NATIONAL INSTITUTE OF TECHNOLOGY JAMSHEDPUR

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

Course Structure of B.Tech. (Hons.)

in

Metallurgical and Materials Engineering

Course Structure for B. Tech. (Hons.) in Metallurgical & Materials Engineering

SEMESTER I

S. No	Subject Code	Subject Name	L-T-P	Credits
1	CH1101	Chemistry	3-1-0	4
2	MA1101	Mathematics-I	3-1-0	4
3	ME1101	Engineering Mechanics	3-1-0	4
4	HS1101	English for Communication	3-1-0	4
5	CS1101	Computer Programming	2-0-2	3
6	ME1102	Engineering Mechanics Laboratory	0-0-3	2
7	CH1102	Chemistry Laboratory	0-0-3	2
8	MF1101	Workshop Practice	0-0-3	2
			Total	25

SEMESTER II

S. No	Subject Code	Subject Name	L-T-P	Credits
1	PH1201	Physics	3-1-0	4
2	MA1202	Mathematics-II	3-1-0	4
3	EE1201	Basic Electrical and Electronics Engineering	3-1-0	4
4	CE1201	Environment and Ecology	3-0-0	3
5	MM1201	Material Science	3-0-0	3
6	PH1202	Physics Laboratory	0-0-3	2
7	EE1202	Basic Electrical & Electronics Laboratory	0-0-3	2
8	ME1203	Engineering Graphics	2-0-2	3
9		Yoga/ NSS/ NCC/ Life Skills		
			Total	25

SEMESTER III

S. No	Subject Code	Subject Name	L-T-P	Credits
1	MA1301	Mathematics-III	3-1-0	4
2	MM1302	Principles of Physical Metallurgy	3-1-0	4
3	MM1303	Thermodynamics and Kinetics of Materials	3-1-0	4
4	HS1301	Introduction to soft skills	3-0-0	3
5	MM1305	Transport Phenomena in Materials Processing	3-1-0	4
6	MM1306	Numerical Methods in Materials Processing	2-1-0	3
7	MM1307	Physical Metallurgy and Metallography Lab	0-0-3	2

8	MM1308	Numerical Methods and Thermodynamics Lab	0-0-2	2
			Total	26

SEMESTER IV

S. No	Subject Code	Subject Name	L-T-P	Credits
1	MM1401	Deformation Behavior of Materials	3-1-0	4
2	MM1402	Phase Transformations and Heat Treatment of Materials	3-1-0	4
3	MM1403	Principles of Extractive Metallurgy	3-1-0	4
4	MM1404	Physics of Materials	3-1-0	4
5	MM1405	Materials Characterization	3-1-0	4
6	MM1406	Mechanical Testing and Working of Materials Lab	2-1-0	2
7	MM1407	Extractive Metallurgy Lab	0-0-3	2
8	MM1408	Materials Characterization Lab	0-0-2	2
			Total	26

SEMESTER V

S. No	Subject Code	Subject Name	L-T-P	Credits
1	MM1501	Extractive Metallurgy of Non-Ferrous Metals	3-1-0	4
2	MM1502	Manufacturing Process in Metallurgy – Casting, Solidification and Joining	3-1-0	4
3	MM1503	Deformation Processing and Forming Technology	3-1-0	4
4	MM1504	Powder Metallurgy and Ceramics	3-1-0	4
5	MM1505	Iron Making	3-1-0	4
6	MM1506	Powder Metallurgy Lab	0-0-2	2
7	MM1507	Manufacturing Process in Metallurgy Lab	0-0-3	2
8	MM1508	Seminar/Minor Project Presentation	0-0-2	2
			Total	26

SEMESTER VI

S. No	Subject Code	Subject Name	L-T-P	Credits
1	MM1601	Surface Engineering	3-1-0	4
2	MM1602	Materials Selection and Design	3-1-0	3
3	MM1603	X-ray Diffraction and Electron Microscopy	3-1-0	4
4	MM1604	Steel Making	3-1-0	4
5	MM16XX	Professional Elective - I	3-0-0	3

6	HS1601	Intellectual Property Rights	3-0-0	3
7	MM1607	Heat Treatment Lab	0-0-2	2
8	MM1608	Seminar Presentation	0-0-2	2
			Total	25

Professional Elective I:

MM1609 Non-Equilibrium Processing of Materials
MM1610 Materials for High Temperature Applications
MM1611 Materials for Automotive Applications
MM1612 Materials for Strategic Applications

SEMESTER VII

S. No	Subject Code	Subject Name	L-T-P	Credits
1	MM1701	Environmental Degradation of Materials and its Protection	3-1-0	4
2	MM1702	Advanced Engineering Materials	3-1-0	4
3	MM1703	Creep, Fatigue and Fracture	3-1-0	3
4	MM17XX	Professional Elective II	3-1-0	3
5	HS17XX	Open Elective I	3-0-0	3
6	MM1706	Design Lab	1-0-2	2
7	MM1707	Industrial Training and Tour	0-0-3	2
8	MM1708	Project	0-0-2	4
			Total	25

Professional Elective II:

MM1704 Nanomaterials: Processing and Properties
MM1705 Materials for Biomedical Applications
MM1709 Energy Management in Metallurgical Industries
MM1710 Tool and Alloy Steels
MM1711 Continuous Casting of Steel
MM1712 Electrical and Magnetic Materials

Open Elective I:

HS1701 Principles of Management
HS1702 Total Quality Management

SEMESTER VIII

S. No	Subject Code	Subject Name	L-T-P	Credits
1	MM1801	Non-Destructive Testing	3-1-0	4
2.	MM1802	Entrepreneurship and Professional Ethics	3-0-0	3
3.	MM18XX	Professional Elective III	2-1-0	3
4.	MM1804	Organizational Behavior and Industrial Psychology	3-0-0	3
5.	MM1805	Project	0-0-10	10
6.	MM1806	Comprehensive Viva	0-0-0	3
			Total	26

Professional Elective III:

MM1807 Pollution Control and Waste Management in Iron and Steel Industries
MM1808 Process Modelling
MM1809 Nuclear Metallurgy

L-Lecture, T-Tutorial, P-Practical

Total number of credits in B.Tech. (Hons.) course structure

Semester	Credits
I	25
II	25
III	26
IV	26
V	26
VI	25
VII	25
VIII	26
Total no. of credits	**204**

SEMESTER I

CH1101: Chemistry (3-1-0)

UNIT-I:
Thermodynamics: Laws of thermodynamics, system, thermodynamic functions, state of a system, equilibrium, enthalpy, work done in different processes, C_p, C_v, adiabatic PVT relations, Carnot cycle, concept of entropy, Clausius-Clapeyron equation & its applications, Maxwell relations, concept of free energy, chemical potential, Maxwell relations.

UNIT-II:
Electrochemistry and corrosion: Electrochemical cells, origin of electrode potential, standard potential, Nernst equation, EMF series, rechargeable batteries, Types of corrosion, galvanic series, Cathodic and anodic reactions, differential aeration cells, corrosion prevention methods.

UNIT-III:
Kinetics & Solution Chemistry: Kinetics of chemical reaction, 1^{st}, 2^{nd} order reactions, reversible, consecutive and parallel reaction. Steady state approximations, Arrhenius equation, Chain reactions, photo chemical reactions, Solution chemistry and colligative properties, Real and ideal solutions, Diffusion, Osmosis, Osmotic pressure, Lowering of vapor pressure, Elevation in boiling point, Depression of freezing point, Abnormal molecular weight, Degree of association and dissociation.

UNIT-IV:
Chemical Bonding & Co-ordination chemistry: Bonding models in inorganic chemistry, Molecular orbital theory (MOT), Valance bond theory (VBT), and crystal field theory (CFT), Co-ordination chemistry: Co-ordination number, Chelate effect, EAN rule, splitting of 'd' orbital in octahedral, tetrahedral and square planar complex, Example of Bio-inorganic & metals in biological systems

UNIT-V: Industrial chemistry: Polymers: types of polymer, polymerization, applications, important synthetic polymers. Refractory & ceramics material: Classification, manufacturing and Applications, Water treatment, Air pollution and Control techniques.

Reference Books:
1. A Text Book of Engineering Chemistry by Shashi Chawla
2. A Text Book of physical Chemistry by S. Glaston.
3. Physical Chemistry by Atkins.
4. Engineering Chemistry by Jain & Jain

MA1101: Mathematics-I (3-1-0)

UNIT-I:
Successive differentiation, Leibnitz theorem, Taylor's and Maclaurin's theorem with remainders, Indeterminate forms, Concavity and Convexity of a curve, Points of inflexion, Asymptotes and Curvature.

UNIT-II:
Limit, Continuity and Differentiability of function of several variables, partial derivatives and their geometrical interpretation, Directional derivatives of composite and implicit functions.

UNIT-III:
Euler's theorem on homogeneous functions, Taylor's expansion of functions of several variables, maxima and minima of functions of several variables, Lagrange's method of multipliers.

UNIT-IV:
First order differential equations : Exact, Linear and Bernoulli's form, Second order differential equations with constant coefficients, Method of undetermined coefficients, variation of parameters, Euler's equations, system of differential equations.

UNIT-V:
Review of limit, continuity, differentiability of functions of complex variables, Analyticity of functions, Cauchy- Riemann equations, Harmonic functions. Reduction formula for indefinite and definite integrals of type $\sin^n x, \cos^n x, \sin^m x \cos^n x$ and their evaluation.

Text Books:
1. Higher Engineering Mathematics by Dr. B.S.Grewal.
2. Differential Calculus by B.C.Das& B.N.Mukherjee
3. Integral Calculus by B.C.Das& B.N.Mukherjee.

Reference Books:
1. Advanced Engineering Mathematics by Erwin Kreyszig (10^{th} Edition, John Wiley & Sons)
2. Differential Calculus and Integral Vol I & II by Piskunov (Mir publishers)
3. Calculus and Analytical Geometry by Thomas & Finncy

ME1101: Engineering Mechanics (3-1-0)

UNIT-I:
Fundamental principles of mechanics: Idealization of mechanics, Laws of mechanics, Force vector in 2D & 3D, Directions cosines, Dot and vector product, Moment of a force, Component of moment an axis, Couple & Couple moment, Force system, Reduction of complex force system to simplest form, Equivalent force system, Wrench.

UNIT-II:
Equilibrium: Definition, Conditions & Criteria of equilibrium, Free body diagram, 2 D & 3D problems on engineering applications.Plane Truss: Simple truss, Idealization of plane truss, Methods of sections & Joints.

UNIT-III:
Friction: Coulomb's law of dry friction, Roller, wedge & belt friction, Screw jack. Kinematics and kinetics of a particle: Types of motion, Rectilinear & curvilinear translation, Relative velocity and relative acceleration, Dependent motion, kinematics w.r.t. a moving frame of reference, Kinematics in normal & tangential component & polar coordinates, Kinetics of particle, D'Alembert's principle, Principle of work & energy, Principle of Impulse & momentum, Collision of two bodies, Central & oblique impact.

UNIT-IV:
Kinematics and Kinetics of rigid body: Kinematics of rotation, Non-Centroidal rotation Plane motion, Instantaneous centre of rotation, D'Alembert's principle, Principle of work & energy & principle of impulse-momentum of rigid body.

UNIT-V:
Axial force, shear and bending moment: Concept of Internal forces, Relation between axial force, shear force and bending, Shear force and bending moment diagram, Summation method and Singularity function.

Text Books:
1. Strength of Materials by Dr. J. P.Singh.
2. Strength of Materials by B. C. Purnima.
3. Strength of Materials by J. H. Rider.
4. Strength of Materials by Singh & Jha

HS1101: English for Communication (3-1-0)

UNIT-I:
Art of communication: Basic grammatical concept, Elementary theories of phonetics, sound of English, Mechanics of sound production, Rules of phonetics with examples,

UNIT-II:
Reading, listening, advanced writing skills. Business Letters, effective speaking (interactive sessions).Essay, poems and stories;

UNIT-III:
The world is too with us: William wordsworth,

the scientific point of view: JBS Haldane,
Strange Meeting: Wilfred Owen,

UNIT-IV:
If: Rudyard Kipling,
The Necklace: G D Maupassant,
Piano: D H Lawrence

UNIT-V:
Basic concepts in Communications: Nature of communication, Types of communication, Process of communication, Barriers to communication, Characteristics of successful communication, Informal communication: Chat, the grapevine, Rumour. Merits and limitations.

Text Books:
1. Bansal R. K. and J.B. Harrison, Spoken English: Orient Longman: Mumbai
2. Rizvi, M. Ashraf, Effective Technical Communication Tata McGraw- Hill: New Delhi
3. V.Sasi Kumar and P.V Dhamija, A Self – Learning Guide to English Conversation Tata McGraw- Hill: New Delhi
4. John Seely, The Oxford Guide to Writing and Speaking. Oxford University Press

Reference Books:
1. Tickoo and Shashi Kumar, Writing with a Purpose. Oxford University Press.
2. Narayanswamy, V.R. Strengthen your Writing. Orient Longman.
3. Hornby, Gatenby and Weikfield, The Ox ford Advanced Learners Dictinary. OUP.
4. CIEFL, Enrich your English Communication skills. OUP.

CS1101: Computer Programming (2-0-2)

UNIT-I:
Digital computer fundamentals: Historical perspective, Early computers, the von Neumann architecture. Pseudo code, and Flowchart. Memory, Variables, Values, Instructions, Programs. Assembly language, High level language, Compiler, Assembler, Operating Systems. Binary and other number system representations and conversion between them.
The C language. Phases of developing a running computer program in C.

UNIT-II:
Data Concepts in C: Constants, Variables, Expressions, Operators, and operator precedence in C. Managing input and output statements, Sequential control statements, Decision making statements (If-Else constructs), Loop control statements (While construct, Do While construct, For construct).

UNIT-III:

Different basic data types and their sizes. One-dimensional Arrays: Declaration and Initialization, Two-dimensional Arrays: Declaration and initialization, Multidimensional Arrays.

String variables, Reading and writing strings, Arithmetic operations on characters, Putting strings together, Comparison of two strings.

UNIT-IV:

Functions: The prototype declaration, Function definition.

Function call: Passing arguments to a function (by value, by reference). Scope of variables. Recursive function calls, Tail recursion, Tree of recursion.

Sorting problems: Selection sort, Insertion sort. Sorting in multidimensional arrays. Sorting in arrays. Search problems: Linear search and binary search. Recursive and iterative formulations.

Pointers: Declaring and dereferencing pointer variables. Pointer arithmetic. Accessing arrays through pointers. Pointer types, Pointer and strings.

UNIT-V:

Structures in C: Motivation, examples, declaration, and use. Operations on structures. Passing structures as function arguments. Type defining structures.

Self-referential structures, Dynamic data structures, Linked lists with examples.

File operations in C: Input, output, and error streams. Opening, closing, and reading from files. Searching through files using functions such as fseek(), ftell(), and rewind().

Programming for command line arguments.

Text Books:

1. Programming in ANSI C – E. Balagurusami
2. Let Us C – Yasvant Kanetkar

Reference Books:

1. Programming in C by J. B. Dixit, FireWall Media, New Delhi
2. C Programming, SCHAUM outline series.

SEMESTER II

PH1201: Physics (3-1-0)

UNIT-I:
Electromagnetic Waves: Introduction to del operator, gradient of a scalar, divergence and curl of vectors, Gauss divergence theorem, Stake's theorem, equation of continuity, Introduction to displacement current, Maxwell's Equations, Wave Equation, Plane electromagnetic waves, Poynting's Theorem, Electromagnetic Boundary Conditions, Reflection and Refraction.

UNIT-II:
Polarization:Unpolarised light, Production of plane polarized light by grid polarizer, Polarization by reflection and Brewster's Law, Malus' Law, Double refraction, quarter wave plate, half wave plate, Production and analysis of various kinds of polarized lights.

UNIT-III:
Magnetic properties of matter: Dia, Para and Ferromagnetic materials, Magnetic domains, Magnetic Hysteresis, Calculation of Hysteresis loss, Three magnetic vectors, Magnetic circuit. Interaction of Radiation with Matter: Compton Effect and pair production (qualitative).

UNIT-IV:
Laser: Coherent waves and interference, Temporal and Spatial coherence, Metastable states, Optical pumping, Population inversion, spontaneous and stimulated emission, Einstein's A and B coefficients, He-Ne laser.

UNIT-V:
Wave Mechanics: Failure of classical physics, Qualitative review of relevant experiments, de Brogile waves, Phase and Group velocities, Davisson and Germer experiment, Uncertainty principle, wave function and Schrodinger equation, probability interpretation, Application of time-independent Schrodinger equation -Particle in a box.

Text Books:
1. Concept of Modern physics by Arthur (Tata Mc Graw Hill- New Delhi)
2. Optics by A.K. Ghatak (TMH- New Delhi)
3. Electricity and Magnetism by Rakshit and Chattopadhyay (Central book agency Kolkata)
4. Electrodynamics by Griffiths

Reference Books:
1. Quantum Mechanics by Landau and Lifshitz.
2. Optics by Jankin and White
3. Electrodynamics by Jac sion
4. Quantum Mechanics by Ajay Ghatak

MA1201: Mathematics-II (3-1-0)

UNIT-I:
Linear dependence and independence, rank and inverse of a matrix, solution of algebraic equations-consistency conditions. Eigen values and Eigen vectors, Hermitian and skew Hermitian matrices.

UNIT-II:
Convergence of improper integrals, test of convergence, Beta and Gamma functions elementary properties, differentiation under the integral sign. Series solution, Frobenius Method, Legendre's and Bessel's differential equation, Recurrence formula, Generating functions, orthogonality.

UNIT-III:
Rectification, double and triple integrals, computations of surfaces and volumes, change of variables in double integrals, Jacobians of transformations.

UNIT-IV:
Scalar and vector fields, level surfaces, directional derivative, Gradient, Divergence, Curl, Laplacian, line and surface integrals, theorems of Green, Gauss and Stokes.

UNIT-V: Finite differences, Newton's forward and backward interpolation formulae, Central difference interpolation. Lagrange's interpolation. Trapezoidal rule and Simpson's $1/3^{rd}$ rule of integration. Solution of polynomial and transcendental equations-bisection method, Newton-Raphson method and Regula-falsi method

Text Books:
1. Higher Engineering Mathematics by Dr. B. S. Grewal.
2. Differential Calculus by B. C. Das & B. N. Mukherjee
3. Integral Calculus by B. C. Das & B. N. Mukherjee.

Reference Books:
1. Advanced Engineering Mathematics by Erwin Kreyszig (10^{th} Edition, John Wiley & Sons)
2. Differential Calculus and Integral Vol I & II by Piskunov (Mir publishers)
3. Calculus and Analytical Geometry by Thomas & Finncy

EE1201: Basic Electrical and Electronics Engineering (3-1-0)

UNIT-I:
Electrical circuit: D.C circuit: voltage and current sources, mesh current method, nodal voltage method. Delta star and Star-delta transformation, Thevenin's theorem, super position theorem, Norton's theorem, maximum power transfer theorem

UNIT-II:
A.C. Circuit: single phase and three phase A.C phasor representation. Electrical Circuit Element's R-L-C, their physical origin based on electromagnetic and electrostatics, R-L, R-C, R-L-C series circuits, sinusoidal study state: power factor, active and reactive power, parallel

and series circuits. Delta and star connections, line and phase quantities, single and three phase power measurement

UNIT-III:
A.C Fundamentals, Active, Reactive and Apparent power. Basics of transformers, D.C Machines and Induction motor.

UNIT-IV:
Semiconductor devices: construction, working and V-I characteristics of diode, zener diode, LED, photodiodes, SCR, Diac, Traic and their applications.

UNIT-V:
Transistors: BJT, FET,MOSFET, Construction, working, type of configuration, V-I characteristics, biasing transistor circuits-fixed bias, emitter bias, feedback bias, voltage divider bias, transistor as an amplifier Operational amplifier: introduction, parameters application-inverting, non-inverting amplifier unity follower, integrator, differentiator, summing circuit. Introduction of logic gates.

Text Books:
1. Electronics Device & Circuits by Boylstad & Nashelky PHI
2. Integrated Electronics by Millman & Halkias Tata Macgrow Hill
3. Operational Amplifier and Linear Integrated Circuit by R.A. Gayakwad (PHI)

Reference Books:
1. Principle of Electronics by V.K. Mehta S- Chand Publication
2. Principle of Electronics by Sanjay Sharma

CE1201: Environment and Ecology (3-0-0)

UNIT-I:
Ecosystern: Concept of ecosystem. Structure and function of an ecosystem, Producers, consumers and decomposers. Energyflow in the ecosystem, Ecological succession, Food chains, food webs and ecological pyramids, Introduction, types, characteristic features, structure and function of the following ecosystem: Forest ecosystem. Grassland ecosystem, desert ecosystem, Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries.

UNIT-II:
Biodiversity and its conservation: Introduction-Definition: Genetic, species and ecosystem diversity, Biogeographical classification of India, Value of diversity: Consumptive use, productive us, social, ethical, aesthetic and option values, Biodiversity at global, national and local levels, India as a mega-diversity nation, Hot space of biodiversity, threats to biodiversity: Habitat loss, poaching of wildlife., man-wildlife conflicts, Endangered and

endemic species of India, Conservation of biodiversity: In-situ and Ex-situ conservation of biodiversity.

UNIT-III:
Environment pollution: Causes, effects and control measures of: (a) Air Pollution, (b) Water pollution, (c) Soil pollution, (d) Marine pollution. (e) Noise pollution. (f) Thermal pollution, (g) nuclear pollution, Solid waste management: causes effects and control measures of urban and industrial wastes, role of individual in prevention of pollution, Pollution case studies, and Disaster management: floods, earthquake, cyclone and landslides.

UNIT-IV:
Solid issues and the environment: From understandable to sustainable development, urban problems related to energy, Water conservation, rain water harvesting. Watershed management, resettlement and rehabilitation of people: its problems and concerns, case studies.

UNIT-V:
Environmental ethics: issues and possible solutions. Climate change, global warning, acid rain, ozone layer depletion, nuclear accidents and holocaust, case studies, Wasteland reclamation, consumerism and waste products, Environment protection act. Air (prevention and control of pollution) act, Water (prevention and control of pollution) act, Wild life protection act, Forest conservation act. Issues involved in enforcement of environmental legislation, public awareness.

MM1201: Material Science (3-0-0)

UNIT-I:
Introduction: Types of materials from structure to property, Crystal structure: Bravias lattices, Lattice direction and planes. Crystal Imperfections: point, line and planer defect.

UNIT-II:
Deformation of material: Recovery recrystallization and grain growth, Mechanical properties of materials: Tensile, Impact, Fatigue and Creep of metals.

UNIT-III:
Electron theory of Metals: Free electron theory, Zone theory, The dependence of the energies on the wave number, The density of state curves, Conductors and insulators, Semiconductors, Dielectric behavior, Ferroelectricity, Piezoelectricity, Magnetism.

UNIT-IV:
Principles of solidification: Nucleation and growth, Homogeneous and heterogeneous nucleation, Phase Diagrams: Phase rule, isomorphous, eutectic, peritectic, eutectoid and

peritectoid transformation, Fe-cementite diagram; Heat Treatment of Steel: TTT diagram, different heat treatment process: Annealing, normalizing and Hardening, Hardenability.

UNIT-V:
Selection of Engineering Materials: Common engineering materials including metals and alloys, ceramics composites, polymers.

Text Books:
1. Elements of Material Science by Van Vlack
2. Material Science and Engineering by William D. Callister
3. Material Science and Engineering by V. Raghavan

Reference Book:
1. Physical Metallurgy Principles by Abbaschian.R, Abbaschian.L, Reed Hill R.E.

ME1203: Engineering Graphics (2-0-2)

UNIT-I:
Introduction to basic engineering drawing, instruments, sheet layouts, lines, lettering, dimensioning

UNIT-II:
Projection of points and lines.
Projection of Solids.
Section of solids.

UNIT-III:
Development of surfaces of solids.

UNIT-IV:
Isometric projections

UNIT-V:
Orthographic projections. Use of CAD software to draw plan, elevation and other views of different objects.

Text Books:
1. Engineering drawing by N.D. Bhatt.
2. Engineering drawing by D.A. Jolhe

Reference Books:
1. Engineering drawing by P. S. Gill
2. Text Book on Engineering Drawing by K. L. Narayana & P. Kanhaiah
3. Engineering graphics by K. R. Mohan

4. Text book on Engineering Drawing by R. K. Dhawan

SEMESTER III

MA1301: Mathematics-III (4-0-0)

UNIT-I:
Laplace Transform and its properties, Unit step functions, Dirac delta function, , Periodic functions, Inverse Laplace transform, Convolution theorem, Evaluation of integrals by L.T., Solution of Boundary value problems.

UNIT-II:
Fourier Series and its convergence, Fourier coefficients, Dirichlet's Condition, Change of interval, Half-range series, Complex form of Fourier Series, Fourier integral, Formula. Fourier Transform, Fourier sine and cosine transform, Linearity, Scaling, Frequency shifting and time shifting properties, self reciprocity of Fourier transform.

UNIT-III:
Convolution theorem, Application to boundary value problems, Z-Transform and its properties, initial and final value theorem, Convolution theorem, Evaluation of Inverse Z-transform.

UNIT-IV:
Difference equation and its application, Line integration, Cauchy theorem, Cauchy Integral formula, Power series, Taylor's and Laurent's series, singularity and residues.

UNIT-V:
Discrete and continuous random variable, cumulative distribution function, Probability mass function, Probability density function, Mathematical expectation, Mean variance, Moment generating function, Binomial Poisson and Normal Distribution.

Text Book:
Higher Engineering Mathematics by Dr. B.S. Grewal.

Reference Book:
Advanced Engineering Mathematics by Erwin Kreyszig.(10^{th} Edition, John Wiley & Sons)

MM1302: Principles of Physical Metallurgy (3-1-0)

UNIT-I:
Crystal structure: Space lattice, Unit Cell, Bravais crystal system, Miller indices for planes and direction. Coordination number, Packing Factor and Density Calculations. Allotropy, Stacking sequence and Interstitial Voids.

Crystal Defects: Types of Crystal defects such as point defects, line defects, plane defect – Stacking faults and twins, and Volume defects.

UNIT-II:

Phase equilibria, thermodynamics of phase evolution, solid solutions, Vegard's Law, Hume-Rothery Rules, Intermediate Alloy phase

UNIT-III:
Diffusion Laws: Fick's first and second laws, Kirkendall effect, Darken's analysis, Atomic theory of diffusion. Other diffusion processes.

UNIT-IV:
Construction of Equilibrium diagrams, Isomorphous systems, Lever rule, Coring, Miscibility gap, Eutectic systems, Congruent melting intermediate phase, Eutectoid, Peritectic, Peritectoid. Introduction to Monotectoid, Monotectic and Syntectic reactions. Phase Rule.

Introduction to Ternary Diagrams (Fe-Fe_3C, Cu-Zn, Cu-Sn, Al-Cu and Al-Si)

UNIT-V:
Introduction to TTT and CCT.

Solidification of alloys with special reference to the evolution of various microstructures, Microstructure-Properties relationship. Introduction to ferrous alloys – Stainless and special steels, cast Iron. Commercially important non-ferrous alloy systems – Aluminium alloys, Titanium alloys, copper based alloys, super alloys, shape memory alloys. Their physical metallurgy and applications.

Text Book:
Physical Metallurgy by Abbaschian.R, Abbaschian.L, Reed Hill R.E.

MM1303: Thermodynamics and Kinetics of Materials (3-1-0)

UNIT-I:
Importance of Thermodynamics, definition of thermodynamic terms; concept of states, systems equilibrium. Equation of states, extensive and intensive properties, homogeneous and heterogeneous systems. Phase diagram of a single component system. Internal energy, heat capacity, enthalpy, isothermal, and adiabatic processes. Concept of Equlibrium. First Law of thermodynamics, constant volume and constant pressure processes; Spontaneous processes, entropy and quantification of irrversibility, properties of heat engines, thermodynamic temperature scale.

UNIT-II:
Second Law of thermodynamics, criterion for equilibrium, Entropy and disorder, most probable microstate, configurational entropy and thermal entropy; auxiliary functions, Maxwell's equations, Gibbs Helmholtz equation; Third Law of thermodynamics; variation of Gibbs energy with temperature and pressure, Clausius-Clapeyron equation.

UNIT-III:

Thermodynamic properties of mixtures of ideal and imperfect gases; reactions in gas mixtures; reactions of pure condensed phases with gas mixtures standard Gibbs energy of reactions, Ellingham diagrams; Raoult's and Henry's Law, activity of a component, Gibbs-Duhem equation, non-ideal solutions, regular solutions, quasi-chemical model of solution, activity and alternative standard states; reaction equilibrium in condensed system. Gibbs phase rule, binary systems involving compound formation, solubility of gases in metals, formation of oxide phases of variable composition; Free energy composition diagrams for binary alloy systems, determination of liquidus, solidus and solvus lines.

UNIT-IV: Relation between chemical and electrical driving forces, Thermodynamics of electrochemical cells, solid electrolytes. Nernst equation, concentration cells, formation cells, Pourbaix diagrams; Thermodynamics of Point Defects.

UNIT-V: Introduction to Metallurgical Kinetics: Rate-controlling step. Order of reactions, Determination of Order of reactions. Rate Phenomena. Effect of concentration and temperature on the reaction rate. Heterogeneous reaction kinetics-gas-solid, solid-liquid, liquid-liquid and solid-solid systems. Empirical and semi-empirical kinetics. Concept of Johnson-Mehl equation, thermal analysis.

Text Book:
1. Introduction to Thermodynamics of Materials by David R. Gaskell
2. Metallurgical Kinetics by A Ghosh

References:
1.Thermodynamics of Solids by Richard A. Swalin
2. Physical Chemistry of Metals by L. Darken and R.W.Gurry
3. Problems in Metallurgical Thermodynamics and Kinetics by G. S. Upadhyaya and R. K. Dubey

HS1301: Introduction to Soft Skills (3-0-0)

UNIT-I:
Speech Skill: Rules of Accent, Intonation, Group Discussions and Mock Interviews

UNIT-II:
Formal Communication, Curriculum Vitae, Report Writing, Presentation Skills

UNIT-III:
Negotiation Skills, Non-Verbal Communication and Body Language

UNIT-IV:
Multicultural Communication, Time Management

UNIT-V:

Decision Making, Emotional Intelligence

Text Books:

1. Rizvi, M. Asraf, Effective Technical Communication. Tata McGraw- Hill: New Delhi
2. Sethi J, Kamalesh Sadanand and D.V. Jindal. A Practical Course in English Pronunciation.
3. Chaturvedi, P.D. and Mukesh Chaturvedi. Bussiness Communication, Concepts, Cases, and Applications. Pearson Education: Delhi.
4. Mishra Sunita and C. Muralikrishtna. Communication Skills for Engineers. Pearson Education: Delhi

MM1305: Transport Phenomena in Materials Processing (3-1-0)

UNIT-I:

Fluid dynamics: Introduction to Transport phenomena in materials processing, Newton's law of viscosity, equation of continuity, Navier Stokes equations, Macroscopic mass and energy balance; Characteristics of industrial flows, Numerical problems on above topics of interest to metals and materials processing.

UNIT-II:

Heat transfer: Fundamentals of conduction heat transfer; Laws and equations; Steady and unsteady heat conduction. Numerical problems on conductive heat transfer. Fundamentals of convective heat transfer; free and forced convective heat transfer, Convective, heat transfer rate laws and heat transfer coefficient. Problems on Convective heat transfer

UNIT-III:

Fundamentals of Radiation: Radiation heat transfer and rate laws; view factors, Problems on Radiation heat transfer, Application of heat transfer in: Heat treatment, solidification, cooling of slabs, heat flow, through refractory walls etc.

UNIT-IV:

Mass Transfer: Fundamentals of diffusion; rate laws, Uphill diffusion and Kirkendal's effect, steady and unsteady diffusion. Numerical problems on diffusion mass transfer.

UNIT-V:

Fundamentals of convective mass transfer; free and forced convective mass transfer. Convective mass transfer, rate laws and mass transfer coefficient, Problems on Convective mass transport, Application of mass transfer in: case hardening, doping of semi conductors, homogenization, oxidation, absorption/desorption of gases in liquid metals.

Text Books:
1. Transport phenomena by D. R. Geiger and G. H. Poirier
2. An Introduction to Transport Phenomena in Materials Engineering by D. R. Gaskell
3. Engineering in process metallurgy by R.Guthrie
4. Mass transport in solids and fluids by D. S. Wilkinson

Reference books:
1. Diffusion in solids by P. G. Shewmon
2. Atom movements, diffusion and mass transport in solids by J. Philibert
3. Diffusion in solids: field theory, solid state principles and applications by M. E. Glicksman

MM1306: Numerical Methods in Materials Processing (2-1-0)

UNIT-I:
Introduction, Roots of equation: Simple one-point method, Newton-Raphson and Secant method. Bi-section method, false-position method, determining initial guesses, multiple roots, rate of convergence. Case study: Pidgeon process for magnesium production.

UNIT-II:
Curve fitting: Linear and Polynomial regression, multiple linear regression. Case studies: (i) Desulphurisation of Iron Melts (ii) Thermodynamics of solutions.

UNIT-III:
Interpolation: Newton's divided difference interpolating polynomials. System of Linear Algebraic Equations: Elementary matrix properties, Gauss elimination, Pivoting, Gauss-Siedel method, Ill-conditioned system. Case studies: (i) Variation of melting point with composition of Pb-Zn alloy (ii) General solution of equilibrium problem.

UNIT-IV:
Numerical Integration: Trapezoidal and Simpson's Rule, Gauss-Quadrature. Case Study: Third law of thermodynamics.

UNIT-V:
Numerical Differentiation: Euler's Method, Runge-Kutta Method, finite-difference techniques. Case Studies: (i) Reaction Kinetics (ii) Radiative heat transfer to thin metal piece.

Text Book:
1. Applied Numerical Methods with MATLAB for Engineers & Scientist by S.C.Chapra

Reference Books:
1. Numerical Methods in Engineering & Science by Dr. B.S. Grewal
2. A friendly Introduction to Numerical Analysis by Brian Bradie
3. Numerical Methods for Scientists and Engineers by K Sankara Rao

SEMESTER IV

MM1401: Deformation Behavior of Materials (3-1-0)

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

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

UNIT-III:
Microscopic basis of plastic deformation: Elements of dislocation theory, movement of dislocation, elastic properties of dislocation, intersection of dislocation, dislocation reactions in different crystal structures, origin and multiplication of dislocations.

UNIT-IV:
Plastic deformation of single crystals: Critical resolved shear stress, deformation by twinning, deformation band and kink band, strain hardening of single crystal; stress-strain curves of fcc, bcc and hcp materials.

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

Text Books:
1. Mechanical Metallurgy, 3rd Ed by G.E. Dieter
2. Mechanical Behaviour of Materials by T.H. Courtney
3. Mechanical Behavior of Materials by M. A. Meyers and K. K. Chawla

MM1402: Phase Transformations and Heat Treatment of Materials (3-1-0)

UNIT-I:

Introduction to thermodynamics of phase transformations and phase equilibria. Introduction and classification of phase transformations. Diffusion in solids: phenomenological approach and atomistic approach. Nucleation and growth theories of vapour to liquid, liquid to solid, and solid to solid transformations; homogeneous and heterogeneous nucleation. Strain energy effect during nucleation; interface-controlled growth and diffusion controlled growth

UNIT-II:

Precipitation from solid solution: types of precipitation reactions, crystallographic description of precipitates, precipitation sequence and age hardening, spinodal decomposition.

UNIT-III:

Iron-carbon alloy system: iron-carbon diagram, nucleation and growth of pearlite, cooling of hypo-eutectoid, eutectoid, and hyper-eutectoid steels, development of microstructures in cast irons. Massive transformation. Order-disorder transformation. Phase transformations in and heat treatment of some common non-ferrous metals and alloys.

UNIT-IV:

Heat treatment of steels and cast iron: TTT and CCT diagrams. Effects of alloying elements on TTT diagram, construction of TTT diagram. Hardenability, role of alloying elements on hardenability in steels, determination of hardenability, Special heat treatment techniques. Maraging, martempering, austempering, Ausforming, patenting

UNIT-V: Heat treatments of non-ferrous alloys. e.g. age hardening in Al-Cu-X alloys. Heat treatment furnaces, atmospheres, quenchants.

Text Books:

1. Phase Transformation by D. A. Porter and K. Easterling
2. Steels-Heat Treatment and Processing Principles by George Krauss
3. Phase Transformations in Materials by R. C. Sharma.
4. Solid State Transformations by V. Raghavan.
5. Principles of Heat treatment by Rajan and Sharma

MM1403: Principles of Extractive Metallurgy (3-1-0)

UNIT-I:
Importance of mineral dressing, Equipments and steps involved-liberation, comminution, Principles of Crushing, Grinding and Grindability. Evaluation of Particle size, size distribution curves and their significance.

UNIT-II:
Mechanism of breakage of materials, industrial screening, classification. Dry and wet classifiers. Free and hindered settling. Thickness, hydroclones, filtration, agitation and mixing, tabling, jigging, magnetic and electrostatic separation. Surface behaviour and flotation principles. Flotation Machines.

UNIT-III:
Fuels for metallurgical processes, Refractories and their uses, Reactor design considerations, sizing of fluidized and fixed bed metallurgical reactors. Unit Processes in pyrometallurgy: Drying, calcination, roasting, pelletising and sintering. Thermodynamics of metal extraction, Slags-classification and properties. Reduction, smelting in shaft furnace, alternative reductants, hydrogen as reductant, metallothermic reduction. Thermodynamic principles and applications of matte smelting and converting. Flash smelting and submerged bath smelting.

UNIT-IV:
Principles of metal refining with examples for metals like Cu, Ni, Pb, Sn and Zn; design of metal separation using high temperature distillation.

Unit processes in hydrometallurgy: leaching, purification of leach liquor, solvent extraction and ion exchange systems and flow sheet design.

UNIT-V:
Unit processes in electrometallurgy: Faradays laws of electrolysis, concept of overvoltage, limiting current density, overall cell voltage, series and parallel electrical circuits in refining. Electrowinning and electrorefining with reference to metals like Cu, Ni ,Co, Cd, Fe, Zn, Al and Mg.

Text Books:
1. Will's Mineral Processing Technology by B. Will and T. Napier-Munn
2. Principles of Extractive Metallurgy by Terkel Rosenqvist
3. Unit Processes of Extractive Metallurgy, R. D. Pehlke, Elsevier publishing Company, 1973.

MM1404: Physics of Materials (3-1-0)

UNIT-I:

Properties of materials and some important relationships, Free electron theory of metals, Drude model Electronic Conductivity, Drude model Thermal Conductivity – Ratio, the Wiedemann Franz Law.

UNIT-II:

Maxwell-Boltzmann Statistics, Limitations of the Drude model, Elementary quantum mechanics: History and Significant concepts, The Drude-Sommerfeld model, Fermi-Dirac statistics, Density of states, Fermi Energy and Fermi Surface, Improvements over Drude model, remaining limitations.

UNIT-III:

Specific heat, phonons, Real space Vs Recirpocal space, Diffraction condition and its significance for electron energy, Wigner Seitz cells, Brillouin zones, Band Theory, Density of occupied states, the origin of anisotropy.

UNIT-IV:

Electrons and Holes, Classification of semiconductors, Direct Band gap, indirect Band gap, Effective mass of electrons and holes, Electrical conductivity, Hall Effect. Optoelectronic materials, Magnetic properties, superconductivity, Meissner effect, BCS theory, High temperature superconductors, physics of nano-scale materials.

UNIT-V:

Principles of photoconductivity, luminescence- - photo detectors – Optical disc and optoelectronicmaterials –LCD, LED and diode laser materials - electro optic modulators - Kerr and Pockel's effect –LiNbO3.

Text books:

1. Introduction to the Modern Theory of Metals by Alan Cottrell
2. Introduction to Electron Theory of Metals by Mizutani
3. Introduction to Solid State Physics by Charles Kittel
4. Solid State Electronic Devices by B. G. Streetman and S. Banerjee

MM1405: Materials Characterization (3-1-0)

UNIT-I:

Chemical bonding, fundamentals of crystallography, reciprocal lattice, structures in metals, inorganic compounds, polymers, silicates and glasses, stereographic projections. Production, characterization, and interaction of X-rays with matter, Bragg's Law and Laue's equations,

Ewald's construction, diffraction techniques and applications; Diffraction Methods like texture measurement, residual stress analysis, EXAFS, neutron diffraction, etc.;

UNIT-II:
Optical principles of microscopy resolution, magnification, depth of focus. Optical Metallography techniques like polarized light microscopy, DIC, fluorescence, etc.; Principles of Quantitative Microscopy: volume density, surface density, length density, numerical density, particle and grain size;

UNIT-III:
Electron, Optical and related techniques like TEM, SEM, EDS, WDS/EPMA, CBED, HREM, EELS, etc.; determination of crystal structure, burgers vector, electron beam specimen interactions and other applications of Transmission Electron Microscopy; Applications of Scanning Electron Microscopy and, Electron Probe Micro Analyser.

UNIT-IV:
Principles, application, working and interpretation of data of Surface Analysis and related techniques like Auger, XPS, SIMS, RBS, STM, AFM, etc. Thermal Analysis like DTA, DSC, TGA, TMA, etc.;

UNIT-V:
Spectroscopy Techniques like optical emission spectroscopy, atomic absorption spectrometry, x-ray spectrometry, infrared spectroscopy, Raman spectroscopy, electron spin resonance, nuclear magnetic resonance, Mossbauer spectroscopy, Auger electron spectroscopy, Scanning Tunneling Microscopy, Atomic Force Microscopy etc.; Electrical Resistivity measurement.

References:
1. Microstructural Characterization of Materials, David Brandon and W. D. Kaplan
2. Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, Yang Leng.
3. Electron Microscopy and Analysis, Peter Goodhew

SEMESTER V

MM1501: Extractive Metallurgy of Non-Ferrous Metals (3-1-0)

UNIT-I:
COPPER: Principal ore minerals, traditional bath smelting processes viz., Blast furnace, Reverberatory furnace, Electric furnace. Autogenous smelting – Outokumpu flash smelting, INCO flash smelting. Converting. Continuous smelting and converting- Noranda process and Mitsubishi process, other processes. Hydro-metallurgical extraction - principles, leaching processes. Recovery of copper from leach solutions- cementation and electro-winning. Refining - fire refining, electrolytic refining.

UNIT-II:
ZINC: General principles, roasting. Retort processes- horizontal and vertical retort processes. Electro-thermal production. Production in shaft furnace - Imperial Smelting Process. Hydrometallurgical zinc production - leaching practice, solution purification; Electrolytic production.New developments in zinc production.Refining of crude zinc- liquation and fractional distillation.

UNIT-III:
LEAD: Ore concentration. Smelting- sintering reduction process, reduction in the blast furnace. Roast reaction processes. Direct smelting reduction processes- air flash smelting, oxygen flash smelting, oxygen - slag bath smelting, QSL Process. Refining of lead bullion – pyrometallurgical and electrolytic refining.

UNIT-IV:
ALUMINUM: Raw materials, Production of pure alumina- Bayer process; Deville-Pechiney process; Hall-Heroult cell- electrolyte, electrode reactions, current efficiency, cell voltage, anode effect. Refining of aluminum. Alternate processes for the production of aluminum.

UNIT-V:
Simplified flow sheets for the extraction of Nickel, Magnesium, Tin, Gold, Silver, Uranium and Titanium. Non-ferrous metal industry in India.

References:
1. Extraction of Non-ferrous Metals by H. S. Ray, K. P. Abraham and R. Sridhar
2. Nuclear Reactor Engineering by S. Glasstone and A. Sesonke
3. Rare Metals Hand book by C.A. Hampel
4. Hand Book of Extractive Metallurgy, Vols. II and III, Editor. Fathi Habashi

MM1502: Manufacturing Process in Metallurgy – Casting, Solidification and Joining (3-1-0)

UNIT-I:
Foundry principles. Pattern and pattern making materials, mould and mould making materials, core and core making materials, testing of moulding and core making materials, principles of gating systems, principles of risering systems, foundry clay, theory of clay bonding. Special casting techniques: Ceramic shell, investment casting, Rheo & thixocasting, squeeze casting, high and low pressure die casting, continuous casting, cast metal matrix components.

UNIT-II:
Solidification microstructure: Cells, dendrites, solidification of polyphase alloys, eutectic and peritectic solidification. Constitutional Supercooling. Growth of graphite in cast iron, segregation in castings, inclusions in castings. Importance of solidification in metal casting processes, heat flow and heat evolution, shrinkage during cooling and solidification. etc.

UNIT-III:
Plane front solidification: Solidification of single phase alloys, directional solidification, crystal growth etc. Grain refining, lateral growth, continuous growth, instability at the solid/liquid interface

UNIT-IV:
Principles and details of joining processes: Arc welding, SAW, GMAW or MIG/ MAG welding TIG welding, Resistance welding, Soldering, Brazing

UNIT-V:
Welding metallurgy of carbon and alloy steels, Cast irons, Stainless steels, Al- and Cu-based alloys. Weldability and Heat affected zones (HAZ). Welding defects and detection techniques. Equipment requirement, electrodes for welding of different materials, coating constituents and their functions, types of coatings, current and voltage selection for electrodes.

Textbooks:
1. Principle of Metal casting-Rosenthal
2. Foundary Technology-P. L. Jain
3. Principles of Solidification - Chalmers
4. Metallurgy of Welding. J F Lancaster, Allen and Unwin,
5. Welding and Welding Technology, R L Little.

MM1503: Deformation Processing and Forming Technology (3-1-0)

UNIT-I:
Classification of forming processes, mechanics of metal working, temperature and strain rate effects, instability and flow localization, shear banding, workability, microstructure and texture evolution, friction and lubrication, residual stress.

UNIT-II:
Forging: Closed-die and open-die forging, forging equipment, mechanics. Rolling: Terminology of rolled products, different kinds of rolling mills, forces and geometric relationships, variables affecting roll pressure, power and friction hill, theories of cold and hot rolling, roll pass design.

UNIT-III:
Extrusion: Direct and indirect extrusion, impact extrusion, hydrostatic extrusion, equipment, extrusion variables, extrusion pressure. Wire and Tube drawing: Processes and equipments, hydrodynamic lubrication, draw stress, factors affecting draw stress and reduction.

UNIT-IV:
Sheet metal forming: Different forming methods, forming limit criteria Non-conventional methods: Powder performs forging, superplastic forming, high energy rate forming, mushy state forming, forming of plastics.

UNIT-V:
Principles of forming through material removal processes – Machining etc. Analysis of defects in products of all metal forming processes. Deformation of plastics and polymers; super-plasticity; Formability; Failures; Friction wear and lubrication

Text Books:
1. Mechanical metallurgy G.E. Dieter:
2. Mechanical Working of Metals- Theory and Practice by J.N. Harris:

MM1504: Powder Metallurgy and Ceramics (3-1-0)

UNIT-I:
Powder Production (Chemical Methods, Electrolytic Methods, Atomization, Mechanical Methods)

UNIT-II:
Powder Characterization (Chemical Composition and Structure, Particle Size and Surface Topography, Pyrophorocity and Toxicity)

UNIT-III:

Powder Compaction, Phenomenological Aspects of Sintering, Solid State Sintering, Analytical Approach to Sintering, Non Isothermal Sintering, Microstructural Evolution,

UNIT-IV:
Liquid Phase Sintering, Stages of Liquid Phase Sintering, Super solidus Sintering, Activated Sintering, Pressure Assisted Sintering, Microwave Sintering, Select Case Studies.

UNIT-V:
General overview of Ceramics: Structure and properties of ceramics, Types according to various applications; Various consolidation methods, casting of ceramics, conventional and advanced sintering processes for ceramics

Text Books:

1. Powder Metallugy Science, 2nd ed R.M. German.
2. Powder Metallurgy: Science, Technology and Materials by A. Upadhyaya, G.S. Upadhyaya,
3. ASM Handbook, Volume 7: Powder Metal Technologies & Applications (1998)
4. Introduction to Ceramics by Kingery W.D, Bowmen H. K., Uhlmann D.R

MM1505: Iron Making (3-1-0)

UNIT-I:
General overview of iron and steel making in India and abroad. General layout of an integrated steel plant. Raw materials in ferrous production metallurgy, Reserves of iron ores in India and abroad, impurities in iron ores, evaluation of iron ores, characteristics of iron ores, coal reserves of India and abroad, functions of coke in blast furnace, coke quality, precarbonisation of coal, reserves of limestone and its quality for blast furnace ironmaking.

UNIT-II:
Beneficiation of iron ores, agglomeration of iron ores, briquetting, nodulising, sintering, palletizing, quality control of sinter and pellets, their effects on furnace operation, alkali cycle in blast furnace. General constructional features of the blast furnace, different regions within a blast furnace. Different zones in a blast furnace and their physico-chemical functions. Blast furnace refractory lining. Charging of raw materials from the top, double bell, movable throat armour and the bellless top. Blast furnace plant and accessories.

UNIT-III:
Thermodynamics and kinetics of iron ore reduction by CO and hydrogen gas. Kinetics of gasification of carbon by CO_2. Critical analysis of conditions prevalent in B.F. and their interaction on the reduction of iron oxides. Slag formation and metalloid reduction.

UNIT-IV:

Techniques of intensification of blast furnace process for higher productivity and low coke rates i.e. fuel injection, humidification of blast, oxygen enrichment of the blast, high blast temperature, high top pressure, pre reduction etc. controlling iron quality and slag rate. Irregularities in blast furnace, their causes and remedies.

UNIT-V:

Alternate routes of iron making, their technology and present status, economics, their special relevance under Indian conditions.

Text Books:

1. Principles of Blast Furnace Iron making Dr. A.K.Biswas by UBS publication .
2. Blast furnace – Theory and Practice Vol- I & II by J. Strauss, US publications.
3. Beyond The Blast Furnace by Dr. Amit Chatterjee, CRC press , Boka Raton, USA

References:

1. Iron making and steel making – Theory and Practical - Dr. Ahindra Ghosh & Dr. Amit Chatterjee Prentice Hall of India learning New Delhi.
2. Sponge Iron production by Direct reduction of Iron oxide - Dr. Amit Chatterjee. PHI Learning New Delhi.
3. Hot Metal production by smelting reduction of Iron Oxide- Dr. Amit Chatterjee PH9 Learning, New Delhi.
4. An Introduction of Iron making - Dr. R.H. Tupkary – Khanna publisher, New Delhi

SEMESTER VI

MM1601: Surface Engineering (3-1-0)

UNIT-I:
Surface dependent engineering properties, viz., wear, friction, corrosion, fatigue, reflectivity, emissivity, etc.; common surface initiated engineering failures; mechanism of surface degradation; importance and necessity of surface engineering;

UNIT-II:
Classification and scope of surface engineering in metals, ceramics, polymers and composites, tailoring of surfaces of advanced materials. Surface protection (Physical); surface modification (Chemical) techniques: classification, principles, methods, and technology;

UNIT-III:
Conventional surface engineering methods: carburising, nitriding, cyaniding, diffusion coating, hot dipping, galvanizing etc.; electrochemistry and electro-deposition; scope and application of conventional surface engineering techniques in engineering materials; advantages and limitations of conventional processes.

UNIT-IV:
Recent trend in surface engineering: physical/chemical vapour deposition; plasma spray coating; plasma assisted ion implantation; surface modification by directed energy beams like ion, electron and laser beams; energy transfer, beam configuration and modes.

UNIT-V:
Surface integration, heat and mass transfer (composition and temperature profile) during directed energy beam irradiation; novelty of composition and microstructure; post irradiation characterization (microstructural & compositional) and testing/evaluation of surface-properties; structure-property correlation. Economics and energy considerations, designing of surface engineering processes.

Text books:
1. Surface Engineering for Wear and Corrosion Resistance, Ed. by J. R. Davis
2. Introduction to Surface Engineering by P.A. Dearnley
3. ASM Handbook Volume 5

MM1602: Materials Selection and Design (2-1-0)

UNIT-I:
Basic concepts of materials science: processing-structure-property-performance correlation; overview of conventional and advanced materials Brief introduction to the manufacturing processes for metals, polymers, ceramics, glasses and composite materials.

UNIT-II:
Overview of the design process: concepts and stages of engineering design and design alternatives to develop materials with tailored properties; Performance indices of materials; function, objective and constraints in design, specific stiffness-limited and strength-limited design for maximum performance, Performance indices for thermal, mechanical, thermomechanical applications, damage tolerant designs for structural applications. Design for manufacturability, Ashby's material property charts. Application of statistics in materials and materials selection.

UNIT-III:
Specification of steels, Composition, heat treatment, microstructure and properties of ferrous and non-ferrous alloys, ceramics and polymers for light and heavy structural, Corrosion resistant, high temperature, low-temperature and cryogenic, wear resistant.

UNIT-IV:
Materials selection – case studies: magnetic, electrical and electronic applications, pressure vessels and boilers, springs, bearings, tools, medical implants and prostheses application, Composites, shape memory alloys, metallic glasses.

UNIT-V:
Decision matrices and decision matrix techniques in materials selection, relationship between materials selection and processing; Case studies: designing of Metals and alloys, ceramics and glasses, composite materials (MMC, CMC and PMC/ FRC) for specific applications. Materials and the Environment.

Text books:
1. Engineering Materials, 4th Edition by M.F. Ashby.
2. Materials Selection in Mechanical Design by M.F. Ashby.
3. Materials Selection and Design, ASM Publication, Vol.20.
4. The Principles of Materials Selection and Design by Pat L. Mangonon

MM1603: X-Ray diffraction & Electron Microscopy

UNIT-I:
Introduction to X-Ray; Production and Properties of X-Rays; continuous and Characteristic- X-Rays, absorption, filter.

UNIT-II:
Diffraction of X-Rays; Crystallography, Stereographic projection, Intensities of the diffracted beam. Experimental Methods in X-Rays analysis; Laue Method, Powder method.

UNIT-III:
Diffractometer and spectrometer. Indexing of diffraction pattern (Powder Method) for cubic systems.

UNIT-IV:
Application of X-Ray diffraction: Construction of Binary phase diagram. Order- disorder transformations; residual stress and texture.

UNIT-V:
Transmission Election Microscope, Scanning Electron Microscope. Theories of diffraction contrast in TEM.

Text Books:
1. Elements of x-Ray Diffraction by B.D. Cullity (Addition – Wesley Publishing Company)
2. Electron Microscopy of Materials – An Introduction by M.V. Heimendahl, Academic Press
3. Structures of Metals by Charles Barrett & T. B. Massalski by McGraw Hills Publishers

Reference Books:

1. Physical Metallurgy by R.W .Cahn & Peter Hassan Vol I to Vol IV
2. Modern Physical Metallurgy by R. E. Smallman.

MM1604: Steel Making (3-1-0)

UNIT-I:
Fundamentals of Steel making, Historical development of steel making processes. Thermodynamics, kinetics and transport phenomena in steel making. Reactions in steelmaking such as C, P, S and Mn reaction. Basic oxygen steel making processes, Mechanism and removal of impurities. electric arc and induction furnace steel making processes.

UNIT-II: Sources of inclusion, types of inclusions and their morphology, their effects on properties of steel and their control.

UNIT-III: Importance and economy of Secondary refining of steels, Classification of Secondary Steelmaking, Functions of Secondary steel making, Metallurgical Principles in Secondary Steelmaking

UNIT-IV: Temperature and composition homogenization in Secondary Steelmaking, The ladle furnace, Synthetic slag refining (SAB, CAB Processes), Deoxidation Practices in Secondary Steelmaking. Degassing of steel, Critical studies of vacuum degassing, Vacuum Degassing Processes like, VAD, RH, DH, RHOB, RH-PI, etc processes Alloy steelmaking, AOD, CLU, etc. Processes.
Powder Injection and wire feeding techniques, TN, SL, ALT, etc Processes, Remelting Refining Processes like ESR, VAR, etc. Refractories for secondary Steelmaking, Process selection in secondary steelmaking. Secondary steelmaking under Indian scenario present & future prospect.

UNIT-V:
Stainless Steel making, AOD, VOD, CLU - theory and practice; Continuous casting of Steel, Defects in continuous cast products, Recent advances in continuous casting.

Reference Books:
1. Iron making and Steel making – Theory and Practice Dr. A.Ghosh & Dr. Amit Chatterjee.P.H.6 learning New. Delhi.
2. Electro Metallurgy of Steel & Ferroalloys –F.P .Edneral, M.K. Publisher , Moscow.
3. Metallics of Steel making – Production & use – Dr.Amit Chatterjee, B.D.Pandey& Ramesh Singh , Allied publisher , New Delhi.
4. Electro - Slag Refining W.E .Duckworth, G.Hoyle

HS1601 Intellectual Propoerty rights (IPR)

UNIT-I

Concept and Relevance of IPR

Concept of Intellectual Property; Concept of IPR; Need, Relevance of IPR; Role of IPR in the Socio-Economic Development of country,Contribution of IPR in the technological innovation and growth ; Implication of IPR for in globalized scenario

UNIT-II

Patent

Patent: Meaningof Patent, Concept of Novelty, Inventiveness and Utility; Patentable Subject matter, Patentability criteria, Duration of patent, Inventions not patentable; Process and Product Patents.

UNIT-III

Copy Right

Copy Right: Meaning & Scope,Nature of copyright, copyright works, Author & Ownership of Copyright, duration. Trademark: Definition of Trademark; Kinds of marks - brand names, logos, signatures, symbols, well known marks, Domain Names.

UNIT-IV

Other forms of Intellectual Property:

Industrial Design, its novelty and originality, Registrable design, Items not protected under Design.Layout - Semiconductor Integrated Circuits,Design of Plant varieties, Geographical Indications, Undisclosed information.

UNIT-IV

Emerging Dimensions of IPR:

WTO, TRIPS & International IP Regime, Future Challenges and Issues relating to globalization

Global Trade and IPR, Issues in Commercialization of IPR, Recent government policies and interventions relating to IPR

1. Prabuddha Ganguli, (2001): Intellectual Property Rights. Tata McGraw Hill
2. W.R. Cornish, (2013): Intellectual Property: Patents, Copyright, Trade Marks and Allied Rights. Sweet and Max Well London
3. Blakeney, (1996), Trade Related Aspects of Intellectual Property Rights: A Concise Guide to the TRIPS Agreement. Sweet and Max Well London
4. Satyawrat Ponkshe, (1991) The management of intellectual property: Patents, designs, trade marks & copyright, Exclusive distributors, UBSPD
5. Ahuja V K, Law Relating to Intellectual Property Rights, LexisNexis, 2017
6. Gopalakrishnan and Agitha, Principles of Intellectual Property, Eastern Book Co., 2006

Professional Elective - I

MM1609: Non-Equilibrium Processing of Materials

UNIT-I:
Introduction to non-equilibrium processing. Thermodynamics of meta-stable phase formation: Free energy of elements and alloy phases-determination of free energy of meta-stable phases, lattice parameter of the super-saturated phase; Kinetics of meta-stable phase formation – Nucleation of metastable and alloy phases. Grain growth rate of metastable phases

UNIT-II:
Rapid solidification: Methods, constitution and microstructure formation, properties performance and applications. Mechanical Alloying: process, mechanism of alloying, consolidation, synthesis of non-equilibrium phases, industrial applications.

UNIT-III:
Laser processing: principles, classification, laser quenching, laser surface-alloying and cladding, laser annealing, laser beam joining, micro joining. Thermal plasma processing: advantages, principles of plasma generation, plasma processing systems, processing of materials by plasma spraying.

UNIT-IV:
Spray forming: Principles, applicability, non-equilibrium phenomena in spray forming, effects of non-equilibrium features on mechanical/physical properties.

UNIT-V:
Physical Vapor Deposition and Chemical Vapor Deposition: basic principles, processing and application. Bulk amorphous alloys.

Text books:
1. Non-equilibrium processing by C Suryanarayana.
2. Elements of Rapid Solidification: Fundamentals and Applications, Editor Monde A. Otooni, Springer series in Materials Science.

MM1610:Materials for High Temperature Applications

UNIT-I:
Need for High Temperature Materials, Historical Development of High Temperature Materials, Design and Manufacture, Requirements of High Temperature Materials, Environmental Resistance: Oxidation, Sulphidation, Carburisation, Erosion, Wear, Mechanical Behaviour: Creep, Mechanical Fatigue, Thermo-Mechanical Fatigue, Corrosion-Fatigue.

UNIT-II:
Increasing Temperature Capability, Metallic Materials: Solid Solution Strengthening, Precipitation Strengthening, Dispersion Strengthening, Grain Size and Grain Boundary Effects, Environmental Resistance. Ceramic Materials: Phase Control, Defect Tolerance, Thermal Shock Resistance. Composite Materials.

UNIT-III:
Steels: Ferritic Heat Resistant Materials, Creep Resisting Martensitic Steels, Austenitic Steels, Corrosion Resistant Austenitic Steels, High Strength Austenitic Steels, Controlled Transformation Stainless Steels. Cast Iron: Grey Cast Irons, Spheroidal Graphite Irons, Austenitic Irons. Nickel Alloys, Oxidation and Corrosion Resistant Nickel Alloys, Nickel Superalloys, Cobalt Alloys, Titanium Alloys.

UNIT-IV:
Intermetallic Materials: Titanium Aluminides, Nickel Aluminides, Iron Aluminides, Speculative Intermetallics. Cermets: Cemented Carbide Cutting Tools, Wear Resistant Coatings. Refractories and Insulating Materials. Engineering Ceramics: Alumina, Zirconia, Silicon Carbide, Silicon Nitride, Glass Ceramics.

UNIT-V:
High Temperature Composite Materials: Metal Matrix Composites, Titanium Matrix Composites, Carbon and Carbon-Carbon Composites, Ceramic Matrix Composites, Intermetallic Matrix Composites, Coatings for High Temperature Materials, Corrosion/Oxidation Resistant Coatings, Thermal Barrier coats.

Reference Books:

1. Materials for High Temperature Engineering Applications, by Meetham, G.W. and Van de Voorde, M.H.
2. High Temperature Materials and Mechanisms, by Yoseph Bar-Cohen, CRC Press

MM1611: Materials for Automotive Applications

UNIT-I:
Advanced materials and vehicle light weighting, An overview of advanced materials for automotive applications: Steels, Light alloys, Stainless steels, Cast iron, Composite materials, Glazing materials.

UNIT-II:

Advanced metal-forming technologies for automotive applications: Formability, Forming technology, Economic considerations. Nanostructured steel for automotive body structures: Fabricating nanostructured low-C steel sheets, Improving ductility, Crash-worthiness.

UNIT-III:
Aluminium sheet for automotive applications: Sheet alloys for outer applications, inner closure panels and structural applications, Fusion alloys, Surface treatment of the aluminium strip. High-pressure die-cast (HPDC) aluminium alloys for automotive applications: AlSi heat-treatable alloys – Silafont®-36, AIMg non heat-treatable alloys – Magsimal®-59, AlSi non heat-treatable alloys – Castasil®-37, Automotive trends in die-casting.

UNIT-IV:
Magnesium alloys for lightweight powertrains and automotive bodies: Cast magnesium, Sheet magnesium, Extruded magnesium, Future trends. Polymer and composite moulding technologies for automotive applications: fibre-reinforced polymer composites (FRPCs), Advanced automotive body structures and closures. Advanced materials for reducing noise and vibration in automobiles.

UNIT-V:
Recycling of materials in automotive engineering, Joining technologies for automotive components.

Text Books:
1. Advanced Materials in Automotive Engineering, by Jason Rowe, Springer, 2012.
2. Lightweight and Sustainable Materials for Automotive Applications, by Omar Faruk, Jimi Tjong, Mohini Sain.
3. Advanced Composite Materials for Automotive Applications: Structural Integrity and Crashworthiness, by Ahmed Elmarakbi.

MM1610: Materials for Strategic Applications

UNIT-I:
Types and Nature of Materials: Crystal Structure, Crystalline and Amorphous Structures, Metals, Alloys, Intermetallics, Ceramics, Electrical Conductivity, Conductors, Semiconductors, Ferroelectric, Piezoelectric, Pyroelectric, Defects in Crystalline Solids, Magnetism, Optical Properties, Shape Memory Effect and Superelasticity, Mechanical Properties of Materials.

UNIT-II:

Functional and Multifunctional Materials. Key Applications of Functional Materials for Defense (Warheads, Missiles, Tanks, etc.), Aerospace, and Nuclear Applications, with examples and elaborations.

UNIT-III:
Introduction to Key Energy Materials, Design and Application of Energy Storage Materials including Fuel Cells and Hydrogen Storage Materials. Case Studies related with issues and application.

UNIT-IV:
Important Structural Materials for Aerospace, Defense (Warheads, Missiles, Tanks, etc.), and Nuclear Applications, including Metallic Materials, Intermetallics, Ceramics, and Composites.

UNIT-V:
High Temperature Structural Materials and their relevance to Strategic Applications. Cryogenic Technology and Materials. Case Studies related with issues and application.

Text books:
1. Introduction to Physical Metallurgy S. H. Avnor.
2. Yoseph Bar-Cohen, High Temperature Materials and Mechanisms: CRC Press.
3. Ashutosh Tiwari and Lokman Uzun: Advanced Functional Materials: Wiley.

SEMESTER VII

MM1701: Environmental Degradation of Materials and its Protection (3-1-0)

UNIT-I:
Corrosion as non equilibrium process, corrosion rate expressions, electrochemical principles of corrosion-cell analogy, concept of single electrode potential, reference electrodes, e.m.f. and galvanic series-their uses in corrosion studies, polarization, passivity. Different forms of corrosion-uniform attack, galvanic, crevice, pitting, intergranular, selective leaching, erosion, stress corrosion cracking-their characteristic features, causes and remedial measures.

UNIT-II:
Principles of corrosion prevention-material selection, control of environment including inhibitors, cathodic and anodic protection, coatings and design considerations.

UNIT-III:
Corrosion testing methods. Introduction to high temperature corrosion, Pilling-Bedworth ratio, oxidation kinetics, oxide defect structures, Wagner-Hauffe valence approach in alloy oxidation, catastrophic oxidation, internal oxidation.

UNIT-IV:
Scaling of binary and ternary alloys, Considerations in high temperature alloy design, prevention of high temperature corrosion - use of coatings.

UNIT-V:
Hydrogen Damage-Sources, Types of damage, Mechanisms and preventive methods, Liquid metal attack - liquid metal embrittlement, preventive measures, Chemical degradation of non-metallic materials like rubbers, plastics, ceramics etc.

Text Books:
1. Corrosion Engineering M. G. Fontana
2. Environmental Degradation of Metals by U. K. Chatterjee, S. K. Bose and S. K. Roy

MM1702: Advanced Engineering Materials (3-1-0)

UNIT-I:
Advanced Al Alloys: High temperature and high strength Al alloys such as Al-Fe-V-Si, nano-crystalline Al alloys, etc.

UNIT-II:
Ti based Alloys: Advances in Ti based Alloys; Super alloys: Ni-base, Fe-base and Co-base super alloys; Shape Memory Alloys: physical metallurgy, properties, etc. Advanced Composites: in-situ composites, nanocomposites, etc.; Intermetallics.

UNIT-III:
Overview of Structural biomaterials – metals, alloys, ceramics, polymers and composites.

UNIT-IV:
Nano-crystalline Materials: Synthesis, Structure and Properties. Amorphous Materials: Metallic glasses, Glass forming ability, Thermodynamics and kinetics of glass formation, Bulk Metallic Glasses, Properties;

UNIT-V:
Quasicrystalline Materials, Structure, Synthesis, Properties; Advanced Processes: Rapid solidification processing, Laser surface Modification, Mechanical Alloying.

Text books:
1. Light Alloys: from traditional alloys to nanocrystal by I. J. Polmiar, Elsevier/Butterworth Heinemann.
2. Titanium and Titanium alloys by C. Leyens and M. Peters, Wiley-VCH
3. Ultra fine grained steels by Yuqing Weng, Springer.
4. Bulk Metallic Glasses: an overview by Michael Miller and Peter Liaw, Springer.
5. Bio-materials an Introduction by Joon Park and R. S. Lakes, Springer.

MM1703: Creep, Fatigue and Fracture (3-1-0)

UNIT-I:
Creep of solids, temperature - stress – strain relationships, Creep and stress rupture tests, deformation mechanisms at elevated temperature, deformation mechanism maps, parametric relationships. Design of materials for elevated temperature application, Superplasticity and Life Prediction.

UNIT-II:
Cyclic stress-and-strain controlled fatigue, S-N curve, effect of notch on fatigue life, fatigue crack initiation mechanisms, macroscopic fracture modes, microscopic fracture mechanisms, creep-fatigue interaction, corrosion fatigue, parameters affecting fatigue, fatigue crack growth, Paris law, Fatigue threshold, Life estimation.

UNIT-III:
Fracture: Introduction, Types of fracture in metals, Theoretical cohesive strength of metals, Griffith theory, Fracture of single crystals, Metallographic aspects of fracture, Fractography, Dislocation theories of brittle fracture. Ductile fracture, Notch effects, Concept of fracture curve, Fracture under combined stress, effect of high hydrostatic pressure on fracture.

UNIT-IV:
Elements of fracture mechanics, Stress energy release rate, stress intensity factor, fracture toughness and design, K_{IC}, Plain strain toughness testing, plasticity corrections, crack opening displacement, J Integral, R curve, Probabilistic aspects of fracture mechanics, toughness of materials.

UNIT-V:

Microstructural aspects of Fracture: Some useful generalities, toughness and microstructural anisotropy, Improved alloy cleanliness, Optimizing microstructures for maximum toughness, microstructural refinement, Metallurgical embrittlement.

Environment assisted cracking: Embrittlement Models, Fracture Mechanics Test methods, Life and crack length calculations.

Text Books:

1. Deformation and Fracture of Engineering Materials by R.W. Hertzberg
2. Mechanical Behaviour of Materials by T.H. Courtney
3. Mechanical Metallurgy by G.E. Dieter

Professional Elective-II

MM1704: Nanomaterials Processing and Properties (3-1-0)

UNIT-I:
Definition and Classification of Nanomaterials, Fundamental Properties of various primary material classes (Metals, ceramics and Polymers), Size dependent properties and various characterization techniques of Nanomaterials

UNIT-II:
Synthesis/Consolidation routes to produce Nanomaterials, Mechano-chemical synthesis to produce nano-sized precursor powders, Various routes to produce Nanometallic alloys (Rapid solidification).

UNIT-III:
Challenges in processing bulk ceramic nanomaterials, Various densification routes for nano-ceramics and nano-ceramic composites.

UNIT-IV:
Processing-structure-properties of important bulk nanomaterials, Mechanical Properties, Thermal properties, Tribological Properties, Biological Properties (Biomedical applications),

UNIT-V:
Applications of bulk nanomaterials, Critical issues related to understanding properties of nanomaterials.

Text books:

1. Nanostructured Materials: Processing, properties and applications by Carl. C Koch
2. Non-equilibrium processing by C Suryanarayana
3. Nano-structured materials: Science and Technology, Edited by Gan-Moog Chow, Nina Ivanovna Noskova, NATO ASI Series.
4. Ultra fine grained steels by Yuqing Weng, Springer.

MM1705: Materials for Biomedical Applications

UNIT-I:
Introduction to basic concepts of Materials Science; Salient properties of important material classes; Property requirement of biomaterials;

UNIT-II:
Concept of biocompatibility; cellmaterial interactions and foreign body response; assessment of biocompatibility of biomaterials,

UNIT-III:
Important biometallic alloys: Tibased, Stainless steels, CoCrMo alloys; Bioinert, Bioactive and bioresorbable ceramics;

UNIT-IV:
Processing and properties of different bioceramic materials with emphasize on hydroxyapatite; Synthesis of biocompatible coatings on structural implant materials; Microstructure and properties of glassceramics; biodegradable polymers;

UNIT-V:
Design concept of developing new materials for bioimplant applications.

References/Text Books:

1. Biomaterials Science: An introduction to Materials in Medicine, Edited by Ratnes, Hoffman, Schoet and Lemons,Second Edition: Elsevier Academic Press, 2004.

2. Comprehensive structural lnterity, Vol.9: Bioengineering 3.Editors: Mithe, Ritchie and Karihaloo, Elsevier Academic Press, 2003.

3. Biomaterials Science and Biocompatibility, Frederick H. Silver and David L.Christiansen, Piscataway, Springer, New Jersey.

4. Biological Performance of Materials: Fundamentals of Biocompatibility, Janathan Black, Marcel Dekker, Inc., New York and Basel, 1981.

5. Basic Cell Culture: A Practical Approach, Edited by J.M. Davis, IRL Press, Oxford University Press, New York, 1994.

MM1709:Energy Management in Metallurgical Industries

UNIT-I:
Outline of energy requirements in Metallurgical Processes, Sources of Energy in Metallurgical processes, Need of Energy conservation,

UNIT-II:
Energy Audit, Types of Energy audit and methods of doing energy audit. Primary thermo-chemical operations in Iron and Steel Industry.

UNIT-III:
Heat balance of B.F., coke making, sintering, BOF steel making, EAF steelmaking, Hot and cold rolling processes, continuous casting, etc and Approaches for energy optimization/minimization in above mentioned processes, particularly effecting saving in fuel and power.

UNIT-IV:
Norms for optimization in energy consumption. Recent technologies for energy optimization like EOF, CONARC, CONTIARC, etc.

UNIT-V:
Energy scenario in Non-ferrous metal industries, Measures to minimize energy consumption in Non-ferrous metal industries particularly, in Aluminum and Copper extraction plant.

Text Book:

1. Energy and Environmental Management in Metallurgical Industries by R C Gupta

MM1710:Tool and Alloy Steel

UNIT-I:
Characteristics, Classification and Composition of Tool Steels,

UNIT-II:
Principal Properties of Tool Steels such as hardness, resistance to plastic deformation, toughness, fatigue fracture resistance, thermal stability and thermal fatigue resistance, hardenability.

UNIT-III:
Properties of Tool Steels that govern their behaviour during manufacture and heat treatment, such as hot and cold workability, resistance to decarburization and oxidation, cracking resistance.

UNIT-IV:
Composition and heat treatment of selected tool steels (e.g. high speed tool steels).

UNIT-V:
Surface treatment of tools steels, e.g. cyaniding, nitriding, boriding, chromising, etc.

Reference Books:

1. Tool Steels, by George Adam Roberts, Richard Kennedy, G. Krauss, ASM Int. 1998.
2. Steels: Microstructure and Properties, by H. Bhadeshia, R. Honeycombe.

MM1711:Continuous Casting of Steel

UNIT-I:
Importance of continuous casting, Principle of continuous casting, Different equipments of continuous casting (The ladle, the would, the tundish, The cooking spray, Bending and cutting devices, etc)

UNIT-II:
Types of continuous casting machines (Vertical Type, Vertical should horizontal discharge type, the curved mould-s type), Horizontal continuous casting and its merits.

UNIT-III:
Solidification characterization of continuous cast ingots, Rote of Primary and secondary cooking, Heat withdrawal system in continuous casting, Prediction and control of super heat in continues casting of steel.

UNIT-IV:
Steel Quality for continuous casting Quality control of continuous cast products, Defects in continuous cast products, their causes and remedies. Recent advances in continuous casting technology.

UNIT-V:
Refractories in continuous casting, Continuous casting in the Indian Steel Industries- Present and Future prospect.

Text Books:
1. The making shaping and treating of steel (IIth Edition) , Casting volume The AISE Steel foundation
2. Continuous Casting of Steel - Alok Nayar & Dr .M.D .Maheshwari & Dr .T.Mukherjee published by Iron and Steel Division , Indian Institute of Metals , Jamshedpur Chapter
3. Monograph on Continuous Casting - Dr. Amit Chatterjee & PVT Rao published by Tata Steel

MM1712:Electrical and Magnetic Materials

UNIT-I:
Geometry of crystals, Reciprocal lattice, Reflection condition and Bragg's law. Free electron theory of metals, Kronig-Penney model, Brillouin zones, Energy bands, energy-wave vector diagrams.

UNIT-II:

Conductivity in metals and Hall effect. Semiconductors: intrinsic and extrinsic. Carrier concentration, effective mass, Fermi energy determination. Preparation and characterization of elemental, compound, polycrystalline, single crystal and amorphous semiconductors.

UNIT-III:

Dielectric and Optical properties- polarization, types and mechanisms, macroscopic and local fields, Polarizability. Dispersion and complex dielectric constant. Complex refractive index, Transmission, Reflection, Absorption and Plasma resonance. Preparation, characterization and properties of BaTiO3, PLZT, PMN ceramics. Relaxors. Hysteresis loops and factors influencing them.

UNIT-IV:

Magnetic Properties: Para-magnetism, Curie-Weiss law, Pauli para-magnetism, molecular field theory, exchange interactions, ferro-, anti-ferro and ferri-magnetism. Magnetic order, Weiss molecular field, magnetism in metals and insulators, exchange and superexchange, magnetic anisotropy and magnetostriction, domain and domain walls, magnetic hysteresis and superparamagnetism. Introduction to superconductivity.

UNIT-V:

Soft and hard magnetic oxides (spinel, garnet, hexaferrite and perovskite), structure properties relations, soft and hard magnetic alloys and their properties, dc, low frequency, RF, microwave and recording applications of oxides and alloys, Colossal magnetoresistance, and Unconventional applications. Synthesis of single crystal, polycrystalline, nano size and amorphous magnetic materials, Specific characterisation techniques for magnetic materials.

Text books:

1. Introduction to Solid State Physics, 7th Ed., by C. Kittel.
2. Introduction to magnetic materials, by B.D. Cullity.
3. Introduction to magnetism and magnetic materials, D. Jiles

References:

1. Electronic Properties of Materials, 3rd Ed., by R.E. Hummel.
2. Electrical Properties of Materials, 7th Ed., by L. Solymar and D. Walsh.
4. Solid State Electronic Devices, 5th Ed., by B.G. Streetman and S. Banerjee.
5. Modern Ferrite Technology, by A. Goldman.

Open Elective-I

HS17101:Principles of Management

UNIT-I:
Introduction: Nature of Management. Meaning, Definition, its nature purpose, importance & Functions, Management as Art, Science & Profession, Management as social System, Concepts of management-Administration-Organization, MBO

UNIT-II:
Evolution of Management Thought. Contribution of Taylor, Fayol, Mary Follet, Elton Mayo.; Various approaches to Management

UNIT-III:
Planning: Definition of Planning, Nature of Planning, Importance of Planning ,Types of plans, Types of Planning, Process of Planning, Decision Making - Concept, Significance and Types of Decisions.

UNIT-IV:
Organizing: Concept, Process of Organizing, Forms of Organizational Structure, Span of Control, Authority, Responsibility, Accountability, Delegation of authority, Departmentation, Decentralization.
Staffing: Concept, Manpower Planning, Job Design, Recruitment & Selection, Training & Development, Performance Appraisal.

UNIT-V:
Leading: Core of Leadership: Influence, Functions of Leaders, Leadership Style, Leadership Development
Communication: Process, Importance of Communication, Communication Channels, Barriers to Communication
Controlling: Definition, importance of controlling, Characteristics of control, Control process, Types of Control System, Essentials of good Control Systems, Techniques of Control, Budgetary and Non-Budgetary Control.

Suggested Readings:
1. Management, Stoner and Freeman, Prentice Hall of India.
2. Fundamentals of Management, Stephen Robbins.
3. Essentials of Management, Koontz and Heinz Weihrich, Mc Graw Hill.
4. Management, Robbins & Coulter, Prentice Hall of India.
5. Principles of Management, Gilbert, Mc Graw Hill.
6. Principles of Management, P.C.Tripathi and P.N.Reddy, Mc Graw Hill
7. Principles of Management , Ramasamy , Himalya Publication , Mumbai

HS1702:Total Quality Management (TQM)

UNIT -I:
Introduction to Quality Management: Evolution of Quality Management, Concepts of Product and Service Quality, Dimensions of Quality, Deming's, Juran's, Crosby's Quality Philosophy, Barriers to TQM , Customer focus, Costs of quality.

UNIT-II:
TQM Principles, Leadership: Strategic quality planning, Employee involvement: Motivation, Empowerment, Team and Teamwork, Quality circles, Recognition and Reward, Performance appraisal, Continuous process improvement : PDCA cycle, 5S, Kaizen ; Supplier partnership: Partnering, Supplier selection, Supplier Rating.

UNIT-III:
Process Quality Improvement: Introduction to Process Quality, Graphical and statistical techniques for Process Quality Improvement, 7 QC tools, Lean and JIT Quality Philosophy, Benchmarking process, FMEA, Process failure mode and effect analysis (PFMEA), Service Quality: Six sigma for Process Improvement, Quality Audit.

UNIT-IV:
Product Quality Improvement: Quality Function Deployment, Robust Design and Taguchi Method, Product Reliability Analysis, Six Sigma in Product Development

UNIT-V:
Quality Systems: Need for ISO 9000, ISO 9001-2008 Quality System, Elements, Documentation, Quality Auditing: QS 9000, ISO 14000, TQM Implementation in different sectors.

Text Books:
1. Total quality Management, Dale H. Besterfiled, et at., Pearson Education Asia, Third Edition, Indian Reprint (2006).
2. Total Engineering Quality Management, Sunil Sharma, 1st Edition, MacMillan India Limited.
3. Total Quality Management, Poornima M. Charantimath, 2nd Edition, Pearson Education.

References:
1. Quality and Performance Excellence, James R Evans, Edition, 7th Edition, Cengage Learning.
2. Quality Management, Howard S Gitlow, Alan J. Oppenheim, Rosa Oppenheim, David M Levine,3rd Edition , Tata McGraw Hill Limited.
3. Fundamentals of Quality Control & Improvement, Amitava Mitra, 3rd Edition, Wiley Publications, 2012.
4. The Management and Control of Quality, James R. Evans and William M. Lindsay, 8th

Edition, First Indian Edition, Cengage Learning, 2012.
5. Total Quality Management, Suganthi.L and Anand Samuel, Prentice Hall (India) Pvt. Ltd., 2006.
6. Total Quality Management - Text and Cases, Janakiraman. B and Gopal . R.K., Prentice Hall (India) Pvt. Ltd., 2006.
7. Introduction to Statistical Quality Control, D. C. Montgomery, John Wiley & Sons, 3rd Edition.
8. The Management and Control of Quality, J Evans and W Linsay, 6th Edition, Thomson, 2005
9. Fundamentals of Quality Control and Improvement, Mitra A., PHI, 2nd Ed., 1998.

SEMESTER VIII

MM1801: Non-Destructive Testing (3-1-0)

UNIT-I:
Basic concepts and surface inspection: Concepts of Non-Destructive testing – relative merits and limitations. Types of defects, Visual inspection, Liquid penetrant inspection – principles, practice, applications, advantages and limitations. Principles application and instrumentation of thermal inspection. IR Thermography, Industrial Computed Tomography.

UNIT-II:
Radiography, X-rays and Gamma rays, Properties of X-Rays relevant to NDE. Absorption, scattering and use of filters, screens, geometric factors inverse square law, film: types processing and characteristics, density speed and contrast. Characteristics curves, Penetrameters, Exposure charts, radiographic equivalence, Gamma ray sources and characteristics. Flouroscopy, Xero-radiography of pipes, welds and castings. Safety with X-rays and Gamma rays.

UNIT-III:
Ultrasonics: Types, properties and charcateristics of ultrasonic waves, Attenuation, Production of ultrasonic waves, Ultrasonic probes, couplants. Inspection methods – pulse echo, transmission and resonance technique. Types of scanning. Immersion testing, thickness measurement, test block. IIW standard and reference blocks, calibration in UT of welds and castings.

UNIT-IV:
Principles, applications, Magnetization methods, magnetic particles. Dry and wet technique, demagnetization. Eddy current testing – principles, impedance diagrams, test coils and probes, inspection methods and applications

UNIT-V:
Other Techniques: Holography and Acoustic emission technique. Pressure and leak testing. Condition, monitoring of machines, Wear monitoring, spark testing. Brief overview of NDT standards-ASTM, ISO, ASNT, API, ASME, boiler and pressure vessel code.

Text Books:
1. Non-Destructive Testing by Barry Hull and Venom Jhon.
2. Practical Non Destructive Testing by Baldev Raj, Jayakumar T. and Thavasimuthu M.
3. Non Destructive Testing by McGonnagle W T.

MM1802: Entrepreneurship and Professional Ethics (3-0-0)

UNIT-I:
Introduction to Entrepreneurship: Basis and challenges of entrepreneurship, Technological entrepreneurship, Entrepreneurial characteristics, Concept of new ventures, Technology absorption, Appropriate technology, Networking with industries and institutions.

UNIT-II:
New Venture Development: Starting a new technological venture and developing the business: Business idea, Business plan, Marketing plan, Financial plan, Organizational plan; Financing a new venture, Sources of Capital: Venture Capital, Going public; Entrepreneurship and liberalization.

UNIT-III:
Managing the New Venture: Developing systems in new venture; Managing early operations; Growth and expansion; Legal issues; Franchising and acquisition; Globalization and Entrepreneurship.

UNIT-IV:
Engineering Ethics: Senses of Engineering ethics, Variety of moral issues, Moral dilemmas, Moral Autonomy, Kohlberg's theory, Gilligan's theory, Consensus and Controversy, Theories of right action, Self-interest, Customs and Religion.

UNIT-V:
Global Issues: Environmental Ethics, Computer ethics, Weapons Development, Engineers as managers, Moral Leadership, Code of conduct, Corporate Social Responsibility.

Text Books:
1.Technology Entrepreneurship: Creating, Capturing, and Protecting Value, Duening et al., Academic Press., 2009.
2.Technology Entrepreneurship: Taking Innovation to the Marketplace, Duening et al., Academic Press, 2014.
3. Ethics in Engineering, Mike W Martin and Roland Schinzinger, Tata McGraw Hill, New Delhi, 2003
4. Engineering Ethics, Govindarajan M, Natarajan S, Senthil Kumar V S, Prentice Hall of India, New Delhi, 2004

References:
1. The Startup Owner's Manual: The Step-By-Step Guide for Building a Great Company, Steve Blank and Bob Dorf, 2012.
2. Entrepreneurship, R.A. Baron, S.A. Shane, Thomson, 2004, ISBN 0-324-27356-8.
3. Entrepreneurship: Successfully Launching New Ventures, Barringer and Ireland, Third edition Pearson Prentice Hall.
4. Engineering Ethics, Charles B Fleddermann, Pearson Prentice Hall, New Jersey, 2004.

5. Engineering Ethics-Concepts and Cases, Charles E Harris, Michael S Pritchard and Michael J Rabins, Cengage learning, 2009.
6. Ethics and the Conduct of Business, John R Boatright, Pearson education, New Delhi, 2003.
7. Fundamentals of Ethics for scientists and engineers, Edmund G Seebauer and Robert L Barry, Oxford University Press, 2001.
8. Business Ethics: Decision making for personal integrity and social responsibility, Laura P. Hartman and Joe Desjardins, Mc Graw Hill education, India Pvt, New Delhi, 2013.

MM1804: Organizational Behavior and Industrial Psychology (3-0-0)

UNIT-I:
Personality and Self-awareness; Perception and Attribution; Learning; Values and Attitudes, Motivation; Groups, Group Dynamics, Teams; Skills for Managing Teams – Communication, Conflict, Power and Influence; Leadership.

UNIT-II:
What is an Organization; Determinants and Parameters of Organizational Design; Organization and Environment; Organizational Strategy;

UNIT-III:
Power and Conflicts in organization; Organization Decision Making and Strategy-formulation; Organizational Culture; Organizational Failure and Pathology.

UNIT-IV:
Organizational Change and Development; Organizational Learning and Transformation

UNIT-V:
Cross Cultural Management

Professional Elective - III

MM1807: Pollution Control and Waste Management in Steel Industries (3-0-0)

UNIT-I:
Concept of pollution: Classification of pollutants and their sources, Biodegradable and non-biodegradable pollutants. Nutrients, toxic and other hazardous pollution.

UNIT-II:

Air pollution: Gaseous and particulates. Primary and secondary pollutants, Acid rain, Photochemical smog, Effect on human health, materials and generation, air pollution in industrial units in general, Pollution control in Ferrous and non-ferrous metallurgical operations, Mining operation, coal utilization process etc. control of Automobile pollution, Air quality standard, sampling and analysis of air pollutants, Air quality monitoring instruments, Control of specific gaseous pollutants like SO_2, $NO2$, CO_2 and HC. Global climate change and stratospheric ozone depletion.

UNIT-III:
Water pollution: Sources of water pollution like suspended solids, BOD, COD, Nutrients, Metals (Toxic and non-toxic), Hazardous wastes, water quality monitoring instruments, water quality standards for different uses.

Water pollution control in selected process industries of current interest like integrated steel plants, Electroplating and metal finishing etc. pollution control for specific pollutants such as Chromium, Cadmium, Mercury, Phenolic wastes, Arsenic, Ammonia etc. waste water treatment technology in general- physical, chemical and biological processes.

UNIT-IV:
Noise pollution: sources of noise pollution in general and particularly in integrated steel plants. Effects of noise pollution on environment and workers. Noise pollution standard, noise pollution control measures in blast furnace, BOF steelmaking and Electric Arc furnace technology. Disposal of solid wastes from industrial processes i.e. B.F. slag, steelmaking slag, fly ash, refractory bricks, etc. different disposal techniques. Utilization of solid wastes.

UNIT-V:
Legislation and code of practice in regard to pollution and pollution control. Industry specific effluent standards of Pollution Control Board, role of PCB in pollution control.

Text Books:
1. Environmental Pollution Control Engineering**,** C. S. Rao, Willey Eastern Ltd., 1991.
2. Environmental Engineering, G. N. Pandey & G. C. Carney, Tata McGraw Hill Publishing Company, 1989.

MM1808: Process Modeling (3-0-0)

UNIT-I:
Basics of mathematical modeling of metallurgical processes.

UNIT-II:
Developments of Mathematical Models for Continuous casting, Annealing, wire injections.

UNIT-III:
Sintering, reheat furnaces.

UNIT-IV:

Welding, Hall Heroult Cell.

UNIT-V:
Discussion on results and limitations of models.

Text Books:
1. Mathematical Modeling of Materials Processing Operations Edtd. by I. Szekely, L. B . Hales, H. Henein, N. Jarret, K. Rajamani, and I. Samarasekara
2. Mathematical and Physical Modeling of Materials Processing Operations by Olusegun J.Ilegbusi, Manabu Iguchi, Walter Wahnsiedler

MM1809: Nuclear Metallurgy (3-0-0)

UNIT-1:
Nuclear Structure: Structure of nucleus, binding energy, fission reaction, neutron cross sections, moderation of neutrons, multiplication factor, fusion reaction.

UNIT-II:
Reactors and Materials: Classification of nuclear reactors, materials for nuclear reactors, fuels, moderators, control rods, coolant, reflectors and structural materials. Fabrication of fuel and cladding materials.

UNIT-III:
Radiation Effects: Effect of radiation on reactor materials, Radiation hazards, safety and shielding, disposal of radioactive wastes.

UNIT-IV:
Production of Nuclear Materials: Atomic minerals, their occurrence in India, General methods of their processing. Production metallurgy of nuclear grade uranium, thorium beryllium and zirconium; Production of enriched uranium; Processing of spent fuel.

UNIT-V:
Indian reactors and atomic energy program in India. Use of nanomaterials for nuclear application.

Text books
1. R. Stephenson, Introduction to Nuclear Engineering, Mcgraw-Hill.
2. H. S. Ray, R. Sridhar and K. P. Abraham, Extraction of Non ferrous Metals, Affliated East-West Press Private Limited.

Reference:
1. S. Glasstone and A. Sesonke, Nuclear Reactor Engineering, Van Nostrand