Course Structure & Syllabus

of

B.Tech Programme

in

Metallurgy & Materials Engineering

(From the Session 2015-16)

VSSUT, BURLA

COURSE STRUCTURE
1ST YEAR

FIRST SEMESTER				SECOND SEMESTER			
Theory		Contact Hrs.	CR	Theory		Contact Hrs.	CR
Course Code	Subject	L-T-P		Course Code	Subject	L-T-P	
	Mathematics - I	3 - 1 - 0	4		Mathematics - II	3-1-0	4
	Physics/Chemistry	3 - 1 - 0	4		Chemistry/ Physics	3-1-0	4
	Engineering Mechanics/ Computer Programming	3 - 1 - 0	4		Computer Programming/ Engineering Mechanics	3-1-0	4
	Basic Electrical Engineering/ Basic Electronics	3 - 1 - 0	4		Basic Electronics/ Basic Electrical Engineering	3-1-0	4
	English for Communication/ Environmental Science	3 - 1 - 0	4		Environmental Science/ English	3-1-0	4
	Sessionals				**Sessionals**		**20**
	Applied Physics Laboratory/Chemistry Lab			0 - 0 - 3	2		
	Workshop-I/ Engineering Drawing	0 - 0 - 3	2		Engineering Drawing/ Workshop-I	0-0-3	2
	Basic Electrical Engg. Lab/ Basic Electronics Lab	0 - 0 - 3	2		Basic Electronics Lab/ Basic Electrical Engg. Lab	0-0-3	2
	Business Communication Skill/ Programming Lab	0 - 0 - 3	2		Programming Lab/ Business Communication Skill	0-0-3	2
	Business Communication and Presentation Skill/Programming Lab	0-0-3	2		Programming Lab/Business Communication and Presentation Skill	0-0-3	2
		15-5-12	**28**			**15-5-12**	**28**

2ND YEAR

THIRD SEMESTER				FOURTH SEMESTER			
Theory		Contact Hrs.	CR	Theory		Contact Hrs.	CR
Course Code	Subject	L-T-P		Course Code	Subject	L-T-P	
	Mathematics-III	3-1-0	4		Mathematics-IV	3-1-0	4
	Engineering Economic	3-1-0	4	**MM – 15 - 050**	Transport Phenomena	3-1-0	4
MM – 15 - 019	Introduction to Physical Metallurgy	3-1-0	4	**MM – 15 - 030**	Mineral Processing	3-1-0	4
MM – 15 - 013	Fuels Furnace & Refractories	3-1-0	4	**MM – 15 - 052**	Unit Process of Extraction	3-1-0	4
MM – 15 - 029	Metallurgical Thermodynamics & Kinetics	3-1-0	4		Organizational Behaviour	3-1-0	4
			20				**20**
	Sessional				**Sessional**		
MM – 15 - 027	Mechanics of Materials Lab.	0-0-3	2	**MM – 15 - 031**	Mineral Processing Lab.	0-0-3	2
MM – 15 - 047	Metallurgical Thermodynamics and Kinetics Lab.	0-0-3	2	**MM – 15 - 051**	Transport phenomena Lab.	0-0-3	2
MM – 15 - 038	Physical Metallurgy Lab.	0-0-3	2	**MM – 15 - 014**	Fuel Testing Lab.	0-0-3	2
	Workshop Practice – II	0-0-3	2	**MM – 15 - 034**	Non destructive Testing Lab.	0-0-3	2
		15-5-12	**28**			**15-5-12**	**28**

3RD YEAR

FIFTH SEMESTER				SIXTH SEMESTER			
Theory		Contact Hrs.	CR	Theory		Contact Hrs.	CR
Course Code	Subject	L-T-P		Course Code	Subject	L-T-P	
MM – 15 - 020	Iron Making	3 -1 - 0	4	MM – 15 - 044	Steel Making	3 -1 - 0	4
MM – 15 - 036	Phase Transformations	3 -1 - 0	4	MM – 15 - 022	Materials Characterization	3 -1 - 0	4
MM – 15 - 008	Deformation Theory of Metals	3 -1 - 0	4	MM – 15 - 015	Heat Treatment	3 -1 - 0	4
MM – 15 - 025	Materials Testing	3 -1 - 0	4	MM – 15 - 035	Non Ferrous Extractive Metallurgy	3 -1 - 0	4
MM – 15 - 007	Corrosion and Degradation of Materials	3 -1 - 0	4		Core Elective I	3 -1 - 0	4
			20				20
	Sessional				Sessional		
MM – 15 - 009	Electro Metallurgy & Corrosion Lab.	0-0-3	2	MM – 15 - 016	Heat Treatment Lab.	0-0-3	2
MM – 15 - 039	Process Metallurgy Lab.	0-0-3	2	MM – 15 - 023	Materials Characterization Lab.	0-0-3	2
MM – 15 - 037	Phase Transformations Lab.	0-0-3	2	MM – 15 - 024	Materials Processing Lab.	0-0-3	2
MM – 15 - 026	Materials Testing Lab.	0-0-3	2	MM – 15 - 041	Powder Metallurgy Lab.	0-0-3	2
		15-5-12	28			15-5-12	28

4TH YEAR

SEVENTH SEMESTER				EIGHTH SEMESTER			
Theory		Contact Hrs.	CR	Theory		Contact Hrs.	CR
Course Code	Subject	L-T-P		Course Code	Subject	L-T-P	
MM – 15 -040	Powder Metallurgy & Composite Materials	3 -1 - 0	4	MM – 15 - 010	Engineering Materials	3-1-0	4
MM – 15 -028	Mechanical Working of Metallic Materials	3 -1 - 0	4	MM – 15 - 046	Surface Engineering	3-1-0	4
MM – 15 -004	Casting Processes & Solidification	3 -1 - 0	4		Open Elective-II	3-1-0	4
	Core Elective II	3 -1 - 0	4				
	Open Elective-I	3 -1 - 0	4				
			20				12
	Sessional				Sessional		
MM – 15 -006	Computer Applications in Metallurgical Engg. Lab	0-0-3	2	MM – 15 - 021	Major Project	0-0-6	8
				MM – 15 - 042	Seminar	0-0-0	2
MM – 15 -032	Minor Project	0-0-3	2	MM – 15 - 005	Comprehensive viva voce	0-0-0	2
		15-5-6	24			9-3-6	24
	CORE ELECTIVE - I	Contact Hrs.	CR		OPEN ELECTIVE – I & II		CR
Course Code	Subject	L-T-P		Course Code	Subject	L-T-P	
MM – 15 -053	Welding Technology	3 -1 - 0	4	MM – 15 - 001	Advanced Materials	3 -1 - 0	4
MM – 15 -002	Alternative routes of iron making	3 -1 - 0	4	MM – 15 - 018	Introduction to Nano Science & Nano Technology	3 -1 - 0	4
MM – 15 -043	Sintering Theory and Practice	3 -1 - 0	4	MM – 15 - 048	Thermo-mechanical processing of Materials	3 -1 - 0	4
MM – 15 -017	Hydro & Electro Metallurgy	3 -1 - 0	4	MM – 15 - 054	X-ray diffraction	3 -1 - 0	4
	CORE ELECTIVE - II			MM – 15 - 011	Fabrication of Materials	3 -1 - 0	4
MM – 15 -049	Theory of alloys	3 -1 - 0	4	MM – 15 - 045	Steel Technology	3 -1 - 0	4
MM – 15 -033	Modeling of Materials Processes	3 -1 - 0	4		Numerical Methods in Engineering	3 -1 - 0	4
MM – 15 -012	Failure analysis	3 -1 - 0	4		Finite Element Method	3 -1 - 0	4
MM – 15 -003	Bio materials	3 -1 - 0	4		Modeling & Simulation	3 -1 - 0	4
					Manufacturing & Design of Composites	3 -1 - 0	4

SYLLABUS

FIRST & SECOND SEMESTER

(COMMON TO ALL BRANCHES)

PHYSICS – I (3 – 1 – 0)

Module I

Interference

Superposition of waves - coherent and incoherent superposition, Intensity distribution.

Two source interference theory, Interference in thin films. Newton's Rings, Determination of wavelength of light and refractive index of liquid.

Diffraction

Diffraction: Introduction, Types of diffraction ,Fraunhofer diffraction at a single slit,Plane Diffraction grating,Diffraction spectra, Determination of wavelength of light, angular dispersion, resolving power.

Polarization

Polarization: Introduction, Types of Polarization, Production of polarized light(elementary idea) Brewster's law, Malu's law, Double refraction(only statement, explanation), Construction and working of :Nicol prism, Half wave plate and Quarter wave plate, Application of polarization(Polrimeter:Construction,Principle,Working).

Module II

Electromagnetism

Vector Calculus : Gradient, Divergence, Curl of vector field, Gauss divergence theorem. Stoke's theorem, Green's theorem,Maxwell's electromagnetic equation in differential form and in integral form , Electromagnetic wave equation: in vacuum and in conducting medium. Pyonting vector ,Pyonting theorem, preliminary ideas about waveguides.

Module III

Quantum mechanics

Need for Quantum Physics, wave particle duality,Davisson Germer experiment, Schroedinger wave equation (time dependent and time independent), properties of wave function, Operators , eigen value , eigen function, expectation value, probability current, Simple applications: particle in a box, finite well, step potential and tunneling

Module IV

Lasers

Introduction, Characteristics of lasers, Einstein's coefficients & Relation between them, Lasing action, Population inversion, Different types of Lasers (Ruby Laser,He-Ne Laser), Three and Four level pumping schemes, Applications of LASER(elementary ideas)

Fiber optics

Introduction, Principle of wave propagation in Optical Fiber, Structure of Optical Fiber,Types of Optical Fibers, Acceptance angle and acceptance cone, Numerical aperture, Applications of optical fibers in communications

Nanomaterials

Introduction, Classification, Physical characteristics and applications (fundamental)

Text books:

1. Optics – A.K.Ghatak
2. Concepts of Modern Physics – A. Beiser

Reference Books:

1. Electricity & Magnetism – D. Griffiths
2. Quantum Mechanics – Gascirowicz
3. Lasers, theory and applications - K. Thyagarajan and A.K. Ghatak, New York : Plenum Press.
4. Quantum Mechanics – M. Das and P.K Jena
5. An Introduction to Fiber Optics - A.Ghatak, K.Thyagarajan: Cambridge University Press.
6. .Nano Materials by B.Viswanathan,Narosa Book Distributer

List of Experiments

1. To Determine the Young's Modulus (Y) of the material of a Wire by Searle's Method.
2. Determination of Surface Tension of water by Capillary rise method.
3. Determination of Acceleration due to gravity by using a Bar Pendulum.
4. To determine thermal conductivity of a bad conductor by using Lee's Apparatus.
5. Determination of Wavelength of monochromatic light with the help of a Newton's Ring Apparatus.
6. Determination of Grating element of a Diffraction grating using spectrometer.
7. To verify the laws of transverse vibration of string by using sonometer.
8. To determine the Rigidity modulus of the material of a wire by using Barton's apparatus.
9. To draw the characteristics of a Bipolar Junction Transistor.
10. To draw the V-I characteristics of a P. N Junction diode.

CHEMISTRY – I **(3 – 1 – 0)**

Module–I 10 Hours

Failure of Classical Mechanics, Schrodinger's Wave Equation (Need not be Derived), Energy for 1-D Potential Box, Interaction of Wave with Matter
Fundamental of Microwave, IR, UV-Vis Spectroscopy:
Basic Concept of Spectroscopy, Selection Rule, Numericals, Frank-Condon Principle,

Module – II 10 Hours

Thermodynamics of Chemical Processes: 05 Hours
Concept of Entropy, Chemical Potential, Equilibrium Conditions for Closed Systems, Phase and Reaction Equilibria, Maxwell Relations

Module – III 10 Hours

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

Module–IV 10 Hours

Electrode Potentials and its Relevance to Oxidation and Reduction, Measurement of EMF, Determination of pH, Hydrogen, Glass, Quinhydrone Electrodes, Dry Cells, Fuel Cells and Corrosion: Concept, Galvanic Corrosion
Kinetics of Chemical Reactions: 05 Hours
Reversible, Consecutive and Parallel Reactions, Steady State Approximation, Chain
Engineering application of materials: 05 Hours
Organometallics and Nanomaterials

1) P. W. Atkins, Elements of Physical Chemistry, 4th Edition, Oxford University Press
2) C. N. Banwell and E. M. MacCash, Fundamentals of Molecular Spectroscopy, 5th Edition,
3) P. K. Kar, S. Dash and B. Mishra, B.Tech. Chemistry Vol. I, Kalyani Publications

Chemistry Laboratory

(Any ten Experiments)

1. Determination of amount of sodium hydroxide and sodium carbonate in a Mixture.
2. Determination of Total hardness of water by EDTA method.
3. Estimation of calcium present in the limestone.
4. Preparation of aspirin.
5. Standardization of $KMnO_4$ using sodium oxalate.
6. Determination of ferrous iron in Mohr's salt by potassium permanganate.
7. Determination of Rate constant of acid catalyzed hydrolysis of ester.
8. Determination of dissolved oxygen in a sample of water.
9. Determination of Viscosity of lubricating oil by red wood Viscometer.
10. Determination of Flash point of given oil by Pensky Marten's Flash point Apparatus.
11. Determination of available chlorine in bleaching powder.

Reference Book: B.Tech practical Chemistry-Kalyani publisher

MATHEMATICS - I

(Calculus, Linear Algebra and Numerical Method) (3-1-0)

Module 1: (10 Lectures)

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

Module 2: (10 Lectures)

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

Module 3: (10 Lectures)

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

Module 4: (10 Lectures)

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

Text Books:

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

Chapters: S.C. Malik - 2(2.1- 2.3), 5(5.1-5.3), 6(6.1, 6.3-6.7), 7(7.1), 9(9.1, 9.6, 9.7, 9.9,9.10)
E. Kreyszig - 7(7.1-7.5, 7.7, 7.8,7.9), 8, 20 (20.7, 20.8), 19(19.1, 19.2, 19.3, 19.5)

Reference Books:

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

MATHEMATICS - II

Differential Equations (3-1-0)

Module 1: (10 Lectures)
Basic Concepts, Modeling, Separable ODEs, Modeling, Exact ODEs, Integrating Factors, Linear ODEs, Bernoulli Equation, Population Dynamics, Existence and Uniqueness of Solutions. Homogeneous Linear ODEs of Second Order, Homogeneous Linear ODEs with Constant Coefficients, Euler-Cauchy Equations, Existence and Uniqueness of Solutions, Wronskian, Nonhomogeneous ODEs, Solution by Variation of Parameters.

Module 2: (10 Lectures)
General linear differential equations of order n, Differential Operators, Homogeneous Linear ODEs, Homogeneous Linear ODEs with Constant Coefficients, Nonhomogeneous Linear ODEs, Conversion of an nth-Order ODE to a System, Basic Theory of Systems of ODEs.

Power Series Method, Theory of the Power Series Method, Frobenius Method, Sturm-Liouville Problems, Orthogonal Functions.

Module 3: (10 Lectures)
Laplace Transforms, Laplace Transform, Inverse Transform, Linearity. s-Shifting, Transforms of Derivatives and Integrals, ODEs, Unit Step Function, t-Shifting, Short Impulses, Dirac's Delta Function, Partial Fractions, Convolution, Integral Equations, Differentiation and Integration of Transforms.

Module 4: (10 Lectures)
Partial differential equations, Basic Concepts, Modeling: Vibrating String, Wave Equation Solution by Separating Variables, Use of Fourier Series, D' Alembert's Solution of the Wave Equation. Characteristics, Heat Equation: Solution by Fourier Series, Solution of PDEs by Laplace Transforms.

Text Book:

1) Erwin Kreyszig, Advanced Engineering Mathematics, Wiley India Pvt. Ltd, 9^{th} edition.

Chapters: 1(1.1-1.5, 1.7), 2(except 2.4, 2.8, 2.9), 3, 4(4.1, 4.2), 5(5.1, 5.2, 5.4), 6(6.1-6.5), 12(12.1-12.5, 12.11)

Reference Books:

1) R.K. Jain and S.R.K. Iyengar, Advanced Engineering Mathematics, Taylor & Francis
2) K.A. Stroud, Advanced Engineering Mathematics, Industrial Press
3) J. Sinha Roy and S. Padhy, Ordinary and Partial Differential Equation, Kalyani Publisher.
4) Richard Bronsan and Gabriel Costa, Scahum's Outline of Differential Equations, McGraw Hill
5) Paul Duchateau and D.W. Zachmann, Scahum's Outline of Partial Differential Equations, McGraw Hill
6) B.V. Ramana, Higher Engineering Mathematics, McGraw Hill

English for Communication

(Credit: 4-0-0)

Objective- For developing the ability to communicate effectively in professional environment by enhancing their skills in communication.

Module 1:Fundamentals of Communication (10 Hours)

- Communication:Process, pattern and stages of communication, channels and types of communication and Barriers to Communication.
- Functions of language: Descriptive, Expressive and Social Functions.
- Formal and Informal English
- Plain English
- Bias free language

Module 2: Communicative Grammar (10 Hours)

- Time, Tense and Aspects
- Verbs of State and Events
- Use of Modal Verbs
- Phrasal Verbs
- Passive and Active Voice
- Conditionals

Module 3: Sounds of English (10 Hours)

- The Speech Mechanism and Organs of Speech
- ConsonantSounds of English
- Vowel Sounds of English
- Stress Pattern: Syllable, Stress and Intonation.
- Problem sounds for Indian Speakers

Module 4: Business and Official Writing (10 Hours)

- Paragraph writing and Sentence Linker
- Business and Official Letters
- Report and Proposal writing,
- Notice, Circular and Memo writing
- Résumé (CV) Writing.

Text Books:

1. Effective Technical Communication by M Ashraf Rizvi (Tata McGraw Hill)
2. Better English Pronunciations By J. D.O Conner (Cambridge University Press)
3. A Communicative Grammar of English by G.N. Leech and Jan Svartik (OUP)

Reference Books: "Business communication" by Ramachandran, Lakshmi and Krishna (Macmillan)

ENGLISH COMMUNICATION SKILLS (Credit :0-0-2)

Objective: For enhancing corporate readiness among students by inculcating several skills of communication through activities.

Laboratory Activities:

1. **Giving Introduction (Self and others)**
2. **Group Discussion**
3. **Interviews**
4. **Role Play**
5. **Listening skill Development**
6. **Reading skill Development**
7. **Writing skill Development**
8. **Speaking skill Development**
9. **Meeting**
10. **Presenatation**

Books Recommended:

1. Soft Skills – By Dr K Alex (S Chand)

ENGINEERING MECHANICS

Module - I

1. **Concurrent forces on a plane**: Composition, resolution and equilibrium of concurrent coplanar forces, method of moment, friction (chapter 1). (7)
2. **Parallel forces on a plane**: General case of parallel forces, center of parallel forces and center of gravity, centroid of composite plane figure and curves(chapter 2.1 to 2.4) (4)

Module - II

3. **General case of forces on a plane**: Composition and equilibrium of forces in a plane, plane trusses, method of joints and method of sections, plane frame, principle of virtual work, equilibrium of ideal systems.(8)
4. **Moments of inertia**: Plane figure with respect to an axis in its plane and perpendicular to the plane, parallel axis theorem(chapter 3.1 to3.4, 5.1, appendix A.1 to A.3) (3)

Module - III

5. **Rectilinear Translation:** Kinematics, principle of dynamics, D Alembert's Principle, momentum and impulse, work and energy, impact (chapter 6). (11)

Module – IV

6. **Curvilinear translation:** Kinematics, equation of motion, projectile, D Alembert's principle of curvilinear motion. (4)
7. **Kinematics** of rotation of rigid body (Chapter 9.1) (3)

Text book:

1. Engineering mechanics: S Timoshenko & Young; 4th Edition (international edition) MC Graw Hill.

Reference books:

1. Fundamental of Engineering mechanics (2nd Edition):
   S Rajesekharan & G Shankara Subramanium; Vikas Pub. House Pvt ltd.

2. Engineering mechanics: K.L. Kumar; Tata MC Graw Hill.

SESSIONAL

Workshop Practice-I
(Consists of 3 sections) **:**

1. Carpentry Section: Wooden rack/bench/chair/stool (any one)
2. Fitting Section: Paper Wt. Square or Rectangular joint (male and female joint) (any one)
3. Black Smith **Section** : Weeding hook/Hexagonal headed bolt blank (any one)

COMPUTER PROGRAMMING

L-T-P: 3-1-0 **Cr.-4**

Module I:

Introduction to computing- Block architecture of a computer, bit, bytes, memory, representation of numbers in memory. Introduction to problem solving- Basic concepts of an algorithm, program design methods, flowcharts.C Language Fundamentals- Character set, Identifiers, Keywords, Data Types, Constant and Variables, Statements.Input &Output - Input & Output Assignments, Formatted Outputs. Operatorsand Expressions-Operators, Precedence of operators.

Module II:

Decision Control Structure, Loop Control Structure and Case Control Structure.Functions- Monolithic vs Modular programs, User defined vs standard functions, formal vs Actualarguments, Functions category, function prototypes, parameter passing, Recursion.Arrays- 1D Array, 2D Array & Multi-Dimensional Array. Strings- Declaration &Initialization,String Handling Functions.

Module III:

Pointers- Pointer variable and its importance, Pointer Arithmetic, Passing parameters, pointer to pointer, pointer to function.Dynamic Memory Allocation.Structure- Nested Structure, Array of Structures, Pointer to Structure, Structure & Functions, typedef, Enumerated Data Type, Bit Fields. Union- Array of Union Variables, Union inside Structure.Storage Class.

Module IV:

Preprocessor Directives- Types, Pragma Directives, Conditional Directives.Files- Reading data from Files, Reading data from Files, Writing data to Files, Error Handling during File Operations.Advanced Issues in Input & Output – using *argc*&*argv*.Operation on Bits.

Text Books:

1. C: The Complete Reference: Herbert Schildt
2. Computer Fundamentals &Programming in C: ReemaThareja, Oxford University Press.

Reference Books:

1. Let us C- Y.Kanetkar, BPB Publications.
2. Programming with ANSI and Turbo C- Kamthane, A.N. Pearson Education
3. C How to Program- Deitel and Deitel, Pearson Education.
4. The C programming Language- Brian W. Kernighan and Dennis M. Ritchie,Prentice-Hall.

PROGRAMMING LAB (CS15-984)

L-T-P: (0-0-3) **Cr:** 2

Introduction to OS : Linux/Unix, Dos, Windows, Vi editor, File Handling, Directory Structure, File Permissions, Creating and editing simple c programs, Compilation and Execution

C programming on variables and expression assignment, simple arithmetic loops, If-else, Case statements, Break, Continue, Go to

Single and Multidimensional arrays

Functions, Recursion, File handling in C

Pointers, address operator, Declaring pointers and operators on pointers, Address of an array, Structures, Pointer to structure, Dynamic memory allocation

Fundamental Programs on Data Structures (Stack, Queue, Linked lists, Trees, Graphs)

(EL15-002) BASIC ELECTRICAL ENGINEERING (3-1-0)

MODULE-I (10 HOURS)

DC Networks: Kirchhoff's laws, node and mesh analysis, Delta-star and star-delta transformations. Superposition, Thevenin's and Norton's theorem. Transients, in R-L, R-C and R-L-C circuits with DC. Excitation.

Single Phase AC Circuits: Single phase EMF generation, average and effective values of sinusoids, j- operations, complex representation of impedances, phasor diagrams, power factor, power in complex notation, solution of series and parallel circuits. Introduction to resonance in series RLC circuit.

Three Phase AC Circuit: Three phase EMF generation, delta and star connection, Line and Phase quantities. Solutions of 3-phase circuits with balanced load. Power in 3-phase balanced circuits.

MODULE-II (10 HOURS)

Magnetic Circuits: B-H Curve, Hysteresis, Permeability and reluctance, solution of simple magnetic circuits, Hysteresis and Eddy current losses.

DC Generator: Different types, Principle of Operation of DC generator, EMF equation, methods of excitation. DC Motor: Back e.m.f., speed and torque of a DC Motor, Conditions for maximum Power. Speed control of DC shunt motor.

Transformers: Construction and Principle of operation of single-phase transformer, EMF equation, Single-phase autotransformer.

MODULE-III (10 HOURS)

Three phase Induction Motor: Construction and principle of operation, types; Slip-torque characteristics.

Synchronous Machines: Construction & principle of operation of Synchronous generator and motor. EMF equation, Voltage regulation, Applications and starting of Synchronous motor.

Introduction to single-phase induction Motor.

MODULE-IV (10 HOURS)

Measuring Instruments: DC PMMC instruments, Extension of range by shunts and multipliers. Moving iron ammeters and voltmeters, Dynamometer type Watt meters, Induction type Energy Meter.

Power supply systems: Principle of generation - thermal, hydel and nuclear. Transmission and distribution of electric energy. Introduction to Electric Heating & Welding.

TEXT BOOKS

[1]. Edward Hughes (revised by Ian McKenzie Smith), “Electrical & Electronics Technology”, Pearson Education Limited. Indian Reprint 2002, 10th Edition.

[2]. D.Kulshreshtha, “ Basic Electrical Engineering” TMH, 1st Edition.

REFERENCE BOOKS

[3]. H.Cotton, “Advanced Electrical Technology", CBS Publishers, New Delhi, 7th Edition.

[4]. C.L. Wadhwa, “Electrical Engineering”, New Age International Publishers, 2nd Edition.

[5]. S. Parker Smith, “Problems in Electrical Engineering”, Asia Publications, 10th Edition.

(EL15-003) BASIC ELECTRICAL ENGINEERING LAB (0-0-3)

1. Preliminary: Preparation of symbol chart for various systems & components as per ISS, To study the constructional & operational features for Voltmeter, Ammeter, Wattmeter, Frequency meter, multi-meter and Rheostat, Study of safety rules as per ISS
2. Measurement of the armature & field resistance of D.C. Machine by volt-amp method. & Starting and speed control of a D.C. shunt motor
3. Study of BH Curve
4. Determination of open circuit characteristics (O.C.C) of D.C shunt generator when separately excited at different speeds.
5. Measurement of earth resistance and insulation resistance
6. Starting of Induction motor and measurement of three phase power & power factor by 2-wattmeter method.
7. Calibration of a single phase Energy Meter by directed loading & Phantom loading

BASIC ELECTRONICS (3-1-0)

UNIT-1 **(10 Hours)**

Introduction to Electronics: Signals, Frequency Spectrum of Signals, Analog and Digital Signals,
Linear Wave Shaping Circuits: RC LPF, Integrator, RC HPF, Differentiator.
Properties of Semiconductors: Intrinsic, Extrinsic Semiconductors, Current Flow in Semiconductors,
Diodes: p-n junction theory, Current-Voltage characteristics, Analysis of Diode circuits, Rectifiers, Clippers, Clampers, Special diodes- LED, Photo diode, Zener Diode.

UNIT-II **(14 Hours)**

Bipolar junction Transistor (BJTs): Device Structure and Operation, Current-Voltage Characteristics, BJT as an Amplifier and as a Switch, Introduction to Power Amplifiers, A,B and C types.
JFET: Physical Structure, Operation and Characteristics MOSFET: Physical Structure, Operation and Characteristics, Feedback Amplifiers & Oscillators: General Feedback Structure, Properties of Negative Feedback, Four Basic Feedback Topologies (block diagram only), Basic Principles of Sinusoidal Oscillators(Crystal, Hartley & Collpit).
Operational Amplifiers (OP-AMPs): The Ideal OP-AMP, Inverting Configuration, Non-Inverting Configuration. OP-AMP Applications (Adder, Subtractor, Integrator, Differentiator).

UNIT-III **(10 Hours)**

Digital Fundamentals: Binary Numbers, Signed-binary numbers, Decimal-to-Binary & Binary-to-Decimal Conversion, Binary Addition, Subtraction, Multiplication and Division, Hexadecimal Number Systems, Logic Gates, Boolean Algebra, De Morgan's Theorems, Laws of Boolean Algebra, RS Flip flop, JK Flip flop.

UNIT-IV **(10 Hours)**

Introduction to Electronic Instruments: CRO: CRT, Waveform Display, Applications of CRO, Electronic Multimeter, Audio Signal Generator: Block diagram, Front Panel Controls.
Principles of Communication: Fundamentals of AM & FM, Block diagram of Transmitters & Receivers.

TEXT BOOKS:

1. Microelectronics Circuits, A.S Sedra, K.C. Smith, Oxford University Press. Selected portions from chapters 1 to 3, 5, 8, 13.
2. Electronics Fundamentals and Applications, D Chattopadhyay and P.C. Rakshit, NewAge International Publications. Selected portions from chapters 4 to 12,14, 16 to 18,20,21.

REFERENCE BOOKS:

1. Integrated Electronics, Millman and Halkias, TMH Publications.
2. Electronic Devices & Circuit Theory, R.L Boylestad and L. Nashelsky, Pearson Education.

BASIC ELECTRONICS LAB
LIST OF EXPERIMENTS

1. Familiarity with electronic components and devices(Testing of semiconductor diode, Transistor, IC Pins connection) Digital multimeter should be used.
2. Study and use of CRO to view waveforms and measure its Amplitude and Frequency.
3. V-I Characteristics of a Semiconductor Diode. Determining DC and AC resistance.
4. Clipper and Clamper Circuit.
5. Half Wave and Full Wave Rectifier without Capacitor filter. Record of Waveforms, Measurement of Average and RMS value.
6. V-I (Output) Characteristics of N-P-N Transistor in CE Configuration.
7. OP-AMP: Inverting and Non-Inverting Configuration. Record of Waveforms.
8. Verification of Truth table of Logic gates (AND, OR,NOT, NAND, NOR, EX-OR)

CE 15001: ENVIRONMENTAL SCIENCE & ENGINEERING (3-1-0) CR-04

Module – I **(6 Hours)**

Components of Earth System: Lithosphere, Cryosphere, Atmosphere, Hydrosphere, Biosphere and Outer space.
Ecological concepts and natural Resources: Ecological perspective and value of environment, Environmental auditing, Biotic components, Levels of organizations in environment Ecosystem Process: Energy, Food chain, Environmental gradients, Tolerance levels of environmental factor.
Natural Resources covering Renewable and Non-renewable Resources, Forests, water, minerals, Food and land (with example of one case study); Energy, Growing energy needs, energy sources (conventional and alternative).
Hydrological cycle, water balance, energy budget, precipitation, infiltration, evaporation and evapotranspiration.

Module – II **(15 Hours)**

Environmental Pollution: Definition, Causes, effects and control measures of: Water pollution, Air pollution, Noise pollution, Soil pollution, Marine pollution, Thermal pollution, Nuclear hazards
Environmental Issues: Climate change, Global warming, Acid rain, Ozone layer depletion, Sustainable development, Bio gas, Natural gas, Biodiversity, Urban problems related to energy, water scarcity, Water conservation, rain water harvesting, artificial recharge, watershed management, carbon trading, carbon foot print
National Ambient Air quality Standards, Noise standards, Vehicle emission standards

Module – III **(12 Hours)**

Drinking water standard (IS 10500), Water Quality Criteria and wastewater effluent standards
Water treatment: Water sources and their quality, Lay out of a water treatment plant and working of each unit/ principles of each process i.e. Screening, Aeration, Sedimentation, coagulation, flocculation, Filtration, Disinfection. Miscellaneous treatment: Removal of color, tastes and odour control, removal of iron and manganese, fluoridation and defloridation. Advanced water treatment: Ion exchange, electro-dialysis, RO, desalination
Working principles of ready-made water filter/purification system commercially available
Lay out of a wastewater treatment plant and working of each unit.

Module – IV **(7 Hours)**

Solid waste management: Source, classification and composition of MSW, Storage and transport of MSW, MSW management, Waste minimization of MSW, Reuse and recycling, Biological & thermal treatment (principles only), land fill
Biomedical Waste management – sources, treatment (principles only) and disposal
Hazardous Waste Management- Introduction, Sources, Classification, treatment (principles only)
Introduction to e-waste management.
Environmental impact Assessment: Project screening for EIA, Scoping studies
Environmental policies and acts (Air, Noise, Water, Forest, E-waste, Hazardous waste acts).

Text Book:

1 Environmental Engineering, G. Kiely, TMH, 2007

Reference Books:

1 Environmental Engineering, H.S. Peavy, D.R.Rowe and G. Tchobanoglous, McGraw Hill, 1985.
2 Introduction to Environmental Engineering, M. L. Davis and D. A Cornwell, McGraw Hill International, 2005.

CE 15002: ENGINEERING DRAWING (0-0-3) CR-02

(Minimum 8 sheets and 2 Auto Cad classes)

Introduction to Engineering Drawing: Drawing instruments, lines, lettering and dimensioning.

Scales: Plain, Diagonal and Vernier Scales.

Curves: Parabola, Ellipse, Hyperbola, Cycloid, Epicycloid, Hypocycloid and Involute.

Orthographic Projections: Concepts, Orthographic projections of points, Lines, Planes and Solids.

Sections of solids; Development of surfaces

Isometric Projections: Principles, Isometric Scale, Isometric Views, Isometric Views of lines, Planes, Simple and compound Solids,

Introduction to Auto-Cad:

Curves: Parabola, Ellipse, Hyperbola, Cycloid, Epicycloid, Hypocycloid and Involute.

Text Book:

1 Engineering drawing by N.D. Bhatt and V.M Panchal, Charotar Publishing House, Anand.

Reference Books:

1. Engineering Drawing by Venugopal, New Age publisher.

THIRD SEMESTER

MATHEMATICS - III

Multivariable Calculus and Special Functions (3-1-0)

Module 1: (10 Lectures)
Vector and Scalar Functions and Fields, Derivatives, Gradient of a Scalar Field, Directional Derivative, Divergence of a Vector Field, Curl of a Vector Field; Line Integrals, Path Independence of Line Integrals, Double Integrals, Green's Theorem in the Plane, Surfaces for Surface Integrals, Surface Integrals, Triple Integrals, Divergence Theorem of Gauss, Further Applications of the Divergence Theorem, Stokes's Theorem.

Module 2: (10 Lectures)
Fourier series and integral, Dirichlet criterion, Parseval's identity, the convolution theorem.

Module 3: (10 Lectures)
Orthogonal curvilinear coordinates, Jacobians, gradient, divergence, curl and Laplacian in curvilinear coordinates, Special curvilinear coordinates.

Module 4: (10 Lectures)
Gama function, The Beta function – Dirichlet integral; Other special functions– Error function, exponential integral, sine and cosine integrals, Bessel's Equation, Bessel Functions $J_{\square}(x)$, Bessel Functions of the Second Kind $Y_{\square}(x)$, Legendre's Equation, Legendre Polynomials $P_n(x)$.

Text Books:

1) Erwin Kreyszig, Advanced Engineering Mathematics, Wiley India Pvt. Ltd
   Chapters: 5(5.3, 5.5, 5.6), 9(9.4, 9.7, 9.8, 9.9), 10, 11(11.1-11.3, 11.6, 11.7), A3.4, A3.1

Reference Books:

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

HUM01 ENGINEERING ECONOMICS (4-0-0)

MODULE- 1

Theory of Demand- Modern Utility Theory, The Neumann- Morgenstern approach, The Friedman-Savage Hypothesis, Uncertainty and Consumer Behaviour, Expected value of Perfect Information, Revealed Preference Theory, Intertemporal Choice- Slutsky equation, Annual Economic Worth, Present Value, Discount rate IRR and NPV

MODULE- 2

Profit Maximisation: Theory of Production- Laws of Production, Returns to scale and variable proportions, Equilibrium of firm, and Choice of optimal combination of factors, Cost Minimisation- Calculus analysis of cost minimisation, Algebric approach to cost minimisation, average and marginal costs- the short run Cobb-Douglas cost function, constant returns to scale and cost functions, Long run and short run curves- factor prices and cost functions , The envelop theorem for constrained optimisation , Cost control techniques, Critique of the principle of profit maximisation and Modern theories of firms- Baumol's sales maximisation hypothesis, Morris Model of Managerial Enterprise, Hall and Hitch Report and the full cost pricing principle, Bain's limit pricing theory

MODULE- 3

Analysis of Public Projects: Benefit cost analysis, Public goods, Common Property, Free Rider Problem, market failure and externalities, private and social cost, Social Welfare Functions- Welfare maximisation and pare to optimality, market responses to externalities- Mergers, social conventions, property right and bargaining case theorem

MODULE- 4

Linear models: simple regression model -the problem and estimation, classical normal linear regression model, Two- Variable regression- Internal estimation and hypothesis testing, Multiple Regression analysis- The problem of estimation, Dummy Variable Regression Models, Multiple parameter sensitivity analysis, linear Programming- graphic and simplex method; Game theory- the pay off matrix of game, Nash Equilibrium, the mixed strategies and the prisoner's dilemma

READING LIST

1. Varian, H.R. (1992). Introduction to Micro Economic Analysis, Norton and company, New York
2. Woolridge, J.M. (2009). Introductory Econometrics- A Modern Approach, South Western CENGAGE learning
3. Pearce, D.W. and Turner.(1990). Economics of Environment and Natural Resources, Harvester Wheatsheaf. New York
4. Koutsoyiannis, A.(1979). Modern Micro Economics, Macmillan, London
5. Damodaran, S. (2012). Managerial Economics, second Edition, OUP
6. Gujrati and Sangeeta. (2007). Basic Econometrics, TMH, New Delhi
7. Kolstad, C.D. (2000). Environmental Economics, OUP

MM 15 019 - INTRODUCTION TO PHYSICAL METALLURGY

Module I (10 Hours)

Introduction, Atomic structure of materials, Symmetry aspects in crystals, Crystal systems, crystal planes and directions, atomic packing efficiency, voids in common crystal systems, Solidification of pure metal, Homogeneous and heterogeneous nucleation processes, cooling curve, concept of supercooling, microstructures of pure metals, solidification of metal in ingot mould. Crystal imperfections,

Module II (10 Hours)

Mechanical properties of metals, concept of plastic deformation of metals, CRSS, Slip and twinning Concept of cold working : Recovery ; Recrystallization and grain growth; Hot working. Concept of equilibrium, Concept of alloy formation, types of alloys, solid solutions, factors governing solid solubility; **U**nary phase diagram, phase rule, binary phase diagrams : Isomorphous, Eutectic, Peritectic, Eutectoid, Peritectoid, Monotectic and Monotectoid system.

Module III (10 Hours)

Lever rule and its application, interpretation of solidification behavior and microstructure of different alloys belonging to those systems, effect of non equilibrium cooling, coring and homogenization. Allotropic transformations, order disorder transformations, Iron cementite and iron- graphite phase diagrams, microstructure and properties of different alloys (both steels and cast irons),

Module IV (10 Hours)

Concept of heat treatment of steels i.e., annealing, normalizing, hardening and tempering; Microstructural effects brought about by these processes and their influences on mechanical properties. Effect of common alloying elements on the Fe-Fe_3C and Fe-C diagrams, concept to hardenability, factors affecting hardenability. Alloy steels- Stainless steels. Physical metallurgy of non ferrous alloys Cu-Al, Bronze, Brass.

Text Books:

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

MM 15 013 - FUEL, FURNACE AND REFRACTORIES

Module I (10 Hours)

Introduction of fossil fuels and their world wide reserves; Primary and secondary fuels, Coking and non-coking coals, Characterization of coal properties (caking and swelling indices, calorific value, proximate and ultimate analysis, etc.); Coal carbonization and effects of different parameters; Properties of coke, char and graphite. Selection of coal for sponge iron making and thermal power plants. Alternative sources of energy (viz. ferro-coke, formed coke, charcoal, solar, wind, tidal, etc.) and their suitability for metallurgical and power industries.

Module II (10 Hours)

Classification of refractories, raw materials, manufacture, testing and properties of heavy and special refractories, silica, silicousaluminosilicate, high alumina, magnetisite, chrome, chrome-magnesite, dolomite, forsterite, chemically bonded basic, carbon and insulating refractories and special purpose oxides, carbide nitride refratories. Binary phase diagrams of Al_2O_3-SiO_2, CaO - MgO,Cr_2O_3-MgO and MgO - SiO_2 systems. Refractory mortars and cements, Refractory castables, selection of refractories for coke oven ,ironblast furnace, copper convertor ,soaking reheating furnaces and heat treatment furnaces, electric arc furnaces.

Module III (7 Hours)

Classification of furnaces: basis and uses. Mechanism of combustion, ignition temperature. Flames: Flame propagation, flame speed and inflammability limits, types of flames; premixed and diffusion flames and their characteristics.

Module IV (13 Hours)

Combustion control; variables of control, viz.: temperature, pressure and gas ratio control, modes of combustion control. Theoretical, adiabatic & true flame temperature.Available heat and factors affecting it. Heat losses in furnaces: Heat balance and furnace efficiency. Liquid and gaseous fuel burners: methods of atomization, types of liquid fuel burners and principle of design. Low pressure, high pressure and injection type gaseous fuel burners and principles of their design.

Text Books:

1. Fuels,Furnaces and Refractories by J.D. Gilchrist.
2. Fuels,Furnaces and Refractories by O. P. Gupta.

MM 15 029 - METALLURGICAL THERMODYNAMICS & KINETICS

Module I (10 Hours)

Importance of Thermodynamics, Definition of Thermodynamics ; concept of state and path functions, Equation of states, thermodynamic processes, first law of thermodynamics, Phase diagram of a single component system, Internal energy, heat capacity, enthalpy Hess's law, Kirchhoff's law. Second law of thermodynamics, entropy, and entropy changes for various processes.

Module II (10 Hours)

Free energy and its significance, free energy change as a function of temperature, reversible and irreversible process, criteria of equilibrium, auxiliary functions, combined statements, Maxwell's relations, transformation formula, Gibbs-Helmoltz equation, Concept of standard state.

Module III (10 Hours)

Fugacity, activity, equilibrium constant, Concept of Third law of thermodynamics, temperature dependence of entropy, statistical interpretation of entropy, relation between C_p and $C_{v,}$ consequences of third law, Ellingham – Richardson diagrams. Solutions: partial molal quantities, ideal and non-ideal solutions, Roult's law; Henry's law, Gibbs – Duhem equation, regular solution, Chemical potential.

Module IV (10 Hours)

Free energy – composition diagrams for binary alloy systems, determination of liquidus, solidus and solvus lines, Thermodynamics of electrochemical cells, solid electrolytes.

Introduction of metallurgical kinetics: heterogeneous reaction kinetics: gas-solid, solid-liquid, liquid-liquid and solid-solid systems. Concept of Johnson-Mehl equation, thermal analysis.

Text Books:

1. Introduction to the Thermodynamics of Materials by D.R.Gaskell; Taylor and Francis.
2. Textbook of Materials and Metallurgical Thermodynamics by A. Ghosh; Prentice Hall of India Pvt. Ltd.

MM 15 027 - MECHANICS OF MATERIALS LABORTAORY

1. Determination of rigidity modulus of a given wire
2. Dermination of M.I of a fly wheel
3. Study of Epicyclic gear train
4. Determination of mechanical advantage & velocity ratio of various lifting machines
5. Ericson cupping test and impact test for 3different specimen
6. Fatigue Test of a given specimen

MM 15 047 - METALLURGICAL THERMODYNAMIC & KINETICS LABORATORY

1. To determine the tumbler and abrasion indices of iron ore, sample.
2. To determine the micuum indices of coke sample.
3. To determine the partial molal volume of each component in binary solution.
4. To determine the equilibrium constant and free energy change for the $C+CO_2 = 2CO$ reaction.
5. Reduction of Iron Ore Pellets by coke powder and calculation of % reduction and % swelling.
6. Reduction of Iron Ore by non-coking coal power and calculation of % reduction and % swelling.
7. To carry out Pelletization of iron ore fines.
8. To carry out Firing of pellets and measurement of their crushing strength.

MM 15 038 - PHYSICAL METALLURGY LABORATORY *(Third Semester)*

1. To make the crystal structures and study these systems, with the help of ball models.
2. To study the principles and operation of metallurgical microscope
3. To prepare specimen of some metals and alloys for microstructural examination
4. To study the Fe-Fe_3C phase diagram.
5. To study the microstructure, grain size of the carbon steels.
6. To study the microstructure, of the given cast iron samples
7. To study the microstructure, grain size of the selected non ferrous alloys.
8. To find out the grain size/number of the given metals and alloys

FOURTH SEMESTER

MATHEMATICS IV

(Complex Analysis, and Probability and Statistics)

Module I (10 Hours)

Complex Numbers, Complex Plane, Polar Form of Complex Numbers, Powers and Roots Derivative, Analytic Function, Cauchy-Riemann Equations, Laplace's Equation, Exponential Function, Trigonometric and Hyperbolic Functions, Logarithm, General Power; Line Integral in the Complex Plane, Cauchy's Integral Theorem, Cauchy's Integral Formula, Derivatives of Analytic Functions

Module II (10 Hours)

Sequences, Series, Convergence Tests, Power Series, Functions Given by Power Series, Taylor and Maclaurin Series, Laurent Series, Singularities and Zeros, Residue Integration Method, Residue Integration of Real Integrals, Geometry of Analytic Functions: Conformal Mapping, Linear Fractional Transformations.

Module III (10 Hours)

Random Variables, Probability Distributions, Mean and Variance of a Distribution, Binomial. Poisson, and Hypergeometric Distributions, Normal Distribution

Module IV (10 Hours)

Introduction. Random Sampling, Point Estimation of Parameters, Confidence Intervals, Testing of Hypotheses, Fitting Straight Lines, Correlation and regression.

Text Book:

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

Chapters: 13, 14, 15(except 15.5), 16, 17(except 17.5), 24(24.5-24.8), 25(25.1-25.4, 25.9)

Reference Books:

1. B.V. Ramana, Higher Engineering Mathematics, McGraw Hill
2. R.K. Jain and S.R.K. Iyengar, Advanced Engineering Mathematics, Taylor & Francis
3. K.A. Stroud, Advanced Engineering Mathematics, Industrial Press

MM 15 050 - TRANSPORT PHENOMENA

Module I (10 Hours)

Fluid Flow: Classification of fluids, Laminar and Turbulent flows. Flow Newton's law and viscosity, conservation and momentum through pipes and ducts. Friction factor and Drag coelhiout Flow measurement, Application of dimensional analysis of fluid flow. Concept of boundary layer. molecular of Knudsen flow, etc. as in problems and exercises.

Module II (10 Hours)

Heat Transfer I: Steady state and Transient conduction in solids. One dimensional steady state problems of heat flow through composite walls, Cylinder and Spheres. Unsteady conduction in one dimensional system.Use of Heisler charts and applications. Convective heat transfer, equation of energy, free and forced convections.

Module III (10 Hours)

Heat Transfer II: Radiation, Nature of thermal radiation, Black and Grey bodies, Stefan and Boltzmann law, Kirchhoff's laws, Intensity of radiation, lamberts law, View factor. Heat transfer between two black walls in an enclosure. Combined effect of convection, conduction and radiation. Overall heat transfer coefficient. Example problems and exercises on systems of steady heat flow important in Metallurgy.

Module IV (10 Hours)

Mass Transfer and Kinetics: Importance in Heterogeneous metallurgical systems of reactions. Steady state one dimensional mass diffusion of component through stationary media. Convective mass transfer in fluids, concept of concentration boundary layer, Mass transfer coefficient.Heterogeneous reactions of metallurgical importance, their rate controlling steps. Discussion of the following examples from metallurgical systems: Nucleation and growth and bubble formation phenomenon, Interfacial reaction, Carbon gasification by CO_2, slag-metal reaction at the interface, Topo-chemical model of gas-solid reaction

Text Books:

1. F.P. Incropera, D. P. Dewitt, T. L. Bergman and A. S. Lavine, Fundamentals of Heat and Mass Transfer, Wiley.
2. H.S. Ray, Kinetics of Metallurgical Reactions.

MM 15 030 - MINERAL PROCESSING

Module I (10 Hours)

Introduction to mineral beneficiation, sampling, liberation studies and its importance. Comminution: Fundamentals of comminution, crushing: construction and operational features of Blake jaw, gyratory, cone and roll crushers. Grinding: Theory of ball mill, rod mill, critical speed of the mill, open circuit and closed circuit, circulating load.

Module II (10 Hours)

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

Module III (10 Hours)

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

Module IV (10 Hours)

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

Text Books:

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

MM 15 052 - UNIT PROCESS OF EXTRACTION

Module I (10 hours)

Overview of Extractive Metallurgy processes; Pyro-metallurgy, Hydrometallurgy and Electrometallurgy; Thermodynamic and Kinetic Principles of metal extraction; Ellingham diagrams, Calcinations; Roasting; Predominance Area Diagram, Roasting Practices, Smelting, Formation and function of slag and their calculations ,Metallo-thremic reduction of oxides, Smelting Furnaces, Matte Smelting, Pyro metallurgical processes using vacuum

Module II (12 hours)

Hydrometallurgy: Leaching; Theory of Leaching; Role of oxygen in leaching operation; Bacterial and microbial leaching; Contact reduction of metals in aqueous solutions; Gaseous reduction of metals in aqueous solutions; Ion exchange, Solvent Extraction and Electrolysis

Module III (8 hours)

Electrometallurgy: laws of electrolysis, electrolyte Structure of solvent media; Electrolysis of aqueous solution; Electrolysis of fused salts; Cell design; Electro-plating.

Module IV (10 hours)

Halide Metallurgy and Halogenisation.,Basic approaches of refining, preparation of pure compounds; Purification of crude metals produced in bulk; Numerical problems relevant to Pyro, Hydro and Electrometallurgical processes

Text Books:

1. Principles of Extractive Metallurgy: A. Ghosh & H.S. Ray, IIN Publications, Kolkata 1984.
2. Principles of Extractive Metallurgy: Rosenquist, T., McGrawhill-Kogakusha International – 1983

BHU-1301 Organisational Behaviour (3-1-0)

Module-1(8 hours)

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

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

Case Study Analysis

Module-2 (10 hours)

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

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

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

Case Study Analysis

Module-3 (10 hours)

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

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

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

CONFLICT: Nature of Conflict & Conflict Resolution

TRANSACTIONALANALYSIS: An Introduction to Transactional Analysis

Case Study Analysis

Module-4 (12 hours)

ORGANISATIONAL CULTURE: Meaning & Definition, Culture &Organisational Effectiveness

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

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

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

Case Study Analysis

Text Books/References:

[1] Stephen P. Robbins, Organisational Behaviour, Printice hall of India, New Delhi,2000.

[2] K. Aswathappa, Organisational Behaviour, Himalaya Publishing House, Bombay, 1997.

[3] S. S. Khanka, "Organisational Behaviour", S. Chand Publication, Revised edition 2009.

Course Objectives:

1. To predict, understand and control the human behaviour in an organisation
2. To develop interpersonal relation in organisation
3. To maintain cordial industrial relation
4. To manage human resources efficiently in an organisation

Course Outcomes:

1. Students will be able to maintain the interpersonal and industrial relation when they will join into one organization.
2. Able to develop effective leadership quality.
3. Able to apply appropriate motivational techniques in accordance to the nature of the individual employee.
4. Able to manage human resources efficiently in an organisation.

MM 15 031 - MINERAL PROCESSING LABORATORY

1. To determine and analyze the size distribution of a fixed granular solid by using a test sieve stack and a vibratory shaker.
2. Crushing of ore/coal in the jaw crusher. Determination of average size by sieving
3. To study the jaw crusher and determine the actual capacity, reduction ratio and Verification of Rittinger's law of crushing.
4. Crushing of ore/coal in a roll crusher. Determination of average size.
5. To study the effect of grinding with grinding time in ball mill.
6. To separate a mixture of two minerals of different densities by gravity concentration using Wilfley Table and determine the weight and density of each fraction of the products
7. Beneficiation of ore pulp mix using floatation cell.
8. Study of magnetic separator and effect of field on the efficiency of the process

MM 15 051 - TRANSPORT PHENOMENON LABORATORY

1. Study the type of flow by Reynolds experiment.
2. Determination of total thermal resistance and thermal conductivity of a composite wall.
3. Determination of thermal conductivity of Asbestos.
4. Determination of thermal conductivity of a given metal rod.
5. Determination of heat transfer coefficient in natural convection.
6. Determination of heat transfer coefficient in forced convection.
7. Determination of emissivity of a given surface.
8. Determination of Stefan Boltzmann constant.
9. Determination of overall heat transfer coefficient in parallel and counter flow runs and obtaining the effectiveness of the given heat exchanger.
10. Determination of exchange capacity of a cationic resin in the softening of water.

MM 15 014 - FUEL TESTING LABORATORY

1. To determine the calorific value of coal and coke using bomb calorimeter.
2. Proximate analysis of coal and coke.
3. To determine flash point and fire point of a given sample such as kerosene oil. Diesel and petrol by pensky- martins /or other apparatus.
4. To determine the effect of temperature on kinematic viscosity of glycerin by redwood viscometer.
5. To determine the bulk and true density of coal sample.
6. To determine the flow rate of oil.

MM 15 034 - NON DESTRUCTIVE TESTING LABORATORY

1. To study the microstructure of given material without destroying it (Replica method)
2. To inspect the discontinuous in the material using ultrasonic testing
3. To inspect the discontinuous in the material using Dye penetrate testing
4. To inspect the discontinuous in the material using Magnetic particle testing
5. To inspect the discontinuous in the material using ultrasonic testing
6. To inspect the discontinuous in the material using leak testing
7. To study the discontinuous in the material using Eddy current testing
8. To study the discontinuous in the material using Radiography testing

FIFTH SEMESTER

MM 15 020 - IRON MAKING

Module I (8 Hours)

History of Iron making in India, Indian and other resources of raw materials required for iron making. coke making. Blast furnace plant and -Modern blast furnace, plant layout, Details of construction of blast furnace and its main accessories; gas cleaning system, hot blast generation. Blast furnace refractories and blast furnace cooling system

Module II (10 Hours)

Agglomeration of iron ore fines, sintering and pelletision, evaluation of properties of blast furnace, burden materials and application to blast furnace performance. Blast furnace plant operation, blowing in, blowing out and banking of blast furnace, role of burden charging and distribution in iron extraction, irregularities in Blast furnace operation and their remedies. Blast furnace products their quality control and disposal, coke rate and fuel efficiency of B.F. operations.

Module III (12 Hours)

Modern trends in Blast furnace practice-Production of super flux sinter, pellets, super flux and cold bonded pellets. Auxiliary fuel injection in the blast furnace. High temp.blast, humidified and oxy generated blast, high top pressure, Desulphurization of hot metal. Chemical processes in Blast Furnace, Reactions in Tuyere, hearth and bosh zone. Reduction and coke gasification, Reactions in stack and exit gases. Thermodynamics of Blast furnace process requirement in Blast furnace, temp. profile in the furnace. Free energy and equilibrium consideration in Blast furnace a brief discussion on blast furnace stoichiometry and enthalpy balance

Module IV (10 Hours)

Alternate route for iron making charcoal blast furnace, low shaft furnace and electro thermal processes of iron making. Direct reduction processes, their classification, choice of DR process. Introduction to Production of Ferro-alloys. Production of various ferro-alloys Fe-Mn, Fe-V, Fe-Cr etc. uses of ferro-alloys in iron and steel industry

Text Books:

1. Modern Iron Making - Dr. R.H. Tupkary
2. Principles of Blast Furnace iron making - Dr. A K Biswas

MM 15 036 - PHASE TRANSFORMATIONS

Module I (12 Hours)

Classification of phase transformations. Thermodynamics and Kinetics: Introduction, Equilibrium, Gibbs free energy change with single component system, Thermodynamic parameters in binary system, Binary phase diagrams, Free energy Vs Composition phase diagrams.

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

Module II (8 Hours)

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

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

Module III (15 Hours)

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

Module IV (5 Hours)

Diffusionless transformations: Martensitic transformations: characteristics, crystallography, theories of Martensitic nucleation, martensite growth. Recovery, Recrystallization and grain growth.

Text Books:

1. Phase transformations in metals and alloys by D.A.Porter, K.E.Easterling and Sharif, CRC press
2. Phase transformation in materials by Romesh C Sharma, CBS publishers & Distributors

MM 15 008 - DEFORMATION THEORY OF METALS

Module I (10 Hours)

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

Module II (10 Hours)

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

Module III (10 Hours)

Microscopic basis of plastic deformation: Elements of dislocation theory, movement of dislocation, elastic properties of dislocation, intersection of dislocation, dislocation reactions in different crystal structures, origin and multiplication of dislocations. Plastic deformation of single crystals: Critical resolved shear stress, deformation by twinning, deformation band and kink band, strain hardening of single crystal; stress-strain curves of fcc, bcc and hcp materials

Module IV (10 Hours)

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

Text Books:

1. Mechanical Metallurgy, 3rd Ed., McGraw Hill Book Company, New Delhi, 1986 - G.E. Dieter
2. Mechanical Behavior of Materials, McGraw Hill Book Company, New Delhi, 1990 - T.H. Courtney

MM 15 025 - MATERIALS TESTING

Module I (10 Hours)

Engineering materials and their applications, testing of materials: Types of testing systems, significance of measurement of properties and test conditions, interpretation of test results, Tensile Testing: significance of measured parameters, necking, stress distribution, ductility measurement,

Module II (10 Hours)

Effect of gauge length, effect of strain rate and temperature on flow properties, Machine stiffness in tensile testing system, measuring instrument computerization, Torsion Test: Mechanical properties in torsion. torsion vs tension test.

Module III (10 Hours)

Hardness Test: Rockwell, Brinell, Vickers and micro-hardness, elastic and plastic behavior during hardness testing, Special hardness tests: superficial, micro and shore. Fracture Mechanics: Introduction, Strain-Energy Release Rate, Stress Intensity Factor, Fracture Toughness and Design, KI_c Plane-Strain Toughness Testing Ductile, brittle fracture, Griffith theory, Ductile to brittle transition, Notch effect in fracture,

Module IV (10 Hours)

Fatigue Tests: Stress cycles, SN curve, effect of stress concentration, size and surface conditions on fatigue, Creep, Stress rupture tests, Creep curve and its analysis, Non-destructive Testing: Visual, magnetic, radiographic, ultrasonic, electromagnetic, penetrant tests, their applications in quality control and inspection.

Text Books:

1. Mechanical Metallurgy George E. Dieter
2. Materials Testing by S. Bhargava

MM 15 007 - CORROSION AND DEGRADATION OF MATERIALS

Module I (10 Hours)

Introduction, importance of corrosion study, corrosion as non equilibrium process, corrosion rate expressions, electrochemical principles of corrosion-cell analogy, concept of single electrode potential, reference electrodes, e.m.f. and galvanic series-their uses in corrosion studies, polarization, passivity.

Module II (10 Hours)

Different forms of corrosion-uniform attack, galvanic, crevice, pitting, intergranular, stress corrosion cracking - their characteristic features, causes and remedial measures. Principles of corrosion prevention-material selection control of environment including inhibitors

Module III (10 Hours)

Cathodic and anodic protection, coatings and design considerations. Corrosion testing methods. Introduction to high temperature corrosion, Pilling- Bedworth ratio, oxidation kinetics, oxide defect structures.

Module IV (10 Hours)

Considerations in high temperature alloy design, prevention of high temperature corrosion -use of coatings. Hydrogen Damage-Sources, Types of damage, Mechanisms and preventive methods, Liquid metal attack - liquid metal embrittlement, preventive measures.

Text Books:

1. M. G. Fontana : Corrosion Engineering , 3rd edition, Mc Graw Hill International, 1987.
2. U. K. Chatterjee, S. K. Bose and S. K. Roy: Environmental Degradation of Metals, Marcel Dekker, 2001

MM 15 009 ELECTROMETALLURGY AND CORROSION LABORATORY

1. Electro winning of Cu from acidified CuSO4 solution.
2. Electro winning of Zn from SnSO4 solution.
3. Electro deposition of Cu on mild steel electrode from acid bath.
4. Electro deposition of Cu on mild steel electrode from an alkalinebath.
5. Deposition of Nickel on Cu plate by electro plating and thickness determination of deposit by BNF Jet test.
6. Determination of throwing power and throwing efficiency of alkaline Cu plating solution.
7. Monitoring of corrosion rate of mild steel.
8. Adonization of given Aluminium rods.

MM 15 039 - PROCESS METALLURGY LABORATORY

1. To study calcinations process using calcium carbonate ore.
2. To study carbothermic reduction of iron oxide ore
3. To carry out extraction of metals from oxide and sulphide using hydrometallurgical route.
4. To study the chemical composition of alloy steel/ aluminium alloys using OES
5. To carry out purification of two compound using distillation technique.
6. To carryout electro refining of impure Cu.
7. Synthesis of alloy/composite through melting and casting route.
8. To carry out solvent extraction of two compounds
9. Synthesis of alloys/composite using powder metallurgy route.

MM 15 037 - PHASE TRANSFORMATIONS LABORATORY

1. Measurement of volume fraction, surface area in two phase and single phase materials.
2. To study the Recovery, Recrystallization and Grain growth behavior of given material
3. To study the phase transformation of Pb-Sn eutectic alloy using DSC
4. Draw the cooling curves of Pb-Sn alloy with the help of DTA
5. To study the Precipitation Hardening mechanism in Al-alloys
6. To study the microstructure and grain size of Alloy steels
7. To study the microstructure, of the given cast iron samples
8. To study the surface hardening treatments like carburizing/Boronizing on steels.

MM 15 026 - MATERIALS TESTING LABORATORY

1. To learn the how to use Rockwell hardness tester and understand the effect on hardness values
2. To learn the how to use Vickers hardness tester and understand the effect on hardness values
3. To study the principal of creep testing and determine the creep strength of the given sample
4. To study the principle of fatigue testing and required to construct an S-N curve (stress level - number of cycles to failure) of the test samples provided.
5. To determine the Impact strength of materials using Charpy (I-noch and V-noch) test methods
6. Ericson Cupping Test
7. Friction and Wear test
8. Creep Testing of Materials
9. Fatigue Testing
10. Strain Ageing and Yield Point Phenomenon

SIXTH SEMESTER

MM 15 044 - STEEL MAKING

Module I (10 Hours)

Introduction: Principles of steel making reactions, Viz. Decarburisation, dephosphorisation, desulphurisation, silicon and manganese reaction. Slag Theories: Molecular and Ionic theories; Interpretation of the above reactions in terms of ionic theory of slag, LD Process: Design of converter & lance, Quality of raw materials charged, Operation of the converter and control of bath and slag composition,Some characteristics of L. D. blow Viz. Emulsion formation, lance height for dephosphorisation and decarbonisation

Module II (10 Hours)

Recovery of waste heat, OBM/Q-BOP, Process, Concept and operation of the process, Mixed/Combined blowing Processes, Oxygen top blowing with inert gas purging at bottom, Oxygen top blowing with inert and oxidizing gases at bottom, Oxygen top and bottom blowing. Open Hearth Furnace: Its modification into Twin Hearth, Operational principle, Advantages. Electric Arc Furnace: Advantages; Charging, Melting and refining practices for plain carbon and alloy steels, Use of DRI in arc furnace and its effect on performance,

Module III (8 Hours)

Duplex processes of stainless steel making using VOD, AOD. Induction Furnace: Advantages, principle of induction melting, Its use in steel industry. Deoxidation of liquid steel: Requirements of deoxidisers, deoxidationpractice,Use of complex deoxidisers, Inclusions and their influence on quality of steel, Killed, Semi-killed and Rimming steel

Module IV (12 Hours)

Secondary refining of steel: Objectives, Principle of degassing, Different industrial processes such as DH, RH, VAD, SD. LF, and ESR, Limitations and specific applications. Continuous Casting of Steel: Advantages, types of machines, Mould lubrication and reciprocation, Developments in technology with respect to productivity, quality and energy conservation, Near-net-shape casting, Strip casting

Text Books:

1. Iron and steel making theory and practiced - Ahindra Ghosh, Amit Chatterjee
2. Introduction to Modern Steel Making, Khanna Publishers, Delhi - R.H. Tupkary

MM 15 022 - MATERIALS CHARACTERIZATION

Module I (10 Hours)

Introduction to materials characterization & its importance, Fundamentals of Crystallography, levels of characterization (macro, meso and micro), Resolution Depth of field/focus, aberrations (spherical, chromatic and astigmatism) and its remedial measures. Optical microscopy (OM) – Microscope construction and working, reflected/transmitted light microscope, theoretical and practical resolution of optical microscope, numerical aperture, principle of image formation, , effective/empty magnification, Types of illumination - bright field, dark field, polarized light and phase contrast, applications of each type of illumination. Sample preparation for optical microscopy, features of an image

Module II (12 Hours)

Introduction to scanning electron microscope (SEM), working and construction, advantages/disadvantages as compared to OM, types of electron gun and comparison between them. Electron - specimen interaction, imaging modes (secondary and backscattered), effect of spot size, apertures, accelerating voltage on SEM image, Everhart-Thornley detector, Robinson detector. Solid state segmented detector, atomic number and topological contrast. Chemical analysis using SEM, EDS/WDS working principle, construction, resolution of EDS/WDS detector, advantages/disadvantages.

Module III (8 Hours)

X-ray diffraction: Generation of X-rays, characteristic X-ray spectrum, Bragg's Law, Diffraction methods: Laue method, rotating crystal method, powder method, structural factor, applications of X-ray diffraction in materials characterization: determination of crystal structure, lattice parameter.

Module IV (10 Hours)

Thermal analysis techniques & its Importance, principles and applications of differential thermal analysis (DTA), differential scanning calorimetry (DSC) and thermogravimetric analysis (TGA). Brief idea of TEM: principle of operation, application. Introduction to advanced microscopic techniques.

Text Books:

1. Elements of X-Ray Diffraction, B.D. Cullity, Prentice Hall (2001)
2. Electron Microscopy and Microanalysis, Goodhew, Humphreys and Beanland, Taylor and Francis, New York, 2001

MM 15 015 - HEAT TREATMENT

Module I (10 Hours)

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

Module II (10 Hours)

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

Module III (10 Hours)

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

Module IV (10 Hours)

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

Text Books:

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

MM 15 035 - NON-FERROUS EXTRACTIVE METALLURGY

Module I (10 Hours)

General principles of extraction of metals from oxides and sulphides; Mineral resources of non – ferrous metals in India; their production, consumption and demand; Future of non – ferrous metal industries in India; Thermodynamic considerations and process selection in pyro-metallurgical extraction of metals. Aluminium: Bayer's process and factors affecting its operation; Hall – Heroult process: principle & practices, use of electrodes, anode effect; Refining of Aluminium; Alternative methods of Alumina and Aluminium production.

Module II (12 Hours)

extraction of metals from Sulphide ores (Cu, Ni, Pb and Zn) Copper, Roasting of sulphides Matte smelting; Converting; Refining; by-products recovery; recent developments; Continues copper production processes, hydrometallurgy of copper.

Module III (8 Hours)

Extraction of metals from oxide ores (Sn, Mg), and extraction of metals through halide route (Ti and Zr).
Extraction of metals like (U,Nb, etc). Refining involving osidation, chemical transport reactions, zone refining, distillation etc. Ion exchange and solvent extraction processes.

Module IV (10 Hours)

Electro winning and Electro refining of metals:
a) From aqueous salts (Cu, Ni, Au, and Ag)
b) From fused salts (Al and Mg)
Environmental pollution and its address related to various metal extraction processes in general.

Text Books:

1. Extraction of Non Ferrous Metals by H.S.Ray, R.Sridhar&K.P.Abraham, Affiliated EastWest Press, New Delhi
2. Principles of Extractive Metallurgy, by T. Rosenquist, McGraw hill, 1974

MM 15 016 - HEAT TREATMENT LABORATORY

1. To study the microstructure, grain size and hardness of annealed steel
2. To study the microstructure, grain size and hardness of normalized steel
3. To study the microstructure, grain size and hardness of hardened steel
4. To study the microstructure, grain size and hardness of tempered steel
5. To study the Hardenability of a given material (Jominy End Quench Test)
6. To study/draw the TTT diagram of a given material
7. To study/draw the TTT diagram of a given material
8. To study the heat treatment cycles for Titanium and Super alloys

MM 15 023 - MATERIALS CHARACTERIZATION LABORATORY

1. Micro structural analysis of a given (Ferrous & Nonferrous) sample using Optical Microscope
2. Study of electron microscope (SEM &TEM)
3. Determination of interlamellar spacing of pearlite using SEM
4. Study of precipitation hardening of Al-Cu alloy using SEM
5. Compositional Analysis of an unknown sample using EDX
6. Determination of phase transformation temperature of given sample using DSC
7. Determination of melting temperature of a unknown metal using DTA
8. Indexing of XRD Pattern of a given sample
9. Determination of lattice parameter of a given sample
10. Determination of crystallite size of a powdered sample using XRD
11. Determination of lattice strain of a deformed sample using XRD

MM 15 024 - MATERIALS PROCESSING LABORATORY

1. To study the structure property correlation of metals after cold rolling
2. To study the structure property correlation of metals after hot rolling
3. Determination of tensile properties of different classes of materials
4. To determine the compressive strength of the given samples
5. To determine the coefficient of elasticity for given materials
6. Observation of dislocations by using the etch pitting technique
7. Effect of Work-Hardening on Tensile Properties of Metals
8. Study of nucleation and growth in eutectoid steel
9. Carburization of Steel and Hardenability of steel
10. Effect of heat treatment on microstructure and mechanical properties of steels

MM 15 041 - POWDER METALLURGY LABORATORY

1. Determination of size and size distribution of metal powder
2. Determination of apparent and tap density
3. Determination of flow rate of powder
4. Compaction of metal powder and determination of green density
5. Sintering of metal powder and determination of sintered density
6. Determination of surface area

SEVENTH SEMESTER

MM 15 040 - POWDER METALLURGY AND COMPOSITE MATERIALS

Module I (10 Hours)

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

Module II (8 Hours)

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

Module III (12 Hours)

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

Module IV (10 Hours)

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

Text Books:

1 Powder metallurgy technology by G. S. Upadhyaya

2 Composite materials science and engineering by K. Chawla

MM 15 028 - MECHANICAL WORKING OF METALLIC MATERIALS

Module I (10 Hours)

Fundamentals of Metal Working: Classification of forming processes; Temperature in Metal– working, Hot working, Cold working and Warm working of metals, Heating of metals and alloys for hot working, Friction in Metal working, Lubrication, concept of yield criteria.

Module II (10 Hours)

Rolling of Metals: Classification of Rolled products, Types of rolling mills, terminology used in rolling; Forces and Geometrical relationships in rolling, Rolling variables, Theories of rolling, Rolling Torque and HP calculations. Roll-pass Design: Fundamentals of Roll-pass-design; Mill type, Layout and rolling practice adopted for some common products such as Slabs, Blooms, Billets, Plates, Sheets etc. Rolling defects and their control

Module III (10 Hours)

Forging of Metals: Forging principles, types of forging and equipments needed, calculation of forging load under sticking and slipping friction conditions, Forging defects and their control, Manufacture of rail wheels and tyres. Extrusion: Types, Principles and Equipments. Variables in extrusion, deformations in extrusion, calculation of extrusion pressure under plane strain conditions; extrusion defects; production of tubes and seamless pipes.

Module IV (10 Hours)

Wire Drawing**:** Drawing of Rods, Wires and Tubes, calculation of drawing load; drawing defects. Sheet Metal Forming**:** Forming methods such as bending stretch forming, shearing and blanking, deep drawing, and redrawing. Defects in formed products, Special forming methods such as explosive forming (elementary ideas excluding mathematical treatment)

Text Books:

1. G. W. Rowe, Principles of Industrial Metal Working processes, Crane Russak, 1977.
2. Amitabh Ghosh, Asok Kumar Mallick, Manufacturing sciences, East-west press private ltd; latest reprint-1991.

MM 15 004 - CASTING & SOLIDIFICATION OF MATERIALS

Module I (10 Hours)

Introduction: Casting as a process of Manufacturing. Moulding Processes, Equipments and Mechanization: Different types of Moulds, Moulding Materials and Moulding processes, Pattern and other mould making equipments, Different types of binders and their uses in mould and core makings

Module II (10Hours)

Melting of Metals and Alloys for casting: Brief mention of various melting units, melting and post melting treatments, melting practices as adopted for a few metals and alloys such as CI, Al, Cu, steels, cast irons.

Module III (10Hours)

Solidification of Metals and Alloys: Nucleation, Growth, Role of alloy constitution, Thermal conditions and inherent nucleation and growth conditions in the liquid melt, Time of solidification and Chrorinov's rule, concept of directionality in solidification Significance and practical control of cast structure Principles of Gating and Risering: Feeding characteristics of alloys, Types of Gates and Risers, gating ratio.

Module IV (10Hours)

Special casting Methods: Investment casting, Die casting, Centrifugal casting, Full mould casting, Vacuum sealed casting. Casting Defects: A detailed analysis of casting defects Their causes and prescription of remedial measures

Text Books:

1. P. R. Beeley, Foundry Technology, Newnes-Buttterworths, 2001

2. P. D. Webster, Fundamentals of Foundry Technology, Portwillis press, Red hill, 1980.

MM 15 006 - COMPUTER APPLICATIONS IN METALLURGICAL ENGINEERING LABORATORY

Basics of numerical mathematics, Concept of physical domain and computational domain numerical, Integration, Initial value problems, assumptions and limitations in numerical solutions, simulation, instrumentation and data acquisition systems.; To draw a circle using MATLAB; To solve a system of linear equations using MATLAB; To solve an ODE using MATLAB; To find out the standard deviation of a given set of values using MATLAB; Curve fitting techniques using regression and interpolation. Using MATLAB fit a linear curve for given set of data; To draw a sphere using MATLAB and extend the program to draw FCC and BCC crystal structures; To find out the lattice parameter from the XRD data of an element belonging to the cubic system using MATLAB; To create your own design using MATLAB codes.

EIGHTH SEMESTER

MM 15 010 - ENGINEERING MATERIALS

Module I (10 Hours)

Introduction, Metals: the generic metals and alloys; iron-based, copper-based, nickel-based, aluminium-based and titanium-based alloys. Metal structures the range of metal structures that can be altered to get different properties: crystal and glass structure, structures of solutions and compounds, grain and phase boundaries, equilibrium shapes of grains and phases;

Module II (10 Hours)

The light alloys where they score over steels, solution, age and work hardening; thermal stability; *Alloy steel*, solution strengthening, precipitation strengthening, corrosion resistance, and austenitic (f.c.c.) steels; Introduction: Ceramics and glasses: the generic ceramics and glasses: glasses, vitreous ceramics, high-technology ceramics,

Module III (10 Hours)

cements and concretes, natural ceramics (rocks and ice), ceramic composites; Structure of ceramics,crystalline ceramics; glassy ceramics; ceramic alloys; ceramic micro-structures: pure, vitreous and composite; The mechanical properties of ceramics high stiffness and hardness; poor toughness and thermal shock resistance; the excellent creep resistance of refractory ceramics.

Module IV (10 Hours)

Introduction: Polymers and composites Polymers the generic polymers: thermoplastics, thermosets, elastomers, natural polymers; The structure of polymers giant molecules and their architecture; molecular packing: amorphous orcrystalline?; Mechanical behaviour of polymers how the modulus and strength depend on temperature and time;making giant molecules by polymerisation; polymer “alloys”; Composites: fibrous, particulate and foamed how adding fibres or particles to polymers can improve their stiffness, strength and toughness; why foams are good for absorbing energy.

Text Books:

1. Engineering Materials 1 by Michael F Ashby & David R H Jones
2. Engineering Materials 2 by Michael F Ashby & David R H Jones

MM 15 046 - SURFACE ENGINEERING

Module I (10 Hours)

Introduction, Surface dependent engineering properties, viz., Friction and wear, corrosion, fatigue, etc.; common surface initiated engineering failures; mechanism of surface degradation; importance and necessity of surface engineering; classification and scope of surface engineering in metals, ceramics, polymers and composites, tailoring of surfaces of advanced materials.

Module II (10 Hours)

Surface protection (Physical); surface modification (Chemical) techniques: classification, principles, methods, and technology. Conventional surface engineering methods: carburising, nitriding, cyaniding, diffusion coating, hot dipping, galvanizing etc.

Module III (8 Hours)

Electrochemistry and electro-deposition; scope and application of conventional surface engineering techniques in engineering materials; advantages and limitations of conventional processes

Module IV (12 Hours)

Recent trend in surface engineering: physical/chemical vapor deposition; plasma spray coating; plasma assisted ion implantation. Surface modification by directed energy beams like ion, electron and laser beams; energy transfer, novelty of the directed energy beams assisted surface modification techniques.

Text Books:

1. K. G. Budinski (Ed.): Surface Engineering for Wear Resistance, Prentice Hall, New Jersey 1988.
2. J. R. Davis (Ed.): Surface Engineering for Corrosion and Wear Resistance, ASM International, Materials Park, Ohio, 2001.

MM 15 053 – WELDING TECHNOLOGY

(Core Elective - I)

Module I (10 Hours)

Introduction: Principle, Theory and Classification of welding and other joining processes. Types of jomts theory of welding. Manual metal arc (MMA): Equipment requirement, electrodes for welding of structural steels, coating constituents and their functions, types of coatings, current and voltage selection for electrodes,

Module II (10 Hours)

Arc welding power sources; Conventional welding transformers, rectifiers and current and voltage. The influence of these power sources on welding, metal transfer. Submerged arc welding (SAW): Process details, consumables such as fluxes and wires for welding mild steel, Variations in submerged arc welding process. Gas metal arc welding (GMAW) or MIG/ MAG welding: Process details, shielding gases, electrode wires, their sizes, and welding current ranges.

Module III (10 Hours)

TIG welding: Process details, power sources requirements, electrode sizes and materials, current carrying capacities of different electrodes, shielding gases, application of TIG welding process. Resistance welding: General principle of heat generation in resistance welding, application of resistance welding processes. Process details and working principle of spot, seam, and. projection welding, electrode materials, shapes of electrodes, electrode cooling, selection of welding currents, voltages.

Module IV (10 Hours)

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. Soldering and brazing: Difference between both the processes, consumables used, methods of brazing, fluxes used, their purposes and flux residue treatment.

Text Books:

1. J F Lancaster, Allen and Unwin, Metallurgy of Welding.
2. R L Little, Welding and Welding Technology, TMH.

MM 15 002 - ALTERNATIVE ROUTES OF IRON MAKING

(Core Elective - I)

Module I (10 Hours)

Introduction: Present and future of sponge iron industries in India; Classification of DR processes; Characteristics of raw materials and their preparation. Thermodynamics and Kinetics aspects.

Module II (10 Hours)

Direct reduction processes : Reduction of Iron bearing materials in shaft furnace, Rotary kiln Retort and fluidized bed with special reference to reductant, energy consumption and operational problems. Salient features of coal- based (rotary kilns) DR processes; Salient features of gas-based DR processes.

Module III (10 Hours)

Commercially available processes like SL/RN, ACCAR, Krup-CODIR, MIDREX, HyL, Purofer, Iron Carbide, etc. Uses of DRI in steel making, iron making and foundries; effect of DRI on EAF performance and product characteristics.

Module IV (10 Hours)

Smelting Reduction Processes: COREX, ROMELT, Fluidized bed reactors, Hismelt etc. Strengths and weaknesses of different DR processes particularly in context to India; Properties and usage of DRI; Pollution issues in the Indian DR industries. Present status of alternative methods of iron making in India.

Text Books:

1. Alternative Routes of Iron Making by Amit Chatterjee, PHI
2. Beyond the Blast Furnace by Amit Chatterjee

MM 15 043 - SINTERING THEORY AND PRACTICE

(Core Elective - I)

Module I (10 Hours)

Introduction to sintering over view, brief history, the sintering process, overview of sintering technique, goals in sintering, related problems

Module II (12 Hours)

Fundamental of solid state sintering coarsening and densification ,sintering stress, mass transfer , stages of sintering rearrangement mechanism , coarsening and densification., sintering diagrams. Microstructure and processing

Module III (8 Hours)

Liquid phase sintering over view, rearrangement mechanism, grain growth mechanism

Module IV (10 Hours)

Mixed power sintering novel sintering .sintering atmosphere, sintering practices, post sintering process overview

Text Books:

1. Sintering Theory and Practice Hardcover – January 19, 1996 - Randall M. German
2. Powder metallurgy technology by G. S. Upadhyaya

MM 15 017 - HYDRO AND ELECTRO METALLURGY

(Core Elective - I)

Module I (10 Hours)

Introduction**:** Justification of Hydrometallurgical selection of solvent processing, Eh-Pt diagrams Principles underlying hydrometallurgical processes, various commercial hydrometallurgical processes. Criteria for selection of solvents, Types of Solvents.

Module II (10 Hours)

Thermodynamics & kinetics of hydrometallurgical processes, Unit operations in hydrometallurgical processing, Thickness & filters, counter current decantation. Applications of hydrometallurgy to Copper, Zinc, Precious metals etc.

Module III (10 Hours)

Solvent Extraction & Ion Exchange, Purification methods of leach solutions, Recovery of metal values from solution, Precipitation methods Thermodynamics & Kinetics of concentration.

Module IV (10 Hours)

Electrolytic Recovery: Electrowining of methods from Aq. Solutions Electro Refining, Fused Salt Electrolysis – Extraction of Aluminum& Magnesium from their ores, Mass balance calculations.

Text Books:

1. H. S. Ray, K. P. Abraham and R. Sridhar, Extraction of Non-Ferrous Metals, Affliated East- West Press.
2. E. Jackson, Hydrometallurgical Processing & Reclaimation, John Wicky & Sons.

MM 15 049 - THEORY OF ALLOYS

(Core Elective - II)

Module I (10 Hours)

Structure and physical properties of elements: Alloys formation: primary solid solution, intermetallic compounds, concept of atomic size factor, normal valance compounds, electron compounds in noble metals and transition metal systems, size compounds, borides, carbides and silicides of metals:

Module II (10 Hours)

Experimental methods for the study of alloying behaviour of metals Aluminium alloys. Phase diagrams. Alloys and tempers. Alloy characteristics. Review of preciptation hardening, oxidation, corrosion resistance and fatigue. Titanium alloys. Pure Ti. Alloying Ti. Specific alloys: α, α + β, and β. Superplasticity.

Module III (10 Hours)

Magnesium alloys. Mg alloys. Heat treatment of Mg alloys. Nickel alloys: overview and superalloys : Ni-base, Fe-base and Co-base superalloys and their properties.

Module IV (10 Hours)

Steels. Review of plain C, alloy steels and cast irons. Commercial steels: high-strength, lowalloy (HSLA), bainitic, dual-phase, transformation induced plasticity (TRIP), TWIP Steels, IF steels and Stainless steels.

Text Books:

1. The structure of metal and alloys - William Hume Rothery

2. Physical metallurgy Principles - Reza Abbaschian and Robert E.Reed Hill

MM 15 033 - MODELING OF MATERIALS PROCESSES

(Core Elective - II)

Module I (10 Hours)

Solution of linear, non-linear algebraic equations, ordinary differential equations and related metallurgical problems, transport phenomena based Modeling

Module II (10 Hours)

Model formulation based on heat, mass and momentum transfer, governing equations and boundary conditions.

Module III (10 Hours)

Numerical solution of differential equations, process related numerical problems. Stress Analysis. Mesoscopic Modeling: CA based modeling, Monte Carlo Simulation, application to metallurgical processes.

Module IV (10 Hours)

Classical Molecular Dynamics Modeling and its applications in materials, Optimization and control, Elements of modern artificial intelligence (AI) related techniques. Introduction to Genetic Algorithm and Artificial Neural Networks

Text Books:

1. Handbook of Materials Modeling, Springer, 2005 - S. Yip (Ed)
2. Numerical Methods for Engineers, New Age International (P) Limited, New Delhi, 1998 - Santosh K. Gupta

MM 15 012 - FAILURE ANALYSIS

(Core Elective - II)

Module I (10 Hours)

Causes & Sources of Failures, Methodology, Fractography: ductile versus brittle, Fractography: Fatigue, Creep, Stress Calculations, Fatigue Design Fractography: overload Calculations. Case studies related this topic.

Module II (10 Hours)

Fracture Toughness, Creep, Wear, Rolling Contact Fatigue, Advanced Fractography, Case studies related this topic.

Module III (10 Hours)

Non Destructive Evaluation (NDE) Metallography, Introduction to Corrosion, Forms of Corrosion, Galvanic, Pitting, crevice corrosion etc. Polymer Failures Ceramics and Glass Liquid Metal Embrittlement, Case studies related this topic.

Module 1V (10 Hours)

Failures releted to Casting, Welding, Metal working, Fasteners (screws bolts, rivets), Shafts and Gears, Sequencing, Case studies related this topic.

Text Books:

1. ASM Handbook, Vol. 11, Failure Analysis and Prevention," edited by R.J. Shipley and W.T. Becker,
2. Mechanical Metallurgy, 3rd Ed., McGraw Hill Book Company, New Delhi, 1986 - G.E. Dieter

MM 003 - BIOMATERIALS

(Core Elective - II)

Module I (10 Hours)

Introduction: Biomaterials, bio-inert, bioactive, property requirement of biomaterials. Biocompatibility: tissue response to biomaterials; corrosion. Assessment of biocompatibility of biomaterials: in vitro and in vivo testing of biomaterials.

Module II (10 Hours)

Metallic materials in medical application: Stainless steel, cobalt based alloys, titanium based alloys (including shape memory alloys).

Module III (10 Hours)

Ceramics and polymer based implant material. Processing and properties of different bio-ceramics materials

Module IV (10 Hours)

Surface modification of implant material, mechanical, Physical, chemical and high energy based surface modification. Design concept of developing new materials for bio-implant application.

Text Books:

1. J.B. ParkandJ. D. Boonzino, Biomaterials: Principles and Application, CRC Press, 2002.
2. R E Smallman, A. H. W., Butterworth-Heinemann, Physical Metallurgy and Advanced Materials, Seventh Edition, 2007, ISBN: 0750669063.

MM 15 001 - ADVANCED MATERIALS

(*Open Elective*)

Module I (10 Hours)

Nanostructures, Nanomaterials, Nanocomposites. Biomaterials: Metallic biomaterials like 316L stainless steel, Co-Cr Alloys, Titanium Ti6Al4V,.

Module II (10 Hours)

Ceramic biomaterials like Alumina, Zirconia, Carbon Hydroxy-apatite, Polymeric biomaterials like Ultra high molecular weight polyethylene, Polyurethane Smart Materials: Piezoelectric materials, Shape memory alloys and shape memory polymers.

Module III (10 Hours)

High Performance Alloys: Nickel super alloys, Ti alloys, Al-Li alloys, Hastelloy, Inconel, Monel, Nitronic, Cobalt based alloys and commercially available pure nickel alloys. Functional and Engineering Ceramics: diverse applications as cutting tools, fuel cells.

Module IV (10 Hours)

Hybrid Materials: Design, Synthesis and Properties of hybrid materials created by blending disparate materials such as plastics with metals. Processing of Advanced Materials: Superplastic, spray forming, rapid solidification. Materials selection and design.

Text Books:

1. Mark J. Hampden-Smith Wiley-VCH, Chemistry of Advanced Materials: An Overview Leonard V. Interrante, 1st edition (1997) ISBN-10: 0471185906 ISBN-13: 978-0471185901.
2. R E Smallman, A. H. W., Butterworth-Heinemann, Physical Metallurgy and Advanced Materials, Seventh Edition, 2007, ISBN: 0750669063

MM 15 018 - INTRODUCTION TO NANO SCIENCE AND NANO TECHNOLOGY

(Open Elective)

Module I (12 Hours)

Introduction to nano science and nanotechnology, Definition, Background and Development of nanotechnology, Basic ideas about Atoms, Molecules and structure.Length scale and properties of matter. Techniques for Synthesis and preparation of Nanostructured materials, Concept of bottom up and top down approach of nanotechnologies: nanolithography, mask and resist technology, electron beam lithography, dip penlithography, mechanical milling,, Self-assembly, Sol – Gel method, Chemical Vapor deposition (CVD)/PECVD etc.

Module II (12 Hours)

Measurement and Characterization of Nanocrystalline Materials: *Structure* (Atomic structure, Particles size determination, surface structure), Microscopy scanning probe microscopy, principle of working of STM and AFM, Electron microscopy, resolution vs. magnification issue, SEM, Field Ion, high resolution TEM.

Module III (8 Hours)

Carbon nanostructure: Introduction to Carbon Molecules, Carbon Clusters (C60, Bucky ball), Carbon Nanotube –Type of Carbon Nanotube, Formation of Carbon Nanotube and properties and Application of Carbon Nanotube.

Module IV (8 Hours)

Cutting age areas of application of nanotechnology; state of art of the nano technology, current areas of research, scope and opportunity of the technology, some special topics on application of nanomaterials.

Text Books:

1. Introduction to Nanotechnology. Charles P Pool. Frank J Owens, JhonWiely and Son Publication, New Jersey, 2003
2. Introduction to Nanoscience and Nanotechnology , K KChattopadhyay and A. N Banerajee, PHI, Learning Privet Limited, New Dehli, 2010

MM 15 048 - THERMO-MECHANICAL PROCESSING OF MATERIALS

(*Open Elective*)

Module I (10 Hours)

General introduction, Microstructure and Properties, Plasticity, Work hardening Mechanisms and theories, Softening mechanisms, Alternative deformation mechanisms,

Module II (10 Hours)

Phase transformations during thermo-mechanical processing, Textural developments during thermo-mechanical processing, Residual stress modeling of texture and microstructural evolution

Module III (10 Hours)

Forming Techniques, Defects in TMP, Physical Simulation of Properties

Module IV (10 Hours)

Case studies: Thermo mechanical processing of steel, aluminum, magnesium, titanium and other advanced alloy systems, recent trends in thermo mechanical processing, new Technologies

Text Books:

1. Recrystallization and related phenomena - F.J. Humpherys and M. Hatherly
2. Thermo-mechanical Processing of Metallic Materials - Bert Verlinden, Julian Driver, Indradev Samajdar, Roger D. Doherty

MM 15 054 - X-RAY DIFFRACTION

(Open Elective)

Module I (10 Hours)

Introduction to crystallography, Symmetry - point group and space group, X-ray diffraction and analysis: Production and properties of X-rays, X-ray diffraction, Structure factor and intensity calculations. Continuous and characteristics spectrum, absorption. Filter and detectors, Bragg's law, scattering by atom, electron, unit cell, and structure factor calculation.

Module II (10 Hours)

Diffraction Methods: Laue's method, rotating crystal, Debye scherrer – Specimen preparation, film loading, powder method, Determination of crystal structure, determination of precision lattice parameter, sources of error in measurements. Determination of particle size, grain size, residual stresses, determination of phase diagrams, order-disorder transformation, texture, importance of texture, measurement of texture, pole figures (stereographic projections), orientation distribution function, sample symmetry.

Module III (10 Hours)

Electron optical methods –I: Scanning electron microscopy and X-ray microanalysis including electron probe microanalysis, electron optics, electron beam specimen interaction, image formation in the SEM. X-ray spectral measurements: WDS and EDS, quantitative X-ray analysis.

Module IV (10 Hours)

Electron optical methods –II: Analytical transmission electron microscopy: Electron diffraction, reciprocal lattice, analysis of SAD patterns; different electron diffraction techniques, atomic resolution microscopy, analytical devices with TEM, field ion microscopy, and scanning tunneling microscopy, advanced techniques.

Text Books:

1. Elements of X-Ray Diffraction by B. D. Cullity, Adison-Wesley.
2. Materials Characterization, Metals Handbook, Vol. 10, ASM

MM 15 011 - FABRICATION OF MATERIALS

(Open Elective)

Module I (10 Hours)

Foundry : Introduction to patterns and foundry process, Sand binders and different additives, Sand testing and melting furnaces for ferrous and non-ferrous metals such as cupola, Induction furnace, Arc furnace & Resistance furnace. Solidification of castings,

Module II (10 Hours)

Continuous casting process: Precision investment casting, centrifugal casting, Die casting, Casting defects. Shell mould casting, squeeze, casting, slushcasting. Die casting, Casting defects. Principles of Gating and Risering: Feeding characteristics of alloys, Types of Gates and Risers.

Module III (10 Hours)

Welding and cutting: Introduction to gas welding, cutting, Arc welding and equipment's. TIG (GTAW) and submegged ane welding, Electroslag welding MIG (GMAW) welding, resistance welding and thermit welding. Weldability, Newer Welding methods like plasma Arc, Laser Beam, Electron Beam, Ultrasonic, Explosive and friction welding. Brazing and soldering, welding defects. Destructive and non-destructive testing of castings and weldings, Dafects in welded joints.

Module IV (10 Hours)

Brief introduction to powder metallurgy processes.; Plastic deformation of metals: Variables in metal forming and their optimization. Dependence of stress strain diagram on Strain rate and temperature. Hot and cold working of metals.; Rolling: Pressure and Forces in rolling, types of rolling mills, Rolling defects.

Text Books:

1. P. D. Webster, Fundamentals of Foundry Technology, Portwillis press, Red hill, 1980.
2. Kalpakjian, S., & Schmid, S. R. 2008. Manufacturing processes for engineering materials: Pearson Education.

MM 15 045 - STEEL TECHNOLOGY

(Open Elective)

Module I (8 Hours)

Introduction to steel: classification of steels over view:, carbon steels , alloy steel, effect of alloying elements on steel properties , difference between steel and cast iron, steel vs other non ferrous alloys , important application in automotive , construction and power sectors , strengthening mechanism in steels , phases in steels over view

Module II (12 Hours)

Steel making practice over view: history of steel making practices ,general layout of steel making plant Ld, electric arc , bop ,obm , hybrid process , Slag basicity and fluidity, refractory linings , and secondary steel making process like steel degassing , and steel cleaning .deoxidation practice , inclusions in steel .

Module III (8 Hours)

Advance casting process over view: Thin slab casting, near net shape casting continuous casting vs conventional casting , heat treatment over view:, normalising, annealing, hardening , tempering ,

Module IV (12 Hours)

Destructive testing over view like tensile test, charpy impact test, fatigue test , creep test, wear test , problems face by steel industries , further developments in steel industries ,surface treatment over view, anodising, galvanisation ,aluminising.

Text Books:

1. Iron and steel making theory and practice book by Ahindra Gosh and Amit Chatterjee
2. Physical Metallurgy Principles by Reza Abbaschain, Lara Abbaschain, RoberE. Red Hill

CE 15 066 - NUMERICAL METHODS IN ENGINEERING

(Open Elective)

Module 1 (10 Hours)

Introduction to digital computers and programming-an overview, Errors-polynomial approximation ,interpolation: finite differences, Newton's formula for interpolation ,central difference interpolation formulae, interpolation with unevenly spaced points, divided difference and their properties, inverse interpolation and double interpolation Numerical differentiation: errors in numerical differentiation, differentiation formula with function values. Numerical integration: Trapezoidal rule, Simpson's 1/3rd & 3/8th rule, Romberg integration, newton cote's integration formula, Euler-maclaurin formula, Gaussian integration, numerical double integration

Module II (10 Hours)

Solution of linear system - Gaussian elimination and Gauss-Jordan methods , necessity for pivoting, LU decomposition methods , Jacobi and Gauss-Seidel iterative methods sufficient conditions for convergence , Power method to find the dominant Eigen value and eigenvector Diagonal dominance, condition number, ill conditioned matrices, singularity and singular value decomposition. Banded matrices, storage schemes for banded matrices, skyline solver. Solution of nonlinear equation - Bisection method - Secant method - Regula falsi method - Newton- Raphson method

Module III (10 Hours)

Approximate solution technique, static condensation, Rayleigh-Ritz method, subspace iteration, Application of finite difference method, solution of equilibrium equations in dynamics, direct method, central difference method, Houbolts method, Wilson θ method, Newmarks method

Module IV (10 Hours)

Numerical Solution of Ordinary Differential Equations- Euler's method - Euler's modified method ,Taylor's method and Runge-Kutta method for simultaneous equations and 2nd order equations - Multistep methods - Milne's and Adams' methods

Text Book

1. Numerical methods for Scientists and Engineers by M.K. Jain, S.R. Iyengar & R.K. Jain, Wiley Eastern Ltd.
2. Numerical methods in engineering and science, Grewal, B.S., Khanna Publishers, Delhi.

Reference Books

1. Mathematical Numerical Analyis By S.C. Scarborough, Oxford and IBH Publishing Company.
2. Introductory methods in Numerical Analysis by S.S. Sastry, Prentice Hall of India.
3. Theory and problems in Numerical Methods by T. Veeranjan and T. Ramachandran, Tata McGraw-Hill Publishing Company, New Delhi-2004.

CE 15 068 - FINITE ELEMENT METHOD

(Open Elective)

Module I (7 Hours)

Introduction: The Continuum, Equations of Equilibrium, Boundary Conditions, Strain displacement relations, Stress strain Relations, Plane stress and plane Strain problems, Different methods of structural analysis including numerical methods. Basics of finite element method (FEM), different steps involved in FEM, Different approaches of FEM, Direct method, Energy approach, Weighted residual Method.

Module II (17 Hours)

One and Two Dimensional Problems: Detail formulation including shape functions. stress strain relations, strain displacement relations and derivation of stiffness matrices using energy approach, Assembling of element matrices, application of displacement boundary conditions, Numerical solution of one dimensional problems using bar, truss, beam elements and frames. Derivation of shape function using Lagrange's interpolation, Pascal's triangle, Convergence criteria. Finite Element modeling of two dimensional problems using Constant strain Triangle(CST) elements, Stress strain relations for isotropic and orthotropic materials, Four nodded rectangular elements, axisymmetric solids subjected to axisymmetric loading.

Isoparametric Elements: Natural coordinates, isoparametric elements, four node, eight node elements. Numerical integration, order of integration.

Module III (8 Hours)

Plate Bending: Bending of plates, rectangular elements, triangular elements and quadrilateral elements, Concept of 3D modeling.

Module IV (8 Hours)

Dynamic Considerations: General Equation of motion, Lagrange's approach, mass matrix, lumped and consistent mass matrices, Evaluation of eigenvalue and eigenvectors, stability problems.

Text Book

1. R. D. Cook., Concepts and Applications of Finite Element Analysis, Wiley
2. C. S. Krishnamoorthy, Finite Element analysis-Theory and Programming, Tata Mc Hill

Reference

1. Logan, D. L., A First Course in the Finite Element Method, PWS Publishing, Boston

2. O. C Zienkiewicz .and R. L. Taylor, Finite Element Method, Mc Graw Hill

EE – 15 031 MODELLING & SIMULATION

(Open Elective)

Module-I (10 Hours)

System: concept, environment, stochastic activities, continuous and discrete time systems, system modeling and types of system models, Cobweb model, Distributed lag model. Subsystems, corporate models and their segments, type of system studies, analysis, design and postulation.

Module-II (10 Hours)

Continuous system simulation: system models, differential equations, analog methods, CSMP, feedback and interactive simulation, real time simulation. System dynamics: Exponential growth and decay models, logistic curves, system dynamic diagram, multi-segment models, time delays, feedback in socio-economic system, world models.

Module-III (10 Hours)

Random number generators and output data analysis for a single system, statistical techniques for comparing attentive systems, Variable reduction techniques Probability concepts in simulation, Queuing system, arrival of patterns, exponential, erlang and hyper exponential distributions, service time, queuing disciplines, measures of queues, mathematical solutions.

Module-IV (10 Hours)

Discrete system simulation: discrete events, representation of time, generation of arrival patterns, simulation programming tasks, gathering statistics, counters and summary of statistics, measuring utilization and occupancy, recording distributions and transit times. Bond graphs for simple electrical and mechanical engineering systems modeling and simulation of hydraulic, thermal and manufacturing systems.

Text Book

1. A.M.Law and W.D.Kelton, “Simulation Modeling and Analysis”, TMH Publishers.

Reference Books

1. G. Gordon, “System Simulation”, PHI Publishers

2. A. Mukherjee and R Karmakar, “Modeling and Simulation of Engineering Systems through Bond Graphs”, Narosa Publishing House, CRC Press

PE 15-015: MANUFACTURING AND DESIGN OF COMPOSITE

(Open Elective)

Module I (10 Hours)

Introduction to composite materials, Matrix material, Reinforcement and interfaces, Classification: Polymer Matrix Composites, Metal Matrix Composites, Ceramic Matrix Composites, relative merits and demerits, applications. Hybrid Composites, Nanocomposites, Properties and performance of composites, Applications

Module II (10 Hours)

Matrix resins-thermoplastics and thermosetting matrix resins, Coupling agents-surface treatment of fillers and fibres. Reinforcing fibres- Natural fibres (cellulose, jute, coir etc), boron, carbon, ceramic glass, aramids, polyethylene (UHMWPE), polybenz - thiazoles etc., Particulate fillers-importance of particle shape an size, Critical fibre length.

Module III (10 Hours)

Fabrication techniques: Pultrusion, filament winding, prepreg technology, injection and compression moulding, bag moulding, resin transfer moulding, reaction injection moulding.

Module IV (10 Hours)

Macromechanical Behaviour: Stress strain relations of anisotropic materials-Engineering constants for orthotropic and isotropic materials-Plano stress condition-Stress-strain relations for a lamina of arbitrary orientation-strength of an orthotropic lamina. Micromechanics of Composites: Mechanical properties, Thermal properties, Mechanics of load transfer from matrix to fiber, anisotropic behavior, Fatigue and creep.

Text Books:

1. K.K.Chawla, Composite Materials – Science & Engineering, Springer-Verlag, New York, 1987.
2. R.M.Jones – Mechanics of composite Materials, Mc Grew Hill Book Co.,
3. Fibre-Reinfored composites-Materials, Manufacturing and Design. P.K.Mallick Marcel Dekken, Inc. New York & Basel.

Reference Books:

1. F.L.Matthews and R.D.Rawlings, Composite Materials: Engineering and Science, Chapman & Hall, London, 1994.