls. Heat Resistant Materials for Turbines, Super alloys, Tungsten,Nickel and Be metallurgy. Aluminum & Its Alloys – Wrought & Heat treated alloys in auto and airplanes. Copper & Alloys- E.C.Grade, Muntz metal, Cartridge Brass, Phosphor Bronze & Bearing Bronzes.
Titanium & its Alloys- Application & Micro-structures in modern industries.
Nobel Metals – Silver:uses in Electronics; Gold: Foils, Coating;Pt- Thermocouples. Magnetic materials, Dielectric materials, Piezoelectric materials, Load cells.
Polymers & Composites – Nylon-6,6, Melamine, Teflon, Neuprene, Epoxy, PET etc.
Wood , Cement, Reinforced concrete, Asphalt.
Bio materials, Intermetallics

Met / T /414: ELECTIVE – I

a) Theory of Metallurgical Processes
b) Light Metals and Alloy
c) Composite Materials

a) Theory of Metallurgical Processes

Introduction to different metallurgical processes and the importance of thermodynamic and kinetic aspects of the processes.

Gibbs phase rule and its applications to multicomponent and multiphase reactions and to the construction of different stability diagrams; construction of different types of stability diagrams including phase diagrams. Alternative standard states (1 mol fraction and 1 wt%, Henrian); interaction coefficients, their determination, and their applications in iron and steelmaking; quadratic solution model; regular solutions. Thermodynamics of Fe-O, C-O, and Fe-C-O systems and their applications to the blast furnace and steelmaking reactions.

Gibbs adsorption isotherm; thermodynamics of curved surfaces.

Nonisothermal kinetics; reduced time plots for different kinetic models.

Gas diffusion in porous media: molecular and Knudsen diffusion.

Nucleation and growth.

b) Light Metals and Alloys

Introduction; importance of light metals and alloys.
Different methods of synthesis of light-weight metallic materials: ingot metallurgy, semi-solid processing, spray deposition, mechanical alloying, plasma processing, vapor deposition, and electron beam processing.

Ti: Production of Ti; processing, properties, and applications (aerospace and others) of Ti-alloys.

Mg: Production of Mg; melting and casting; recent development of Mg alloys; applications (aerospace, automobile, and others).

Al: Production of Al; wrought Al-alloys; cast Al-alloys; applications (aerospace and others).

New materials and processing methods: metal (Al, Mg, Ti)–matrix composites; rapid solidification processing; amorphous alloys; mechanical alloying; nanophase alloys; titanium aluminides; foams.

c) Composite Materials

Review of engineering materials and their properties.
Introduction of composite materials: definition, functions of the structural members of composites, general requirements of composites.

Overview of composites usage; types of reinforcement and matrix; carbon and glass fibres; PMCs,

MMCs and CMCs; aligned fibre composites.

Axial and transverse Young's moduli for an aligned long fibre composite; derivation of shear moduli and poisson ratios; short fibre and particulate composites – stiffness behavior.
Interfacial bonding mechanisms; measurement of bond strength; pull-out and push-out testing; control of bond strength; silane coupling agents.
Fracture strength of composites: axial tensile strength of long fibre composites, transverse and shear strength.
Fracture toughness of composites: energies absorbed by crack deflection and by fibre pull-out, crack deflection, toughness of different types of composite, constraints on matrix plasticity in MMCs, metal fibre reinforced ceramics.
Compressive loading of fiber composites; thermal expansion of composites.

Fiber making; manufacturing of composites; demand and future applications

Met / S /411: VIVA-VOCE – III

Based on Theoretical Subjects of Current Semester.

Met / S/ 412: MATERIALS LABORATORY

1. Thermal Analysis of dissociation reaction of hydrated copper sulphate and magnesium carbonate (DTA-TGA-DTG) .
2. Electrical property measurement of dielectric materials ($BaTiO_3$)using P-E loop technique.
3. Synthesis of Ni-SiO_2 nanocomposites by Sol-Gel technique.
4. Characterization of nano-composites by XRD & SAXS analysis.
5. Measurement of magnetic properties using PPMS of NSMs.
6. Characterization of ZnO Nanostructured materials using AFM.
7. True & apparent porosity measurement of refractory bricks.

Met / S /413: SEMINAR

Topics relevant to Metallurgical Engineering and allied areas.

Met / S/ 414: PROJECT AND REPORT

Topics relevant to Metallurgical Engineering and allied areas.

FOURTH YEAR: SECOND SEMESTER

SUBJECT CODE	NAME OF THE SUBJECT	THEORETICAL/ SESSIONAL/ TUTORIAL	CREDIT HOURS PER WEEK
THEORETICAL SUBJECTS			
Met / T / 421	X-ray Diffraction	Theoretical	300
Met / T / 422	Industrial Management and Engineering Economics	Theoretical	400 (Industrial Mgmt:: 200) (Engg.Eco: 200)
Met / T / 423	Metal Joining and Powder Metallurgy	Theoretical	300
Met / T / 424	**Elective – II** a) Advanced Characterisation Techniques b) Coating Technology c) Nanostructured Materials	Theoretical	300
Met / T / 425	General Viva-Voce	Theoretical	000
SESSIONAL SUBJECTS			
Met / S / 421	X-ray & Electron Microscopy	Sessional	003
Met / S / 422	Materials Processing	Sessional	003
Met / S / 423	Extractive Metallurgy	Sessional	003
Met / S / 424	Project and Report	Sessional	006
TOTAL CREDIT HOURS (13-0-15) : 12-0-0 (Theoretical); 0-0-15 (Sessional) **Marks: Theoretical: 500; Sessional: 400; Total: 900**			

Met / T / 421: X-RAY Diffraction

Standard projection. Reciprocal lattice concepts. Generation of X-Ray. Continuous and characteristic spectrum of X-ray. Filters. Coherent scattering and diffraction under nonideal conditions. Intensity of diffracted beams, Laue & Powder method. Indexing of cubic and non-cubic crystals, Diffractometer techniques.

Application: Precise Lattice parameter determination, solvus determination, chemical analysis, preferred orientation and texture determination, Pole figures, particle size determination, residual stress measurement.

Met / T / 422: INDUSTRIAL MANAGEMENT AND ENGINEERING ECONOMICS

Industrial Management (2-0-0)

Introduction: Concepts of Management and Industrial Management; Development of management thoughts and ideas – Contribution of Taylor and others; System concepts in management. **Organization:** Organization structure, various types, organization principles – unity of command, responsibility, authority, span of control, structural balance, communication, division of labour, etc. **Types of Production** – Plant location and plant layout (various types); **Materials Management** – Inventory – types, different cost, EOQ and EPQ models,

Basic ideas of MRP and MRP II, purchasing functions, vendor rating etc., ABC analysis, Basic ideas of supply chain management.

Forecasting – Factors affecting demand, Types of forecasts and forecasting techniques, Time series analysis and various qualitative and quantitative forecasting techniques, forecasting errors. **Scheduling** – Gantt chart, network scheduling – PERT, CPM, crashing. **Linear Programming** – Fundamentals, formulations, various variables, graphical solutions etc., Sequencing – simple cases, introduction to transportation models. **Quality Control and Inspection** – Concept of quality, quality control and inspection, Acceptance sampling – OC curve, control charts, Introduction to ISO 9000 standards, Total quality management, quality circle, brainstorming, fishbone diagram, Pareto analysis ; **Work Study** – Work measurement, time study, motion study, method study, job evaluation, merit rating. **Queuing Theory** – Basic concept and a simple model. **Maintenance Management** – Types of maintenance, replacement models, bath tub curve, terotechnology and some fundamentals of safety management. **Break Even Analysis** – Some basic ideas and applications. **Reliability Analysis and Risk Management** – Basic concepts, hazard rate, reliability functions, MTTF

Engineering Economics (2-0-0)

Demand-Law of Demand-Elasticity of Demand, Law of Supply, Production-Production Function-Average and Marginal Product, Cost of Production-Marginal and Average Costs, Revenue-Average and Marginal Revenue, Profit-Profit Maximisation, Market-Different Market Types, Market Economy-Competitive Economy- Non competitive Economy, National Income-Concepts, Fiscal Intervention by Government, Banking and Monetary Intervention by Government, Stock Market-Mutual Fund-Insurance-Concepts, Double Entry Book Keeping-Journal- Cash Book-Ledger, Trial Balance-Profit and Loss Account-Balance Sheet, Industrial Costs-Classifications-Cost Sheet- Estimation of Cost, Inventory Management-Pricing of Issue of Materials, Labour Cost-Wages and Bonus Schemes, Overhead Cost-Allocation and Distribution, Cost Volume Profit Relation Ship-Break Even Point-Margin of Safety, Project Feasibility- Pay back-Net Present Value-Internal Rate of Return, Budgetary Control- Flexible Budget.

Met / T /423: METAL JOINING AND POWDER METALLURGY

Fundamental of bonding, Welding arc and arc physics, Power sources for arc welding, Arc welding processes, High power density welding processes (EB, LBW, PAW), Resistance welding processes, Solid-state welding-Friction-stir welding, Welding Metallurgy and weldability of Ferrous and Non-ferrous Metals & alloys, Brazing, Soldering and Adhesive bonding, Brazability and Solderability of metals and alloys, Defects in welded, brazed and soldered joints and its significance, Destructive and Non-destructive testing of welded joints, Weldability test.

Powder Metallurgy: Powder production methods, powder characterization, compaction, sintering and relevant theories, application of powder metallurgy, a few typical powder-metallurgy products.

Met / T / 424: ELECTIVE – II

a) Advanced Characterisation Techniques
b) Coating Technology
c) Nanostructured Materials

a) Advanced Characterisation Techniques

Transmission and scanning electron microscopy: Basic principles, Imaging techniques, Sample preparation techniques, contrast in TEM. Selected area Diffraction, thin film and repliciation techniques, nature of contrast from dislocations stacking faults and second phase particles. **Surface Characterization Techniques:** SEM, EDAX and AFM; Quantitative phase analysis, Small angle scattering, Grazing Incidence X-ray scattering, Surface characterization: SEM, EDAX, elements mapping, AFM, FESEM, Thermal

Characterization- DTA, TGA & DSC, Dilatometry, Spectroscopy: AAS, UV-VIS, FTIR. Electrical and Dielectric characterization, electrical conductivity & dielectric permittivity.

b) Coating Technology

Introduction; importance of coating; types of coating: metal, inorganic, and organic.
Processes of metal coatings: electrodeposition; flame spraying; cladding; hot dipping; vapor deposition.
Processes of inorganic coatings: spraying; diffusion; chemical conversion.
Processes of organic coatings: surface preparation; priming coat; top coats.
Surface modification processes: ion beam surface treatment; sol-gel coating technology; laser surface alloying.
Coating for corrosion resistance: conversion coatings; compound coatings - diamond-like nanocomposites, nitrides, silicides, and carbides.
Coating for wear resistance: carbon nitride thin films; sputter deposited nanostructured ceramic coatings; dielectric coatings of Si-C alloy films. Electroless coating.

c) Nanostructured Materials

Introduction to Nano phase Materials, effect of reduced size and dimension of materials, properties of nano structured materials, Nano-Physics,

Preparation of nanophase materials- Sol-gel, electro-deposition, plasma assisted deposition, Molecular beam epitaxy etc.

Advanced nano-composites

Thin film preparation of metal oxides,

Application of Nanostructured Materials

Met / T / 425: GENERAL VIVA-VOCE

Based on all subjects of Four-Year Course.

Met / S / 421: X-RAY & ELECTRON MICROSCOPY LABORATORY

1. Problems in stereographic projection.
2. Indexing and lattice parameter determination by Debye Scherrer method.
3. Quantitative analysis by diffractometry.
4. Problem on orientation determination using stereographic projection and Laue technique.
5. Specimen preparation for TEM: replica & thin film.
6. Study of SEM.
7. Fractrography study by SEM.

Met / S / 422: MATERIALS PROCESSING LABORATORY

1. Welding Symbols, Hand practice on MMAW and GMAW processes.
2. Demonstration on Processes: RSW, FSW, DB.

3. Codes and specification of electrodes / filler wires for MMAW, GMAW, GTAW & SAW.
4. To study bead profile, percentage dilution and width of heat affected zone (HAZ) under different arc welding parameters (Heat input).
5. To study microstructure of weld metal and HAZ of steel and aluminium alloys performed under different arc welding parameters (Heat input).
6. To characterize weld defects by DT, Radiography and UT.
7. To study microhardness testing across weld metal and HAZ of welded steel and aluminium.
8. To develop Weld Procedure Specification(WPS) for different materials.
9. Effect of compacting pressure on grain density of metal powders.
10. Characteristics features of sintering of metal powder compacts.
11. Metal powder characteristics like bulk density, true density etc.

Met / S / 423: EXTRACTIVE METALLURGY LABORATORY

1. Determination of the standard free-energy change in the form a + bT for the reaction:

$CaCO_3$ (s) = CaO (s) + CO_2 (g).

2. Determination of the standard free-energy change in the form a + bT for the reaction:

CO_2 (g) + C (s) = 2CO (g).

3. Preparation of DRI by the hydrogen reduction of Fe_2O_3 pellets in a TGA and its kinetic study.
4. Determination of the activity-composition relationship for Zn in the system Zn-Cu by the measurement of vapor pressure.
5. Evaporation of liquid lead in stagnant argon and the determination of the lead vapor-argon interdiffusivity.
6. Hydro- and electrometallurgical recovery of Zn from ZnS.
7. Determination of enthalpy change using a DTA.
8. Extraction of copper by carbothermic reduction of cupric oxide.
9. Oxidation kinetics of copper sulfide.

Met / S/ 424: PROJECT AND REPORT

On relevant topics of Metallurgical Engineering and allied areas.