Jharkhand University of Technology Ranchi

Master of Technology

SPECIALIZATION – METALLURGY AND MATERIALS ENGINEERING

Course Structure & Syllabus

SYLLABUS FOR
CREDIT BASED CURRICULUM
2021 – 22
ON WARDS

Department of Metallurgical Engineering

December 2021

(With effect from Academic Year 2021-22)

METALLURGICAL ENGINEERING DEPARTMENT

SEMESTER I

S. No.	Course Code	Course	Subject	L	T	P	Cr.
1.	MME 1101	Core - I	Metallurgical Thermodynamics and Kinetics	3	0	-	3
2.	MME 1102	Core - II	Advanced Materials Engineering	3	0	-	3
3.	MME 1103 MME 1104 MME 1105	Programme Elective - I	1.Physics of Materials 2.Environmental Engineering 3.Powder Production and Processing	3	0	-	3
4.	MME 1106 MME 1107 MME 1108 MME 1109	Programme Elective - II	1.Alloy Steels Technology 2. Mechanical Behavior of Materials 3. Thin film Technology & Its application. 4. Characterization of Materials	3	0	-	3
5.	MME 1110 MME 1111 MME 1112 MME 1113	Programme Elective - III	1.Joining of Materials 2.Computational Modelling and Simulation of Materials 3.Advanced Non Ferrous Technology 4.Non Destructive Testing	3	0	-	3
6.	MME 1201	Lab - I	Metallurgical Thermodynamics and Kinetics laboratory	-	-	3	2
7.	MME 1202	Lab - II	Materials Characterization Technique Lab.	-	-	3	2
8.	**RMC1101**	Compulsory Paper	Research Methodology & IPR	2	-	-	2
9.	**A10001**	Audit I	English for research paper writing	2	-	-	0
	A10002		Professional ethics				
	A10003		Constitution of India				
	A10004		Stress management by yoga				
	Total Credits						**21**

METALLURGICAL ENGINEERING DEPARTMENT
Course Structure M. Tech.

SEMESTER II

S. No.	Course Code	Course	Subject	L	T	P	Cr.
1.	MME 2101	Core - III	Phase Transformation in Materials	3	0	-	3
2.	MME 2102	Core - IV	Corrosion and Protection of Materials	3	0	-	3
3.	MME 2103 MME 2104 MME 2105	Programme Elective - IV	1. Advanced Foundry Technology 2. Advanced Steel Making 3.Failure Analysis of Materials	3	0	-	3
4.	MME 2106 MME 2107 MME 2108 MME 2109	Programme Elective - V	1.Composite Materials 2.Mineral Engineering 3.Surface Engineering 4. X-Ray and Electron Microscopy	3	0	-	3
5.	MME 2110 MME 2111 MME 2112 MME 2113 MME 2114	Open Elective - I	1. Business Analytics 2. Industrial Safety 3. Operations Research 4. Cost Management of Engineering Projects 5. Composite Materials	3	0	-	3
6.	MME 2201	Lab - III	Heat Treatment of metals and alloyslaboratory	-	-	3	2
7.	MME 2202	Lab - IV	Mineral Engineering laboratory	-	-	3	2
8.	MME 2203		Mini Project	-	-	3	2
9.	**A20001**	Audit II	Disaster management	2	-	-	0
	A20002		Value education				
	A20003		Soft skills				
	A20004		Personality development through life enlightenment skills				
	Total Credits						**21**

SEMESTER- III			
S. No	**Course Code**	**Course/ Subject**	**Credits**
01.	MME3201	DISSERTATION Phase- I	10
Total Credits			**10**

SEMESTER- IV			
S. No	**Course Code**	**Course/ Subject**	**Credits**
01.	MME4201	DISSERTATION Phase- II	16
Total Credits			**16**

CORE-I: Metallurgical Thermodynamics and Kinetics (MME 1101)

COURSE OBJECTIVES

1. To teach the fundamental concepts of Thermodynamics and properties.
2. To teach the different law of thermodynamics and entropy.
3. To teach the kinetics of reactions for the metallurgical processes.

Module1: Introduction to thermodynamics and kinetics – different approaches – emphasis on metallurgical thermodynamics, transport phenomena and applications

Module 2: Laws of thermodynamics and related applications – concepts of free energy and entropy –criteria for spontaneity.

Module 3: Introduction to solutions – partial molar entities – Gibbs Duhem relations – thermodynamic aspects of metallic solutions and salt melts – Raoult's Law and Henry's Law - regular and quasi chemical models.

Module 4: Thermodynamic aspects of phase diagrams – similarity in thermodynamic approach towards different classes of materials – thermodynamic aspects of defect formation in metals and ceramics – approaches used in chemical modeling.

Module 5: Principles of metallurgical kinetics – reaction rates and reaction mechanisms – overview of mass transfer, heat transfer and fluid flow – related applications in metallurgical processes –role of transport phenomena in mathematical and physical modeling.

COURSE OUTCOMES:

1. Apply the laws of thermodynamics with reference to metallurgical processes and materials.
2. Calculate the heat and energy requirements and efficiencies of metallurgical processes.
3. Calculate the heat and energy requirements and efficiencies of metallurgical processes.
4. Summarize the kinetics of metallurgical processes and design the alloy systems by applying the concepts of thermodynamics.

TEXT BOOKS

1. Gaskell, David R., 'Introduction to Metallurgical Thermodynamics', McGraw Hill, 1973
2. Mohanty, A. K., "Rate Processes in Metallurgy", Prentice Hall of India (EEE), 2000
3. Bose and Roy, Principle of Metallurgical Thermodynamics
4. Ahindra Ghosh, Materials and Metallurgical Thermodynamics

CORE II: ADVANCED MATERIALS ENGINEERING (MME 1102)

COURSE OBJECTIVES:

1. To give fundamental knowledge about type of materials, their usage, properties and characteristics, which are important in engineering design. To provide a theoretical background about the analysis of behavior of engineering materials by emphasizing important relationships between internal structure and properties.
2. Use the fundamental science and engineering principles relevant to materials that include the relationships between nano/microstructure, characterization, properties, processing, performance and design of materials.
3. To predict and control material properties through an understanding of atomic, molecular, crystalline, and microscopic structures of engineering materials.

Module-1: Structure of metals: Introduction, SC, BCC,FCC, HCP Crystal structure, Coordination number, Relationship between lattice parameter and atomic radius, Packing factor and density calculations,crystal system and Bravais lattices**,** Space lattices, Miller Indices of planes and directions. (6 hrs)

Module 2 : Imperfections in metals and alloys: Introduction, types of imperfections Point defects, Vacancies, Interstialcy, Substitutional impurity, Interstitial impurity, Schottky and Frenkel imperfections, line imperfections, Dislocations; Edge & Screw dislocations; Burgers vector, surface imperfection, grain boundary, Tilt boundary, Twin boundary, Stacking Foults. (10 hrs)

Module 3 : Iron-Cementite Equilibrium ,Eutectic, Peritectic, Eutectoid, Monotectic and Syntectic systems, Phase rule and Lever rule, TTT and CCT diagrams. Heat-Treatment of steels: Annealing, Normalizing, Hardening and Tempering of steels. (10 hrs)

Module 4: Deformation of material: Recovery recrystallization and grain growth, Mechanical properties of materials: Tensile, Impact , Fatigue and Creep of metals.(6 hrs)

Module 5: Diffusion in metals: Introduction, Fick's First and Second law of diffusion, The Kirkendal effect. Types of diffusion, Diffusion mechanism, application of diffusion.
Introduction : Introduction, classification of polymers, composite and ceramics, Structure and properties of polymers and composites,ceramics materials and applications. (10 hrs)

Course Outcomes : Upon Successful completion of this course, each student should be able to:

- To familiarize with the concept of material science and engineering of different metals, ceramics and composites.
- To understand the basic structures of metals and alloys
- To develop the ability of analyzing complex engineering problems associated with different materials
- To be competent in designing components and processes for particular engineering applications.
- Analyse the binary phase diagrams of alloys including Fe-Fe3C, brass, and bronze
- Identify the crystal structures of metallic materials

- An ability to use modern techniques, skills, and engineering tools appropriate to materials research and engineering
- An integrated understanding of structure, properties, processing and performance of materials systems.

Text / Reference Books :

1. V. Raghavan. (PHI); Materials Science and Engineering - A First Course
2. A. Guy. ; Introduction to Materials Science; McGraw Hill
3. Van Vlack.; Materials Science
4. John Wolf ; Materials Science & Engineering
5. William Callister ; Introduction to Materials Science & Engineering
6. Askeland. D.R.; Introduction to Materials Science & Engineering
7. Shackleford.; Materials Science

Programme Elective I : PHYSICS OF MATERIALS (MME 1103)

COURSE OBJECTIVES: To enrich the understanding of various types of materials and their applications in engineering and technology.

COURSE CONTENT:

Module 1: CONDUCTING MATERIALS
Conductors – classical free electron theory of metals – Electrical and thermal conductivity – Wiedemann – Franz law – Lorentz number – Draw backs of classical theory – Quantum theory – Fermi distribution function – Effect of temperature on Fermi Function – Density of energy states – carrier concentration in metals.

Module 2: SEMICONDUCTING MATERIALS
Intrinsic semiconductor – carrier concentration derivation – Fermi level – Variation of Fermi level with temperature – electrical conductivity – band gap determination – compound semiconductors - direct and indirect band gap- derivation of carrier concentration in n-type and p-type semiconductor – variation of Fermi level with temperature and impurity concentration — Hall effect –Determination of Hall coefficient – Applications.

Module 3: MAGNETIC AND SUPERCONDUCTING MATERIALS
Origin of magnetic moment – Bohr magneton – comparison of Dia, Para and Ferro magnetism – Domain theory – Hysteresis – soft and hard magnetic materials – antiferromagnetic materials – Ferrites and its applications Superconductivity : properties – Type I and Type II superconductors – BCS theory of superconductivity(Qualitative) – High T_c superconductors – Applications of superconductors – SQUID, cryotron, magnetic levitation.

Module 4: DIELECTRIC MATERIALS
Electrical susceptibility – dielectric constant – electronic, ionic, orientational and space charge polarization – frequency and temperature dependence of polarisation – internal field – Claussius – Mosotti relation (derivation) – dielectric loss – dielectric breakdown – uses of dielectric materials (capacitor and transformer) – ferroelectricity and applications.

Module 5: ADVANCED ENGINEERING MATERIALS

Metallic glasses: preparation, properties and applications. Shape memory alloys (SMA): Characteristics, properties of NiTi alloy, application, Nonmaterial's– Preparation -pulsed laser deposition – chemical vapors deposition – Applications – NLO materials –Birefringence- optical Kerr effect – Classification of Biomaterials and its applications.

COUSRE OUTCOMES:

The students will have the knowledge on physics of materials and that knowledge will be used by them in different engineering and technology applications

TEXT BOOKS:

1. Arumugam M., Materials Science. Anuradha publishers, 2010
2. Pillai S.O., Solid State Physics. New Age International(P) Ltd., publishers, 2009

REFERENCES:

1. Palanisamy P.K. Materials Science. SCITECH Publishers, 2011.
2. Senthilkumar G. Engineering Physics II. VRB Publishers, 2011.
3. Mani P. Engineering Physics II. Dhanam Publications, 2011.
4. Marikani A. Engineering Physics. PHI Learning Pvt., India, 2009

Programme Elective I :ENVIRONMENTAL ENGINEERING (MME 1104)

Course Objective- To get students acquainted with basics of general forms of pollution viz air, water, soil and noise, preliminary knowledge of ways to measure and control it and corresponding legislature laws and authorities to monitor such pollutions.

Syllabus Content

Module 1: Introduction: Man and Environment: Overview (socio-economic structure & occupational exposures) – Scope of Environmental Engineering – pollution problems due to urbanization & industrialization (4 hours)

Module 2: Air Pollution: types & sources of air pollutants- Climatic & Meteorological effect on air pollution concentration- formation of smog and fumigation,Collection of Particulate Pollutants – Analysis of Air Pollutants like Sulphur dioxide – Nitrogen oxide – Carbon monoxide – Oxidants &Ozone – Hydrocarbons – Particulate Matter.**Air Pollution Control Measures & Equipment** – Flue Gas Treatment Methods, Gravitational and Inertial Separation, Settling Chambers, Dynamic Separators, Cyclones, Filtration, Liquid Scrubbing, Spray Chambers, Packed Towers, Orifice and Ventury Scrubbers, Electrostatic Precipitators, Gas/solid Adsorption, Thermal Decomposition. (11 hours)

Module 3: Water Pollution: Origin of waste water, Types of water pollutants and their effects, Chemical Pollutants: Toxic Organic & Inorganic Chemicals, Physical Pollutants, Thermal Waste, Radioactive waste, Physiological Pollutants. **Water Pollution Control:** Adverse effects onHuman Health & Environment, Aquatic life, Animal life, Plant life, Water Pollution Measurement Techniques, Water Pollution Control Equipment& Instruments – Indian Standards for Water Pollution Control. (9 hours)

Module 4: Soil Pollution: Domestic & Industrial Wastes, Pesticides, Inorganic & Organic Pollutants, Soil Deterioration, Poor Fertility, Septicity, Ground Water Pollution, Concentration of Infecting Agents in Soil **Solid Waste Disposal**: Methods of Dumping domestic & Industrial Solid Wastes, Incineration, Sanitary Land Field, Management of Careful & Sanitary Disposal of Solid Waste (8 hours)

Module 5: Noise Pollution and Control: Noise Pollution and Intensity range, Types of Industrial Noise, effects of Noise, Noise Measuring &Control,Permissible Noise Limits. **Environmental legislations, authorities & systems:** Air & Water Pollution Control Acts & Rules (Salient Features only) – Functions of State / Central Pollution Control Boards – Environmental Management System: ISO 14 000 (Salient Features only). (10 hours)

Recommended Books:

1. Concept of Ecology Prentice-Hall of India, N. Delhi, PrenticeHall of India, N. Delhi;
2. Environmental Science, J. Turk & A. Turk;
3. Environmental Pollution, Dix; Pollution Control Acts, Rules and Notification / Central Pollution Control Board, New Delhi, Central Pollution Control Board, New Delhi;

CO-1: understand the basic knowledge of general forms of pollution viz air, water, soil and noise.
CO-2: understand the preliminary knowledge of ways to measure and control such pollution being deployed in industries.
CO-3: To know the basic legislature laws and corresponding authorities to monitor and control such pollutions.

Programme Elective I :POWDER PRODUCTION AND PROCESSING (MME 1105)

Course Objective- To introduce students with fundamentals of powder metallurgy and its underlying mechanism, the reason to follow this route as compared to other production techniques and various techniques to produce a variety of industrial application powder product.

Syllabus Content-

Module 1: Production Techniques: Introduction, Different methods of powder production viz Milling, atomization, Reduction, Electrolysis, Carbonyl process. (6 hours)

Module 2:Sintering: Solid state sintering, Liquid phase sintering, Reaction sintering, Hot pressing, Hot isostatic pressing, Self-propagating combustion sintering, Sintering atmosphere. (15 hrs)

Module 3:Characterization: Chemical composition, Structure, Morphology, Shape, Size, Distribution, Surface area, Powder flow, Apparent density, Tap density, Compressibility, Porosity. (10 hours)

Module 4:Powder Processing for various purposes: Powder mixing and blending, Compaction techniques, Uniaxial, Isostatic compaction, Extrusion, Forging, Rolling, casting,Tooling and Die design.Production of filters, self-lubricating bearings, gears, friction parts, electrical materials, sintering of carbide tools, fabrication difficulty of tungsten filament,

Module 5: Synthesis and sintering of hydroxyapatite(HAP) and other bioceramics, powder metallurgy of stainless steel, Application of powder metallurgy in Indian industries. (11 hours)

Recommended Books:

1. Randall M. German, Powder Metallurgy Science, Metal Powder Industires Federation, Princeton, New Jersey (1984).
2. ASM Hand book, Vol. 7: Powder Metallurgy, ASM International, (2010).
3. W.D. Kingery, H.K. Bowen and D.R. Uhlmann: Introduction to Ceramics, John Wiley & Sons, New York, (2009).
4. G. S. Upadhyaya: Powder Metallurgy Technology, Cambridge International Science Publishing, (2002)

CO 1-Understand the basics of powder production techniques, applications of powder processing techniques and its superiority for choice over other production techniques.
CO-2 Understand the fundamentals of powder sintering.
CO-3 Understand various characterization parameters associated with powder metallurgy.
CO-4 Understand the fabrication process of important powder metallurgy products as filters, die and tools, self-lubricating, gears, friction parts, electrical materials, bioceramics and similar through powder metallurgy.

Programme Elective II: ALLOY STEEL TECHNOLOGY (MME 1106)

Objectives of the course
To understand the basic properties, composition and applications of different types of steels and to develop required skills in students so that they are able explain the effect of alloying various elements in steels to form useful steel alloys.

Detailed contents
Module 1: **Introduction to Ferrous Alloys** : Classification of ferrous group of alloys, Properties of ferrous groups of alloys, Plain carbon steels with respect to iron carbon diagram, Classification of steels according to kind, class, grade and quality. (4 Hours)

Module 2: Introduction to Alloy Steels: Composition, properties and applications of different types of carbon steels, Limitations of plain carbon steels, Need of alloy steels, effects of alloying elements, Types of alloy steels (4 Hour)

Module 3: **Low Alloy Steels:** Low alloy steels, Low alloy structural and high strength steels, Effects of Nickel, Chromium and Tungsten on Mechanical properties of steels and applications of these steels, Effects of Vanadium, Silicon, Manganese, Cobalt, Molybdenum on Mechanical properties of steel and applications of these steels. (10 Hour)

Module 4: **Tool Steels**: Types of tools, Classification of tool steels, High speed tool steels (HSS) classification, composition and applications, Effect of various alloying elements - chromium, molybdenum, tungsten, cobalt and vanadium in HSS (8 Hours)

Module 5: **Stainless Steels**:Definition of stainless steels (SS), Classification of stainless steels, Types of stainless steel with reference to composition, microstructure, properties, and application**Steels of Commercial Importance**: Properties, Applications, composition and microstructure of commercially important steels: Spring Steels, Electrical steels, Ball bearing steels, Triple alloy (NiCr-Mo, EN 24) steels, Dual phase steels (16 Hours).

Course Outcomes
After completing this course, the student should be able to:
1) Distinguish between plain carbon steels and alloy steels.
2) Explain composition, properties, and applications of Low alloy, High Speed Steel alloy, stainless steel, and commercial quality steels.

3) Analyze problems pertaining to requirement of material and provide solutions based on development of requisite property of material/alloy using modern tools and solutions be based on societal, health, safety, legal and cultural considerations.

Suggested books:

1. Physical Metallurgy Principles, R.E. Reed Hill, East - West, Latest edition
2. Introduction to Physical Metallurgy, S. H. Avner, Tata Mc-Graw Hill Latest edition
3. Physical Metallurgy for Engineers, D. S. Clark and W. R. Varney, East-West press Latest edition
4. Engineering Metallurgy : Applied Physical Metallurgy, R. A. Higgins, Viva Books Latest edition

Programme Elective II :MECHANICAL BEHAVIOUR OF MATERIALS (MME 1107)

Objectives of the course

1. The students having studied the basics of material structures and properties and strength of materials,
2. To teach dislocation theories of plasticity behaviour,
3. Learn strengthening mechanisms and fracture mechanics.
4. To understand failure mechanisms due to fatigue and creep as well as their testing methods.

Detailed contents

Module 1: Elastic And Plastic Behaviour: Elastic behavior of materials – Hooke's law, plastic behaviour: dislocation theory – Burger's vectors and dislocation loops, dislocations in the FCC, HCP and BCC lattice, stress fields and energies of dislocations, forces on and between dislocations, dislocation climb, intersections of dislocations, Jogs, dislocation sources, multiplication of dislocations, dislocation pile-ups, Slip and twinning. (12 Hours)

Module 2: Strengthening Mechanisms: cold working, grain size strengthening. Solid solution strengthening. martensitic strengthening, precipitation strengthening, dispersion strengthening, fibre strengthening, examples of above strengthening mechanisms from ferrous and non-ferrous systems, simple problems. Yield point phenomenon, strain aging and dynamic strain aging (14 Hour)

Module 3: Fracture And Fracture Mechanics: Types of fracture, basic mechanism of ductile and brittle fracture, Griffith's theory of brittle fracture, Orowan's modification.(4 hrs)

Module4: Izod and Charpy Impacts tests, Ductile to Brittle Transition Temperature (DBTT), Factors affecting DBTT, determination of DBTT. (5 hrs)

Module 5: Fracture mechanics-introduction, modes of fracture, stress intensity factor, strain energy release rate, fracture toughness and determination of KIC, introduction to COD,

J integral. (5 Hour)

Course Outcomes

After completing this course, the student should be able to:

1. Understanding of the mechanical properties and behaviour of materials.
2. Analyze linear elastic fracture mechanics and estimate the effects of cracks in material and structure.
3. Understand the ability to identify engineering problem in using plastic deformation, fatigue, fracture and creep
4. Analyze and describe the mechanism loading to failure when provided with a failure example.

Suggested books:

1. Dieter, G.E., "Mechanical Metallurgy", McGraw-Hill, SI Edition.

Programme Elective II: THIN FILM TECHNOLOGY AND ITS APPLICATION (MME 1108)

OBJECTIVES:

- Discuss the differences and similarities between different vacuum based deposition techniques,
- Evaluate and use models for nucleating and growth of thin films,
- Asses the relation between deposition technique, film structure, and film properties,
- Discuss typical thin film applications,
- Motivate selection of deposition techniques for various applications.

COURSE CONTENT:

Module 1: Vacuum technology:principles of vacuum pumps in range of 10^{-2} torr to 10^{-11} torr, principle of different vacuum pumps: roots pump, rotary, diffusion, turbo molecular pump, cryogenic-pump, ion pump, Ti-sublimation pump, importance of measurement of Pressure, Concept of different gauges: Bayet- Albert gauge, Pirani, Penning and pressure control.

Module 2: Physical Vapor Depostion techniques: Thermal evaporation, resistive evaporation, e-beam evaporation, Electron beam evaporation, Laser ablation, Flash and Cathodic arc deposition, Electron beam, Ion beam lithography techniques and Pulsed LASER Deposition, Electrical discharges used in thin film deposition: Sputtering, Glow discharge sputtering, Magnetron sputtering, Ion beam sputtering, Ion plating, difference between thin films and coating.

Module 3: Electro deposition, molecular beam epitaxy and laser pyrolysis.Chemical vapor deposition techniques: Advantages and disadvantages of Chemical Vapor deposition (CVD) techniques over PVD techniques, reaction types, Boundaries, and flow, Different kinds of CVD techniques: Metallorganic CVD (MOCVD), Plasma Enhanced CVD (PECVD) Thermally activated CVD, CVD, Spray pyrolysis, etc.

Module 4: Conditions for the formation of thin films:Environment for thin film deposition, deposition parameters and their effects on film growth, formation of thin films (sticking coefficient, formation of thermodynamically stable cluster – theory of nucleation), capillarity theory, Growth modes: zone model for sputtering and evaporation, Island growth, Volmer weber, Layer growth, Van Vawler.

Module 5: Properties of thin films: Mechanical, electrical, and optical properties of thin films, few applications of thin films in various fields. Application to Renewable energy technology – Thin film solar cells, Quantum well and Quantum dot solar cells, dye – sensitized solar cells.

TEXT BOOKS:

1. Materials Science of Thin Films: Milton Ohring.
2. Thin Film Phenomenon by K. L. Chopra, McGraw-Hill.

REFERENCES:

1. Methods of Experimental Physics (Vol 14) by G. L. Weissler and R.W. Carlson “Vacuum Physics and Technology”
2. A User’s Guide to vacuum Technology by J. F. O’Hanlon, John Wiley, and Sons.
3. Vacuum Physics and Techniques by T. A. Delchar, Chapman, and Hall.
4. Evaporation: Nucleation and Growth Kinetics” by J.P. Hirth and G. M. Pound, Pergamon Press.

5. Materials and Surface Engineering: Research and Development, J. Paulo Davim; Woodhead Publishing Ltd.,2012.

OUTCOMES:

- Vacuum technology and principle of vacuum pumps- various types and ranges will be covered.
- Various fabrication methods of thin films will be dealt in detail
- Advantages, applications of thin films for devices also will be discussed

Programme Elective II :CHARACTERISATION OF MATERIALS (MME 1109)

COURSE OBJECTIVES: The students will be familiar with various characterization tools and techniques for microstructural, structural and chemical characterization of materials. The course will be first step to advanced structural, microstructural and chemical analysis for post graduate students.

Syllabus Content:

Module 1: Chemical bonding, Fundamentals of crystallography, Reciprocal lattice, Structures in metals, Inorganiccompounds, Polymers, Silicate glasses, Stereographic projection.Properties of materials; physical, chemical, electrical, optical and magnetic properties.

Module 2: Microscopic and diffraction techniques: Abbe's criteria, Resolution and resolving power of microscope,Rayleigh's criteria of resolution, Optical microscope, Aberrations, Electron interaction with materials. Electrondiffraction, Electron microscope,

Module 3:SEM: principle of operation, mode of operation. TEM: principle of operation,sample preparation, mode of operation, advanced microscopic techniques: AFM, STM, EELS.

Module 4:X-ray diffraction:Principle of X-ray diffraction, Bragg's law, structure determination.Thermal characterization techniques: Theory, Thermo Gravimetric Analysis (TGA), Instrumentation, Applications,Differential Thermal analysis (DTA), Apparatus, Methodology, Applications, Differential Scanning Calorimeter(DSC), Applications, Dilatometer.

Module 5: Chemical characterization techniques: Principle underlying techniques, Infrared spectroscopy (IR), Ramanspectroscopy, Mossbauer spectroscopy, Nuclear magnetic resonance spectroscopy (NMR), Emissionspectroscopy (Chromatography techniques).

OUTCOME OF THE COURSE:

The course will enable students to analyse structures, microstructures, chemistry of materials by basic techniques using optical, electron and x-ray, radiation through various microscopy and diffraction techniques. The course will help students to understand concepts on structural metallurgy, phase transformations, diffraction and microscopy.

Essential Readings:

1. Material Characterization, Metals Handbook, Vol 10, Ruth E. Whan, ASM, 1986.
2. Characterization of Materials, Elton N Kaufmann, Willey Publishers, 2003.

Supplementary Readings:

1. The structure and properties of solids, P. J. Grundy and G. A. Jones, Edward Arnold, 1975.
2. Elements of X-ray diffraction, B. D. Cullity, Addison-Wesley publishing company, 2002.
3. Chemical characterization of materials, B. M. Rao, Himalaya publishing house, 2000.
4. Scanning electron microscopy and X-ray microanalysis, J. I. Goldsetin, , C E. Lyman, D. E. newbury, E. Lifshin, P. Echlin, L. Sawyer, D. C. Joy, j. R. Michael, springer, 2003

Programme Elective III :JOINING OF MATERIALS (MME 1110)

COURSE OBJECTIVES:

1. To teach the fundamental concepts of welding technology and its metallurgy.
2. To teach the different types of joining processes.
3. To teach the various welding defects and it's remedial.
4. To Teach the advanced welding techniques

Module 1: Introduction: theory and classification of welding and other joining processes. Manual metal arc welding: equipment, electrodes for structural steels, coating constituents and their functions. Types of coatings, current and voltage selection for electrodes, power sources, conventional transformers, rectifiers, current and voltage. Influence of power sources on welding. Metal transfer and Heat transfer.

Module 2: Submerged arc welding: process details, consumables for welding mild steel, variations in the process.Gas metal arc welding or MIG/MAG welding: process details, shielding gases, electrode wires, sizes and current ranges.

Module 3: TIG welding: process details, power source, electrode sizes and materials, current carrying capacity of electrodes. Shielding gases, applications.

Module 4: Resistance welding: principles, applications, process details and working principle of spot, seam and projection welding, electrode materials, shapes of electrode, electrode cooling, selection of currents, voltages; welding metallurgy of carbon and alloy steels, cast irons, stainless steels, Al- and Cu- based alloys. Weldability and heat affected zones. Welding defects and detection techniques.

Module 5: High energy density welding techniques such as Laser Welding, Electron Beam Welding, their specific applications and advantages.Soldering and brazing: difference between processes, consumables, methods of brazing, fluxes used, their purposes and flux residue treatment.

COURSE OUTCOMES:

1. Classify and differentiate welding processes.
2. Explain heat flow in welding.
3. Identify various defects and remedial measures in weldment.
4. Appreciate the importance of welding metallurgy.

Reference Books:

1. Lancaster, Allen and Unwin, Metallurgy of Welding,
2. Little, R.L., Welding and Welding Technology, TMH
3. Norrish, J. and Woodhead, Advanced Welding processes.

Programme Elective III :COMPUTATIONAL MODELING AND SIMULATION IN MATERIALS SCIENCE (MME 1111)

Objective-To introduce students with the importance of modelling in materials science and upto advance technique like Monte-Carlo and Phase-field theory. Get them acquainted with software tools like MATLAB and similar to model and solve problems.

Syllabus Content-

Module-1: Introduction to physical and mathematical modeling. Simple models based on mass and heat balance for metallurgical processes and examples.

Module-2: Use of software tools like MATLAB, Python etc. (12 hrs)

Module-3: Finite element method, Numerical Solution of ODEs, PDEs. Numerical methods for solving conduction, fluid flow and diffusion equations. Simple mathematical modelling of microstructure, diffusion couple.

Module 4: Introduction to popular modelling techniques in materials viz phase field, molecular and Monte-Carlo method. (20 hours)

Module-5: Simple mathematical modelling of blast furnace, basic oxygen furnace, ladle furnace, continuous casting. (10 hours)

Recommended books/texts

K.G.F Janssens, D. Raabe, E. Kozeschnik, M.A. Miodownik, B. Nestler: Computational Materials Engineering: An Introduction to Microstructure Evolution, Elsevier Academic press, 2007; David V. Hutton, Fundamentals of Finite Element Analysis; K. Binder, D. W. Heermann: Monte Carlo Simulation in Statistical Physics, Springer, 1997; Engineering Process Metallurgy 302226 R. I. L. Guthrie, Oxford UniversityPress; Numerical Heat Transfer and Fluid Flow 302226 Patankar S. V., Hemisphere.Washington. DC, 1980; Secondary Steel Making 302226 Principles and Applications 302226 A. Ghosh. CRCpress, 2001.

COURSE OUTCOMES:

CO-1: to introduce students with importance of modelling and simulation in materials science field and use software tools like MATLAB, C++ etc for such purposes.

CO-2: to introduce few basic mathematical techniques as FEM, numerical methods to solve common ODEs and PDEs frequently observed in materials science and their application in modelling metallurgical processes.

CO-3: to introduce advanced level techniques viz Monte-Carlo methods, Phase Field etc.

Programme Elective III :ADVANCED NON-FERROUS TECHNOLOGY (MME 1112)

Course objectives:

Study the principles of extraction and refining processes of non ferrous metals from their ores and apply the concepts to make tailor made materials for given engineering design and applications. To develop understanding to know the associated principles of different processes of extraction.

Course Details :

Module 1 : General methods of extraction of metals from oxides and Sulphides;Extraction of Metals by Pyro,Hydro and Electro Metallurgy techniques with emphasis on the physico-chemical principles involved.Kinetics of leaching of ores and the effects of operation variables. (6 hrs)

Module 2 : Aluminium ores,Aluminium: Bayer's process and factors affecting its operation; Hall – Heroult process: principle & practices, use of electrodes, anode effect; Refining of Aluminium; Alternative methods of Alumina and Aluminium production. (6 hrs)

Module 3 : Copper: Extraction of copper from sulphide ores by pyrometallurgical process, Refining and uses. Newer process for copper extraction,hydrometallurgy process of copper. (6 hrs)

Module 4 : Zinc: Pyrometallurgical extraction of zinc; principles and practices of roasting, sintering and smelting; Hydrometallurgy of zinc. Lead: Refining and typical flowsheet of plant in production of lead , Blast furnace smelting, uses. (12 hrs)

Module 5 : Simplified flowsheet for extraction of metals Ti, Mg, U and Th, Tin, Ni .Electroplating-Principles of Electrode-position of Metals and alloys, Throwing power, Electroless plating, Electroforming, Anodizing. (12 hrs)

References:

1. Extraction of Non-ferrous Metals, Affiliated East- West Press, 2001– H. S. Ray, K. P. Abraham and R. Sridhar

2. K Grjotheim& B J Welch: Aluminum Smelter Technology, Aluminum – Verlag, 2nd Edn. 1988.
3. A K Biswas & W G Davenport: Extractive Metallurgy of Copper, Pergamon, 4th Edn. 2002.
4. W H Dennis, Metallurgy of Non – Ferrous Metals, Pitman, London, 1954.
5. J N Anderson & P Queneau, Pyrometallurgical Processes in Non – Ferrous Metallurgy, Gorden& Breach, New York, 1967.

6. N Sevryukov, Non – Ferrous Metallurgy, Trans. By I V Savin, Mir Publishers, Moscow, 1975.
7. J L Bray, Non – Ferrous Production Metallurgy, John Wiley, New York.
8. R D Pehlke, Unit Processes of Extraction Metallurgy, Elsevier, Amsterdam, 1982.

Course outcomes: At the end of this course, the students should be able to:

CO1: Define the general principles of extraction of metals from oxides and sulphides;
CO2: Draw the flow sheets for the extraction of non-ferrous metals from their ores.
CO3: Discuss the effect of a change in process parameters of different extraction processes.
CO4: Apply the refining processes for Aluminum, copper, zinc, lead, uranium. Magnesium nickel and titanium and applications.

Programme Elective III: NON-DESTRUCTIVE TESTING (MME 1113)

Objectives of the course

This course provides students a synopsis of non-destructive and destructive evaluation methods that are used in evaluation of welds. This includes understanding the basic principles of various NDT methods, fundamentals, discontinuities in different product forms, importance of NDT, applications, limitations of NDT methods and techniques and codes, standards and specifications related to non-destructive testing technology. Students also will be introduced to relevant quality assurance and quality control requirements in accordance with ASQ, ASME, and ANSI standards.

Detailed contents

Module 1: **Introduction:**Fundamentals of and introduction to destructive and non-destructive testing. Scope and limitations of NDT, Visual examination methods, Different visual examination aids. (4 Hours)

Module 2: Dye penetrant Testing: Dye penetrant Testing/ liquid penetrant testing: Principle, procedure, characteristics of penetrant, types of penetrants, penetrant testing materials, fluorescent penetrant testing method– sensitivity, application and limitations(8 Hour)

Module 3: **Magnetic Particle Testing:**Magnetic Particle Testing: Important terminologies related to magnetic properties of material, principle, magnetizing technique, procedure, equipment, fluorescent magnetic particle testing method, sensitivity, application and limitations. (10 Hour)

Module 4:**Ultrasonic Testing**:Ultrasonic Testing: Basic principles of sound propagation, types of sound waves, Principle of UT, methods of UT, their advantages and limitations, Piezoelectric Material, Various types of transducers/probe, Calibration methods, use of standard blocks, technique for normal beam inspection, flaw characterization technique, defects in welded products by UT, Thickness determination by ultrasonic method, Study of A, B and C scan presentations, advantage, limitations acoustic emission testing – principles of AET and techniques(8 Hours)

Module 5:**Radiographic testing:**Radiographic testing: X-ray and Gamma-Ray radiography, Their principles, methods of generation, Industrial radiography techniques, inspection techniques, applications, limitations, Types of films, screens and penetrameters. Interpretation of radiographs, Safety in industrial radiography.**Eddy current testing:** Eddy current testing: Principle, instrument , techniques, sensitivity, application, limitation Thermal methods of NDT. (12 Hours).

Course outcomes: At the end of this course, the students should be able to:

1. To solve various problems encountered like leakage, cracks, blowholes etc with the manufacturing process by analyzing the data. The student shall be competent enough to make use of modern tools and softwares for analyzing and solving real life problems.

Suggested books:

1. "Ultrasonic Testing of Materials" by Krautkramer
2. "Ultrasonic And Advanced Methods For Nondestructive Testing And Materials Characterization" by C H Chen.

RMC 1101	Compulsory paper	Research Methodology & IPR	2

Course Content

Unit-1: Research Problem and Scope for Solution: Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations.

Unit-2: Format: Effective literature studies approaches, analysis, Plagiarism, Research ethics. Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee.

Unit-3: Process And Development: Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, patenting under PCT.

Unit-4: Patent Rights: Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

Unit-5: New Developments In IPR: New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

Text Books:

1. Stuart Melville and Wayne Goddard, "*Research methodology: an introduction for science & engineering students*"
2. Wayne Goddard and Stuart Melville, "*Research Methodology: An Introduction*"
3. Ranjit Kumar, 2nd Edition, "*Research Methodology: A Stepby Step Guide for beginners*"

Reference Books:

1. Halbert, "*Resisting Intellectual Property*", Taylor & Francis Ltd, 2007.
2. Mayall, "*Industrial Design*", McGraw Hill, 1992.
3. Niebel, "*Product Design*", McGraw Hill, 1974.
4. Asimov, "*Introduction to Design*", Prentice Hall, 1962.
5. Robert P. Merges, Peter S. Menell, Mark A. Lemley, " *Intellectual Property in New Technological Age*", 2016.
6. T. Ramappa, "*Intellectual Property Rights Under WTO*", S. Chand, 2008

‘

METALLURGICAL ENGINEERING DEPARTMENT
Course Structure M. Tech.

SEMESTER II

S. No.	Course Code	Course	Subject	L	T	P	Cr.
1.	MME 2101	Core - III	Phase Transformation in Materials	3	0	-	3
2.	MME 2102	Core - IV	Corrosion and Protection of Materials	3	0	-	3
3.	MME 2103 MME 2104 MME 2105	Programme Elective - IV	1. Advanced Foundry Technology 2. Advanced Steel Making 3.Failure Analysis of Materials	3	0	-	3
4.	MME 2106 MME 2107 MME 2108 MME 2109	Programme Elective - V	1.Composite Materials 2.Mineral Engineering 3.Surface Engineering 4. X-Ray and Electron Microscopy	3	0	-	3
5.	MME 2110 MME 2111 MME 2112 MME 2113 MME 2114	Open Elective - I	1. Business Analytics 2. Industrial Safety 3. Operations Research 4. Cost Management of Engineering Projects 5. Composite Materials	3	0	-	3
6.	MME 2201	Lab - III	Heat Treatment of metals and alloyslaboratory	-	-	3	2
7.	MME 2202	Lab - IV	Mineral Engineering laboratory	-	-	3	2
8.	MME 2203		Mini Project	-	-	3	2
9.	**A20001**	Audit II	Disaster management	2	-	-	0
	A20002		Value education				
	A20003		Soft skills				
	A20004		Personality development through life enlightenment skills				
	Total Credits						**21**

CORE-III :PHASE TRANSFORMATION OF MATERIALS(MME 2101)

Objectives of the course

1. Understanding the thermodynamic and kinetics for phase transformations
2. Understanding of homogeneous and heterogeneous nucleation as well as growth processes leading to a particular microstructure
3. Understanding of different types of solid state phase transformations
4. Study of different heat treatment cycles and their obtained property

Detailed contents

Module 1: Phase rule and phase diagram, Allotropy of Iron and Fe-C Phase diagram, Nucleation and growth kinetics, Atomic models of Diffusion, Steel, Functions of alloying elements in steel, Importance of Austenite Grain size.Formation of Austenite, TTT and CCT Diagrams, Pearlitic, Bainitic and Martensitic Transformations (Mechanisms, Kinetics and Morphologies). (10 Hours)

Module 2: Pearlitic transformation, Factors influencing pearlitic transformation, Mechanism of transformation, Nucleation and growth, Orientation relationship.(8 Hour)

Module 3: Bainitic transformation: Mechanism of transformation, Nucleation and growth, Orientation relationships, Surface relief, Classical and non-classical morphology, Effect of alloying elements. (8 Hour)

Module 4: Martensitic transformation: Characteristics of transformation, Thermodynamics and kinetics, Nucleation and growth, Morphology, Crystallography, Stabilization. (6 Hours)

Module 5: Heat treatment of steels: annealing, normalizing, hardening, tempering, austempering,patenting,industrial practices Strengthening mechanisms, Recovery, Recrystallization and Grain growth . (11 Hours)

Suggested books:

1. R. E. Reed-Hill, Physical Metallurgy Principles, East-West Press
2. Introduction to Physical Metallurgy, S. H. Avner, Tata Mc-Graw Hill Latest edition
3. V. Raghavan, Solid State Phase Transformations

Course Outcomes

After completing this course, the student should be able to:
1) understand the design of a heat treatment for an alloy for a particular application.
2) analyze morphology effect of structure on the melting and glass transition temperature.
3) understand how microstructure affects the ability to crystallize.
4)understand the effect of structure on the melting and glass transition temperature.

CORE IV :CORROSION AND PROTECTION OF MATERIALS (MME 2102)

COURSE OBJECTIVES

- To teach the fundamental concepts of electrochemical reactions and its principle behind the corrosion.
- To teach the different types of corrosion and mechanism.
- To teach the corrosion test procedure and corrosion protection.

Module 1 : Principles of corrosion phenomenon: Thermodynamics and kinetics: emf/galvanic series, Pourbaix diagram, exchange current density, passivity, Evans diagram, flade potential.

Module 2 : Different forms of corrosion: atmospheric/uniform, pitting crevice, intergranular, stress corrosion, corrosion fatigue, de-alloying, high temperature oxidation-origin and mechanism with specific examples.

Module 3 : Corrosion testing and monitoring: Non-Electrochemical and Electrochemical methods: weight
loss method, Tafel Linear polarization and Impedance techniques, Lab, semi plant & field tests, susceptibility test.

Module 4 : Corrosion prevention through design, coatings, inhibitors, cathodic, anodic protection, specific applications, economics of corrosion control.

Module 5 : Corrosion & its control in industries: Power, Process, Petrochemical, ship building, marine and fertilizer industries. Some case Studies-Corrosion and its control in different engineering materials: concrete structures, duplex, super duplex stainless steels, ceramics, composites and polymers. Corrosion auditing in industries, Corrosion map of India.

COURSE OUTCOMES:

1. Explain the principles of corrosion.
2. Evaluate corrosion mechanisms from first principles.
3. Suggest suitable techniques for corrosion monitoring and its prevention.
4. Discuss the mechanism of high temperature oxidation

Text Books.

1. Fontana. M.G., Corrosion Engineering, Tata McGraw Hill, 3rd Edition, 2005.
2. Jones.D.A. Principles and Prevention of Corrosion, 2nd Edition, Prentice Hall, 1996.
3. Corrosion: Metal / Environment Reactions, Volume 1, L.L. Shreir, R.A. Jarman, G.T. Burstein, Butterworth-Heinemann, 1994.
4. Principles and Prevention of Corrosion, Denny A. Jones, Pearson, 1995.

Programme Elective IV : ADVANCED FOUNDRY TECHNOLOGY (MME 2103)

Course Objective- to introduce students with details of various steps in foundry viz moulding, gating systems and mathematical modelling of alloys/metals under different cooling conditions.

Syllabus content-

Module 1: Basic steps in foundry: Preliminary introduction to various steps in foundry, pattern making and types, mould sand preparation, binders and additives, tools to prepare moulding sand, cores, gating system and its types. (6 hours)

Module 2: Foundry tools and methods: Pattern types, materials and various dimensional allowances, types of sand used and its various useful relevant properties viz grain size, shape and its distribution and its effect on casting during solidification. Binders and their characteristics, moulding practices- green and dry, carbon dioxide and shell process. Core making. Tools used like mixer, muller, jolting, squeezing, jolt squeezing, slinging, blowing etc. Gating system and its type. Designing Gating system. gating ratio; pressurized and un-pressurized systems; types of gates; Slag traps and filters etc. with reference to different cast metals and alloys. (14 hours)

Module 3: Solidification analysis in foundry: Thermodynamics of solidification, Nucleation and growth, Pure metal solidification, Gibbs Thomson effect, Alloy.(6 hrs)

Module 4: Solidification: Mathematical Analysis of redistribution of solute during solidification, Constitutional under cooling, Dendrites growth, Multi phase solidification: eutectic and peritectic, Modeling of solidification under different conditions. (8 hours)

Module 5: Industrial Practice: melting furnaces and processes for the production of cast irons and steel castings, special problems in heat treatment to ferrous castings, sand practice for iron and steel casting production, Numerical problems and computers in foundry. (8 hours)

Recommended Books/Texts:

J. Campbell, Castings, Butterworth, 1991, London Heine and Rosenthal, Principles of Metal Casting; 1955, McGraw Hill, NY; Solidification of Metals, W. C. Winegard, Institute of Metals 1964. D.S. Porter & K.E. Esterling, Phase transformation in metals and alloys, Chapman & Hall, 1981. W. Kurtz and D.J. Fischer, Principles of Solidification, edition - 3, Trans Tech Publications, 1992.

CO-1: To get students acquainted with basic steps of foundry and such industrial example.
CO-2: To understand details of Mould/gating system and Mold sand/binders, additives preparation.
CO-3: To understand the Mathematical modelling of solidification of metals/alloys and variations under different cooling conditions.

Programme Elective IV :ADVANCED STEEL MAKING
(MME 2104)

Course Objective- to introduce students with a basic introduction to steel making to advanced level thermodynamics concepts applied for steel making. Further to get them acquainted with post refining process viz ladle metallurgy, continuous casting and refractories used for all general stages/processes in steel making

Syllabus Content-

Module 1: Basic introduction to steel making-Brief History of Steel Making, Integrated and Mini Steel Plants in India. Different Route of Steel making, from Bessemer Steel Making to present day Equipment and current practices. (3 hours)

Module 2: Basic reactions and thermodynamics: Carbon Reaction, Phosphorus Reaction, Sulphur Reaction, Silicon Reaction, Refining Slags and its Properties. Importance and Mechanism of Decarburization Reaction. Types of slags - Acid, Basic, Dry and Wet slags, Reaction at Slag Metal interface. (8 hours)

Module 3: Advanced study of reactions and thermodynamics- solutions, change of standard states, activity interaction parameters. Structure and thermodynamics of slags.C-O, Si-O, Mn-O reactions, reactions of S and P, sulphide and phosphate capacities. Effect of kinetics on thermodynamics reactions during refining. (6 Hrs.)

Module 4: Oxygen steelmaking :design parameters for vessel and lance, material and heat balances. Process dynamics, static dynamic and process models, process control. Comparison of fast processes like oxygen steelmaking to old slow processes like open hearth and corresponding change in reactions output, Reactor models : CSTR and plug flow reactors, residence time distributions. (10 Hrs.)

Module 5: Electric arc furnace : reaction mechanisms, material and heat balances, equipment design principles. **Ladle metallurgy:** Deoxidation and its thermodynamic and kinetic analysis, inclusion shape control. thermo- and kinetic analysis of secondary and alloy steel, model building. **Continuous casting:** solidification mechanisms and structure, fluid flow and heat transfer in tundish and strand, physical and mathematical models, understanding defects, recent developments. **Refractories:** Refractories used in LD and electric arc furnace, effect of steel refining reactions on refractories, chemical and physical erosion rate and lifespan under industrial production condition. (15 hours)

Recommended books/texts-

1. Making, Shaping and Treating of Steel, Vol.1: Ironmaking, 11th Ed., AISE Steel Foundation, 1999.
2. A. Ghosh and A. Chatterji; Ironmaking and Steelmaking : Theory and Practice, Prentice-Hall (India), 2008.
3. F.D. Richardson; Physical Chemistry of Melts in Metallurgy, Academic Press, 1974.T.A. Engh; Principles of Metal Refining, Oxford Univ. Press, 1992.

CO-1: to understand the preliminary overview of steel making.

CO-2: to understand the advanced mathematical thermodynamics concepts used in steel refining.

CO-3: to study the current commercial practice of steel making viz LD and Electric arc furnace.

CO-4:to study the general post steel refining process and refractories employed in different steel making furnaces.

Programme Elective IV :FAILURE ANALYSIS OF MATERIALS (MME 2105)

Objectives of the course

This course is designed to cover the following subjects: understanding failure formation; damage mechanisms such as fatigue, wear, corrosion, creep and other mechanical failures; procedural approaches in failure analysis; metallographic and fractographic studies. Mechanisms in overload, fatigue, impact and creep failures will be discussed in detail. The primary aim of this course is to provide general knowledge on the procedures and mechanisms involved in failure analysis.

Detailed contents

Module 1: Introduction, Fundamentals of fracture – definitions, Fracture modes, Ductile fracture (4 Hours)

Module 2: Brittle Fracture, Cleavage and intergranular fractures(4 Hour)

Module 3: Fracture mechanics, Stress concentration, the Griffith criterion, Fracture toughness Impact fracture testing, The ductile-to-brittle transition, Metallurgical factors affecting the DBTT (10 Hour)

Module 4: Fatigue, the Wöhler curve, Fatigue probability curves, Crack initiation and crack propagation in fatigue.Beachmarks and striations, the Paris-Erdogan equation,Environmental factors affecting fatigue, design against fatigue (10 Hours)

Module 5: Creep, Steady-state creep, Effects of stress and temperature on creep, Creep mechanisms, Linear-viscous creep, Power-law creep, Diffusion and Dislocation creep, the Larson-Miller parameter, High temperature alloys. (12 Hours)

Suggested books:

1. W.D. Callister, Jr., D.G. Rethwisch, Materials Science and Engineering: An Introduction, John Wiley & Sons, 2009.
2. G.E. Dieter, Mechanical Metallurgy (SI Metric Edition), McGraw-Hill
3. W.F. Hosford, Mechanical Behavior of Materials, Cambridge University Press.

Course Outcomes

After completing this course, the student should be able to:

1) Understand the process of materials selection and be able to use available tools for making decisions on materials selection for engineering applications.
2) Understand the variety of fabrication routes and be able to use available tools to identify an appropriate fabrication route for a selected material for any engineering applications
3) Understand and be able to identify the common modes of failure of engineering components

Programme Elective V : COMPOSITE MATERIALS
(MME 2106)

Objectives of the course

- Explain the behavior of constituents in the composite materials
- Enlighten the students in different types of reinforcement
- Develop the student's skills in understanding the different manufacturing methods available for composite material.
- lluminate the knowledge and analysis skills in applying basic laws in mechanics to the composite materials.

Detailed contents

Module 1: **Introduction:** Classifications of Engineering Materials, Concept of composite materials, Matrix materials, Functions of a Matrix, Desired Properties of a Matrix, Polymer Matrix (Thermosets and Thermoplastics), Metal matrix, Ceramic matrix, Carbon Matrix, Glass Matrix etc.

Module 2: Types of Reinforcements/Fibers: Role and Selection or reinforcement materials, Types of fibres, Glass fibers, Carbon fibers, Aramid fibers , Metal fibers, Alumina fibers, Boron Fibers, Silicon carbide fibers, Quartz and Silica fibers, Multiphase fibers, Whiskers, Flakes etc., Mechanical properties of fibres. Material properties that can be improved by forming a composite material and its engineering potential (10 Hours)

Module 3: Various types of composites: Classification based on Matrix Material: Organic Matrix composites, Polymer matrix composites (PMC), Carbon matrix Composites or Carbon-Carbon Composites, Metal matrix composites (MMC), Ceramic matrix composites (CMC); Classification based on reinforcements: Fiber Reinforced Composites, Fiber Reinforced Polymer (FRP) Composites, Laminar Composites, Particulate Composites, Comparison with Metals, Advantages & limitations of Composites. (10 Hour)

Module 4: **Fabrication methods:** Processing of Composite Materials: Overall considerations, Autoclave curing, Other Manufacturing Processes like filament welding, compression molding, resin-transplant method, pltrusion. (10 Hour)

Module 5: **Testing of Composites:** Mechanical testing of composites, tensile testing, Compressive testing, Intra-laminar shear testing, Inter-laminar shear testing, Fracture testing etc. (8 Hours)

Suggested books:

1. Engineering Materials: Polymers, Ceramics and Composites A.K Bhargava Prentice Hall India
2. Composite materials by K. K. Chawla

Course Outcomes

After completing this course, the student should be able to:

1) Explain the mechanical behavior of layered composites compared to isotropic materials.

2) Apply constitutive equations of composite materials and understand mechanical behavior at micro and macro levels.

3) Determine stresses and strains relation in composites materials

Programme Elective V : MINREAL ENGINEERING(MME 2107)

Course Objectives:

- Study the common mineral processing techniques and the associated equipment used in mining and pre-extraction practices. To understand the mechanism behind comminution of ores and minerals.
- To impart fundamental understanding of various unit operations in coal and *mineral processing*.

Syllabus Content:

Module 1 : Ores and Minerals:, Scope and objectives of mineral processing, principal steps and advantages of mineral processing.Mineral resources of India. (3 hrs)

Module 2: Comminution and Liberation: Concept and importance of liberation. Theory and practice of crushing and grinding-primary crushers and secondary crushers. (10 hrs)

Module 3: Sizing and classification: Laboratory sizing techniques, Interpretation and plotting of sizing data. Industrial screens and classifiers. (8 hrs)

Module 4: Concentration: Principles and applications of heavy media separation, Jigging, Flowing film concentration and equipments used. (8 hrs)

Module 5: Froth Flotation : 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. 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. (13 hrs)

Course outcomes:

Upon Successful completion of this course, each student should be able to:

1. Understand the mineral processing basic principles.
2. Describe the physical and chemical properties of various minerals .
3. To know and understand the various separation methods of mineral or gangue particles .
4. To know the common analysis techniques used in metallurgical industries.
5. Explain the various types of process control in mineral processing.

References:

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.

Programme Elective V: SURFACE ENGINEERING (MME 2108)

Course Objective

1. To teach the basics and mechanism of tribology.
2. To teach the different types of surface protection method.
3. To learn the several coating method for the different applications.
4. To teach few advanced spraying techniques.

Module 1: Introduction tribology, surface degradation, wear and corrosion, types of wear, roles of friction and lubrication- overview of different forms of corrosion, introduction to surface engineering, importance of substrate.

Module 2: Chemical and electrochemical polishing, significance, specific examples, chemical conversion coatings, phosphating, chromatins, chemical coloring, anodizing of aluminum alloys, thermochemical processes -industrial practices.

Module 3: Surface pre-treatment, deposition of copper, zinc, nickel and chromium - principles and practices, alloy plating, electro composite plating, electroless plating of copper, nickel phosphorous, nickel-boron; electroless composite plating; application areas, properties, test standards (ASTM) for assessment of quality deposits.

Module 4: Definitions and concepts, physical vapor deposition (PVD), evaporation, sputtering, ion plating, plasma nitriding, process capabilities, chemical vapor deposition (CVD), metal organic CVD, plasma assisted CVD, specific industrial applications.

Module 5: Thermal spraying, techniques, advanced spraying techniques - plasma surfacing, D-Gun and high velocity oxy-fuel processes, laser surface alloying and cladding, specific industrial applications, tests for assessment of wear and corrosion behavior.

Course Outcome

1. Learn the basics of tribology.
2. Understand the surface protection method.
3. Knowledge of several coating method for the different applications.

TEXT BOOKS

1. Sudarshan T S, ‘Surface modification technologies - An Engineer’s guide’, Marcel Dekker, Newyork, 1989
2. Varghese C.D, ‘Electroplating and Other Surface Treatments - A Practical Guide’, TMH, 1993.
3. Sarkar, A.D., Wear of Metals, Pergamon
4. Rabinowiez, E., Friction and Wear of Materials, Wiley
5. Hand book, Friction, Lubrication and Wear Technology, Vol. 18, ASM
6. Surface treatments for protection, Series3, No. 10, , The institute of metallurgist series.

Programme Elective V: X-RAY AND ELECTRON MICROSCOPY (MME 2109)

OBJECTIVES: The students will be familiar with various characterization tools and techniques for microstructural, structural and chemical characterization of materials. The course will be first step to advanced structural, microstructural and chemical analysis for post graduate students.

Syllabus Content:

Module 1: Properties, lattice and its relation with diffraction; factors affecting the intensity of diffracted beam,

Module 2: calculation of integrated intensity; estimation of stress, texture and other defects; interactions between electrons and matter;

Module 3: principles of transmission of electron microscopy, elements of electron optics, electron lenses – their aberrations, resolving powers, depth and field of focus;

Module 4: kinematical theory of electron diffraction, geometry of electron diffraction and their applications, micro-diffractions, trace analysis, bright-field and dark-field image contrast;

Module 5: Principles and applications of SEM, principles of microanalysis.

OUTCOME OF THE COURSE: The course will enable students to analyse structures, microstructures, chemistry of materials by basic techniques using optical, electron and x-ray, radiation through various microscopy and diffraction techniques. The course will help students to understand concepts on structural metallurgy, phase transformations, diffraction and microscopy

References:

1. B.D.Cullity, Elements of X-Ray Diffraction, Addison Wesley.
2. C.S.Barett and T.M. Massalski, Structure of Metals, McGraw Hill.
3. S.K.Chatterjee, X-ray Diffraction, Its theory and Applications, PHI**.**
4. Materials Characterization Techniques, (eds.) G. Sridhar, et al. National Metallurgical Laboratory, Jamshedpur.

OPEN ELECTIVE I : BUSINESS ANALYTICS(MME 2110)

Course Objective

1. Understand the role of business analytics within an organization.
2. Analyze data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization.
3. To gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision making.
4. To become familiar with processes needed to develop, report, and analyze business data.
5. Use decision-making tools/Operations research techniques.
6. Mange business process using analytical and management tools.
7. Analyze and solve problems from different industries such as manufacturing, service, retail, software, banking and finance, sports, pharmaceutical, aerospace etc.

Syllabus Content:

Module 1: Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics.

Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.

Module 2: Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression.

Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.

Module 3: Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes.

Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization.

Module 4: Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models.

Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model.

Module 5: Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making. Recent Trends in : Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.

Course Outcomes

1. Students will demonstrate knowledge of data analytics.
2. Students will demonstrate the ability of think critically in making decisions based on data and deep analytics.
3. Students will demonstrate the ability to use technical skills in predicative and prescriptive modeling to support business decision-making.
4. Students will demonstrate the ability to translate data into clear, actionable insights.

References:

1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press.
2. Business Analytics by James Evans, persons Education.

OPEN ELECTIVE I: Industrial Safety (MME 2111)

Course Objective:

Student will be able to learn

1. The areas of hazards and sensitive places in Industries which need to be careful visit
2. What necessary steps to be taken to prevent the hazards and damage in industries or to reduce the risk of occurrence of hazards

Course Outcomes:

1. Safety skills enhancement in students and professionals.
2. Knowledge and skills of curbing hazards and leadership qualities
3. Pre alertness while doing work

Syllabus Content:

Module 1: Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

Module 2: Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

Module 3: Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

Module 4: Fault tracing: Fault tracing-concept and importance, decision treeconcept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic,automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

Module 5: Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

Reference:

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.

OPEN ELECTIVE I: Operations Research (MME 2112)

Course Outcomes: At the end of the course, the student should be able to

1. Students should able to apply the dynamic programming to solve problems of discreet and continuous variables.
2. Students should able to apply the concept of non-linear programming
3. Students should able to carry out sensitivity analysis
4. Student should able to model the real world problem and simulate it.

Syllabus Contents:

Module 1: Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models.

Module 2: Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming

Module 3: Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT

Module 4: Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

Module 5: Competitive Models,Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation.

Course Outcomes:

At the end of the course, the student should be able to

1. Students should able to apply the dynamic programming to solve problems of discreet and continuous variables.
2. Students should able to apply the concept of non-linear programming
3. Students should able to carry out sensitivity analysis
4. Student should able to model the real world problem and simulate it.

References:

1. H.A. Taha, Operations Research, An Introduction, PHI, 2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009
5. Pannerselvam, Operations Research: Prentice Hall of India 2010
6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010.

OPEN ELECTIVE I: Cost Management of Engineering Projects (MME 2113)

Course Objective:

To provide youwith appropriate knowledge, skills and techniques that would be used to maximise project outcomes and success. This will be useful for your final-year project proposal, and will include areas such as project life cycle, project management processes, project scope, time management, quality, and procurement**.**

Syllabus Content:

Introduction and Overview of the Strategic Cost Management Process.

Module 1: Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making. Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning.

Module 2: Project execution as conglomeration of technical and nontechnical activities.Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts.Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process.

Module 3: Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems.Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning,

Module 4: Total Quality Management and Theory of constraints.Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis.Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets.Measurement of Divisional profitability pricing decisions including transfer pricing.

Module 5: Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

Course Outcomes:

1. On successful completion of this course, you should be able to:
2. understand and explain the nature of engineering projects
3. illustrate and understand how engineering project activities may be influenced by economic, environment, societal and organisational factors
4. access and evaluate information relevant to an engineering project
5. understand complex issues associated with engineering projects
6. understand ethical dimensions associated with conducting an engineering project

References:

1. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
2. Charles T. Horngren and George Foster, Advanced Management Accounting
3. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
4. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher.
5. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

OPEN ELECTIVE I: COMPOSITE MATERIALS (MME 2114)

Course Objectives:

To understand the manufacturing processes of reinforcement fibers and matrices for composites and extend a knowledge of applications and selection of different composites in consideration of the properties and characteristics.

Syllabus Content:

Module 1: INTRODUCTION: Definition – Classification and characteristics of Composite materials. Advantages and application of composites.Functional requirements of reinforcement and matrix.Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

Module 2: REINFORCEMENTS: Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

Module 3: Manufacturing of Metal Matrix Composites: Casting – Solid State diffusion technique, Cladding – Hot isostaticpressing.Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.

Module 4: Manufacturing of Polymer Matrix Composites: Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.

Module 5: Strength: Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

Course Outcomes:

1. Understands the purpose and the ways to develop new materials upon proper combination of known materials

2. Is able to predict a wide range of mechanical and transport properties of materials as a function of parameters such as volume fraction, orientation & regularity arrangement and particle aspect ratio
3. Is capable of comparing/evaluating the relative merits of using alternatives (corresponding to various simple and composite materials) for important engineering and other applications.

Text books:

1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.

2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.

References:

1. Hand Book of Composite Materials-ed-Lubin.
2. Composite Materials – K.K.Chawla.
3. Composite Materials Science and Applications – Deborah D.L. Chung.
4. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi.