National Institute of Foundry and Forge Technology, Hatia Ranchi-834003

(Centrally Funded Technical Institute, Under MHRD, Govt of India)

(Affiliated under Jharkhand Technical University)

Syllabus

B.Tech (Metallurgy & Materials Engineering)

Department of Materials and Metallurgical Engineering

2020

Bachelors of Technology (B. Tech) in Metallurgy and Materials Engineering

Programme Objectives

- Apply knowledge of basic sciences and metallurgical engineering to extract & refine metals and to manufacture products.
- Design, characterize and evaluate material systems for metallurgical and materials applications.
- Work effectively as individuals and as team members in multidisciplinary projects.
- Pursue life-long learning to enhance knowledge base and skills for professional growth.

Programme Outcomes

- Engage in lifelong learning for professional advancement.
- Design processes for concentrating ores and minerals.
- Identify processes to produce products as per specifications.
- Assess performance of metallurgical processes.
- Select processes for extraction of ferrous and non-ferrous metals Produce defect free products using metal forming and metal joining processes.
- Design thermo-mechanical treatment processes to modify the properties of metals and alloys for specific engineering applications.
- Analyze processes for protecting materials from mechanical and environmental degradation.
- Design material systems, components, processes for specific applications considering environmental sustainability.
- Apply modern science, engineering and project management principles to address the specific needs of metallurgical industries.
- Function in multi-disciplinary teams using tools and environment to achieve project objectives.
- Practice professional ethics for improved moral and human values.

Course structure

Year	Semester	Code	Subject	L - T - P - C
I (41.5)	I (17.5)	BSC-101	Physics-I (Introduction to Mechanics)	3 - 1 - 0 - 4
		BSC-103	Mathematics I	3 - 1 - 0 - 4
		ESC-101	Basic Electrical Engineering	3 - 1 - 0 - 4
		ESC-102	Engineering Graphics and Design	1 - 0 - 4 - 3
		BSC-101P	Physics Laboratory	0 - 0 - 3 - 1.5
		ESC-101P	Basic Electrical Engineering Laboratory	0 - 0 - 2 - 1
	II (24)	BSC-102	Chemistry-I	3 - 1 - 0 - 4
		BSC-104	Mathematics II	3 - 1 - 0 - 4
		BSC-105	Physics-II (Mechanics of Solid)	3 - 1 - 0 - 4
		HSM-101	English	3 - 1 - 0 - 4
		ESC-103	Programming for Problem Solving	2 - 0 - 2 - 3
		BSC-102P	Chemistry Laboratory	1 - 0 - 4 - 3
		ESC-104	Workshop/Manufacturing Practices	0 - 0 - 2 - 1
		ESC-103P	Programming for Problem Solving Laboratory	0 - 0 - 2 - 1
II (42)	I (21)	MA-2101	Mathematics III	3 - 0 - 0 - 3
		MT-2101	Fluid Mechanics	3 – 0 - 0 - 3
		MT-2102	Mineral Dressing	2 - 0 - 0 - 2
		MT-2103	Fuels, Furnaces and Refractories	2 - 0 - 0 - 2
		MT-2104	Metallurgical Thermodynamics and Kinetics	3- 1 - 0 - 4
		MT-2105	Principles of Extractive Metallurgy	3 - 0 - 0 - 3
		MT-2111	Fluid Mechanics Laboratory	0 - 0 - 2 - 1
		MT-2112	Mineral Dressing Laboratory	0 - 0 - 2 - 1
		MT-2113	Fuels, Furnaces and Refractories Laboratory	0 - 0 - 2 - 1
		EA-2121	Extra Activities (NSO/NCC/YOGA/CREATIVE ARTS/ MINI PROJECT)	0 - 0 - 2 - 1
	II (21)	MT-2201	Numerical Methods and its applications Laboratory	2 – 0 - 0 - 2
		MT-2202	Heat and Mass Transfer	3 - 0 - 0 - 3
		MT-2203	Phase equilibria in Materials system	3 - 0 - 0 - 3
		MT-2204	Iron Making	3 - 0- 0 - 3
		MT-2205	Physical Metallurgy-I	3 - 0- 0 - 3
		MT-2206	Mechanical behavior of Materials	3 - 1- 0 - 4
		MT-2211	Numerical Methods and its applications	0 - 0 - 2 - 1
		MTD-2212	Physical Metallurgy-I	0 - 0 - 2 - 1
		EA-2221	Extra Activities (NSO/NCC/YOGA/CREATIVE ARTS/ MINI PROJECT)	0 - 0 - 2 - 1
III	I	MT-3101	Steel Making	3 - 0 - 0 - 3

(42)	(21)	MT-3102	Physical Met-II	3 – 1 - 0 - 4
		MT-3103	Welding Metallurgy	2 – 0 - 0 - 2
		MT-3104	Foundry Technology	3 – 0 - 0 - 3
		MT-3105	Powder Metallurgy	2 - 0 - 0 - 2
		MT-3106	Mechanical Properties of Materials and its Evaluation	3 - 0 - 0 - 3
		MT-3111	Welding Metallurgy Laboratory	0 - 0 - 2 - 1
		MT-3112	Foundry Technology Laboratory	0 - 0 - 2 - 1
		MT-3113	Powder Metallurgy Laboratory	0 - 0 - 2 - 1
		MT-3114	Mechanical Properties of Materials and Evaluation	0 - 0 - 2 - 1
	II (21)	MT-3201	Metal Forming Technology	2 – 0 - 0 - 2
		MT-3202	Corrosion Science and Engineering	3 - 0 - 0 - 3
		MT-3203	Extraction of Non ferrous Metals	3 - 0 - 0 - 3
		MT-3204	Heat treatment Technology	3 - 0 - 0 - 3
		MT-3205	Characterization of Materials	3 - 0 - 0 - 3
		MT-323*	Elective -I	3 - 0 - 0 - 3
		MT-3211	Metal Forming Technology Laboratory	0 – 0 - 2 - 1
		MT-3212	Corrosion Science and Engineering Laboratory	0– 0 - 2- 1
		MT-3213	Heat treatment Technology Laboratory	0 – 0 - 2 - 1
		MT-3214	Characterization of Materials Laboratory	0– 0 - 2 - 1
IV (34.5)	I (18)	MT-4101	Composite materials	3 - 0 -0 - 3
		MT-4102	Environment and Pollution Control in iron and steel industry (Audit)	2 - 0 - 0 - 0
		MT-4103	Industrial Engineering and Management	2 - 0 - 0 - 2
		MT-4104	Engineering Economics	2- 0 - 0 - 2
		MT-414*	Elective -II	2 - 0 - 0 - 2
		MT-415*	Elective -III	3 - 0 - 0 - 3
		MT-4111	Environment and Pollution Control in iron and steel industry (Audit)	0 - 0 - 2- 0
		MT-411*	Elective –II Laboratory	0 - 0 - 2 - 1
		MT-4122	Industrial /R&D Lab Training and Report Evaluations	0 - 0 - 0- 2
		MT-4121	Project-I	0 - 0 - 0- 3
	Minimum Four weeks of industrial Training if possible, Mini projects to be carried out in the industry/R&D lab itself.			
	II (16.5)	MT-4201	Org. Behavior and Industrial Psychology	3 - 0 -0 - 3
		MT-426*	Elective -IV	3 - 0 - 0 - 3
		MT-4223	Seminar presentation	0 - 0 - 0 - 2
		MT-4224	Comprehensive Viva-voce	0 - 0 - 0 - 2.5
		MT-4225	Project Work-II and Viva -voce	0 - 0 - 0 - 6

Elective –I **(3-0-0-3)**

MT-3231: Methoding of Castings
MT-3232: Materials handling
MT-3233: Failure Analysis
MT-3234: Advanced Materials
MT-3235: Surface Engineering
MT-3236: Non metallic materials

Elective – II **(2-0-2-3)**

MT-4141: Modern NDT
MT-4142: Instrumentation and Control
MT-4143: Computer application in Metallurgy
MT-4144: Fracture Mechanics
MT-4145: Physics of metals
MT-4146: Modeling and Simulation in Metallurgy

Elective – III **(3-0-0-3)**

MT-4151: Secondary Steel Making
MT-4152: X-Ray crystallography
MT-4153: Wear, Friction & Lubrication
MT-4154: Nano Materials and Applications
MT-4155: Bio material
MT-4156: Functional materials

Elective-IV **(3-0-0-3)**

MT-4261: Electronic ,Optical & Magnetic Properties Of Materials
MT-4262: Forging Die Design and Manufacturing
MT-4263: Light Metals and Alloys
MT-4264: Aerospace Materials
MT-4265: High Temperature Materials
MT-4266: Automotive Materials

SEMESTER–I

BSC -101 Physics I (Introduction to Mechanics L-T-P-C **(3-1-0-4)**

Course content and List of books:

Module 1:Particle motion and Newton's law 8 Lectures

Transformation of scalars and vectors under Rotation transformation; Forces in Nature; Newton's laws and its completeness in describing particle motion; Form invariance of Newton's Second Law;

Module 2:Central potential and Kepler's laws 7 Lectures

Potential energy function; F = -Grad V, equipotential surfaces and meaning of gradient; Conservative and non-conservative forces, curl of a force field; Central forces; Conservation of Angular Momentum; Energy equation and energy diagrams; Kepler problem;

Module 3:Rotating coordinate system 5 Lectures

Non-inertial frames of reference; rotating coordinate system: Five-term acceleration formulaCentripetal and Coriolis accelerations; Foucault pendulum;

Module 4:Harmonic Oscillations 6 Lectures

Harmonic oscillator; Damped harmonic motion – over-damped, critically damped and lightlydamped oscillators; Forced oscillations and resonance.

Module 5:Planar rigid body mechanics 5 Lectures

Definition and motion of a rigid body in the plane; Rotation in the plane; Kinematics in a coordinate system rotating and translating in the plane; Angular momentum about a point of a rigid body in planar motion; Euler's laws of motion, their independence from Newton's laws, and their necessity in describing rigid body motion;

Module 6:Three-dimensional rigid body motion 7 Lectures

Introduction to three-dimensional rigid body motion - in terms of (a) Angular velocity vector, and its rate of change and (b) Moment of inertia tensor; Three-dimensional motion of a rigid body: Rod executing conical motion with centre of mass fixed - show that this motion looks twodimensional but is three-dimensional.

Reference books:

1. Engineering Mechanics, 2nd ed. Publisher: Cengage Learning; 2 edition (January 22, 2013) -MK Harbola

2. Introduction to Mechanics, CRC Press - MK Verma

3. An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw-Hill
4. Principles of Mechanics. by Synge, John. L; Griffith, Byron. A. Publication date Publisher McGraw-5. Hill Mechanics - JP Den Hartog
6. Engineering Mechanics - Dynamics, 7th ed. - JL Meriam
7. Mechanical Vibrations - JP Den Hartog
8. Theory of Vibrations with Applications - WT Thomson

Course Outcome: Students to learn basics of particle dynamics including the rotational motion in central potential field following Kepler's laws. To learn the rotating co-ordinate system and harmonic motion with the effect of damping and forced oscillation

BSC-103 Mathematics I (Calculus and Linear Algebra) L-T-P-C**(3-1-0 -4)**

Course content and List of books:

Module 1: Calculus I **6 Lectures**

Evolutes and involutes; Evaluation of definite and improper integrals; Beta and Gamma functions and their properties; Applications of definite integrals to evaluate surface areas and volumes of revolutions.

Module 2: Calculus II **6 Lectures**

Rolle's Theorem, Mean value theorems, Taylor's and Maclaurin theorems with remainders; indeterminate forms and L'Hospital's rule; Maxima and minima. Sequences and series

Module 3: Sequences and series **10 Lectures**

Convergence of sequence and series, tests for convergence; Power series, Taylor's series, series for exponential, trigonometric and logarithm functions; Fourier series: Half range sine and cosine series, Parseval's theorem.

Module 4:Multivariable Calculus (Differentiation) **8 Lectures**

Limit continuity and partial derivatives, directional derivatives, total derivative; Tangent plane and normal line; Maxima, minima and saddle points; Method of Lagrange multipliers; Gradient, curl and divergence.

Module 5: Matrices **10 Lectures**

Inverse and rank of a matrix, rank-nullity theorem; System of linear equations; Symmetric, skew symmetric and orthogonal matrices; Determinants; Eigen values and eigenvectors; Diagonalization of matrices; Cayley-Hamilton Theorem, and Orthogonal transformation.

Textbooks/References:

1. G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9th Edition,Pearson,Reprint, 2002.
2. Erwin kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
3. Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi, 2008.
4. Ramana B.V., Higher Engineering Mathematics, Tata McGraw Hill New Delhi, 11thReprint, 2010.
5. D. Poole, Linear Algebra: A Modern Introduction, 2nd Edition, Brooks/Cole, 2005.
6. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2008.
7. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 36th Edition, 2010.

Course Outcome (COs):

CO_1: To introduce the idea of applying differential and integral calculus to notions of curvature and to improper integrals.

CO_2: To introduce the fallouts of Rolle's Theorem that is fundamental to application of analysis to Engineering problems.

CO_3: To develop the tool of power series and Fourier series for learning advanced Engineering Mathematics.

CO_4: To familiarize the student with functions of several variables that is essential in most branches of engineering.

CO_5: To develop the essential tool of matrices and linear algebra in a comprehensive manner.

ESC-101 Basic Electrical Engineering L-T-P-C (3-1-0-4)

Course content and List of books:

Module 1: DC Circuits 6 Lectures

Electrical circuit elements (R, L and C), voltage and current sources, Kirchoff current and voltage laws, analysis of simple circuits with dc excitation.Superposition, Thevenin and Norton Theorems.Time-domain analysis of first-order RL and RC circuits.

Module 2: AC Circuits 6 Lectures

Representation of sinusoidal waveforms, peak and rms values, phasor representation, real power, reactive power, apparent power, power factor.Analysis of single-phase ac circuits

consisting of R, L, C, RL, RC, RLC combinations (series and parallel), resonance. Three phase balanced circuits, voltage and current relations in star and delta connections.

Module 3: Transformers **6 Lectures**

Magnetic materials, BH characteristics, ideal and practical transformer, equivalent circuit, losses in transformers, regulation and efficiency.Auto-transformer and three-phase transformer connections.

Module 4: Electrical Machines **6 Lectures**

Generation of rotating magnetic fields, Construction and working of a three-phase induction motor, Significance of torque-slip characteristic.Loss components and efficiency, starting and speed control of induction motor.Single-phase induction motor.Construction, working, torquespeed characteristic and speed control of separately excited dc motor.Construction and working of synchronous generators.

Module 5: Power Converters **6 Lectures**

DC-DC buck and boost converters, duty ratio controls. Single-phase and three-phase voltage source inverters; sinusoidal modulation.

Module 6: Electrical Installations **6 Lectures**

Components of LT Switchgear: Switch Fuse Unit (SFU), MCB, ELCB, MCCB, Types of Wires and Cables, and Earthing. Types of Batteries, Important Characteristics for Batteries. Elementary calculations for energy consumption, power factor improvement and battery backup.

Reference Books

1. D. P. Kothari and I. J. Nagrath, "Basic Electrical Engineering", Tata McGraw Hill, 2010.
2. D. C. Kulshreshtha, "Basic Electrical Engineering", McGraw Hill, 2009.
3. L. S. Bobrow, "Fundamentals of Electrical Engineering", Oxford University Press, 2011.
4. E. Hughes, "Electrical and Electronics Technology", Pearson, 2010.
5. V. D. Toro, "Electrical Engineering Fundamentals", Prentice Hall India, 1989.

Course Outcome (COs):

CO_1: To understand and analyze basic electric and magnetic circuits.

CO_2: To study the working principles of electrical machines and power converters.

CO_3: To introduce the components of low voltage electrical installations.

ESC 102 Engineering Graphics and Design

Calculus and Linear Algebra L-T-P-C **(1-0-4-3)**

Course content and List of books:

Module 1: Traditional Engineering and Computer Graphics: 2 Lectures

Principles of Engineering Graphics; Orthographic Projection; Descriptive Geometry; Drawing Principles; Isometric Projection; Surface Development; Perspective; Reading a Drawing; Sectional Views; Dimensioning & Tolerances; True Length, Angle; intersection, Shortest Distance. Engineering Graphics Software; -Spatial Transformations; Orthographic Projections; Model Viewing; Co-ordinate Systems; Multi-view Projection; Exploded Assembly;

Module 2: Model Viewing: 2 Lectures

Animation; Spatial Manipulation; Surface Modeling; Solid Modeling; Introduction to Building Information Modeling (BIM) (Lab modules also include concurrent teaching) Introduction to Engineering Drawing Principles of Engineering Graphics and their significance, usage of Drawing instruments, lettering, Conic sections including the Rectangular Hyperbola (General method only); Cycloid, Epicycloid, Hypocycloid and Involute; Scales – Plain, Diagonal and Vernier Scales; Orthographic Projections Principles of Orthographic Projections-Conventions - Projections of Points and lines inclined to both planes; Projections of planes inclined Planes - Auxiliary Planes; Lab Projections of Regular Solids those inclined to both the Planes- Auxiliary Views; Draw simple annotation, dimensioning and scale. Floor plans that include: windows, doors, and fixtures such as WC, bath, sink, shower, etc. and Sectional Views of Right Angular Solids Prism, Cylinder, Pyramid, Cone – Auxiliary Views; Development of surfaces of Right Regular Solids - Prism, Pyramid, Cylinder and Cone; Draw the sectional orthographic views of geometrical solids, objects from industry and dwellings (foundation to slab only)

Module 3: Isometric Projections: 2 Lectures

Principles of Isometric projection – Isometric Scale, Isometric Views, Conventions; Isometric Views of lines, Planes, Simple and compound Solids; Conversion of Isometric Views to Orthographic Views and Vice-versa, Conventions; Overview of Computer Graphics listing the computer technologies that impact on graphical communication, Demonstrating knowledge of the theory of CAD software [such as: The Menu System, Toolbars (Standard, Object Properties, Draw, Modify and Dimension), Drawing Area (Background, Crosshairs,

Coordinate System), Dialog boxes and windows, Shortcut menus (Button Bars), The Command Line (where applicable), The Status Bar, Different methods of zoom as used in CAD, Select and erase objects.; Isometric Views of lines, Planes, Simple and compound Solids]; Customization & CAD Drawing consisting of set up of the drawing page and the printer, including scale settings, Setting up of units and drawing limits; ISO and ANSI standards for coordinate dimensioning and tolerancing; Orthographic constraints, Snap to objects manually and automatically; Producing drawings by using various coordinate input entry methods to draw straight lines, Applying various ways of drawing circles; Annotations, layering & other functions applying dimensions to objects, applying annotations to drawings; Setting up and use of Layers, layers to create drawings, Create, edit and use customized layers; Changing line lengths through modifying existing lines (extend/lengthen); Printing documents to paper using the print command; orthographic projection techniques;

Module 4: Model Viewing: 2 Lectures

Drawing sectional views of composite right regular geometric solids and project the true shape of the sectioned surface; Drawing annotation, Computer-aided design (CAD) software modelling of parts and assemblies. Parametric and nonparametric solid, surface, and wireframe models. Part editing and two-dimensional documentation of models. Planar projection theory, including sketching of perspective, isometric, multiview, auxiliary, and section views.Spatial visualization exercises. Dimensioning guidelines, tolerancing techniques; dimensioning and scale multi views of dwelling; Demonstration of a simple team design project Geometry and topology of engineered components: creation of engineering models and their presentation in standard 2D blueprint form and as 3D wire-frame and shaded solids; meshed topologies for engineering analysis and tool-path generation for component manufacture; geometric dimensioning and tolerancing;

Module 5: Model Viewing: 2 Lectures

Use of solid-modeling software for creating associative models at the component and assembly levels; floor plans that include: windows, doors, and fixtures such as WC, bath, sink, shower, etc. Applying colour coding according to building First Year UG Courses Engg. & Tech. Jharkhand University of Technology drawing practice; Drawing sectional elevation showing foundation to ceiling; Introduction to Building Information Modelling (BIM).

Suggested Text/Reference Books:

1.Bhatt N.D., Panchal V.M.& Ingle P.R., (2014), Engg Drawing, Charotar Pub House
2. Shah, M.B. &Rana B.C. (2008), Engg Drawing & Comp. Graphics, Pearson Education
3. Agrawal B.&Agrawal C. M. (2012), Engineering Graphics, TMH Publication
4. Narayana, K.L. & P Kannaiah (2008), Text book on Engg Drawing, Scitech Publishers
5. Corresponding set of CAD Software Theory and User Manuals.

Course Outcome (CO$_S$)::

All phases of manufacturing or construction require the conversion of new ideas and design concepts into the basic line language of graphics. Therefore, there are many areas (civil, mechanical, electrical, architectural and industrial) in which the skills of the CAD technicians play major roles in the design and development of new products or construction. Students prepare for actual work situations through practical training in a new state-of-the-art computer designed CAD laboratory using engineering software.

This course is designed to address:

CO$_1$: To prepare you to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability

CO$_2$: To prepare you to communicate effectively

CO$_3$: To prepare you to use the techniques, skills, and modern engineering tools necessary for engineering practice the student will learn:

i. Introduction to engineering design and its place in society

ii. Exposure to the visual aspects of engineering design

iii. Exposure to engineering graphics standards

iv. Exposure to solid modeling

v. Exposure to computer-aided geometric design

vi. Exposure to creating working drawings vii. Exposure to engineering communication

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BSC-101P Physics Laboratory L-T-P-C **(0-0-3-1.5)**

Choice of 08-10 experiments from the following:

1. Experiments on electromagnetic induction and electromagnetic breaking;

2. LC circuit and LCR circuit

3. Resonance phenomena in LCR circuits

4. Magnetic field from Helmholtz coil

5. Measurement of Lorentz force in a vacuum tube

6. Coupled oscillators 7. Experiments on an air-track

8. Experiment on moment of inertia measurement

9. Experiments with gyroscope

10. Resonance phenomena in mechanical oscillators

11. Frank-Hertz experiment

12. Photoelectric effect experiment

13. Recording hydrogen atom Spectrum

14. Diffraction and interference experiments (from ordinary light or laser pointers)

15. Measurement of speed of light on a table top using modulation

16. Minimum deviation from a prism

Course Outcome COs:

CO_1: Students to have hands on experiences with experiments on the basic's laws and principles of Physics in the field of Mechanics, Optics, Electricity, Magnetism, Modern Physics, etc.

ESC-101P Basic Electrical Engineering Laboratory	L-T-P-C	**(0-0-2-1)**

List of experiments/demonstrations:

1. Basic safety precautions. Introduction and use of measuring instruments – voltmeter, ammeter, multi-meter, oscilloscope. Real-life resistors, capacitors and inductors.

2. Measuring the steady-state and transient time-response of R-L, R-C, and R-L-C circuits to a step change in voltage (transient may be observed on a storage oscilloscope). Sinusoidal steady state response of R-L, and R-C circuits – impedance calculation and verification. Observation of phase differences between current and voltage. Resonance in R-L-C circuits.

3. Transformers: Observation of the no-load current waveform on an oscilloscope (non sinusoidal wave-shape due to B-H curve nonlinearity should be shown along with a discussion about harmonics). Loading of a transformer: measurement of primary and secondary voltages and currents, and power.

4. Three-phase transformers: Star and Delta connections. Voltage and Current relationships (line-line voltage, phase-to-neutral 15 voltage, line and phase currents).Phase-shifts between the primary and secondary side. Cumulative three-phase power in balanced three-phase circuits.

5. Demonstration of cut-out sections of machines: dc machine (commutator-brush arrangement), induction machine (squirrel cage rotor), synchronous machine (field winging - slip ring arrangement) and single-phase induction machine.

6. Torque Speed Characteristic of separately excited dc motor.

7. Synchronous speed of two and four-pole, three-phase induction motors. Direction reversal by change of phase-sequence of connections. Torque-Slip Characteristic of an induction motor. Generator operation of an induction machine driven at super synchronous speed.

8. Synchronous Machine operating as a generator: stand-alone operation with a load. Control of voltage through field excitation.

9. Demonstration of (a) dc-dc converters (b) dc-ac converters – PWM waveform (c) the use of dc-ac converter for speed control of an induction motor and (d) Components of LT switchgear.

Course Outcome (CO_s):

CO_1: Get an exposure to common electrical components and their ratings.

CO_2: Make electrical connections by wires of appropriate ratings.

CO_3: Understand the usage of common electrical measuring instruments.

CO_4: Understand the basic characteristics of transformers and electrical machines.

CO_5: Get an exposure to the working of power electronic converters

SEMESTER- II

BSC -102 Chemistry-I

L-T-P-C **(3-1-0-4)**

Course content and List of books:

Module 1: Atomic and molecular structure **6 Lectures**

Schrodinger equation. Particle in a box solutions and their applications for conjugated molecules and nanoparticles. Forms of the hydrogen atom wave functions and the plots of these functions to explore their spatial variations.Molecular orbitals of diatomic molecules and plots of the multicentre orbitals.Equations for atomic and molecular orbitals.Energy level diagrams of diatomics.Pi-molecular orbitals of butadiene and benzene and aromaticity.Crystal field theory and the energy level diagrams for transition metal ions and their magnetic properties. Band structure of solids and the role of doping on band structures.

Module 2: Spectroscopic techniques and applications **6 Lectures**

Principles of spectroscopy and selection rules. Electronic spectroscopy. Fluorescence and its applications in medicine.Vibrational and rotational spectroscopy of diatomic molecules.

Applications. Nuclear magnetic resonance and magnetic resonance imaging, surface characterisation techniques. Diffraction and scattering.

Module 3: Forces in Materials **6 Lectures**

Intermolecular forces and potential energy surfaces Ionic, dipolar and van Der Waals interactions. Equations of state of real gases and critical phenomena.Potential energy surfaces of H_3, H_2F and HCN and trajectories on these surfaces.

Module 4: Thermodynamics **6 Lectures**

Use of free energy in chemical equilbria, Thermodynamic functions: energy, entropy and free energy. Estimations of entropy and free energies.Free energy and emf. Cell potentials, the Nernst equation and applications. Acid base, oxidation reduction and solubility equilibria. Waterchemistry. Corrosion. Use of free energy considerations in metallurgy through Ellingham diagrams.

Module 4: Periodic properties and Stereochemistry **6 Lectures**

Effective nuclear charge, penetration of orbitals, variations of s, p, d and f orbital energies of atoms in the periodic table, electronic configurations, atomic and ionic sizes, ionization energies, electron affinity and electronegativity, polarizability, oxidation states, coordination numbers and geometries, hard soft acids and bases, molecular geometries Representations of 3 dimensional structures, structural isomers and stereoisomers, configurations and symmetry and chirality, enantiomers, diastereomers, optical activity, absolute configurations and conformational analysis. Isomerism in transitional metal compounds

Module 5: Organics **6 Lectures**

Organic reactions and synthesis of a drug molecule Introduction to reactions involving substitution, addition, elimination, oxidation, reduction, cyclization and ring openings Synthesis of a commonly used drug molecule

Reference Books:

1.University chemistry, by B. H. Mahan

2.Chemistry: Principles and Applications, by M. J. Sienko and R. A. Plane

3.Fundamentals of Molecular Spectroscopy, by C. N. Banwell

4. Engg Chemistry (NPTEL Web-book), by B. L. Tembe, Kamaluddin and M. S. Krishnan

5. Physical Chemistry, by P. W. Atkins

6. Organic Chemistry: Structure and Function by K. P. C. Volhardt and N. E. Schore, 5th Edition

Course Outcome (COs): The concepts developed in this course will aid in quantification of several concepts in chemistry hat have been introduced at the 10+2 levels in schools. Technology is being increasingly based on the electronic, atomic and molecular level modifications. Quantum theory is more than 100 years old and to understand phenomena at nanometer levels, one has to base the description of all chemical processes at molecular levels. The course will enable the student to:

CO_1: Analyse microscopic chemistry in terms of atomic and molecular orbitals and intermolecular forces.

CO_2: Rationalise bulk properties and processes using thermodynamic considerations.

CO_3: Distinguish the ranges of the electromagnetic spectrum used for exciting different molecular energy levels in various spectroscopic techniques

CO_4: Rationalise periodic properties such as ionization potential, electronegativity, oxidation states and electronegativity.

CO_5: List major chemical reactions that are used in the synthesis of molecules.

BSC-104 Mathematics II L-T-P-C **(3-1-0-4)**

Course content and List of books:

Module 1: Multiple Integration **8 Lectures**

Double integrals (Cartesian), change of order of integration in double integrals, Change of variables (Cartesian to polar), Applications: areas and volumes, Center of mass and Gravity (constant and variable densities);Triple integrals (Cartesian), orthogonal curvilinear coordinates, Simple applications involving cubes, sphere and rectangular parallelepipeds; Scalar line integrals, vector line integrals, scalar surface integrals, vector surface integrals, Theorems of Green, Gauss and Stokes.

Module 2: Equations **8 Lectures**

Exact, linear and Bernoulli's equations, Euler's equations, Equations not of first degree: equations solvable for p, equations solvable for y, equations solvable for x and Clairaut's type.

Module 3: Differential Equations **8 Lectures**

Second order linear differential equations with variable coefficients, method of variation of parameters, Cauchy-Euler equation; Power series solutions; Legendre polynomials, Bessel functions of the first kind and their properties.

Module 4:Differentiation **8 Lectures**

Cauchy-Riemann equations, analytic functions, harmonic functions, finding harmonic conjugate; elementary analytic functions (exponential, trigonometric, logarithm) and their properties; Conformal mappings, Mobius transformations and their properties.

Module 5:Integrals **8 Lectures**

Contour integrals, Cauchy-Goursat theorem (without proof), Cauchy Integral formula (without proof), Liouville's theorem and Maximum-Modulus theorem (without proof); Taylor's series, zeros of analytic functions, singularities, Laurent's series; Residues, Cauchy Residue theorem (without proof), Evaluation of definite integral involving sine and cosine, Evaluation of certain improper integrals using the Bromwich contour.

Reference Books:

1.G.B. Thomas & R.L. Finney, Calculus & Analytic geometry, Pearson, Reprint, 2002.

2. Erwin kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.

3. W.E. Boyce and R. C. DiPrima, Elementary Differential Equations and Boundary Value Problems, 9th Edn., Wiley India, 2009.

4. S.L. Ross, Differential Equations, 3rd Ed., Wiley India, 1984.

5. E.A. Coddington, An Introduction to Ordinary Differential Equations, PHI, 1995.

6. E.L. Ince, Ordinary Differential Equations, Dover Publications, 1958.

7. J.W. Brown & R. V. Churchill, Complex Variables &Appln, Mc-Graw Hill, 2004.

8.N.P. Bali and Manish Goyal, Engineering Mathematics, Laxmi Pub, Reprint, 2008.

9. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 36th Edition, 2010.

Course Outcome (COs):

CO_1: To familiarize the prospective engineers with techniques in multivariate integration, ordinary and partial differential equations and complex variables.

CO_2: To equip the students to deal with advanced level of mathematics and applications that would be essential for their disciplines.

BSC-105 Physics-II (Mechanics of Solids) L-T-P-C **(3-1-0-4)**

Course content and List of books:

Module 1: Statics **6 Lectures**

Free body diagrams on modelling of typical supports and joints; Condition for equilibrium in three- and two- dimensions; Friction: limiting and non-limiting cases; Force displacement relationship; Geometric compatibility for small deformations.

Module 2: Stress and Strain at a point **6 Lectures**

Concept of stress at a point; Planet stress: transformation of stresses at a point, principal stresses and Mohr's circle; Displacement field; Concept of strain at a point; Planet strain: transformation of strain at a point, principal strains and Mohr's circle.

Module 3:Material behaviour **10 Lectures**

One- dimensional material behaviour; Concepts of elasticity, plasticity, strain hardening, failure (fracture / yielding); Idealization of one dimensional stress-strain curve; Generalized Hooke's law with and without thermal strains for isotropic materials.

Module 4:Force analysis **8 Lectures**

Force analysis - axial force, shear force, bending moment and twisting moment diagrams of slender members (without using singularity functions);; Moment curvature relationship for pure bending of beams with symmetric cross-section; Bending stress; Shear stress; Cases of combined stresses.

Module 5: Strain energy **8 Lectures**

Concept of strain energy; Yield criteria; Deflection due to bending; Integration of the moment curvature relationship for simple boundary conditions; Method of superposition (without using singularity functions); Strain energy and complementary strain energy for simple structural elements (i.e. those under axial load, shear force, bending moment and torsion).

Reference books:

1. An Introduction to the Mechanics of Solids, 2nd ed. with SI Units – S.H. Crandall, N.C.
2. Dahl & T.J. Lardner
3. Engineering Mechanics: Statics, 7th ed. – J.L.Meriam
4. Engineering Mechanics of Solids – E.P. Popov

Course Outcome (COs):

CO_1: To familiarize students with the understanding of the elastic and plastic behavior of solids.

CO_2: To understand the importance of stress and strain at a point on solid.

CO_3: To be able to do force analysis and understand strain energy of solid.

HSM-101 English L-T-P-C **(2-0-2-3)**

Course content and List of books:

Module 1: Vocabulary Building 6 Lectures

The concept of Word Formation, Root words from foreign languages and their use in English, Acquaintance with prefixes and suffixes from foreign languages in English to form derivatives, Synonyms, antonyms and standard abbreviations.

Module 2:Basic writing skills 6 Lectures

Sentence Structures, Use of phrases and clauses in sentences, Importance of proper punctuation, Creating coherence, Organizing principles of paragraphs in documents, Techniques for writing precisely.

Module 3: Identifying Common errors in Writing 7 Lectures

Subject-verb agreement, Noun-pronoun agreement, Misplaced modifiers, Articles, Prepositions, Redundancies, Clichés

Module 4: Nature and Style of sensible Writing 6Lectures

Describing, Defining, Classifying, Providing examples or evidence, Writing introduction and conclusion

Module 5: Writing Practices 6 Lectures

Comprehension, Précis Writing, Essay Writing, (This unit involves interactive practice sessions in Language Lab)

Module 6: Oral Communication 7 Lectures

Listening Comprehension, Pronunciation, Intonation, Stress and Rhythm, Common Everyday, Situations: Conversations and Dialogues, Communication at Workplace, Interviews, and Formal Presentations.

Suggested Readings:

1. Practical English Usage. Michael Swan. OUP. 1995.

2. Remedial English Grammar. F.T. Wood. Macmillan.2007
3. On Writing Well. William Zinsser. Harper Resource Book. 2001
4. Study Writing. Liz Hamp-Lyons and Ben Heasly. Cambridge University Press. 2006.
5. Communication Skills. Sanjay Kumar and PushpLata. Oxford University Press. 2011.
6. Exercises in Spoken English. Parts. I-III. CIEFL, Hyderabad. Oxford University Press

Course Outcome (COs):

COs: The student will acquire basic proficiency in English including reading and listening comprehension, writing and speaking skills.

ESC-103 Programming for Problem Solving L-T-P-C **(3-1-0-4)**

Course content and List of books:

Module 1: Introduction **8 Lectures**

Introduction to components of a computer system (disks, memory, processor, where a program is stored and executed, operating system, compilers, etc.). Idea of Algorithm: steps to solve logical and numerical problems. Representation of Algorithm: Flowchart/Pseudo code with examples. From algorithms to programs; source code, variables (with data types) variables and memory locations, Syntax and Logical Errors in compilation, object and executable code.

Module 2: Introduction **8 Lectures**

Conditional Branching and Loops Writing and evaluation of conditionals and consequent branching**,** Iteration and loops.

Module 3: Introduction **8 Lectures**

Arrays (1-D, 2-D), Character arrays and Strings (Bubble, Insertion and Selection), Finding roots of equations, notion of order of complexity through example programs (no formal definition required)

Module 4: Introduction **8 Lectures**

Functions (including using built in libraries), Parameter passing in functions, call by value, Passing arrays to functions: idea of call by reference

Module 5: Introduction **8 Lectures**

Idea of pointers, Defining pointers, Use of Pointers in self-referential structures, notion of linked list (no implementation).First Year UG Courses Engg.& Tech. Jharkhand University of Technology

Module 6: Introduction **8 Lectures**

Recursion, as a different way of solving problems. Example programs, such as Finding, Factorial, Fibonacci series, Ackerman function etc. Quick sort or Merge sort.

Structures, Defining structures and Array of Structures

Suggested Text Books

1. Byron Gottfried, Schaum's Outline of Programming with C, McGraw-Hill
2. E. Balaguruswamy, Programming in ANSI C, Tata McGraw-Hill

Course Outcome (COs):

(CO_1): To formulate simple algorithms for arithmetic and logical problems.

(CO_2): To translate the algorithms to programs (in C language).

(CO_3): To test and execute the programs and correct syntax and logical errors.

(CO_4): To implement conditional branching, iteration and recursion.

(CO_5): To decompose a problem into functions and synthesize a complete program using divide and conquer approach.

(CO_6): To use arrays, pointers and structures to formulate algorithms and programs.

(CO_7): To apply programming to solve matrix addition and multiplication problems and searching and sorting problems.

(CO_8): To apply programming to solve simple numerical method problems, namely rot finding of function, differentiation of function and simple integration.

BSC-102P Chemistry Laboratory L-T-P-C **(1-0-4-3)**

Choice of 08-10 experiments from the following:

1. Determination of surface tension and viscosity
2. Thin layer chromatography
3. Ion exchange column for removal of hardness of water
4. Determination of chloride content of water
5. Colligative properties using freezing point depression
6. Determination of the rate constant of a reaction
7. Determination of cell constant and conductance of solutions

8. Potentiometry - determination of redox potentials and emfs

9. Synthesis of a polymer/drug 10. Saponification/acid value of an oil

11. Chemical analysis of a salt

12. Lattice structures and packing of spheres

13. Models of potential energy surfaces

14. Chemical oscillations- Iodine clock reaction

15. Determination of the partition coefficient of a substance between two immiscible liquids

24 16. Adsorption of acetic acid by charcoal

17. Use of the capillary visco meters to the demonstrate of the isoelectric point as the pH of minimum viscosity for gelatin sols and/or coagulation of the white part of egg.

Course Outcome (CO$_s$): The students will learn to:

(CO$_1$): Estimate rate constants of reactions from concentration of reactants/products as a function of time

(CO$_2$): Measure molecular/system properties such as surface tension, viscosity, conductance of solutions, redox potentials, chloride content of water, etc

(CO$_3$): Synthesize a small drug molecule and analyse a salt sample

ESC-104 Workshop (Manufacturing Practices)	L-T-P-C	**(2 - 0 - 2- 3)**
Module 1:		**2 Lectures**
Manufacturing Methods- casting, forming, machining, joining, advanced manufacturing methods		
Module 2:		**2 Lectures**
CNC machining, Additive manufacturing		
Module 3:		**2 Lectures**
Fitting operations & power tools		
Module 4:		**2 Lectures**
Electrical & Electronics		
Module 5:		**2 Lectures**
Carpentry		
Module 5:		**2 Lectures**
Plastic Moulding, glass cutting		
Module 6:		**2 Lectures**
Metal casting		

Module 7: **2 Lectures**

Welding (arc welding & gas welding), brazing

Suggested Text/Reference Books:

1. HajraChoudhury S.K., HajraChoudhury A.K. and Nirjhar Roy S.K., "Elements of Workshop Technology", Vol. I 2008 and Vol. II 2010, Media promoters and publishers private limited, Mumbai.

2.Kalpakjian S. And Steven S. Schmid, "Manufacturing Engineering and Technology", 4th edition, Pearson Education India Edition, 2002.

3.Gowri P. Hariharan& A. Suresh Babu, "Mfg. Tech- I" Pearson Education, 2008.

4.Roy A. Lindberg, "Processes and Materials of Manufacture", 4th edition, PHl, 1998.

5.Rao P.N., "Manufacturing Technology", Vol. I & Vol. II, Tata McGrawHill House, 2017.

Course Outcome (COs):

(CO_1): The students will gain knowledge of the different manufacturing processes which are commonly employed in the industry, to fabricate components using different materials.

ESC-103P Programming for Problem Solving Laboratory L-T-P-C **(2 - 0 - 2- 3)**

[The laboratory should be preceded or followed by a tutorial to explain the approach or algorithm to be implemented for the problem given.] Tutorial 1: Problem solving using computers:

Lab1: Familiarization with programming environment

Tutorial 2: Variable types and type conversions:

Lab 2: Simple computational problems using arithmetic expressions

Tutorial 3: Branching and logical expressions: Lab 3: Problems involving if-then-else structures Tutorial 4: Loops, while and for loops: Lab 4: Iterative problems e.g., sum of series

Tutorial 5: 1D Arrays: searching, sorting: Lab 5: 1D Array manipulation

Tutorial 6: 2D arrays and Strings Lab 6: Matrix problems, String operations

Tutorial 7: Functions, call by value: Lab 7: Simple functions

Tutorial 8 & 9: Numerical methods (Root finding, numerical differentiation, numerical integration): Lab 8 and 9: Programming for solving Numerical methods problems

Tutorial 10: Recursion, structure of recursive calls Lab 10: Recursive functions

Tutorial 11: Pointers, structures and dynamic memory allocation Lab 11: Pointers and structures Tutorial 12: File handling:

Lab 12: File operations

Course Outcome (COs):

CO_1: To formulate the algorithms for simple problems.

CO_2: To translate given algorithms to a working and correct program.

CO_3: To be able to correct syntax errors as reported by the compilers.

CO_4: To be able to identify and correct logical errors encountered at run time.

CO_5: To be able to write iterative as well as recursive programs.

CO_6: To be able to represent data in arrays, strings and structures and manipulate them through a program.

CO_7: To be able to declare pointers of different types and use them in defining self-referential structures.

CO_8: To be able to create, read and write to and from simple text files.

SEMESTER- III

MA-2101 Mathematics III

L-T-P-C **(3-0-0-3)**

Course content and List of books:

Module 1: The concept of Word Formation **8 Lectures**

Differential Equations: Definitions, Differential equation of first order, of first degree and higher, Singular solutions, Geometrical interpretations of differential equations,

Module 2: The concept of Word Formation **8 Lectures**

Linear equations of higher order with: constant coefficients and variable coefficients (Second order and homogeneous equations), Simultaneous differential equations of one or more variable, partial differential equations, total differential equations, geometrical interpretations, solution of Laplace equation, Heat conduction equation and wave equations by separation of variables in Cartesian, cylindrical and spherical polar co ordinate systems.

Module 3: The concept of Word Formation **6 Lectures**

Special Functions: Solution of Legendre and Bessel differential equations, Different kinds of associated functions, Orthogonality conditions, Expansion of functions in terms of Legendre polynomials and Bessel functions.

Module 4: The concept of Word Formation **8 Lectures**

Integral Transforms: Definitions, Laplace transforms, Inverse Laplace transforms, Fourier series- Expansion, Conversion into different intervals, Fourier integral formula, Fourier Mellin theorem, Infinite and Finite Fourier Transforms and Hankel transforms. Definite integrals with the help of Transforms, Application of Transforms to the solution of boundary value problems. Heat and wave equations.

Reference Books:

1. Sandro Salsa (Springer, 2010): Partial Differential Equations in Action: From Modelling to Theory. 2. Erwin Kreyszig (John Wiley, India 10th Edition): Advanced Engineering Mathematics,

3. B.V. Ramana (McGraw Hill Education Pvt. Ltd, New Delhi): Higher Engineering Mathematics

Course Outcome (COs):

CO_1: One of the main outcomes of the course is to familiarize the students with the fundamental concepts of Partial Differential Equations (PDE) which will be used as background knowledge for the understanding of specialized courses in the field of Materials Science and Engineering that follow.

Thus, this course provides an introduction to the study and solution methods of:

CO_2: Special functions and Orthogonal Polynomials

CO_3: Solving Homogeneous Heat, Wave, Laplace's Equations

CO_4: Integral Transforms (Laplace – Fourier)

CO_5: Sturm-Liouville and Generalized Fourier series

CO_6: PDE's in Higher Dimensions

MT-2101 Fluid Mechanics L-T-P-C **(3-0-0-3)**

Course content and List of books:

Module 1: Flow and Fluid Properties **6 Lectures**

Definitions, Fluid properties, classification of fluids and flow regimes, Fluid statics: Stationary fluids and liquids subjected to constant linear acceleration and to constant rotation.

Module 2: Kinematics **6 Lectures**

Fluid kinematics: Lagrangian and Eulerian descriptions, Pathlines, Streaklines and streamlines, acceleration.

Module 3: Integral Analysis **6 Lectures**

Integral flow analysis: Reynolds transport theorem, conservation of mass/continuity equation and conservation of linear and angular momentum for a control volume in inertial and accelerating reference frames, energy equation, Bernoulli's equation. Engineering applications,

Module 4: Differential Analysis **6 Lectures**

Differential analysis of flow: Continuity and Navier- Stokes equations. Dimensional analysis, Similitude theory.

Module 5: Inviscid Flows **6 Lectures**

Inviscid flows: Irrotational flow, circulation, velocity potential and applications. Viscous 12 flows in pipes and ducts, External viscous flows: Concepts of boundary layer, Momentum integral equation, drag and lift, separation.

Reference Books:

1. Szekley J.S. &Themlis N.J., Rate Phenomena in Process metallurgy
2. Bird R.B., Stewart W.E. & Lightfoot J.F., Transport Phenomena.
3. Geiger G.H. &Priorer D.R., Transport Phenomena in Materials Processing, Addison Wesley.

Course Outcome (COs):

CO_1: To familiarize with basic principles of fluid mechanics.

CO_2: To learn and apply physical and mathematical methods used in analyzing engineering applications involving fluids

CO_3: To understand the concept of fluid measurement, types of flows and dimensional analysis.

MT-2102 Mineral Dressing L-T-P-C **(2-0-0-2)**

Course content and List of books:

Module 1: Introduction **5 Lectures**

Ores and Minerals: Rocks, Minerals, Ores and Gangue, Elementary ideas of formation of rocks and mineral deposits and their mode of occurrence associations. Scope of mineral processing.Comminution and Liberation: Concept and importance of liberation.

Module 2: Mineral Processing **5Lectures**

Theory and practice of crushing and grinding. Sizing and classification: Laboratory sizing techniques, Interpretation and plotting of sizing data. Industrial screens and classifiers. Concentration: Principles and applications of heavy media separation, Jigging, Flowing film concentration and equipments used.

Module 3: Principles **5 Lectures**

Physico chemical principles of Flotation, Flotation reagents, Machines and circuits, Electrostatic and magnetic separation.Pre concentration techniques. Dewatering and Drying: Principles and practice of thickening, Filteration and Drying.

Module 4: Flow Sheets **5 Lectures**

Flow sheets: Typical flow sheets for the beneficiation of Coal and ores of Cu, Pb, Zn, Iron, Al and Mn with special reference to Indian deposits.

Reference Books:

1. Wills B.A., Mineral Processing Technology, Pergamon.
2. Gaudin A.M., Principles of Mineral Dressing, Tata McGraw-Hill.
3. Pryor E.J. Mineral Processing, Allied Science.
4. Jain S.K., Ore Processing, Oxford & IBH.

Course Outcome (CO_S):

- **CO_1:** Understand the importance of mineral processing technology.
- **CO_2:** Understand techniques of mineral processing for concentration of ore minerals economically.
- **CO_3:** Review environment friendly techniques for concentration of sulphide minerals.
- **CO_4:** Compute the recovery of ore mineral after concentration.

MT-2103 Fuels, Furnaces, and Refractories L-T-P-C **(2-0-0-2)**

Course content and List of books:

Module 1: Fuels **8 Lectures**

Fuels: Classification, Their merits and limitations Solid Fuels- Origin of coal, its types, properties, proximate and ultimate analysis, Storage and reserve in India. Coal Washing, Preparation and blending methods, application of coal. Coke making by beehive and

byproduct ovens.Modern practices of coke making, Characterization of coke and coal.Selection of reductant fuel for BF, DRI, COREX, Cupola and Pit furnaces.Liquid and gaseous fuels- Types and uses of liquid and gaseous fuels. Flame characteristics. Burners for liquid, gas and pulverized coal.Synthesis and reformation of gas for direct reduction.Producer and water gas.

Module 2:Furnaces **6 Lectures**

Furnaces: Classification of Furnaces, Basic working principles of fuel fired, resistance, induction and arc furnaces. Energy conservation measures in furnaces. Advantages and disadvantages of various kind of furnaces.

Module 3:Refractories **6 Lectures**

Refractories: Classification of refractories, Properties and application of fireclay, silica, chromite, graphite, magnesite, dolomite, zirconia, silicon carbide, silimanite and kyanite refractories.

Reference Books:

1. Gupta O.P., Elements of Fuels, Furnaces and Refractories, Khanna Publishers.
2. Gilchrist J.D., Fuels, Furnaces and Refractories, Pregamon.
3. Nandi D.N., Handbook of Refractories, Tata McGraw-Hill.
4. Norton F.H., Refractories, McGraw-Hill.

Course Outcome (CO_S):

CO_1: By understanding the fuels, furnace and refractories, students will be able to apply them suitably in the field of iron and steel making

MT-2104 Thermodynamics and Kinetics L-T-P-C **(3-1-0-4)**

Course content and List of books:

Module 1: **8 Lectures**

Basic concepts: Thermodynamic systems and processes, state and path functions, Extensive and Intensive properties, Internal Energy, First Law of Thermodynamics and its applications in various metallurgical processes. Enthalpy, Heat capacity, Hess's Law, Kirchoff's Law, Second Law of Thermodynamics and Entropy.

Module 2: **8 Lectures**

Entropy changes for various processes, Significance of sign change of entropy. Trouton's and Richard rules. Driving force of a chemical reaction, Combined statement of First and Second

Law of Thermodynamics. Statistical concept of entropy. Free Energy and its Significance: Helmoltz and Gibbs free energy, Free energy change as a function of temperature.

Module 3: 8 Lectures

Concepts of standard state, Fugacity, Activity and Equilibrium constants. Gibbs- Helmoltz equation, Van't Hoff equation, Le Chatelier principle, Clausius- Clapeyron equation, Maxwell equation. Ellingham Diagram and its significance in metallurgical engineering.

Module 4: 8 Lectures

Third Law of Thermodynamics. Solution Thermodynamics: Solution, Mixture and Compounds, Raoult's Law, Ideal, Non ideal and Regular solutions and their thermodynamic properties, Free energy of mixing, excess and integral quantities, Alpha function,

Gibb's– Duhem equation and its integration. Dilute solutions, Henry's Law and Sivert's Law, Alternate standard states, Interaction coefficients. Kinetics: Basic concepts of reaction steps, rate of reactions,

Module 5: 8 Lectures

Order of reaction, Determination of order of reactions. Arrhenius equation in reaction kinetics, Mechanism of reaction and rate controlling steps, Activated complex and its thermodynamic and kinetic aspects, Effect of concentration and temperature on reaction kinetics.Kinetics of heterogeneous reactions.

Reference Books:

1. Gaskell D.R., Introduction to Metallurgical Thermodynamics, McGraw-Hill.

2. Darken L.S. and Gurry R.W., Physical Chemistry of Metals, McGraw-Hill.

3. Upadhayaya G.S. and Dube R.K., Problems in Metallurgical Thermodynamics and Kinetics, Pergamon.

4. Szekely J and Themelis N.J., Rate Phenomena in Process Metallurgy, Addison Wesley.

5. Mohanty A.K., Rate Processes in Extractive Metallurgy, PHI.

Course outcomes (CO_S):

Upon completion of the course, the student will be able to

CO_1: Understand the basic laws of thermodynamics

CO_2: Understand the multiple approaches to thermodynamics, from the bulk property point of view and from the atomistic point of view

CO_3: Understand concepts such as the theory of solutions, free energy, entropy, criteria for equilibrium and conditions for feasibility

CO_4: Obtain the skill to use metallurgical thermodynamic concepts and equations for understanding phase diagrams, phase transformations, theory of solutions

CO_5: Obtain problem solving skills in order to improve / modify industrial processes, in extraction metallurgy, liquid metal treatment and in heat treatment

CO_6: Understand the concept behind rate of chemical reactions and order of chemical reactions

MT-2105 Principles of Extractive Metallurgy L-T-P-C (3-0-0-3)

Course content and List of books:

Module 1: 8 Lectures

Introduction: Scope of extractive Metallurgy, Occurrence of Metals in Nature, Minerals and Ores, Elementary concepts of extraction of Metals from their ores.

Module 2: 8 Lectures

Ellingham diagrams for oxides and sulphides. Pyrometallurgy: Ore preparation, Calcination, Roasting, Predominance area diagram, Roasting practice, Reduction smelting, Matte smelting, Converting, Role of Slags.

Module 3: 8 Lectures

Refining Methods: Fire refining, Liquation, Poling, Cupellation, Vacuum distillation, Zone refining, Electrolytic refining.Hydrometallurgy: Ore preparation, Leaching practice, Bio leaching, Kinetics of leaching, Role of oxygen in leaching, Recovery of metals from leach liquor by solvent extraction, ion exchange, precipitation, cementation and electro winning methods.

Module 4: 6 Lectures

Electrometallurgy: Theory of electrodeposition, Faraday's Laws, Electrode potential, EMF series, Nernst equation, Hydrogen over voltage, Electro winning, Pourbaix diagram. Calculation of material and heat balances pertaining to some important metal extraction process.

Reference Books:

1. Newton J., Extractive Metallurgy, Wiley.
2. Gilchrist J.D., Extraction Metallurgy, Pergamon.
3. Rosenqvist T., Principles of Extractive Metallurgy, McGraw Hill.

4. Ray H.S. and Ghosh A., Principles of Extractive Metallurgy, New Age International

Course outcomes (COs):

CO_1: List out ore minerals for ferrous and non-ferrous metals.

CO_2: Understand the principles of calcination, reduction and smelting.

CO_3: Estimate the percent reduction of metal from its ore by pyro-metallurgical route.

CO_4: Understand the principles of electro-metallurgy.

CO_5: Predict the metal recovery of a hydrometallurgical process.

CO_6: Discuss the principles of fire refining, liquation, distillation refining and zone refining.

CO_7: Examine the importance of slag chemistry in the extraction process.

CO_8: Recognize the importance of Ellingham diagrams and criteria required for reduction of metals.

SEMESTER IV

MT-2201 Numerical methods and its applications L-T-P-C (2-0-0-2)

Course content and List of books:

Module I: 6 Lectures

Errors in computation, instability, Nonlinear equation in one variable: Direct and Iterative methods, order of convergence, Iterative methods for systems of nonlinear equations. Linear system of equations, direct and iterative methods, rate of convergence of iterative methods, ill conditiondness of systems and condition numbers.

Module II 6 Lectures

Interpolation: Lagrange, Newton divided difference formula, Newton's interpolations, errors in interpolation, Gauss, Stirling, Bessels, Splines.

Module III 4 Lectures

Approximation: Least square and uniform approximations, differentiation –differentiation using interpolation formulas. **4 Lectures**

Module IV: Integration: Integration using interpolation, Newton-cotes formulas, Gauss quadrature rules. **4 Lectures**

Module V: Ordinary Differential Equation: Taylor, Euler and Runge- Kutta formula, Multi step methods. **4 Lectures**

Module VI: Computer implementation of various methods. **4 Lectures**

Reference Books:

1. Sastry S.S. Introductory Methods of Numerical Analysis.

2. Chapra S.C. and Canale R.P., Numerical Methods for Engineers, Tata McGraw Hill.

3. Hildebrand F.B., Introduction to Numerical Analysis, Tata McGraw Hill.

Course Outcomes (COs)

At the end of the course, students will be able to learn:

CO_1: Errors in computation, instability, solution of linear system of simultaneous linear equations like Gauss's elimination method, Gauss-Jordan method, solution of ill-conditioned systems, Jacobi iteration method, Gauss-Seidel method, numerical solution of nonlinear equations.

CO_2: Interpolation: Lagrange, Newton divided difference formula, Newton's interpolations, errors in interpolation, Gauss, Stirling, Bessels, Splines.

CO_3: Approximation: Least square and uniform approximations.

CO_4: Numerical differentiation: Newton's formulae.

CO_5: Numerical evaluation of integrals by various methods like Trapezoidal-rule, Simpson's-1/3 and 3/8 rules, Newton-Cotes formula, Gauss method.

CO_6: Numerical solution of first order and higher order ODEs: Taylor's series method, Euler's method, Runge-Kutta method.

CO_7: Elements of computer programming: MATLAB and its application in numerical analysis.

MT-2208 Heat and Mass Transfer L-T-P-C **(3-0-0-3)**

Course content and List of books:

Module I:

Conduction: Mechanism, Fourier's general conduction equation in 3D; 1D Steady state conduction with heat generation, Composite plane wall and cylinders, thermal resistance network, Critical thickness of insulation; extended surface heat transfer, 2D Steady state conduction , Solution for simple boundary condition, Unsteady heat conduction: lumped

parameter system, semi infinite wall with convection boundary condition, Use of Heisler charts. **(16 Lectures)**

Module II:

Convection: Review of hydrodynamics equation of boundary layer theory .Convection boundary layers: Velocity and thermal boundary layers. Laminar boundary layer analysis on flat plate. Fully developed heat transfer through smooth pipe, Relation between fluid friction and heat transfer .Turbulent boundary layer, Forced convection correlations. free convection, laminar free convection on a vertical flat plate, empirical correlations.

(10 Lectures)

Module III:

Boiling and Condensation: Mechanism, different regimes of boiling, boiling curves and correlation, laminar film condensation on a vertical plate

Heat exchangers: types, analysis, LMTD, effectiveness-NTU method

(8 Lectures)

Module IV:

Radiation: Physical mechanism, Radiation properties, Black body radiation, Gray body, Special dependence of radiation properties, Kirchoff's Law, Wein's displacement Law. View factor; Radiation exchange between infiniteplanes and between gray bodies; Radiation shielding; re- radiating surface and 3- surface enclosures, network representation.

(16 Lectures)

Module V:

Mass transfer: Fick's Law, Similarity with convection and correlations. **(6 Lectures)**

Recommended Books:

1. Holman J.P., Heat Transfer.

2. Geankopolis C.J., Transport Process: Heat Mass & Momentum.

3. Welty J.R., Wicks C.E. & Wilson R.E., Fundamentals of Momentum, Heat & Mass Transfer.

Course Outcomes (COs)

At the end of the course, students will be able to:

CO1: Understand the basic laws of heat transfer, account for the consequence of heat transfer in thermal analyses of engineering systems, analyze problems involving steady state heat conduction in simple geometries, develop solutions for transient heat conduction in simple geometries, obtain numerical solutions for conduction and radiation heat transfer problems,

CO2: Understand the fundamentals of convective heat transfer process, Evaluate heat transfer coefficients for natural convection, Evaluate heat transfer coefficients for forced convection inside ducts, Evaluate heat transfer coefficients for forced convection over exterior surfaces

CO3: Analyze heat exchanger performance by using the method of log mean temperature difference, Analyze heat exchanger performance by using the method of heat exchanger effectiveness

CO4: Calculate radiation heat transfer between black body surfaces, Calculate radiation heat exchange between gray body surfaces

CO5: Understanding of Fick's Law, Similarity with convection and correlations

MT-2203 Phase Equilbria in Materials system L-T-P-C (3-0-0-3)

Course content and List of books:

Module I: **(5 hrs)**

Introduction to thermodynamics of phase change: Equilibrium, phase stability, evolution of phase diagrams, chemical potential gradient

Module II: **(5 hrs)**

Atomic model of diffusion, solid solution, Theories of alloying, Hume- Rothery rules, Single component systems, P-T diagrams, Allotropy

Module III: **(6 hrs)**

Free energy- composition diagram, Binary equilibrium diagrams, Gibbs phase rule, Tie line, Lever rule, Isomorphous, eutectic, eutectoid, monotectic, peritectic, peritectoid, Syntactic systems

Module IV: **(6 hrs)**

Common alloy systems, Ceramic systems, Microstructure of plain carbon steels and cast irons, Complex phase diagram: Rule for construction of phase diagrams for complex system

Module V: **(5 hrs)**

Metastability, computation of phase diagrams. (Illustrations of previous modules with graphic/video)

Module VI: (5 hrs)

Ternary system: Ternary phase diagrams, representation, isothermal and vertical sections, Ternary isomorphous and eutectic systems, Tie lines, Gibb's triangle representation

ModuleVII: (5 hrs)

Two phase, Three phase and four phase equilibrium, Experimental determination of phase diagrams. Microscopy, X-ray diffraction technique

Module VIII: (5 hrs)

Thermal analysis, Dilatometry, Electrical resistivity, Diffusion couples and Magnetic methods

Reference Books:

(a) Gordon P., Principles of Phase Diagrams in Materials Systems, McGraw Hill.

(b) Prince A., Alloy Phase Equilibria, Elsevier.

(c) Rhines F.N., Phase Diagrams in Metallurgy, McGraw Hill. 16

(d) Hume- Rothery W., Christian J.W. and Pearson W.B., Metallurgical Equilibrium Diagrams, The Institute of Physics (London).

Course Objective (COs)

CO_1: Students should learn about the equilibrium binary, ternary and quaternary phase diagrams of elemental metals.

CO_2: Starting from binary isomorphous phase diagram, eutectic and eutectic type of phase equilibria (eutectic, eutectoid), peritectic and peritectic type of equilibria (peritectic, peritectoid, monotectic), metatectic and syntactic type of phase equilibria are to be thorough with.

CO_3: Ternary, quaternary phase equilibria have to be known along with their application-oriented examples.

CO_4: Ultimately, students should get a prior idea if the elements and their atomic fraction in an alloy are known, they should be able to predict what phase the alloy would form in equilibrium at a particular given temperature.

MT-2204 Iron Making L-T-P-C **(3-0-0-3)**

Course content and List of books:

Module 1: Raw Materials 6 Lectures

Raw Materials and their properties: Iron ore, flux, Agglomerates and coke. Sintering and palletizing, blast furnace burdening and distribution, testing of raw materials for B.F Design:

Module 2: Blast furnace Iron making 8 Lectures

B.F profile, Stove and gas cleaning units, instrumentation, refractory used in B.F and stove Reactions: Fe-C-O, Fe-O-H phase equilibrium, Reaction in stack, bosh and hearth, formation of primary slag, bosh slag and hearth slag. Slag composition and its control, Metal–slag reactions, control of hot metal composition.

Module 3: Blast furnace productivity and development 8 Lectures

Process Control, Factors affective fuel consumption and productivity, Recent development in B.F Operations like, Bell-less top charging system, High top pressure, Humified and oxygen enrichment of B.F and auxiliary fuel injections through tuyers. Irregularities in B.F Operations and their remedies.B.F Stoichiometry, mass and enthalpy balance, problems based on charge calculations.

Module 4: Alternative Iron making 8 Lectures

Alternate routes of Iron Making: Processes of sponge iron production. Coal based and gas based. Smelting reduction processes.

Reference Books:

1. Biswas A.K., Principles of Blast Furnace Iron Making, SBA.

2. Tupkary R.H., Introduction to Modern Iron Making, Khanna Publishers

3. Gupta S.S. and Chatterjee A., Blast Furnace Iron Making, SBA New Delhi.

4. Chatterjee A., Singh R. and Pandey B., Metallics for Steel Making- Production and Use, Allied Publishers.

Course outcomes (COs):

After the successful completion of this course, the student would be able to

CO_1: Criteria for selection of raw materials for blast furnace iron making.

CO_2: Classify different kinds of furnaces and the ancillary units used for Iron making in conventional blast furnace.

CO_3: Analyse various factors influencing quality of the product in blast furnace

CO_4: Analyse the irregularities and cause of failures in blast furnace and apply the remedial measures for immediate rectification

CO_5: Compare the conventional blast furnace iron making with modern alternative routes of iron making.

CO_6: To evaluate the performance of a running blast furnace

CO_7: To calculate coke rate and oxygen demand of a running blast furnace

MT-2205 Physical Metallurgy L-T-P-C **(3-0-0-3)**

Course content and List of books:

Module 1:Crystal structure and crystal defects **8Lectures**

Introduction, Crystal structure and crystal defects.

Module 2: Metallography **8Lectures**

Metallurgical microscope, Specimen preparation, Techniques for microscopic observation.High-temperature microscopy, Quantitative metallography.

Module 3:X-ray crystallography: **10 Lectures**

Fundamentals of crystallography, Reciprocal lattice, X- Ray diffraction, Bragg's Law. Lau, Powder and rotating crystal methods, Intensity calculations, Lorentz polarization, absorption, temperature, multiplicity factors.Application of x-ray diffraction to identification of Bravais lattices, calculation of lattice parameters, residual stresses and orientation determination.

Module 4:Diffusion: **10 Lectures**

Fick's first law of diffusion, self-diffusion and interstitial diffusion in alloys, diffusion mechanisms, activation energy.Fick's second law of diffusion & its solution.

Module 4:Applications **6 Lectures**

Boltzaman-Matano analysis, kirkendall effect. Darken analysis.

Reference Books:

1. Reed Hill R.E., Physical Metallurgy Principles, Affiliated East West Press.
2. Azaroff L.A., Introduction to Solids, Tata McGraw Hill.
3. Barret C.S. &Massalski T.B., Structure of Metals, Pergamon.
4. Cullity B.D. Elements o0f X-Ray Diffraction, Addition-Wesley.
5. Smallman R.E. &Ashbee K.H.G., Modern Metallography, Pergamon.
6. Gifkins R.C., Optical Microscopy of Metals, Pitman.

Course outcome (CO_s)

CO_1: Students learned about crystal structures, symmetry elements of seven different Bravais lattices.

CO_2: Basics of X-ray diffraction (xrd), xrds from different crystal systems.

CO_3: The most importantly, how to index the xrd pattern that has been taught to the students in detail. Besides, diffusion and Fick's laws have been taught with various numerical examples of real industrial and application examples.

MT-2206 Mechanical Behaviour of Materials L-T-P-C (3-1-0-4)

Course content and List of books:

Module 1: Introduction 8 Lectures

Theory of elasticity and plasticity, Generalised Hooke`s law, stress-strain relationship. Mechanism and crystallography of slip and twinning. Concept of critical resolved shear stress. Deformation of single crystals and poly-crystals. Hall–Petch relationship.

Module 2: Dislocation Theory 8 Lectures

Type of dislocations, their geometrical and elastic properties, movement and multiplication of dislocations, dislocation intersection and reactions.Partial dislocations and stacking faults.Application of dislocation theory to strengthening mechanism and yield point.Strain ageing and work hardening phenomena.Effect of strain rate and temperature on flow properties.

Module 3:Mechanisms of Creep 8 Lectures

Generation and analysis of creep and rupture data. Dislocation and diffusion mechanisms of creep.Grain boundary sliding and migration. Deformation mechanism maps. Effect of metallurgical and test variation on creep and fracture. Superplasticity. Parametric methods for prediction of long time properties.

Module 4: Fatigue of Materials 8 Lectures

Fatigue testing methods and machines. Stress controlled and strain controlled fatigue. Analysis of cyclic stress–strain data.Mechanism of fatigue crack, nucleation and propagation.

Module 5: Fracture of Materials 8Lectures

Fracture: Mode and mechanism of fracture, Griffith`s theory, Ductile to brittle transition. Transition temperature phenomena, Factors affecting transition temperature, Fracture mechanism, strain energy release rate, stress intensity factor, plane strain fracture, toughness, Design approach.

Module 6: Failure mechanism and analysis 8Lectures

Fracture and fatigue of composites.Fractographic aspects of failure. Environment assisted fracture.

Reference Books:

1. Dieter G.E., Mechanical Metallurgy, McGraw Hill.

2. Hertzberg R.W., Deformation and Fracture Mechanics of Engineering Materials, John Wiley.

3. Hull D., Introduction to Dislocations, Pergamon.

4. Meyers M.A. and Chawla K.K., Mechanical Behavuior of Materials, PHI.

Course outcome (COs)

CO_1: The mechanical behavior of materials has been taught where the materials' responses to tensile or compressive loads were studied, with their industrial and engineering applications.

CO_2: Students learned how an alternating load plays a role for a catastrophic failure of an engineering structural part. Quantification of the life in such environment of a structural part also has been learned by the students satisfactorily.

CO_3: Students understood material's behaviour when it is exposed to high temperature and how the temperature activated deformation process leads to failure of a part.

Students learned to determine and quantify how existence of internal flaw (cracks, voids etc) leads to material failure.

SEMESTER V

MT-3101 Steel Making L-T-P-C **(3-0-0-3)**

Course content and List of books:

Module 1: Principles of Steel Making 4 Lectures

Introduction: Principles of steel making reactions,viz decarburization, dephosphorization, desulphurization, silicon& manganese reaction. Slag Theories: Molecular & ionic theories, Interpretation of the above reactions in terms of ionic theory of slag.

Module 2: Basic Oxygen steel making 8 Lectures

LD Process: Design of converter & lance, Quality of raw materials charged, Operation of the converter and control of bath and slag composition. Chemical reactions involved, Temperature and residual bath oxygen control. Use of oxygen sensor, some characteristics of L.D blow viz emulsion formation, slopping, manoeuvring lance height for dephosphorisation and decarburisation. Catch carbon technique, Recovery of waste heat, OBM/Q-BOP process,

Concept and operation of the process. Mixed/Combined blowing process. Oxygen top blowing with inert gas purging at bottom, Oxygen top blowing with inert and oxidizing gases at bottom, Oxygen top and bottom blowing, Steel making Scenario in India. Open hearth Furnace: modification into twin hearth, operational principle, advantages.

Module 3:Electric arc furnace steel making 6 Lectures

Advantages, charging, melting and refining practices for plain carbon and alloys steels.Use of DRI in arc furnaces and its effect on performance.UHP electric arc furnace with DC supply.Duplex processes of stainless steel making using VOD, AOD and CLU. Induction Furnace: Advantages, Principles of induction heating, Use in steel industry. Deoxidation of liquid steel: Requirement of deoxidizers, deoxidation practice, Stoke's law, use of complex deoxidizers, Inclusions and their influence on quality of steel. Killed, semi killed and rimming steels.

Module 4: Secondary Steel Making 4 Lectures

Secondary refining of steels: Objectives, principles of degassing, Different industrial processes such as DH, RH, VAD, SD, LF and ESR. Limitations and specific applications.

Module 5:Continuous casting of steel 8 Lectures

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.

Reference Books:

1. Tupkary R.H., An Introduction to Modern Steel Making, Khanna Publishers.
2. G.R. Bashforth, The Manufacture of Iron and Steel, Chapman & Hall.
3. Schrewe H.F. Continuous Casting of Steel, Stahl-eisen.
4. Edneral F.P., Electrometallurgy of Steel and Ferroalloys, Vol. 1&2, Mir.

Course outcome (CO_s):

CO_1: Analyse the physicochemical principles involved in steelmaking.

CO_2: Understand the recent developments in secondary refining of steels.

CO_3 :Understand the recent developments in continuous casting of steel

MT-3102 Physical Metallurgy II L-T-P-C **(3-1-0-4)**

Course content and List of books:

Module 1: **10 Lectures**

Theory of solidification: Nucleation and growth, mechanism of nucleation and driving force for growth. Morphology, Zone refining, crystal growth, crystallography, stabilization, Recovery, recrystallisation and grain growth.Annihilation of point imperfections,

Module 2: **10 Lectures**

Order disorder transformation, eutectoidal reaction, cellular reaction.Strengtheming mechanisms, massive and spinodal decomposition.Mechanism and kinetics of precipitation of age hardenable alloys. Fe- C system:

Module 3: **10 Lectures**

Effects of alloying elements, Formation of Austenite, Decomposition of Austenite, Pearlitic, Bainitic and Martensitic phase transformations, TTT and CCT diagrams, Hardenability, Critical diameter, Jominy end quench Test, Tempering of steel, Temper brittleness, Thermomechanical Treatment,

Module 4: **10 Lectures**

Ausforming, Maraging steels, Processing- structure property relationship in multiphase alloys, Rapid solidification processing, Metallic Glasses, Single crystal processing. Nano crystalline materials.

Reference Books:

1. Reedhill R.E., Physical Metallurgy Principles, Affiliated East West Press.
2. Avner S.H., Introduction to Physical Metallurgy, Tata McGraw Hill.
3. Porter D.A. &Easterling K.E., Phase Transformations in Metals and Alloys.
4. Clarke & Varney, Introduction to Physical Metallurgy.

Course outcome (COs):

CO_1: Students learned about crystal structures, symmetry elements of seven different Bravais lattices. Basics of X-ray diffraction (xrd), xrds from different crystal systems

CO_2: The most importantly, how to index the xrd pattern that has been taught to the students in detail. Besides, diffusion and Fick's laws have been taught with various numerical examples of real industrial and application examples.

MT-3103 Welding Metallurgy L-T-P-C **(2-0-0-2) 20 Lectures**

Course content and List of books:

Module 1: Introduction **2 Lectures**

Welding Metallurgy: Introduction to various welding processes (in brief)

Module 2: Chemical reactions in welding **4 Lectures**

Gas- Metal reactions, Slag- Metal reactions, Effect of gaseous inclusions in weld metal.

Module 3: Weld Zones **10 Lectures**

Fusion Zone: Basic solidification concepts, Weld metal solidification, Post solidification phase transformations, Weld metal chemical inhomogeneity. Partially melted zone: Formation of partially melted zone, Difficulty associated with the partially melted zone. Heat affected zone: Recrystallization and grain growth in welding, Effect of welding parameters and process.

Module 4: Weldability **4 Lectures**

Weldability of common engineering materials like carbon and alloy steels, cast irons, stainless steels, Al- and Cu- based alloys, Welding defects and its remedies.

Recommended Books:

1. Modern welding technology, Cary, 4th Edition
2. The Metallurgy of Welding Brazing and Soldering, Lancaster
3. Manufacturing Technology-Foundry, Forming and Welding, P.N. Rao, 5e (vol.1)

Course outcome (COs):

This experience is to provide a solid understanding of metals as a background for learning welding process. At the end of the course,

CO1: Students are familiar with all the common welding process and common welding problems associated with welding ferrous materials and aluminum alloys. Can describe the basic concepts of welding metallurgy and weldability, welding process, the nature and types of welding process.

CO2: Review basic principles that govern microstructure evolution in welds, Regions of Fusion weld, Explain the effects of weld on the strength of metals, apply various heat treatments and testing techniques to reach desired outcome.

CO3: Students are exposed the static and fatigue strength of weldments-one of the most important applications of fracture mechanics and science of metallic fatigue- in the last part of the course.

CO4: Topics such as plasma physics, heat flow, physical metallurgy, nondestructive testing, fracture mechanics, economics, industrial safety, physical chemistry, thermodynamics, and electrical circuits arise in the course and are integrated through in a rational discussion of welding.

CO5: Students appreciate the great skill of good welders after their attempts at welding. Students become aware of the difficulty of making good welds and why welds defects as frequently as they do. The students are asked to become thoroughly familiar with and comment on one of the classical studies of the failure of the welded structure at the conclusion of the course.

MT-3104 Foundry Technology

L-T-P-C **(3-0-0-3) 30 Lectures**

Course content and List of books:

Module 1: Introduction **2 Lectures**

Design and process selection in metal casting, Foundry processes,

Module 2: Patterns **2 Lectures**

Patterns: materials and design, features of moulding processes, equipments, mechanizations, forces acting on moulds, mould factors in metal flow, molding factors in casting design. Different types of binders and their uses in mould and core makings.

Module 3: Melting and Casting **8 Lectures**

Melting of metals and alloys for castings: Brief mention of various melting units, melting & post melting treatments, melting practices as adopted for a few metals and alloys such as Cu, Al, Steel, Cast irons.

Module 4: Solidification **8 Lectures**

Solidification of metals and alloys: Nucleation, growth, role of alloy constitutions, thermal conditions and inherent nucleation and growth conditions in the liquid melt, significance & practical control of cast structure.

Module 5: Principles of Metal Casting **5 Lectures**

Principles of Gating and Risering: Feeding characteristics of alloys, types of gates and risers. Time of solidification and Chowrinov rule, wlodawer system for feeder head calculations, gating ratio, concept of directionality in solidification. Yield of casting and prescription for its augmentation.

Module 6: Special Casting Techniques **5 Lectures**

Special casting methods: Investment casting, Die casting, centrifugal casting, Full mold casting, vacuum sealed casting. Thixo and Rheo casting, strip casting, near net shape casting. Development in modern casting processes. Casting defects: A detailed analysis of casting defects, their causes and prescription of remedial measures.

Reference Books:

1. Heine R.W., Lopper C.R. & Rosenthal P.C., Principles of Metal Casting, McGraw Hill.
2. Davis, G.J., Solidification in Casting, Applied Sciences.
3. Beeley P.R., Foundry Technology, Butterworth.
4. Kondic V., Metallurgical Principles of Foundry, Edward Arnold.

Course outcome (COs):

At the end of the course, students will be able to:

COs: Have an Understand the technology, variables and complexity involved in producing a casting.
COs: Be able to make selection of the type of furnace required for any specific casting problem and design the pattern requirement
COs: Have the basic knowledge for selecting the type of sand, for molds and cores as well as the molding process.
COs: Know about the special molding processes and when their use is warranted.

COs: Have a broad knowledge of casting of ferrous and non-ferrous alloys and of the inspection techniques to detect casting defects.

MT-3105 Powder Metallurgy L-T-P-C **(2-0-0-2) 20 Lectures**

Course content and List of books:

Module 1: Introduction to Powder Metallurgy **4 Lectures**

Introduction, Metal powder production methods.

Module 2:Composition & their structure, particle size & shape **4 Lectures**

Characterization of Powders: determination, treatment of metal powders.

Module 3: Introduction to Powder Metallurgy **4 Lectures**

Powder flow, Compressibility and porosity measurements.Behavior of powder during compaction, Die compaction, Types of presses, Tooling & Design.

Module 4:Modern Methodology **4 Lectures**

Modern methods of powder consolidation, Isostatic pressing, Roll compaction, powder extrusion & forging, slip casting. Sintering of powders & evaluation of sintered products.

Module 5: Sintering **4 Lectures**

Sintering theories, solid and liquid phase sintering, and applications of sintered products.

Reference Books:

1. Randal G., Powder Metallurgy, John Wiley.

2. Metal Powder Handbook, ASM.

Course outcome (COs):

At the end of the course, students will be able to:

CO_1: Acquire the knowledge of Powder Metallurgy History, Applications and its importance, Acquainted the knowledge of metal powder production methods

CO_2: Aware about the powder characterization techniques, Measure the various powder characteristics like apparent density, tap density, flow rate, friction index.

CO_3: Understand the basic methods of Powder compaction for green compact, Familiar about compaction tooling and role of lubricants in compacting

CO_4: Explain various powder forming techniques other than the compaction, understand the application in various fields of powder metallurgy.

CO_5: Explain the mechanism of sintering and types sintering for development of mechanical properties. Understand causes of defects in Powder metallurgy processed materials and method to minimize defects

MT-3106 Mechanical properties of Materials & Evaluation L-T-P-C **(3-0-0-3)**

Course content and List of books:

Module 1: Hardness Tests **4 Lectures**

Principles involved in Hardness Test. Types of Hardness Test, Brinell hardness, Analysis of indentation, Relationship between Hardness and the Flow Curve; Vicker's Hardness, Rockwell Hardness, Micro and Nanohardness tests, Hardness Conversion Relationship; Hardness at elevated Temperature.

Module 2: Tensile Test **4 Lectures**

Specimen Geometry, Engineering and True Stress-Strain Curves, Evaluation of Tensile Properties, Strain Hardening and Plastic Instability. Testing Machines, Strain and Load Measuring Devices, Temperature and Strain Rate Effects.

Module 3: Torsion Test **4 Lectures**

Torsion Test: Mechanical Properties in Torsion, Torsional Stresses for Large Plastic Strains, Types of Torsion Failure, Tension Test Vs. Torsion Test, Hot Torsion Testing.

Module 4: Impact Test **4 Lectures**

Notched Bar Impact Tests, Instrumented Charpy Test, Significance of Transition Temperature Curve, and Metallurgical Factors affecting Transition Temperature.

Module 5: Fracture Toughness Test **4 Lectures**

Strain Energy Release Rate, Stress Intensity Factor, Fracture Toughness and Design, KIC Plane Strain Toughness Testing, Plasticity Corrections.

Module 6: Creep and Stress Rupture Test **4 Lectures**

Creep Test: Creep Curve, Stress Rupture Test, Structural Changes During Creep, Mechanism of Creep, Fracture at Elevated Temperatures, Prediction of Long Time Properties.

Module 7: Fatigue Test **6 Lectures**

S-N Curve, Cyclic stress strain Curve, Low Cycle Fatigue, Effect of Stress concentration on Fatigue, Effect of Metallurgical Variables on Fatigue. Unusual properties of ceramics, testing of ceramics.Non destructive testing of materials.

Reference Books:

1. Dieter G.E., Mechanical Metallurgy, Tata McGraw Hill.
2. Patratia Han (ed), Tensile Testing, ASM.
3. Boyer H.E. (ed), Hardness Testing, ASM.
4. Metals Handbook, 9th edition Vol. 8, Mechanical Testing, ASM.
5. Halmshaw R., Non Destructive Testing, Gordon & Breach

Course outcome (COs):

CO_1: Interpret the relationship between structure of a material and its mechanical properties

CO_2: Apply the knowledge of plastic deformation of metals to design efficient metal working operations

CO_3: Apply the fracture mechanics principles to determine the fracture toughness of brittle and ductile materials

CO_4: Apply the knowledge of fatigue, creep and superplasticity phenomena to design processes for improved microstructure and properties

SEMESTER VI

MT-3201 Metal Forming Technology L-T-P-C **(2-0-0-2) 20 Lectures**

Course content and List of books:

Module 1: Introduction 4 Lectures

Classification of metal forming processes, hot, cold and warm working. Flow curve for materials, effect of temperature, Strain rate and microstructural variables, residual stresses, experimental techniques, yielding theories, processing maps. Friction in metal working, Lubrication.

Module 2: Rolling 4 Lectures

Rolling of Metals: Classification of rolled products, Types of rolling mills, Terminology used; Forces and Geometrical relationships in rolling, Rolling variables, Theories of design, Mill type, Lay out and rolling practice, adopted for some common products such as slabs, blooms, billets, plates, sheets etc., Rolling defects and their control.

Module 3: Forging 4 Lectures

Forging of Metals: Forging principles, Type of Forgings and equipment needed; Calculation of Forging load under sticking and slipping Plain strain forging analysis, friction conditions. Manufacture of rail wheels and tyres. Forging defects and their control.

Module 4: Extrusion 2 Lectures

Extrusion: Types, Principles and equipments, Variables in extrusion, deformation in extrusion, Calculation of extrusion pressure under plain strain conditions, extrusion defects, production of tubes and seamless pipes.

Module 5: Wire Drawing 2 Lectures

Wire drawing: Drawing of rods, wire and tubes, Calculation of drawing loads, drawing defects.

Module 6: Sheet Metal Forming and drawing 2 Lectures

Sheet metal forming: Forming methods such as bending, stretch forming, shearing, blanking, deep drawing and redrawing. Formability diagrams, Defects in formed products.

Module 7: Special Forming Techniques 2 Lectures

Special forming methods such as high energy forming: explosive forming, electrohydraulic and magnetic forming processes.

Reference Books:

1. Dieter G.E., Mechanical Metallurgy, McGraw Hill.
2. Harris J.N., Mechanical Working of Metals- Theory and Practice, Pergamon.
3. Kalpakjian S. and Schmid S.R., Manufacturing Processes for Engineering Materials, Pearson.

Course outcome (COs):

COs: Understand and apply the mechanism of deformation for different metal forming processes and develop analytical relation between input and output parameters of process.

COs: Understand and analyse the concept of yield criteria applicable to different material deformation processes.

COs: Apply theoretical and experimental techniques for measurement of important outcomes of metal forming processes.

COs: Understand the different lubrication mechanisms, lubricants and other valuable affecting the metal forming processes under different working conditions.

COs: Understand the different types of defects, causes and apply their remedial measures in metal forming processes.

MT-3202 Corrosion Science and Engineering L-T-P-C (3-0-0-3)

Course content and List of books:

Module 1: Principles of Corrosion 6 Lectures

Introduction, Importance of Corrosion, Economics of corrosion.Electrochemical and thermodynamic principles, Nernst equation and electrode potentials of metals.

Module 2: Galvanic Series 8 Lectures

EMF and Galvanic series, Merits and demerits; Origin of Pourbaix diagram and its importance. Exchange current density, Polarisation, Concentration, Activation and Resistance, Tafel equation; Passivity, Electrochemical behaviour of active/ passive metals, Flade potential, Theories of passivity.

Module 3: Types of Corrosion 8 Lectures

Atmospheric, Pitting, De-alloying, Stress corrosion cracking, intergranular corrosion, Corrosion fatigue, Fretting corrosion and high temperature oxidation, Causes and remedial measures. Purpose of testing, laboratory, semi plant and field tests, susceptibility tests for IGC, strees corrosion cracking and pitting, sequential procedure for laboratory and onsite corrosion investigations, corrosion auditing and corrosion map of India.

Module 4: Protection against Corrosion **8 Lectures**

Corrosion prevention by design improvements, anodic and cathodic protection, metallic, non metallic and inorganic coatings, Mechanical and chemical methods, Various corrosion inhibitors.

Reference Books:

1. Fontana M.C., Corrosion Engineering, McGraw Hill.
2. Glasstone S., An Introduction to Electrochemistry, Van Nostrand.
3. Narain S. and Saran R., An Introduction to Electrometallurgy, Standard Publishers.
4. Scully J.C., The Fundamentals of Corrosion, Pergamon.

Course outcome (COs):

CO_1- Able to understand theoretical basis of environmental degradation of metallic materials

CO_2- To know various anodic and cathodic reactions and their thermodynamic feasibility

CO_3- To understand forms of corrosion and their mechanisms

CO_4-To understand methods used for corrosion testing

MT-3203 Extraction of Non Ferrous Metals L-T-P-C **(3-0-0-3)**

Course content and List of books:

Module 1:Principles of Metal Extraction **4 Lectures**

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.

Module 2: Aluminium **4 Lectures**

Bayer's process and factors affecting its operation, Hall- Heroult process: Principle and practices, anode effect, refining of aluminum. Alternate methods of production of alumina and aluminium.

Module 3: Copper **4 Lectures**

Roasting of sulphides, Matte smelting, Converting; Refining, Byproducts recovery; Recent developments, Continuous copper production processes, Hydrometallurgy of Copper.

Module 4: Zinc **4 Lectures**

Pyrometallurgy of Zinc; Principle and practices of roasting; sintering and smelting; Hydrometallurgy of Zinc.

Module 5: Lead **4 Lectures**

Agglomeration of galena concentrates and roasting, blast furnace smelting, refining of lead bullion.

Module 6: Uranium **4 Lectures**

Process for the digestion of uranium ores; Purification of crude salts; Production of reactor grade UO2.

Module 7: Titanium and other Metals **6 Lectures**

Methods of upgrading Ilmenite; Chlorination of Titania, Kroll and Hunter processes; Consolidation and refining. Other Metals: Simplified flow sheets and relevant chemical principles of extraction of Ni, Mg, Au, Ag, Sn, Zr.

Reference Books:

1. Ray H.S., Sridhar R. & Abraham K.P., Extraction of Non Ferrous Metals, Affiliated East West.

2. Biswas A.K. & Davenport W.G., Extractive Metallurgy of Copper, Pergamon.

3. Zelikman A.N., Krein O.E. &Samsonov G.V., Metallurgy of Rare Metals, Israel Program for Scientific Translation.

4. Burkhin A.R. (ed), Production of Al & Al2O3, Wiley.

Course outcome (COs):

Classify the ores of copper, zinc, lead, nickel, aluminum, magnesium and uranium metals.

CO_1: Select techniques for extraction of common, light and nuclear reactor metals.

CO_2: Understand the refining processes for copper, zinc, lead, nickel, aluminum, magnesium and uranium.

CO_3: Draw flow sheets for the extraction of non-ferrous metals.

MT-3204 Heat treatment Technology L-T-P-C **(3-0-0-3)**

Course content and List of books:

Module 1: Principles of Heat Treatment **8 Lectures**

Objectives and variables involved in heat treatment. Role of alloying elements including microalloying.Decomposition of Austenite, Pearlitic, Bainitic and Martensitic transformations.Limitations of Fe- C diagram. TTT and CCT diagrams.

Module 2: Heat Treatment Techniques **8 Lectures**

Annealing: (Full, Homogenising, spheroidisation and stress relieving), Normalising, Comparison of annealing and normalizing. Hardening: Objectives, Volume and surface hardening, Austenitising temperature and internal stresses, Quenching medium and methods, Retained austenite and defects in hardening. Tempering of steels, Aims and stages of tempering, Tempering of alloy steels and multiple tempering.

Module 3: Thermomechanical Treatments **6 Lectures**

Thermomechanical treatment of steels, Principles and practices.Ausforming and isoforming; Heat treatment of alloy steel castings and forgings. Heat treatment of cast iron, malleable cast iron and S.G iron.

Module 4: Heat Treatment of Metals and Alloys **8 Lectures**

Heat treatment of general engineering steels: Stainless steel, Hadfield steel, Spring steels, Bearing steels, Tool steels, HSLA steels, Maraging steels and dual phase steels. Heat treatment of Non ferrous metals and alloys, Brasses, Bronzes, Al and Mg - alloys.Heat treatment defects and their rectification.Advances in heat treatment technology.

Reference Books:

1. Reed Hill R.E., Physical Metallurgy Principles, Affiliated East West.
2. Sharma R.C., Principles of Heat Treatment of Steels, New Age International.
3. Sinha A.K., Physical Metallurgy Handbook, McGraw Hill.
4. Singh V., Heat Treatment of Metals, Standard Publishers.
5. Brooks C.R., Heat Treatment, Structure and Properties of Non Ferrous Alloys, ASM. 25

Course outcome (COs):

CO_1: Develop the concept behind selection of a heating rate, holding temperature, holding time and cooling rate to obtain desired properties in the job piece.

CO_2: Understand the effect of various heat treatment parameters on the final properties of the work piece.

CO_3: Modification of the microstructure with the help of suitable heat treatment cycle.

MT-3205 Characterization of Materials L-T-P-C (3-0-0-3)

Course content and List of books:

Module 1: Scanning electron microscope 8 Lectures

Modes of operation, Study of surface topography and elemental composition analysis, Electron probe analysis (EPMA/ EDX) and Auger spectroscopy.

Module 2:Transmission electron microscopy 8 Lectures

Imaging and different modes, bright and dark field imaging, selected area diffraction, specimen preparation techniques. Advanced microscopic techniques: AFM

Module 3: Thermal characterization techniques 8 Lectures

Theory, TGA, Instrumentation, and applications. DTA, Apparatus, methodology, applications; DSC, applications, Dilatometer.

Module 4:Chemical characterization techniques: 8 Lectures

Principle underlying techniques, Infrared spectroscopy, Emission spectroscopy, Chromatography techniques.Resistivity and Magnetic measurements.Structure- Property co-relationship.

Reference Books:

1. Cullity B.D., Elements of X-Ray Diffraction, Addition Wesley.

2. Shridhar G., Ghosh C.S. and Goswami N.G., Materials Characterization Techniques. (ed), NML Jamshedpur.

3. Williams, D.B. & Carter C.B. , Transmission Electron Microscopy: A Text Book of Materials science. 4. Krishna, R., Ananthraman T.R., Pande C.S., Arora, O.P., Advanced Techniques for Microstructural Characterization (ed), Trans Tech Publication

Course Outcomes (COs)

At the end of the course, students will be able:

CO_1: An understanding of, image formation by glass and electromagnetic lenses, the physics of scattering, the construction of various types of electron microscope, the function of the various parts and methods of image formation. This course teaches the students to use light microscope (LM), the scanning and transmission electron microscope (SEM & TEM), and X-ray diffraction and scattering.

CO_2: Describe the theories and construction of TEM, SEM and reflection optical microscope

(OM), the factor that controls the resolution, interference, and contrast mechanism. An understanding of methods of sample preparation for SEM and TEM.

CO_3: Calculate intensities of microscope image of a one-dimensional diffractions grating using bright-field, dark-field, and phase contrast apertures.

CO_4: Given a powder specimen of a materials with simple crystal structure, be able to collect analyze and understand powder diffraction data. Be able to use Ewald sphere construction, and calculations of structure factors to predict diffraction conditions and intensities from a three-dimensional crystal. Be able to calculate estimate of x-ray mass absorption coefficient at x-ray energies.

CO_5: To calculate estimates of AES, XRF, EELS etc. and able to utilize EDS, and WDS results for micromechanical analysis. Upon completion of the course, the students will be able to suggest common characterization techniques for the characterization of surfaces, particles, crystal structures, and microstructures, analyze the information such as methods give and relate it to current methods for the modification of materials.

SEMESTER VII

MT-4101 Composite Materials	L-T-P-C	**(3-0-0-3)**

Course content and List of books:

Module 1: Introduction **5 Lectures**

Introduction to composites, Matrices, Reinforcements, Classifications, applications, advantages, Fundamental concept of reinforcement, Review of current developments.

Module 2: Introduction **5 Lectures**

Design, fabrication and economic considerations; Basic mechanics of reinforcement, Stiffness of parallel arrays of fibers in a matrix.Discontinuous and particulate reinforcement.Fibers and Resin materials.

Module 3: Introduction **5 Lectures**

Rule of mixtures, critical fiber length, Short and continuous fibers, Fiber orientations; Matrix and reinforcement materials, Polymeric matrices, Metallic matrices, Ceramic matrices, Particulates, flakes, whiskers, Fibers: Glass, aramid, alumina, silicon carbide.

Module 4: Introduction **5 Lectures**

Nature and Manufacture of Glass, Carbon and aramid fibres.Review of the principal thermosetting and thermoplastic polymer matrix systems for composites.

Module 5:Polymer matrix composites **5 Lectures**

Polymer matrix composites, CFRP and carbon- carbon composites; Types, Manufacturing, processing methods, Interfaces, Properties, Applications. Toughening mechanisms, Fiber forms, Prepregs, The role of interface. The nature of fiber surfaces, Wetting and adhesion, Strength, stiffness, fracture toughness and toughening mechanism of composites, strength of unidirectional composites.Application of fracture mechanics to composite materials.

Module 6: Nano-composites **5 Lectures**

Synthesis and properties of nano-composites.

Reference Books:

1. Chawla, Composite Materials Science and Engineering, Springer.

2. Hull, An Introduction to Composite Materials, Cambridge.

3. Mathews and Rawlings, Composite Materials: Engineering and Science, Chapman and Hall.

Course Outcomes (COs)

At the end of the course, students will be able to:

CO_1: Describe synthesis, processing and properties of Fibers for composite reinforcements.

CO_2: Examine bonding and properties of composite interfaces. To provide guidelines for selectionof the matrix materials.

CO_3: Describe key processing techniques for producing metal-, ceramic-, and polymer-matrixcomposites.

CO_4: Demonstrate the relationship among synthesis, processing, and properties in composite materials.

CO_5: Analyze the mechanics of the composite properties. To provide theoretical treatment of the composite properties.

MT-4102 Environmental and Pollution control in Iron and Steel Industry

L-T-P-C **(2-0-2-0)**

Course content and List of books:

Module-I **5 Lectures**

Various types of solid, liquid and gaseous pollutants and their harmful effects;

Module-II **5 Lectures**

Environmental impact assessment in metallurgical Industries; Pollutant emissions from integrated iron and steel plants, Sponge iron plants,

Module-III **5 Lectures**

Coal washeries, Environmental aspects of coal and metal mines; Management of solid, liquid and gas wastes generated during iron and steel making operations;

Module-IV **5 Lectures**

Environmental audit; Preventive measures to reduce atmospheric pollution from these industries; scope of alternative energy sources to combat pollution from metallurgical industries.

Module-V **5 Lectures**

Environmental legislation related to metallurgical industries.

Reference Books:

1. Pandey, G.N, A Text book for energy system engineering, Vikas publishing
2. Rao, C.S, Environmental pollution control Engineering, Wiley Eastern Limited
3. Ray, H.S et al (ed), Energy and the mineral and metallurgical industries, Allied publishers
4. Nathanson, J.A, Basic environmental Technology, Prentice Hall

Course outcomes (CO_s)

At the end of the course, students will be able to:

CO1: explain several kinds of solid, liquid and gaseous contaminants and their impact of environment and human health

CO2: relate various process involoved in the metallurgical Industries and pollutant released from them

CO3: describe various regulatory laws and preventive measures to reduce pollution from metallurgical industries

MT-4103 Industrial Engineering and Management L-T-P-C **(2-0-0-2)**

Course content and List of books:

Module 1: Introduction **5 Lectures**

Factory Planning: Types of industrial organizations, organizational structures. Management functions and concepts.Plant location and layout.

Module 2:Financial Management **5 Lectures**

Financial Management: Functions, Relevance of fixed and working capital, Elements of cost, Depreciation, Break even analysis, Budget and budgetary control.

Module 3:Production Management **5 Lectures**

Production Management: Production and productivity, productions, planning & control, sales fare casting, Inventory control.

Module 4:Project Management **5 Lectures**

Project Management: Elementary concepts of operation research, networking, CPM & PERT.

Module 5:Quality Control **5 Lectures**

Concepts of quality control, statistical quality control, quality circles and total quality management, ISO standards. Personnel Management: Leadership & motivation work study, time and motion, wages and incentives.

Module 6:Management information system **5 Lectures**

Management information system: Aims, Characteristics, Designs and implementation. Entrepreneurship: Relevance and benefit, Essential qualities of Entrepreneur, preparation of prefect report, feasibility study, Market survey, Agencies available for financial and technical assistance.

Reference Books:

1. Bangra T.R. & Sharma S.C., Industrial Organization and Engineering Economics, Khanna Publishers.
2. Khanna O.P. Industrial engineering and Management, DhanpatRai& Sons.
3. Gupta C.B. &Shrinivasan N.P., Entrepreneural Development, S.Chand& Sons.
4. Shrinath L.S. PERT and CPM- Principles and Application, Affiliated East West.

Course outcomes (CO_2)

CO_1 Able to understand the functions of production system its planning and control.

CO_2 Able to make demand forecasts in the manufacturing sectors using selected quantitative and qualitative techniques.

CO_3 Able to explain the importance and function of pre planning and post planning of production system.

CO_4 Able to solve inventory problems and to be able to apply selected techniques for its control and management under dependent and independent circumstances.

CO_5 Understand plant layout, building layout and location theory.

CO_6 Able to Understand Work System Design, Work Measurements

CO_7 Able to Understand Project Management, PERT, CPM etc.

MT-4104 Engineering Economics L-T-P-C **(2-0-0-2)**

Course content and List of books:

Module 1: Introduction 4 Lectures

Definition, nature and scope of the subject, central problems of economic science, micro-economics.

Module 2: Theory of production 6 Lectures

Theory of production: law of returns, marginal productivity theory, determination of optimum input levels under cost or output restriction, expansion path, long run and short run function, supply functions and elasticity of supply.

Module 3:Theory of consumer behaviour 10 Lectures

Theory of consumer behaviour: Determination of optimum levels of consumption. Income-consumption curve, derivation of demand function, elasticity of demand and slutsky's equation.Perfect competition and pricing of output.Market imperfections and the determination of equilibrium price and output.Classical and Keynesian theories of income employment and output.Multiplier and accelerator. Consumption function, capital budgeting. Theories of inflation, methods of credit control, fiscal policy and full employment. Cyclical fluctuations.

Reference Books:

1.Banga, T.R and Sharma, S.C, Industrial organization and Engineering Economics, Khanna Publishers.

2. Khanna, O.P, Industrial Engineering and Management, DhanpatRai and Sons

Course outcomes (CO_s):

Students will be able to

CO_1: Describe the role of economics in the decision making process and perform calculations in regard to interest formulas

CO_2: Estimate the Present, annual and future worth comparisons for cash flows

CO_3: Calculate the rate of return, depreciation charges and income taxes

CO_4: Enumerate different cost entities in estimation and costing

CO_5: Explain the importance of finance functions, financial ratios and solve related problems

CO_6: Explain the elements of budgeting and bench marking

SEMESTER –VIII

MT-4201 Organisational behaviour and Industrial Psychology L-T-P-C (3-0-0-3)

Course content and List of books:

Module 1: 10Lectures

Scope of scientific psychology & industrial psychology, Basis process, perception. Training & Learning: Human variables, selection and placement: Intelligence, MA & IQ measurement.

Module 2: 10 Lectures

Personality: Development, Approaches, Assessment, tests, selection and placement, job analysis, interviewing, psychological test, decision making process, motivation and work;

Module 3: 10 Lectures

Needs: Hierarchy of needs, leadership, supervision. 28 Ergonomics: Three process, work space& human factors in job design. Working environment, noise, atmospheric conditions and illumination.

Reference Books:

1. Parrek U., Understanding Organizational Behavior.
2. Robbins S., Organizational Behavior.
3. Luthans F., Organizational Behavior.
4. Prasad L.M., Organizational Behavior, S. Chand.

Course outcomes (COs)

CO1: Understanding Human Relation, Human Engineering

CO2: Recruitment, Selection and placement

CO3: Development and Training of Personnel.

CO4: Accident Prevention

CO5: Promotional Schemes and Wage and salary Administration

CO7: Motivation, Attitude and Morale.

MT- 3231 Elective I

MT-3231 Methods of Casting L-T-P-C **(3-0-0-3)**

Course content and List of books:

Module I: Principles of casting design, pattern design considerations, pattern allowances, pattern design and construction **10 Lectures**

Module II: Design of different types of cores and core prints. **08 Lectures**

Module III: Fundamentals of fluid flow, design of gating system, slag traps and filters etc. Risering curves, NRL, Caine method, Gating systems and their characteristics.

08 Lectures)

Module **IV:** Directional and progressive solidification, differential methods of feeder design, feeding distance, feeding efficiency. **08 Lectures**

Reference Books:

1. Heine R.W., Lopper C.R. & Rosenthal P.C., Principles of Metal Casting, McGraw Hill.

2. Davis, G.J., Solidification in Casting, Applied Sciences.

3. Beeley P.R., Foundry Technology, Butterworth.

4. Kondic V., Metallurgical Principles of Foundry, Edward Arnold

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Course outcomes (COs)

At the end of the course, students will be able to:

CO_1: Have the basic knowledge for pattern design.

CO_2: Have an Understand the technology variables and complexity involved in producing a core.

CO_3: To impart knowledge about principles/methods of casting with detail design of gating/riser system needed for casting

CO_4: To inculcate the principle, thermal and metallurgical aspects during solidification of metal and alloys.

MT-3232 Materials Handling L-T-P-C **(3-0-0-3)**

Course content and List of books:

Module 1: Objective of Materials Handling System 10 Lectures

Objectives of material handling systems, material handling engineering survey, basic features of handling, types of material handling systems, various material handling considerations including combined handling, space for movements, analysis of handling methods, economical and technical considerations of handling equipments, cost analysis of material handling systems.

Module 2: Material handling equipments 10 Lectures

Material handling equipments, types of material handling equipment; selection and maintenance of material handling equipments used in foundries, forging machinery and assembly shops. Lifting and lowering devices, Conveying devices; Design of belt conveyers, Use of limit switches and Micro processors, Programmable logic controllers; Automation in Foundries; Use of robots; Kinematics of industrial robots. Amount of equipments required and predicting in process inventory by graphical technique.

Module 3: Others 10 Lectures

Procedures for travel charting, numerical problems in optimum arrangement of various departments and shops under given constraints and to check their effectiveness.

Reference Books:

1. Plant Layout and design, Moore
2. Plant Layout and Material handling, Apple
3. Plant Layout, Shubhin
4. Construction management, Verma, M.

Course outcomes (COs)

CO1: Describe and determine the effect of product, process, and schedule design parameters on plant layout and materials handling systems design.

CO2: Identify the characteristics of product and process layouts and their needs in terms of materials handling.

CO3: Develop and analyze plant layouts using manual and computer aided software methodologies.

CO4: Identify and select various types of material handling equipment.

CO5: Design material handling systems for a variety of scenarios pertaining to manufacturing and service industry.

MT 3233 Failure Analysis L-T-P-C **(3-0-0-3)**

Course content and List of books:

Module 1: 10Lectures

Types of failure and techniques for failure analysis Failure data retrieval, Procedure steps for investigation of a failure for failure analysis. Failure analysis methodology,

Module 2: 10Lectures

Tools and Techniques of Failure analysis. . Reliability concept and hazard function, life prediction, condition monitoring, application of Poisson, Exponential and Weibull distributions for reliability, bath tub curve, parallel and series system, mean time between failures & life testing. Some case studies of failure analysis.

Module 3: 10Lectures

Introduction to quality management, concept of ISO 9000, ISO 14000, QS 9000; Inspection; Inspection by sampling.

Reference Books:

1. Metals Handbook, Failure Analysis and Prevention, Vol.10 ASM.
2. Colangelo V.J. &Heiser F.A., Analysis of Metallurgical Failures, John Wiley.

Course outcomes (COs)

After completion of the course the students shall be able to:

CO1: Explain the significance of failure analysis in engineering design

CO2: Design and implement an appropriate strategy to handle the specific failure component

CO3: Implement detailed root-cause analysis.

CO4: Apply various tools and techniques to identify the failure mechanism

MT-3234 Advanced Materials L-T-P-C **(3-0-0-3)**

Course content and List of books:

Module 1: Advanced Materials 6 Lectures

Processing of Advanced materials: Super plastic, spray forming, rapid solidification.

Module 2:Materials selection and design 8 Lectures

Nanostructures, Nano materials, Nano composites. Bio materials: Metallic bio materials like 316L stainless steel, Co-Cr alloys, Ti6 Al4V, ceramic bio materials like Alumina, Zirconia, carbon hydroxyapatite, polymeric bio materials like ultra high molecular weight polyethylene, polyurethane.

Module 3: Smart Materials **8 Lectures**

Smart Materials: Piezo electric materials, shape memory alloys and shape memory polymers. High performance alloys: Nickel super alloys, Ti-alloys, Al-Li alloys, Haste alloy, Inconel, Monel, Nitronic, Co-based alloys and commercially available pure Ni-alloys.

Module 4: Nuclear Materials **8 Lectures**

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

Reference Books:

1. Gandhi M.V., Thompson B.S., Smart Materials and Structures, Chapman and Hall.

2. Ray A.K. (ed), Advanced Materials, Allied Publishers.

3. Rama Rao P. (ed), Advances in Materials and Their Applications, Wiley Eastern Ltd. 4. Bhushan B., Nano Technology (ed), Springer

Course outcomes (COs)

CO_1: Describe metallic and non-metallic materials.

CO_2: Explain preparation of high strength materials.

CO_3: Suggest materials for low and high temperature applications.

CO_4. : Integrate knowledge of different types of advanced engineering materials

CO_5: Analyses problem and find appropriate solution for use of materials.

MT-3235 Surface Engineering L-T-P-C **(3-0-0-3)**

Course content and List of books:

Module 1: Surface Engineering **8 Lectures**

Introduction: Material surfaces and their importance in tribology.

Module 2:Surface modification processes **8 Lectures**

Case hardening, Short peening, Chemical vapour deposition, Physical vapour deposition, Thermal barrier coatings, Plasma deposition, Sputter coating, Laser processing, Ion implantation, Electro and electroless plating processes, Surface cleaning and finishing processes, Testing and evaluation of surface coatings.

Module 3: Friction **8 Lectures**

Fundamentals, Types and measurement of solid, liquid and gaseous friction.Friction heat and calculation.

Module 4: Wear **8 Lectures**

Wear: Modes of adhesive, abrasive, erosive, fretting, Corrosive, erosive- corrosive, sliding, rolling, impact and lamination wear, Worn surface topography, debris analysis and wear mechanism maps.

Module 5: Lubrication **6 Lectures**

Lubricants and additives, mechanism of solid, liquid and gaseous lubricants. Mode of friction and wear: Al- Si, Ti- alloys, Cemented carbides and metal, polymer and ceramic matrix composites. Friction and wear: Sliding bearings, Pistons, Cylinders, Brakes, Cutting Tools, Dies, Electrical contacts.

Reference Books:

1. Sarkar, A.D., Wear of Metals, Pergamon
2. Rabinowiez, E., Friction and Wear of Materials, Wiley
3. Hand book, Friction, Lubrication and Wear Technology, Vol. 18, ASM
4. Surface treatments for protection, Series3, No. 10, , The institute of metallurgist series.

Course outcomes (COs):

CO_1: Discuss the basic principles of surface engineering

CO_2: Differentiate diffusion and overlay coatings

CO_3: Explain the principles of thermo-chemical surface engineering techniques and thin film coatings

CO_4: Evaluate the performance of various coatings by different testing methods

MT-3236 Non Metallic Materials L-T-P-C **(3-0-0-3)**

Course content and List of books:

Module 1: Introduction **6 Lectures**

Definition and classification of materials, comparison of properties of metals and nonmetallic materials.Nature of bonding.

Module 2: Ceramics **6 Lectures**

Structure, defects.Ionic and semiconducting behaviour. Processing techniques. Glasses and glass-ceramics, glass fibres. Structural ceramics: fracture toughness, toughening mechanisms.

Module 3: Special Ceramics **6 Lectures**

Special ceramics: Electro-optic, dielectric, ferroelectric, piezoelectric, magnetic, superconducting, laser and dilute magnetic and bio-ceramics.

Module 4: Polymers **6 Lectures**

Structure, properties and applications of thermoplastics and thermosets.Conducting and biopolymers.

Module 5: Biomaterials **6 Lectures**

Introduction to biomaterials, Structure and properties of biomaterials.Different types of biomaterials. Preparation methods. Physical Characterization. Cell biomaterial interactions. Applications.

Reference Books:

1. W.D.S. Kingrey: Introduction to Ceramics, John Wiley.
2. W.S. Smith: Principles of Materials Science and Engineering, McGraw-Hill.
3. V. Raghavan: Materials Science and Engineering, Prentice-Hall.
4. Robert J. Young, Peter A. Lovell:Introduction to Polymers, Third Edition
5. Biomaterials: A Nano Approach, S. Ramakrishna, M. Ramalingam, T.S.S. Kumar, W. O. Soboyejo, CRC Press, Taylor and Francis Group, 2010.

Course outcomes (COS):

The students are expected to understand about polymer and ceramic materials. They will also gain a view about biomaterials. This will help them to utilize their in future carrier.

Elective II

MT-4141 Modern NDT L-T-P-C **(2-0-2-3)**

Course content and List of books:

Module 1: Modern NDT **6 Lectures**

Review of conventional methods of non-destructive testing. Acoustic emission inspection: Types, basic concepts, instrumentation and read out, signal description, background noise, inspection of pressure vessels, flaw location, inspection of wire ropes, welds, ceramic materials, composite materials.

Module 2: Leak Testing **8 Lectures**

Visible indications, electronic indications, basic methods of leakage measurements, characteristics of gaseous tracers in leak testing, reference standards. Calibration of standard

reference leaks, safety aspects of leak testing. Thermography: Contact and non contact inspection methods, heat sensitive paints and papers; thermally quenched phosphors liquid crystals, techniques for applying liquid crystals, calibration and sensitivity; other temperature sensitive coatings; non-contact thermographic inspection- advantages and limitations, infrared radiation and infrared detectors. Instrumentation and methods, applications.

Module 3: Optical Holography **8 Lectures**

Laser fundamentals, holography, recording and reconstruction, holographic interferometry, real time, double exposure and time averaged techniques, holographic NDT, methods of stressing and fringe analysis, typical applications, advantages and limitations. Acoustical holography: Liquid surface acoustical holography, optical system, object size and shape, sensitivity and resolution, commercial liquid surface equipment; scanning acoustical holography, reconstruction, object size, sensitivity and resolution, commercial scanning equipment, read out methods, calibration, interpretation of results, applications, inspection of welds in thick materials.

Module 4: Stress Analysis **8 Lectures**

Polariscope, calibration of photoelastic materials, isochromatic and isoclinical fringes, stress determination, time edge effects, Moire fringes techniques, photo elasticity, strain gauges, X-ray residual stress analysis. Magnetic resonance imaging: Magnetic resonance phenomena, chemical shift, relaxation phenomena, back projection imaging, practical consideration of experimental set up, magnetic resonance imaging systems, applications. Acceptance standards.

Reference Books:

1. Miller, R and Paul, M; Non destructive testing handbook; Acoustic emission testing, Vol 5, American society for non destructive testing, 1987.
2. Spanner, J.C; Acoustic emission techniques and applications., Latex publishing, 1974
3. American Society for Metals, Non destructive inspection and quality control; Metals handbook, Vol 11, 8th edition.
4. ASM handbook, Non destructive testing and quality control, Vol. 17.

At the end of the course, students will be able to:

CO_1.Understand basic theoretical concepts of various conventional NDT methods like

1.visual examination,2.leakage testing,3.penetrant methods(dye/fluroscence),4.magnetic particle inspection,5.sonic and ultrasonic(acoustic)methods,6.radiography,7.thermal methods,8.electrical methods and etc.related to all these.

CO_2.Students will also learn importance of the subject because of its applications in manufacturing industries as it is helpful in quality assurance of any component.Similarly it can assure the quality of any type of structure including critical areas where difficult to work by human being.Residual Life Assesment (RLA) study of critical components and structures can be done by utilizing these techniques.Different techniques in this subject like Ultrasonics,Radiography ,Eddy Current are very much helpful in assuring the quality of the important components.

CO_3. As mentioned above this subject is very much helpful to graduate engineers,managers,policy planners in manufacturing industry and construction industry.Our students both B.Tech and Advance Diploma are gaining much out of this subject.Even our M.Tech students are impressed with the subject.

MT-4142 Instrumentation and Control L-T-P-C **(2-0-0-2)**

Course content and List of books:

Module 1: Generalized measurement systems. 12 Lectures

Basic standards; static and dynamic measurements; measurement of temperature, pressure, velocity, force strain, vibration and acceleration by transducers.

Module 2: Transducers 12 Lectures

Role of transducers in automatic control systems, Feed back systems and their characteristics. P.I.D. controllers; Response characteristics and compensation of electrical, hydraulic and pneumatic systems.

Reference Books:

1. L.E. Murr: Electron and Ion Microscopy and Microanalysis - Principles and Applications, Marcel Dekker.
2. C.R. Brundle and A.D. Baker: Electron Spectroscopy, Vol.l-3, Academic.
3. D.A.Skoog et al.: Principles of Instrumental Analysis, Brooks Cole
4. H.H. Willard et.al.: Instrumental Methods of Analysis, CBS.

Course outcomes (CO_S):

CO_1: Students will learn about the common methods of bulk and surface analysis and how to select the best instrumental method given a particular measurement need.

MT-4143 Computer application in Metallurgy L-T-P-C **(2-0-0-2)**

Course content and List of books:

Module I: Numerical methods for solution of ordinary differential equations, Application of regression analysis and curve fitting techniques, Composition-process-microstructure-property correlation in materials design, Multiscale understanding of materials structure, Modelling and Simulations, Role of modelling and simulations in materials design, Basic steps for the development of model, Characteristic features of simulation.

(06 Lectures)

Module II: Quantum mechanical description of single electron, Many body (electron) system, Density Functional Theory, Basis of DFT in dealing with many body problems, Working algorithm of DFT, Cellular automata, Application of cellular automata in microstructural simulations, Cellular automata algorithm for recrystallization and grain growth in the form of flow diagram, Calculation of phase diagrams, stereographic projections.

(06 Lectures)

Module III: Phase field modeling, Driving force for microstructural evolution in phase field modelling, Concept of order parameter in phase field, conservative and non-conservative phase filed variables, Conservative and non-conservative Diffused interface approach and sharp interface approach, Cahn-Hillard and Allen-Cahn approach, Computer applications for energy & material balance in B.F. and BOF Steel making processes. **(06 Lectures)**

Module IV: Microstructure simulation techniques, Classical nucleation and growth, Basic theory, Numerical Kampmann-Wagner Model, Fuzzy interference system, Working principles, Fuzzy linguistic description, Fuzzification and defuzzification, Introduction to Artificial Neural Network (ANN), ANN as biologically inspired technique, Transfer function and back propagation algorithm, Numerical solution of partial differential equations pertinent to heat, mass & momentum transfer.

(06 Lectures)

Module V: Introduction to genetic algorithm (GA), Working principles of GA, Linear rank selection, evolution of the binary string (chromosome) through evaluation of fitness of solution, selection of solution, crossover and mutation, Molecular dynamic simulation, Computer applications in solidification, Newtonian principle in tracking the trajectory of particles, Potential energy diagrams and experiments in metallurgy. Analysis of test data using software.

(06 Lectures)

Reference Books:

1. Chapra S.C. and Canale S.C., Numerical Methods for Engineers, Tata McGraw Hill.

2. Szekley J.S., Evans J.W. and Brimakombe J.K., The Mathematical and Physical Modeling of Primary Metals Processing Operations, Wiley.

Course Outcomes (COs)

CO_1: Describe the challenges in integrated computational materials engineering

CO_2: Apply mesoscale modelling techniques to solve material problems

CO_3: Apply thermodynamic modelling for alloy design

CO_4: Apply FEA techniques for solving material related problems

MT-4144 Fracture Mechanics L-T-P-C **(2-0-0-2)**

Course content and List of books:

Module 1: Griffith Theory of Fracture 6 Lectures

Griffith's crack theory, stress intensity factor, stress analysis of cracks, strain energy release rate, Derivation of relationship between strain energy release rate and stress intensity factor, crack tip plastic zone, Dugdale's plastic strip model.

Module 2: Mode of Fracture 8 Lectures

Fracture mode transition: Plane stress vs. plane strain, crack opening displacement, plane strain fracture toughness (KIC) testing, Fracture toughness determination with elastic plastic analysis (JIC), concept of R-curve and Fracture toughness measurement using it, Microstructural aspect of fracture toughness, optimizing microstructure and alloy cleanliness to enhance fracture toughness. Fatigue stress life approach, Basquin's equation, Fatigue strain life approach, Low cycle fatigue, Cofin- Manson's equation, Fatigue total strain life relation,

Fatigue life prediction, Neuber's analysis for notched specimens, Fatigue crack growth rate, Paris law, fatigue life calculation using this approach.

Module 3: Fracture Analysis **6 Lectures**

Mechanism of fatigue crack nucleation and propagation, factors affecting fatigue crack growth rate, influence of load interaction, short fatigue crack; stress corrosion cracking and KIscc determination. Corrosion fatigue, temper embrittlement, hydrogen embrittlement, liquid metal embrittlement, neutron embrittlement

Reference Books:

1. Hertzberg, R.W., Deformation and fracture mechanics of engineering materials, John Wiley.

2. Dieter, G.E., Mechanical Metallurgy, McGraw Hill

3. Metal Hand book, Failure analysis and prevention (Volume- XI), ASM Pub.

4. Metal Hand book, Fractography (Volume- XII), ASM Pub

Course outcomes (COs):

CO1: Correctly apply fracture mechanics to predict mechanics to predict brittle fracture. Identify and describe the basic fracture and fatigue mechanisms

CO2 Understand crack resistance and energy release rate for crack criticallty. Application of Linear Elastic Fracture Mechanics on brittle materials.

CO3: Student shall be able to identify the plane stress and plane strain conditions based on the shape and size of plastic zones. This concept made them capable to select the type of analysis subjected to plane stress and plain strain condition. Understanding of experimental techniques to determine the critical values of parameters at crack tip.

MT-4145 Physics of Metals L-T-P-C **(2-0-0-2)**

Course content and List of books:

Module 1: Crystallography **5 Lectures**

Crystalline and amorphous structures, Elements of crystal symmetry, symmetry elements and axes, two, three, four and six fold symmetry, review of atomic bonding.

Module 2:Order-disorder transformations **5 Lectures**

Ordering, Degrees of long range and short range ordering, Anti phase domain, super lattice, Elements of super lattice theories, properties and applications.

Module 3: Semiconductors and Magnetic properties **5 Lectures**

Alloy phases; Conductors and insulators, semi conductors, P- and N- type semi conductors. Magnetic Properties: Dia, Para and Ferro- magnetism, Domain theory of Ferro magnetism, Anti ferromagnetism and Ferrites, Hysteresis loop, soft magnetic materials, Hard magnetic Materials, Super conductivity, BCS theory, Type- I and Type- II super conductors.

Module 4:Elements of X-ray diffraction **5 Lectures**

X- Ray, Bragg's Law, Lau, Rotating crystal and powder methods, structure determinations with the help of X-Ray. Stereographic Projections.

Reference and Text Books:

1. Reed Hill R.E., Physical Metallurgy Principles, Affiliated East West.
2. Kakani S.L. and Kakani A., Materials Science, New Age International.
3. Higgins R.A., Engineering Metallurgy, Standard Publishers.
4. Raghavan V., Materials Science and Engineering, PHI.

Course outcomes (COs):

CO_1: Understand the different bonding mechanisms in solids, Learn symmetry operations in crystallography and Bravais lattice systems.

CO_2: Learn diffuse and order-disorder type phase transition. Understand the mechanism of supper lattice formation and its thermodynamic models.

CO_3: Learn basic of semiconducting materials. Understand basic magnetic property of metals and alloy, Phenomenology of superconductivity.

CO_4: Learn basics of powder X-ray diffraction, single crystal X-ray diffraction and their use for determination of crystal structure.

MT-4146 Modelling and Simulation in Metallurgy L-T-P-C **(2-0-0-2)**

Course content and List of books:

Module 1: Modelling **10 Lectures**

Classification, functions, limitations and interrelationship of different types of models.Types and development of mathematical models.Development of rigorous and semirigorous physical models.Multi-scale modelling of materials.Phase-field methods for modelling solidification microstructures of metals and alloys.

Module 2: Simulation **10 Lectures**

Survey of simulation techniques.Molecular dynamics and Monte-Carlo simulations.Fuzzy logic, neural networks and genetic algorithms.

Module 3: Applications **10 Lectures**

Computation of phase diagrams using solution models and Monte-Carlo simulations.Modelling of blast furnace operations, steel making processes and materials processing.

Reference Books:

1. J.S.Szekely, J.W. Evans and J.K. Brimakombe: The Mathematical and Physical Modelling of Primary Metals Processing Operations, Wiley.

2. D. Mazumdar and J.W. Evans: Modelling of Steel Making Processes, CRC.

3. N. Provatas and K. Elder: Phase-field Methods in Materials Science and Engineering, Wiley-VCH.

4.S. Rajasekaran, G.A.V. Pai: Neural networks, Fuzzy Logic and Genetic AlgorithmsSynthesis and Applications, Prentice-Hall of India

Course outcomes (CO_s):

CO_1: Students will appreciate the importance of modeling and simulation methodologies and their potential application in supplementing and complementing experiments for achieving a comprehensive understanding of materials behaviour.

Elective III

MT- 4151 Secondary Steel Making L-T-P-C **(3-0-0) 30 Lectures**

Course content and List of books:

Module 1: Objective and Techniques **10 Lectures**

Objectives and techniques adopted in secondary steel making. Vacuum degassing processes: ladle degassing processes (VOD, VAD), Steam degassing processes, circulation degassing processes (RH,DH), Inert gas purging, ladle furnace etc.

Module 2: Slag Metallurgy **10 Lectures**

Role of slag and powders in inclusion control: Desulphurization, Dephosphorisations. Modification of inclusion morphologies, production of ultra low carbon, ultra low sulphur, ultra low phosphorus and inclusion free steels. Powder injection systems.

Module 3: Post Solidification Treatment **10 Lectures**

Production of alloy steel through post solidification treatments (VAR, ESR); Refractories used in secondary steel making furnaces, their properties and selection criteria. Process selection in secondary steel making.

Reference Books:

1. Ghosh A., Secondary Steelmaking- principle & Applications, CRC Press.
2. Ghosh A., Principles of Secondary Steelmaking Processing and Casting of Liquid Steel, Oxford & IBH Publication.
3. GhoshAhindra, Chatterjee A., Ironmaking and Steelmaking Theory and Practices, PHI Pvt. Ltd

Course outcomes (CO_s):

CO1-Develop clear understanding of the concept of clean steels – their characteristics and importance

CO2-Understand the fundamentals and practices of secondary steel making processes

CO3-To appreciate the science and technology of stainless steel making

CO4-Appreciate and evaluate Mass balance, thermodynamic parameters, kinetics etc. of reactions and processes

MT-4152 X-ray crystallography L-T-P-C **(3-0-0)**

Course content and List of books:

Module 1: Basic concepts in X-ray Crystallography **10 Lectures**

Use of X-Rays, electrons and neutrons for diffraction studies

Module 2: Fundamentals of crystallography **10 Lectures**

Fundamentals of crystallography, Reciprocal lattice. X-ray diffraction, Bragg's law, Factors affecting intensities of diffracted beams. Atomic scattering factor, structure factor, integrated intensity of diffracted beam, temperature factor, line broadening, Lorentz polarization factor.

Module 3: Powder diffraction methods **10 Lectures**

Lau patterns and orientation of single crystals.Lau, powder & rotating crystal method. Electron diffraction: selected area diffractions, convergent beams, electron diffraction and micro diffraction, Analysis of diffraction patterns. Stereographic projections. Techniques for studying bent crystals, textures, and order-disorder transformations.

Reference Books:

1. Cullity B.D., Element of X-Ray Diffraction, Addition Wesley.

2. Barret C.S. and Massalki T.B., Structure of Metals, McGraw Hill.

3. Chaterjee S.K., X-Ray Diffraction, its theory and applications.

4. Goodhow P.J., J. Humhreys, R. Beanland, Electron Microscopy & Analysis Taylor and Fransis publication.

Course outcomes (CO_s):

CO1-To know basics of crystallography

CO2-To understand point groups, space groups

CO3-To know diffraction from materials

CO4-To understand technique and analysis of X-ray diffraction

MT- 4153 Wear, Friction and & Lubrication L-T-P-C **(3-0-0)**

Course content and List of books:

Module 1: Friction **8 Lectures**

Importance of wear, friction & Lubrication Friction, Solid friction; Fundamentals, basic theories and mechanism; types of friction: sliding and rolling; friction in metals, alloys and composites; effect of parameters affecting friction; measurement of friction; frictional heating and calculations.

Module 2: Wear **8 Lectures**

Introduction to wear; surface damage; types of wear: solid-solid, solid-liquid and solid gas such as adhesion, abrasion, slurry erosion, cavitation erosion, liquid impingement erosion, fretting, erosion-corrosion, types of contacts: sliding, rolling; worn surface topography, debris analysis and wear mechanism mechanisms; parameters affecting wear.

Module 3: Lubrication **8 Lectures**

Lubricants & additives, mechanism of solid, liquid and gaseous lubricants. Friction and wear of different components Solid and rolling contact bearings, gears, seals, dynamic pistons, cylinders, connecting rods, push rods, drive shafts, brakes, IC engine parts, drive chains, cutting tools, dies and electrical contacts. Materials for friction and wear applications

Module 4:Alloys **6 Lectures**

Cast irons, carbon and alloy steels, stainless steels, bearing steels, tool steels, hardfacing alloys, aluminium alloys, intermetallics, and composites.

READING TEXTBOOK:

1. Wear of metals by A.D.Sarkar, Pergamon Press, Oxford
2. Engineering Tribology by PrasantaSahoo, PHI Learning Pvt Ltd, New Delhi
3. Principles and Applications of Trobology by Bhushan B, John wiley and Sons, New York
4. Friction and Wear of Materials by Rabinowicz.E,Jphn Wiley nd Sons, New York
5. Engineering Tribology by Williams. J.A, Oxford University Ptress, New York.

Course outcomes (CO_s):

CO1: Industrial importance of wear and abrasive wear behaviour of engineering materials.

CO2: Erosive wear of engineering materials and wear testing.

CO3: Sliding wear behaviour of metallic and non metallic materials.

CO4: Laws of friction and frictional behaviour of metals and polymers

CO5: Frictional behaviour of ceramic materials and fundamentals of lubrication and wear characterization.

MT- 4154 Nano Materials and Applications L-T-P-C **(3-0-0)**

Course content and List of books:

Module 1: Introduction **8 Lectures**

Types of nano materials, emergence and challenges in Nano Technology.Synthesis routes for nano materials. Bottom up and top down approaches; solid, liquid and gas phase synthesis, hybrid phase synthesis.

Module 2: Bulk Nanostructured Materials **8 Lectures**

Synthesis of bulk nano structured materials: Approaches & challenges. Properties of nano materials: Stability of nano materials, mechanical properties, optical, electrical and magnetic properties, Nano-diffusion.

Module 3: Characterization of Nanomaterials **8 Lectures**

Characterization of nano materials: Structural characterization by XRD, SEM, TEM, SPM. Chemical characterization by spectroscopy techniques, characterization of mechanical properties by nano indentation, hot compression testing, Fracture analysis.

Module 4: Applications **6 Lectures**

Application of nano materials: Electronics and optoelectronic applications, nano dots, biological applications, catalytic applications, quantum devices, application of carbon nano tubes, nano fluids, Future of Nano Technology.

Reference Books:

1. Pradeep T. Nano: The Essentials, McGraw Hill Publishing Co Ltd.

2. Mick Wilson et al, Nanotechnology, Overseas Press India Pvt. Ltd.

3. Charles P. Poole, Jr. Frank J. Owens, Introduction to Nano Technology, Wiley.

4. Gunter Schmid, Nanioparticles: From Theory to applications, Wiley-VCH VerlagGmbh& Co.

Course outcomes (COs):

COs: Discuss the significance, properties and applications of nanomaterials

COs: Distinguish various synthesis techniques for the preparation of nanomaterials

COs: Appraise the effect of size reduction on functional properties of materials

COs: Select suitable nanomaterials for advanced applications

MT- 4155 Biomaterials L-T-P-C **(3-0-0)**

Course content and List of books:

Module 1: Overview **8 Lectures**

Historical development;Materials in Medical Applications; Materials Properties for Bio-applications Biomaterials Classification and Synthesis: Metallic materials;Ceramic and glass implant materials;Polymeric implant materials;Collagen; Thin films; Grafts and coatings;Biologicalfunctional materials

Module 2: Structure **8 Lectures**

Cell Structure: Bone structure; Bone properties; Proteins; Bacteria structure; Antibacterial assay

Module 3: Cell **8 Lectures**

Cell-material Interaction: In vivo testing; Cell-material interaction; Cell-signalling; in vitro testing; Cytotoxicity; Clinical trials

Module 4: Tissue Engineering **6 Lectures**

Tissue Engineering: Scaffolds, cellular materials, stem cells, regeneration engineering

Readings Books

1. Buddy D. Ratner: Bio Material Science- An introduction to Materials in Medicine, Elsevier, 2013.

2. B. Basu, D. Katti and Ashok Kumar; Advanced Biomaterials: Fundamentals, Processing and Applications; John Wiley & Sons, Inc., USA, 2009.

3. S. V. Bhat,Biomaterials; 2nd Ed., Narosa Publishing House, 2006.

4. J. Park, R.S. Lakes, Biomaterials an introduction; 3rd Ed., Springer, 2007

Course Outcomes (COs):

CO_1: Discuss the materials science principles for bio-applications

CO_2: Design the processing methods for biomaterials

CO_3: Apply different characterization techniques to assess biomaterials properties

CO_4: Select materials for different bio-applications

MT- 4156 Functional Materials L-T-P-C **(3-0-0)**

Course content and List of books:

Module 1: Introduction 8 Lectures

The Origin of Functional Materials (FMs), Potential Applications of FMs, Classification of FMs, Processing Techniques: Powder Metallurgy Route, Melt-processing Route, Vacuum arc melting, Vacuum induction melting, Vapor deposition and types

Module 2: Specific Properties 8 Lectures

Specific properties of functional materials: Magnetic materials, Electronic Materials and Sensors, Electric Contact Materials, Conducting Thermoplastics and polymer composites, Surface coatings for functional applications, Biomaterials and Shape memory metals, Invar alloys

Module 3: Fuel Cells 6 Lectures

Batteries and fuel cells, solar energy harvesting, Reflective and antireflective layers, Waste heat recovery materials

Module 4: Microstructure-property correlations 8 Lectures

Microstructure-property correlations, characteristic dimensions and spatial variations, volume fraction, rules of mixture and effective field parameters; characterization of properties of FMs, macrostructural thermomechanical properties, effective material properties for ceramic-metal FMs, basic mathematical modeling.

Reading:

1. D.D.L. Chung: Engineering Materials for Technological Needs, Vol. 2- Functional Materials: Electrical, Dielectric, Electromagnetic, Optical and Magnetic Applications, World Scientific Publishing,2010.

2. D.D.L. Chung: Composite Materials- Functional Materials for Modern Technologies, Springer, 2002.

3. Hui-ShenShen: Functionally Graded Materials - Nonlinear Analysis of Plates and Shells, CRC Press,2009.

4. Y. Miyamoto, W.A. Kaysser, B.H. Rabin, A. Kawasaki, R.G. Ford (Eds): Functionally Graded Materials- Design, Processing and Applications, Springer, 1999.

Course Outcomes (CO_S):

CO_1: Classify functional materials
CO_2: Recognize basic concepts and structure and properties of a broad spectrum of functional materials
CO_3: Discuss processing methods of functional materials
CO_4: Select materials for advanced functional applications

Elective IV

MT- 4261 Electronic, Optical and Magnetic properties of Materials L-T-P-C

(3-0-0)

Course content and List of books:

Module 1: Electrical and Electronic Property **8 Lectures**

Review of free electron and band theories of solids, electrical conduction in metals and semiconductors, Hall effect, Temperature dependence of electrical conductivity, Thermal conductivity. Thermoelectric properties of metals and semiconductors.

Ionic conductivity, Super conductivity, Piezoelectric and ferroelectric properties of dielectric materials.

Module 2: Magnetism **8 Lectures**

Introduction to magnetism; Diamagnetism, Para-magnetism, ferromagnetism, anti-ferromagnetism and ferrimagnetism.Calculation of magnetic moment, Soft and hard magnetic materials.

Module 3: Optical properties **8 Lectures**

Optical properties, Refraction, Absorption, Absorption in dielectrics, photographic images, Luminescence, Lasers.Classification, methods of manufacture and fabrication techniques.Applications of these properties in optical fibers, magnetic data storage, solar cells, transistors and other devices.

Module 4: Experimental determination **8 Lectures**

Experimental determination of the electronic, optical and magnetic properties of materials.

Reference Books:

1. Hummel, R.E, Electronic properties of Materials, Springer
2. Raghavan, V, Materiasls Science and Engineering, Prentice Hall
3. Azaroff, L.I, Magnetic Materials
4. Kasap, S.O, Principles of electronic materials and devices, Tata McGraw Hill

Course Outcomes (CO_s):

CO_1: Comprehend the manufacturing processes of the semiconductor materials and wafer technology

CO_2: Discuss methods of integrated circuit fabrication

CO_3: Design methods for improving life of electronic components

CO_4: Apply principles of magnetism to design advanced magnetic materials

MT- 4262 Forging Die Design and Manufacturing L-T-P-C **(3-0-0)**

Course content and List of books:

Module 1: **6 Lectures**

Study of forging drawing and its simplification from die design point of view. Steps for die design. Location of parting line, Importance of Design of flash and gutter. Determination of flash width and thickness.

Module 2: **6 Lectures**

Design of edger, fuller, bender, blocker, finishing impression, Reduced Roll design, Preform design . Dovetail, cross, key and tapered key. Laws governing the design of the dies of horizontal forging machine. Design of punches and heading tools for up setter (horizontal forging machine). upsetting rule, coning Tool Design Method.

Module 3: **6Lectures**

Determination of stock size, tensile strength of material at the finishing temperature while forging. Capacity calculation of drop hammer, mechanical press, Determination of capacity of trimming press. Design of trimming and piercing tool, die clearance between punch and die. Design of stripping tool. Assembly detail for trimming.

Module 4: **6 Lectures**

Selection of the size of massive die blocks or insert dies. Production of die blocks. Technical requirements for sinking, re-sinking and rectification of dies, Die sinking methods like copy-milling, EDM, ECM etc.

Module 5: **4 Lectures**

Instruction for mounting, setting and working of dies, Die life improvement

Module 6: **4 Lectures**

Computer aided design of forging dies, Optimization of die design parameters, Optimum material utilization, Modeling and analysis of forging process using software

Reference Books:

1. Thomas, A. Forging Die design
2. Thomas, A. Forging Methods
3. Alton, Forging Die design and Practice
4. Cold and Hot Forging, Fundamentals and applications, ASM

Course outcomes:

At the end of the course, students will be able to:

CO_1: Understand basic of Die design , development of forging drg., metal flow in closed dies

CO_2: Design of flash and gutter , different preform impressions including finisher for a product

CO_3: Determine size of billet, die block size, capacity of different equipments needed

CO_4: Understand die manufacturing steps ,die sinking methods

CO_5: Understand die setting procedure for hammer & press

CO_6 : Optimize die design parameters for maximum yield.

MT- 4263 Light Metals and Alloys L-T-P-C **(3-0-0)**

Course content and List of books:

Module 1: General introduction **8 Lectures**

Strengthening by solid solution, precipitation, and dispersion of second phase particles, grain refinement and work hardening.

Module 2: Aluminum and its alloys **8 Lectures**

Production of Aluminum, Designation, temper and characteristics of cast and wrought alloys.Heat treatment of Aluminum alloys – Al-Si, Al-Cu, Al-Mg & Al-Zn-Mg systems.Development of high strength Aluminum alloys by non-equilibrium processing routes such as rapid solidification and powder metallurgy. Applications in consumer, automotive and aerospace industry.

Module 3: Magnesium and its alloys **8 Lectures**

Magnesium and its alloys: Production of Magnesium, Designation, temper and characteristics. Heat treatment of Magnesium alloys – Mg-Sn, Mg-Zn, Mg-Gd, Mg-Li systems.Development of high strength magnesium alloys.Applications in consumer, automotive and aerospace industry.

Module 4: Titanium and its alloys **6 Lectures**

Titanium and its alloys: Production of titanium. Heat treatment of Titanium and its alloys - alpha alloys, alpha - beta alloys, beta alloys. Applications in sports, automotive, aerospace and strategic industries.

Reading:

1. I.J.Polmear, Light Alloys - From Traditional alloys to nanocrystals, Fourth Edition, Butterworth Heinemann, 2005

2. R.W.Heine, C.R.Loper, P.C.Rosenthal, Principles of Metal Casting ,Tata McGraw Hill, 1976.

3. D.H. Kirkwood, M. Surey, P. Kapranos, H.V. Atkinson, K.P. Young, Semisolid Processing of Alloys, Springer Series in materials Science, 2010.

4. M. Gupta, N.M.L. Sharon, Magnesium, Magnesium Alloys, and Magnesium Composites, Wiley, 2011

5. G. Lutjering, J.C. Williams, Titanium, Springer, 2007

6. T.W. Clyne, P.J. Withers, An introduction to metal-matrix composites, Cambridge University Press, 1993.

Course outcomes (COs):

CO1: Correlate the relationship between Processing, Microstructure and Properties

CO_2: Design and develop Al - alloys for automotive application

CO_3: Apply the concepts of microstructure design for high strength Mg- alloy development

CO_4: Apply the concepts of processing for controlling the properties of Ti- alloys

MT- 4264 Aerospace Materials L-T-P-C (3-0-0)

Course content and List of books:

Module 1: General introduction 6 Lectures

Introduction to aerospace engineering and aerospace materials, Requirements of aerospace materials, Identification of components of aero planes, space vehicles and missiles, Materials usage in each sections and criticality of the components and their materials selection;

Module 2: Super Alloys 8 Lectures

Materials for Gas turbines, and Aero engines; Super alloys – Iron, Nickel and cobalt base super alloys; Aluminium alloys for aerospace applications, Cast Aluminium alloys – Designation, properties and applications, Wrought Aluminium alloys for aerospace applications; Titanium alloys for aerospace applications-

Module 3: Titanium Alloys 8 Lectures

Introduction, Alpha Titanium alloys – microstructure, properties and applications, Alpha-Beta Titanium alloys – microstructure, properties and applications, Beta Titanium alloys– microstructure, properties and applications;

Module 4: Advanced Alloys 8 Lectures

Introduction to steels-Special steels for aerospace applications; Intermetallics – Introduction; Ceramics in aerospace applications; Composites for aerospace applications; New high strength materials; Advanced Materials for aerospace applications.

Readings:

1. Balaram Gupta: Aerospace Materials with Material Technology for Engineers, Vol. 1-4, S. Chand & Co. New Delhi, 1996 and 2002

2. I.J.Polmear, Light Alloys - From Traditional alloys to nanocrystals, Fourth Edition, Butterworth Heinemann, 2005

3. G. Lutjering, J.C. Williams, Titanium, Springer, 2007

4. George F. Titterton: Aircraft Materials and Processes, Himalayan Books, New Delhi, 1998

5. Michael F. Ashby: Materials Selection in Mechanical Design, Butterworth-Heinemann, 2005

6. F. C. Campbell: Manufacturing Technology for Aerospace Structural Materials, Elsevier, UK, 2006

Course outcomes (COs):

CO_1: Identify the components of aerospace vehicles and their requirements

CO_2: Identify conventional and advanced materials used for aerospace applications

CO_3: Compare applications and performance of different aerospace materials

CO_4: Appraise advanced materials for aerospace applications

MT- 4265 High Temperature Materials L-T-P-C **(3-0-0)**

Course content and List of books:

Module 1: An Introduction **8 Lectures**

Introduction to high temperature Materials,

Module 2: Characteristics **8 Lectures**

Characteristics of engineering materials at high temperature, oxidation, high temperature corrosion, Creep, thermal fatigue, erosion, aging, structural changes, material damage, crack propagation, damage mechanics, lifetime analysis.

Module 3:High temperature materials **8 Lectures**

Carbon alloy steels, Stainless steels, super alloys and titanium and its alloys, ceramics, composites, Refractory metals, alloys and Structural inter-metallic and high temperature polymers.

Module 4:Coatings **6 Lectures**

Thermal barrier coatings, Oxidation resistant coatings.

Reading:

1. G. W. Meetham and M. H. Van de Voorde, Materials for High Temperature Engineering Applications (Engineering Materials) Springer; 1 edition (May 19, 2000)

2. J. R. Davis: ASM specialty Hand book: Heat-Resistant materials, ASM, 1997

3. Neil Birks, Gerald H. Meier, and Frederick S. Pettit, Introduction to the High Temperature Oxidation of Metals by Cambridge University Press; 2 edition (July 23, 2009)
4. Sudhansu Bose, High Temperature Coatings, Butterworth-Heinemann; 1 edition (February 6, 2007)
5. K. L. Mittal, Polyimides and Other High Temperature Polymers: Synthesis, Characterization and Applications, Brill Academic Publications, 2009
6. R.W. Evans, and B. Wilshire, Creep of metals and alloys, Institute of Metals, London, 1985.
7. Krishan Kumar Chawla, Composite Materials- Science and Engineering, Springer, 2012.

Course Outcomes (COs):

CO_1: Discuss the oxidation mechanisms of metals and alloys

CO_2: Classify materials for high temperature applications

CO_3: Explain mechanisms of creep, thermal fatigue, oxidation and hot corrosion

CO_4: Select the materials and/or coatings for high temperature applications

MT- 4266 Automotive Materials L-T-P-C **(3-0-0)**

Course content and List of books:

Module 1: **10 Lectures**

Classes of materials and its properties: metals, alloys, polymers, ceramics, composites, body materials:

Module 2: **10 Lectures**

Aluminium alloys, steels, special steels, magnesium materials sandwich materials, engine materials: cylinder, piston, cam shaft, valve materials, plastic materials, functional materials,

Module 3: **10 Lectures**

Electronic materials, smart materials advanced materials, light weighting automobiles, future vehicles and materials, materials selection in design.

Readings

1. Brain Cantor, Patrick Grant, Colin Johnston, Automotive Engineering:Lightweight, Functional, and Novel Materials, Taylor& Francis, 2008

2. Hiroshi Yamagata, The science and technology of materials inautomotive engines, Woodhead Publishing, 2005

3. Jason Rowe, Advanced materials in automotive engineering, Wood head Publishing, 2012

4. Sobey, A field guide to automotive technology, Chicago Review Press,2008

Course Outcomes (COs):

CO_1: Describe the material requirements of automobile components

CO_2 : Appraise the applications of iron alloys in automobile applications

CO_3 : Examine the use of polymers and composites in automobiles

CO_4 : Suggest materials for light weight automobiles