SEMESTER - I

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Scheme/Specialization: B.Tech. (Metallurgical and Materials Engineering)

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT101	**Introduction to Engineering Materials**	**3**	**3**	**0**	**0**	**0**

PREREQUISITES: Basic Knowledge of Physics, Chemistry & Mathematics

COURSE OBJECTIVE:

To acquire the knowledge of engineering materials from metals to polymers and ceramics and about their engineering applications in detail.

COURSE OUTCOMES:

CO1	Impart an understanding about different classes of materials.
CO2	Develop the knowledge of fundamental principles related to materials structure, properties and applications.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Weekly Submissions/assignments/Quizzes	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Basic Introduction: History of materials, Atomic structure. Atomic bonding in solids: bonding forces and energies, primary interatomic bonds, secondary bonding with examples of metals, ceramics and polymers.

(No. of lectures - 4)

Unit II Structures of Materials: Crystal structure and Bravias lattice, Unit cell and Miller indices, Crystal system, coordination number and packing fraction. Polymorphism and allotropy. Crystallographic directions and planes. Crystalline materials: single crystals, polycrystalline materials. Non- crystalline materials, Imperfection in solid (point defects, line defects, surface defects and volume defects).Level of Structures: macrostructure, microstructure, substructure, crystal structure, electronic structure, nuclear structure.

(No. of lectures - 10)

Unit III Engineering Materials: Classification of engineering materials: ferrous alloys and nonferrous alloys, ceramics (glasses, glass- ceramics, refractories, abrasives, traditional ceramics, advanced ceramics), polymers, composites. Salient features of metals, ceramics, glass, polymers, composites.

(No. of lectures - 8)

Unit IV Properties of Materials: Physical, chemical and mechanical properties. Physics of thermal, electrical, optical and mechanical properties. Factors controlling these properties.

(No. of lectures - 8)

Unit V Materials with Specific Properties: Electrical conductors, Electrical resisters, Magnetic materials, Structural materials, Nanomaterials. Refractory materials. Applications of metals, alloys, polymers, ceramics and composites.

(No. of lectures - 10)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Introduction to Materials Science, William D. Callister Jr., David G. Rethwisch, John Wiley & Sons; 8th Edition, 2010
2. Introduction to Materials Science, V. Raghvan, Prentice Hall India Learning Private Limited, New Delhi, Sixth Edition, 2015
3. Introduction to Physical Metallurgy, Sidney H. Avner, McGraw Hill Education, New York; 2nd edition, 2017
4. Engineering Materials, A. K. Bhargava, Prentice Hall India Learning Private Limited, New Delhi, 2011
5. Engineering Materials – Properties and applications of Metal and Alloys, C. P. Sharma, Prentice- Hall of India Pvt. Ltd; 1st edition, New Delhi, 2004

ONLINE/E RESOURCES:

1. https://nptel.ac.in

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Scheme/Specialization: B.Tech. (Metallurgical and Materials Engineering)

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT102	**Fuels, Furnaces & Refractories**	**4**	**3**	**1**	**0**	**0**

PREREQUISITE: Basic Science (10+2 level)

COURSE OBJECTIVE:

- To familiarize and equip the students with basic knowledge about different types of fuels, furnaces, and refractories used in metallurgical industries

COURSE OUTCOMES:

CO1	Understand about various solid, liquid, and gaseous fuels and their importance in metallurgical industries.
CO2	Differentiate different manufacturing process of various fuels having industrial significance.
CO3	Analyze the use of stoichiometry for evaluating combustion performances.
CO4	Understand about refractories and metallurgical furnaces.
CO5	Understand different constructional and working principles of different types of furnaces and refractories

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Fuels: Definition, their importance in human life (historical background). Comparative study of solid, liquid, and gaseous fuels. Primary and Secondary fuels. Constitution, classification and grading of coal. Characterization of Coal: Proximate analysis, Ultimate analysis, Calorific value. Coal washing. Coal blending and its importance in metallurgical industries.

(No. of lectures - 7)

Unit II Carbonization of coal: Caking, Coking and Non- coking Coals. Metallurgical coke preparation, Testing and properties of coke. Formed coke, Dry quenching of coke. Manufacture, properties and uses of Producer gas and Water gas. Properties and uses of Blast furnace gas and Coke oven gas.

(No. of lectures - 7)

Unit III Combustion Stoichiometry: Estimation of minimum amount of air required for a fuel of known composition, theoretical and actual combustion processes - Air fuel ratio, estimation of dry flue gases for known fuel composition, calculation of the composition of fuel and excess air supplied from exhaust gas analysis.

(No. of lectures - 6)

Unit IV Furnaces: Definition and Classification of Furnaces, Major furnace components. Furnace atmosphere. Natural, forced, induced, and balanced draft. Chimney height. Heat losses in furnaces and minimization. Waste heat recovery. Flue gas cleaning systems. Various types of heating elements and Electric Furnaces viz. Resistance, Arc, and Induction furnaces

(No. of lectures - 12)

Unit V Refractories: Desirable properties of refractories. Methods of classification. Modes of failure of refractories in service and their prevention. Manufacturing methods and properties of Fireclay, Silica, Magnesite, and Chrome- Refractories. Metallic Refractories. Testing of Refractories. Applications of refractories in the metallurgical industries.

(No. of lectures - 8)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Fuels, furnaces and refractories, R. C. Gupta, 1st Edition, PHI Learning Pvt. Ltd. Delhi, 2016.
2. Fuels, furnaces, refractories and pyrometry, A.V.K. Suryanarayana, 2nd edition, B.S. Publication. 2015.
3. Elements of fuels, furnaces & refractories O.P. Gupta, 6th Edition, Khanna Publishers, 2014.
4. Elements of Refractory Technology, O.P. Gupta, 1st edition, Khanna Book Publishing Co. Ltd., 2017.
5. Industrial Furnaces, W. Trinks, M.H. Mawhinney, R.A. Shannon, R.J. Reed, and J.R. Garvey, 6th edition, John Wiley and Sons, 2003.
6. Fuels, furnaces and refractories, J. D. Gilchrist, Pergamon Press, 1977.

ONLINE/E RESOURCES:

1. https://nptel.ac.in

SEMESTER - II

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT103	**Introduction to Physical Metallurgy**	**4**	**3**	**1**	**0**	**0**

PREREQUISITES: Introduction to Engineering Materials

COURSE OBJECTIVES:

- The course seeks to engage students in critical thinking and understanding regarding the field of physical metallurgy.
- Students will be able to have a critical awareness of how these principles relate to current issues in exploiting structural alloys in engineering applications.

COURSE OUTCOMES:

CO1	Understand the role of crystal structures in material properties.
CO2	Evaluate critically the relevance of phase diagrams, isothermal transformation diagrams to understand real alloys and their microstructure.
CO3	Extend their know- how in areas such as compositions, microstructures, and various technical metals properties.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Introduction: Introduction, atomic structure of materials, crystal systems, crystal planes and directions, atomic packing efficiency, voids in common crystal systems, BCC, FCC, HCP structures.

(No. of lectures - 6)

Unit II Defects in crystals: Types of defects, point defects, line defects- dislocations, partial dislocation, surface defects- stacking fault, volume defects.

(No. of lectures: 4)

Unit III Principles of solidification: Nucleation & growth kinetics, homogeneous & heterogeneous nucleation, diffusion in solids, solidification of metal in ingot mould, directional solidification, dendrite growth, types of segregation, porosity, coring and homogenization.

(No. of lectures - 6)

Unit IV Principles of alloys formation: Concepts of alloy system and explanation of terms like system, component, phase, degree of freedom, constituents of an alloy, phase rule, phase-equilibrium, lever rule, concept of free energy, entropy, surface energy (grain boundary), free energy of mixing. Primary and intermediate phases and their formation, solid solution, Hume-Rothery rules, electron compounds, normal valency compounds, interstitial compounds, intermetallic compounds.

(No. of lectures - 8)

Unit V Phase Diagrams: Equilibrium diagrams and their classification based on solubility of components in liquid and solid states, cooling curves, concept of super cooling, morphology and distribution of phases, effect of non- equilibrium cooling on morphology. Binary phase diagrams: Isomorphous, Eutectic, Peritectic, Eutectoid, Peritectoid, Monotectic and Monotectoid system, common binary systems *viz. Cu- Ni, Cu- Zn, Cu- Sn, Al- Cu, Al- Si, Pb-Sn,* congruent melting phases, ternary phase diagrams, experimental determination of phase diagrams.

(No. of lectures - 10)

Unit VI Fe-Fe_3C phase diagrams: Allotropic changes, order disorder transformations, construction of iron cementite and iron- graphite phase diagrams, critical temperatures and invariant reactions, microstructure and properties of different alloys (both steels and cast irons).

(No. of lectures - 6)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Physical Metallurgy Principles, Reed- Hill, Robert E., Reza Abbaschian, and Lara Abbaschian. 4th Ed. Cengage Learning, 2009.
2. Introduction to Physical Metallurgy, Sidney H. Avner, McGraw Hill Education (India) Private Limited, 2017.
3. Materials Science and Engineering (5th Edition), V. Raghavan, Prentice- Hall of India Pvt. Ltd., 2004.
4. Callister's Materials Science and Engineering, W.D. Callister, Wiley Inida (P) Ltd., 2007.
5. The Science and Engineering of Materials, Donald. R. Askeland & Pradeep Phulé, Cengage Learning, 2006.
6. Engineering Physical Metallurgy, Y Lakhtin, Mir Publishers Moscow, 2009.
7. Physical Metallurgy, 2nd Edition, Willam F. Hosford, Taylor & Francis, 2015
8. Physical Metallurgy, Vijendra Singh, Standard Publishers, 2020.

ONLINE/E RESOURCES:

1. https://nptel.ac.in

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT104	**Mineral Processing**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE: Course: (10+2) Science

COURSE OBJECTIVE:

To familiarize the students with different mineral dressing processes, practices and equipment.

COURSE OUTCOMES:

CO1	Understand different types of comminution operations.
CO2	Distinguish the importance of sizing and classification.
CO3	Understand various types of concentration methods.
CO4	Analyze different ways of separating solids from fluids.
CO5	Understand different coal washing methods.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following four components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I: Importance of mineral processing, Comminution and liberation, Jaw crushers, Gyratory crushers, Cone crushers, Roll crushers, Ball Mill, Rod mill, Tube mill, Sizing and classification: Laboratory methods of sizing and interpretation, Industrial screening.

(No. of lectures - 15)

Unit II: Laws of settling of solids in fluids, Type of classifiers, Gravity concentration by Wilfley table, Spiral shaking tables, Jigging, Heavy media separation, Froth flotation, function of various reagents. Filtration. Electromagnetic, Electrostatic, Amalgamation techniques of concentration, Separation of solids from fluids: dewatering, thickening, filtration, dust elimination, drying.

(No. of lectures - 15)

Unit III: Coal washing: Washability curves, cleaning of coal by gravity concentration and flotation methods.

(No. of lectures - 5)

Unit IV: Recent advances and practices of mineral processing used in industries.

(No. of lectures - 5)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. A.M. Gaudin, Principles of Mineral processing, McGraw- Hill Inc., US, 1939.

2. S.K. Jain, Mineral Processing, CBS, 2nd Edition, 2001.

3. Wills' Mineral Processing Technology seventh edition, Barry A. Wills, Willey, 2006.

OTHER REFERENCES:

1. Recent journal papers

2. Expert lecture from industry persons

ONLINE RESOURCES:

1. https://nptel.ac.in

SEMESTER III

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT203	**Introduction to Extractive Metallurgy**	**4**	**3**	**1**	**0**	**0**

PREREQUISITE: Mineral Processing

COURSE OBJECTIVE:

- To provide basic understanding about different extraction routes of primary metal productions especially non- ferrous metals from their resources. To provide basic knowledge about individual processes involved in different stages of extraction.

COURSE OUTCOMES:

CO1	Understand different extraction routes for metal production.
CO2	Infer thermodynamics and kinetics involved in different extraction routes.
CO3	Classify different refining process of metals keeping in view of cost effectiveness.
CO4	Identify different lean metals and alloys *produced by using electro winning & electro refining processes.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following components.

S. No.	Component	Weightage
d)	Weekly submissions/assignments/Quiz	20%
e)	Mid- term examination	40%
f)	End Semester Examination	40%

COURSE CONTENTS:

Unit I The sources of metals, Minerals and Ores, Primary metal production plants in India especially non- ferrous metals like Al, Cu, Zn and Pb, Unit Processes and Unit Operations, Features of Metal Extraction, Simplified flow sheets for the production of Al, Cu, Zn and Pb. Material Balances in Metallurgical Processes.

(No. of lectures - 8)

Unit II Unit processes in pyrometallurgy - Calcinations, Roasting, Agglomeration (Pelletizing and sintering), Reduction smelting, Matte smelting, Converting, Distillation, Importance of Ellingham diagrams in metal extraction by pyrometallurgy, Refining with suitable examples.

(No. of lectures - 10)

Unit III: Hydrometallurgical processes: Principles and types of leaching, Purification of leach liquor, Solvent extraction and ion exchange process, Techniques of metal recovery from aqueous phase and their applications. Hydrometallurgy for extraction of metals like cu, Zn, Pb.

(No. of lectures - 8)

Unit IV: Unit Processes in Electrometallurgy: aqueous and fused salts, electrochemistry of Aqueous solutions, Cell types and Potentials, Electro- winning and Electro- refining in reference to non- ferrous metals like Al, Cu, Zn and Pb, Current and Energy efficiency & problems related to this.

(No. of lectures - 9)

Unit V: Recent advances and practices for metal extraction in Industry.

(No. of lectures - 5)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Extraction of non- ferrous Metals by H.S. Ray, R. Sridhar and K.P. Abraham, Affiliated East West Press Pvt. Ltd., New Delhi & 2007.
2. Principles of Extractive metallurgy by Terkel Rosenqvist, McGraw Hill, New York & 1983
3. Extractive metallurgy 2nd Edition by J.D. Gilchrist, Oxford; New York: Pergamon Press & 1980.
4. Principles of extractive metallurgy by H.S. Ray and A. Ghosh, Wiley Eastern Ltd., New Delhi & 1991.
5. Principles of Extractive Metallurgy, Vol.1 by F. Habashi, Gordon and Breach, New York & 1969.

ONLINE/E RESOURCES:

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT201	**Electrometallurgy & Corrosion**	**4**	**3**	**1**	**0**	**0**

PREREQUISITE: Thermodynamics of Materials

COURSE OBJECTIVE:

- This basic course defines the concepts and introduces the thermodynamic and electrochemical aspects of corrosion.
- This course deals with the knowledge on the corrosion mechanism and corrosion testing methods about different forms of corrosion for advanced engineering materials.
- Students will get an idea about how corrosion can be controlled during the design process through construction, as well as process parameters, dissimilar metals, crevices.
- To provide various examples and case studies as to how and when to use the control corrosion methods of design, material selection, modification of environment, protective coatings, and cathodic and anodic protection methods.

COURSE OUTCOMES:

CO1	Understand about the mechanisms and causes of different forms of corrosion.
CO2	Understand about corrosion of materials and its prevention techniques & propose materials with better corrosion resistance in specific environments.
CO3	Understand the impact of composition, type of material and its microstructure on corrosion.
CO4	Sketch new inhibitors and coating materials which can sustain in adverse conditions by eliminating/reducing corrosion in particular condition.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following three components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Basics of corrosion: Thermodynamics and electrochemical aspects of corrosion; Faradays' laws of electrolysis, EMF and galvanic series, Evans diagram, Pourbaix diagram and its importance to metals like aluminium, iron and magnesium.

(No. of lectures - 8)

Unit II Kinetics of Corrosion: Rate of carrion, Exchange current density, Polarization, kinetics of polarization, limiting current tendency; Tafel's equation, passivity- theory & applications. Mixed potential theory, Electro- deposition: Classification and mechanism of electro- deposition processes.

(No. of lectures - 11)

Unit III Forms of Corrosion: Uniform, Galvanic, Crevice, Pitting, intergranular, Stress corrosion cracking, Corrosion fatigue, Hydrogen embrittlement, Dealloying, Cavitation, and high temperature oxidation - only description, causes and remedial measures.

(No. of lectures - 10)

Unit IV Corrosion prevention: prevention and control by various methods- change of metal composition, design improvement, inhibitors, coatings and electrochemical methods of protection – anodic (anodizing) and cathodic protection.

(No. of lectures - 6)

Unit V Corrosion in Industries: Relevant case studies.

(No. of lectures - 5)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Corrosion Engineering, 2nd edition, Fontana, M.G., Greene, N.D., McGraw- Hill, USA & 1983
2. An introduction to metallic corrosion and its prevention by Raj Narayan, Mohan Primlani for Oxford & IBH Publishing Company & 1983.
3. Fundamentals of corrosion: mechanisms, causes, and preventative methods, Philip A. Schweitzer, CRC Press & 2010
4. Corrosion and corrosion control: An introduction to Corrosion science and engineering (4th ed.), H. H. Uhlig and R. W. Revie, John Wiley & Sons & 2008.
5. Principles of Corrosion Engineering and Corrosion Control, Zaki Ahmad, Elsevier Science & Technology Books & 2006.

ONLINE RESOURCES:

1. https://nptel.ac.in

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT204	**Mechanical Behaviour and Testing of Metals**	**4**	**3**	**1**	**0**	**0**

PREREQUISITE: Basic Sciences (10+2 level), Introduction to Engineering Materials

COURSE OBJECTIVE:

To provide background on the mechanical properties of materials, mechanisms of deformation, failure mechanisms and mechanical property correlation with microstructure

COURSE OUTCOMES:

CO1	Identify materials with improved mechanical properties
CO2	Identify failure mechanisms in materials for engineering applications
CO3	Measure important mechanical properties and correlate with the microstructure

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following four components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Continuum Theory of Deformation: Stress and strain tensor, Generalized Hooke's Law, Yield Criteria

(No. of lectures - 2)

Unit II Lattice Defects: Vacancies and interstitials, dislocations: Edge and Screw, stress fields around edge and screw dislocations, strain energy of dislocations, force on dislocation, dislocation- dislocation interaction.

(No. of lectures - 6)

Unit III Plastic Deformation: Slip by dislocation movement, Critical Resolved Shear stress, cross- slip and climb, Twinning, Grain boundary sliding, Tensile Testing, Tensile properties, Tensile Testing Machines, Factors affecting tensile properties. Torsion testing, strengthening mechanisms.

(No. of lectures - 8)

Unit IV Hardness Testing: Various hardness tests, advantages and limitations of various hardness tests, Microhardness testing. Impact testing, various impact tests and their relative merits and demerits. Ductile - brittle transition behavior and its significance.

(No. of lectures - 8)

Unit V Fracture: Griffith theory of fracture, Modes of fracture, Fracture toughness, Brittle and ductile fracture, Fracture characterization and failure analysis.

(No. of lectures - 8)

Unit VI Fatigue and Creep: Introduction to fatigue, S- N Curve, mechanisms of fatigue in metals, Factors affecting fatigue, Creep, Creep mechanisms, Factors affecting creep

(No. of lectures - 8)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Dislocations and Mechanical Behavior of Materials, M. N. Shetty, Prentice Hall India Learning Private Limited, 2013
2. Mechanical Behavior of Materials, T. H Courtney, 2nd Edition, Waveland Press Inc., 2005
3. Mechanical Metallurgy, G. E. Dieter, 3rd Edition, McGraw- Hill Book Company, 2017
4. Mechanical Behavior and Testing of Materials, A. K. Bhargava and C. P. Sharma, PHI Learning (P) Ltd., 2011.
5. ASM Handbook, Mechanical Testing and Evaluation, Volume 8, 2000.

ONLINE RESOURCES

1. https://nptel.ac.in

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT205	**Metallurgical Thermodynamics and Kinetics**	**4**	**3**	**1**	**0**	**0**

PREREQUISITES: Basic Sciences, Introduction to physical metallurgy

COURSE OBJECTIVES:

- To provide the fundamental principles of materials thermodynamics
- To train them to explain and apply the laws of thermodynamics on metallurgical reactions.

COURSE OUTCOMES:

CO1	Understand the role of thermodynamics laws on metallurgical reactions
CO2	Analyze the systems from the viewpoint of heat, work, enthalpy, free energy and entropy
CO3	Apply the laws of thermodynamics in metallurgical engineering applications

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following three components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I: Thermodynamic state and state variables, intrinsic and extrinsic properties, isothermal and adiabatic expansion of a perfect gas, Carnot's Engine

(No of Lecture - 3)

Unit II: Laws of thermodynamics: Zeroth and First law of thermodynamics, Hess's law, Kirchhoff's law.

(No of Lecture - 3)

Unit III: Second law of thermodynamics. Reversible and irreversible processes. Criterion for equilibrium. Entropy, its statistical nature and its role on equilibrium, variation in entropy with temperature, Helmholtz and Gibbs free energy.

(No of Lecture - 5)

Unit IV: Gibbs Helmholtz equation, Maxwell equations, Third law of thermodynamics, Phase equilibrium and phase transformation in Metals under high pressures, Clausius-Clapeyron equation

(No of Lectures: 7)

Unit V: Homogeneous and Heterogeneous equlibria, fugacity, activity, Equilibrium constant, Free energy- temperature diagrams (Ellingham diagrams) for the formation of oxides, sulphides, and chlorides and their applications

(No of Lectures: 8)

Unit VI: Partial molar properties, Chemical potential, Gibbs – Duhem equation, Thermodynamics of solutions: Ideal and non- ideal solutions, Regular solutions, Principles of activity determination, Raoult's law, Henry's law and Sieverts law, Thermodynamics of electrochemical cells.

(No of Lectures: 9)

Unit VII: Kinetics: Order of reaction and molecularity. Arrhenius Equation. Theories of reaction kinetics, Collision theory and theory of absolute reaction rate

(No of Lectures: 5)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Problems in Metallurgical Thermodynamics and Kinetics, G. S. Upadhyay and R.K. Dube, Pergamon, 1st Edition, 1977
2. Principles of Metallurgical Thermodynamics, S.K. Bose and S.K.Roy, Universities Press India Pvt. Ltd 2014
3. Introduction of Metallurgical Thermodynamics, Gaskell, Taylor & Francis Inc; 2nd edition 1981
4. Physical Chemistry of Metals, Darken and Gurry, CBS; 1st edition, 2002
5. Principles of Extractive Metallurgy, Rosenquvist, Tapir Academic Press, 2004
6. Chemical and Metallurgical Thermodynamics, Vol. I, M. L. Kapoor, McGraw Hill Education; Fifth edition, 2017

ONLINE RESOURCES

1. https://nptel.ac.in

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT202	**Foundry Technology**	**4**	**3**	**1**	**0**	**0**

PREREQUISITE: Introduction to Physical Metallurgy

COURSE OBJECTIVE:

To provide the students with the knowledge of foundry material, equipment and processes.

COURSE OUTCOMES:

CO1	Familiarize different pattern and mold materials used in foundry industries.
CO2	Understand different molding and allied processes.
CO3	Analyze the solidification of metals.
CO4	Understand different furnaces used in foundry industries.
CO5	Understand casting defects, their causes, remedies and quality control in foundry.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following four components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I: Introduction to foundry practice as a process of manufacturing, Patterns: Functions, classification, materials, allowances and design considerations. Molding materials: Types of molding sand and their characteristics, Ingredients of molding sand, Special additives, Binders: their effect on the properties of molding sand, Parting and facing materials, Core sand, Cores and their types.

(No. of lectures - 10)

Unit II: Molding/Casting processes: Sand mold casting (Green, dry, floor, pit, cement bonded core sand), Shell molding, CO_2 mold casting, Investment casting, Shell casting, Ceramic mold casting, Plaster mold casting, Permanent mold casting: centrifugal casting, gravity die- casting and pressure die casting, Gating and risering: basic requirements of gating and feeding system, design of gating system, types of gates, design of feeders, Use of exothermic compounds, exothermic sleeves, chills and padding.

(No. of lectures - 15)

Unit III: Solidification of castings: nucleation and growth phenomena, Metal mold vs. sand mold, pure metal vs. alloy, Effect of grain refiner, Melting furnaces: selection of remelting furnace, Cast iron foundry practice, Cupola melting practice, Production of SG and cast iron, Remelting practice for ferrous and nonferrous alloys.

(No. of lectures - 10)

Unit IV: Casting defects: causes and remedies, Quality control in foundry, Sand reclamation, Recent practices in foundry industries.

(No. of lectures - 5)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. R.W. Heine, C.R. Loper, P.C. Rosenthal, Principles of Metal Casting, Tata McGraw Hill Pub. Co. Ltd., New Delhi, 2nd edition, 2017.
2. P.L. Jain, Principles of foundry Technology, Tata McGraw Hill Co. Ltd., New Delhi, 2003.
3. P.L. Jain, Tool Engineering for Metal Casting Processes, Tata McGraw Hill Co. Ltd., New Delhi, 2015.
4. H.F. Taylor, M.C. Flemings, J. Wulf, Foundry Engineering, Wiley Eastern Ltd., New Delhi,1962
5. D. Kumar & S.K.Jain, Foundry Technology, CBS, Publishers, New Delhi, 2007.
6. P.C. Mukherjee, Fundamentals of Metal Casting Technology, Oxford& 1BH Pub. Co. Pvt. Ltd., New Delhi, 2nd Edition, 1988.
7. ASM metal handbook, Vol. 15, 2008.

ONLINE RESOURCES:

1. https://nptel.ac.in

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Scheme/Specialization: B.Tech. (Metallurgical and Materials Engineering)

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTP209	**Testing of Materials Lab**	**1**	**0**	**0**	**2**	**0**

PREREQUISITE: Basic Sciences (10+2 level), Introduction to engineering materials

COURSE OBJECTIVE:

- Ability to apply knowledge of mathematics and engineering in calculating the mechanical properties of structural materials.
- Ability to use the techniques, skills and modern engineering tools necessary for engineering.
- Understanding of professional and ethical responsibility in the areas of material testing.
- Evaluation of mechanical properties of structural materials.
- Interpretation of test results.

COURSE OUTCOMES:

CO1	Acquire experimentation skills in the field of material testing.
CO2	Develop theoretical understanding of the mechanical properties of materials by performing experiments.
CO3	Apply the knowledge to analyze a material failure and determine the failure inducing agent/s.
CO4	Apply the knowledge of testing methods in related areas.
CO5	Understand how to improve structure/behaviour of materials for various industrial applications.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following four components.

S. No.	Component	Weightage
a)	Mid- term examination	20%
b)	End Semester Examination	20%
c)	Continuous evaluation (Laboratory performance, record submission etc.)	60%

LIST OF EXPERIMENTS:

1. Principles of hardness testing comparison of different hardness techniques - Brinell, Rockwell and Vickers's Hardness tests on untreated and heat- treated specimens.

2. Determination of the tensile properties of different class of materials - steel, aluminum and cast iron specimen

3. Impact testing of materials - Izod and Charpy Tests on Mild steel and C.I Specimen.

4. To study the wear characteristics and calculate wear loss of ferrous and non- ferrous materials under different parameters (demonstration)

5. Formability test – Erichsen cupping test

6. Study on Creep testing of materials

7. Study on Fatigue testing

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Testing of materials laboratory manual

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Scheme/Specialization: B.Tech. (Metallurgical and Materials Engineering)

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTP206	**Foundry Technology Lab**	**1**	**0**	**0**	**2**	**0**

PREREQUISITE: Introduction to Physical Metallurgy

COURSE OBJECTIVE:

- To provide the students with the practical knowledge of sand testing and casting under different conditions.

COURSE OUTCOMES:

CO1	Acquire practical knowledge on determining molding sand ingredients and properties.
CO2	Acquire practical knowledge on determining the properties of resin coated sand.
CO3	Acquire practical knowledge on the effect of cover flux, degasifier and grain refiner on the microstructure and properties of aluminium casting.
CO4	Acquire practical knowledge on the effect of metal mold and sand mold on microstructure and properties of aluminium casting.
CO5	Acquire practical knowledge on the process of investment casting.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following four components.

S. No.	Component	Weightage
a)	Mid- term examination	20%
b)	End Semester Examination	20%
c)	Continuous evaluation (Laboratory performance, record submission etc.)	60%

COURSE CONTENTS:

1. To study the effect of moisture content and clay content on permeability, green compressive strength and green hardness of a green mold.
2. To study the effect of moisture content and clay content on the shatter index of a green mold.
3. To determine the grain fineness number of a given natural sand using sieve analysis.
4. To determine the moisture content and clay content of a given molding sand.

5. To determine the tensile strength of a given resin coated sand in hot condition as well as in cold condition.
6. To determine the amount and the rate of gas evolution and melting point of a given resin coated sand.
7. To perform melting and casting of aluminium using cover flux and degasifier.
8. To study the effect of grain refiner on the microstructure of cast aluminium.
9. To study the effect of sand mold and metal mold on the cast structure of aluminium.
10. To prepare a metal object through Investment casting.
11. To prepare a metal object through centrifugal casting and to study its microstructure
12. To perform fluidity test of a molten metal.

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Foundry technology laboratory manual

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTP208	**Mineral processing lab**	**1**	**0**	**0**	**2**	**0**

PREREQUISITE: Principles of Mineral Processing

COURSE OBJECTIVE:

To familiarize the students with different mineral dressing processes and equipment.

COURSE OUTCOMES:

CO1	Distinguish different types of crushers.
CO2	Contrast on sizing and classification.
CO3	Analyse various types of concentration methods.
CO4	Analyze different ways of separating solids from fluids.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following four components.

S. No.	Component	Weightage
a)	Mid- term examination	20%
b)	End Semester Examination	20%
c)	Continuous evaluation (Laboratory performance, record submission etc.)	60%

COURSE CONTENTS:

1. Study of various minerals and ores.
2. To study the construction and operation of Blake type jaw crusher, and to find its reduction ratio and production capacity.
3. To study the construction and operation of roll crusher and to find out its reduction ratio, angle of nip and production capacity.
4. To study the construction and operation of disc pulverizer and to find the grindability index of given feed.
5. To study the construction and operation of ball mill and find the grindability index of the given feed.

6. To study the construction and operation of rod mill and find the grindability index of the given feed.
7. To study the single deck and double deck vibrating screens and to find screen efficiency.
8. To find the percentage of iron scrap present in a given feed using magnetic separator.
9. To study the construction and operation of froth floatation cell.
10. To study the construction and operation of mineral jig.
11. To study the construction and operation of pneumatic classifier.
12. To study the construction and operation of spiral classifier.
13. To study the construction and operation of Wilfley table, Richard hindered settling classifier and thickener.
14. To study the process of flocculation.

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Mineral processing laboratory manual

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTP207	**Fuel, Furnaces and Refractories Lab**	**1**	**0**	**0**	**2**	**0**

PREREQUISITE: Basics of fuel, furnaces and refractories

COURSE OBJECTIVE:

To familiarize and equip the students with basic knowledge about characterization and testing of fuels, furnaces, and refractories used in various metallurgical industries.

COURSE OUTCOMES:

CO1	Analyze the estimation of various properties of fuels and oils.
CO2	Understand the working principles thermocouples and their calibration.
CO3	Compare different heating elements used in industrial furnaces.
CO4	Understand constructional and working principles of different types of furnaces.
CO5	Understand the method of making and testing the refractory products.

COURSE ASSESSMENT:

The Course assessment (culminating to the final grade), will be made up of the following four components.

S. No.	Component	Weightage
a)	Mid- term examination	20%
b)	End Semester Examination	20%
c)	Continuous evaluation (Laboratory performance, record submission etc.)	60%

COURSE CONTENTS:

1. To determine the viscosity of the given fuel oil by using the Redwood and Engler's viscometer.
2. To determine the flash point and fire point of the given fuel oil using the Abel, Pensky-Martan, and Cleveland's apparatus.
3. To determine the proximate analysis of the given coal sample.

4. To determine the Sulphur content of the given coal sample.
5. To determine the calorific value of the given fuel using the Bomb's calorimeter.
6. To study about different thermocouples and their calibration.
7. To study about various heating elements including measure of resistance.
8. To study the variation of resistance with respect to temperature in Kanthal / Nichrome wire
9. To study about various parts of furnaces (Muffle, Induction, and Raising Hearth furnace)
10. To determine the packing density of refractory raw materials.
11. To study of effect of composition, forming pressure & firing temperature on some properties of refractory bodies.
12. To determine the spalling resistance (Thermal Resistance Shock Test) of refractory bodies.

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Elements of fuels, furnaces & refractories O.P. Gupta, 6th edition, Khanna Publishers, 2014.
2. Fuels, furnaces and refractories, R. C. Gupta, 1st edition, PHI Learning Pvt. Ltd. Delhi, 2016.
3. Industrial Furnaces, 6th Edition, W. Trinks, M. H. Mawhinney, R. A. Shannon, R. J. Reed, J. R. Garvey, Willey, 2003.

ONLINE/E RESOURCES:

1. https://nptel.ac.in

SEMESTER IV

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT253	**Mechanical Working of Metals**	**4**	**3**	**1**	**0**	**0**

PREREQUISITE: Basic Sciences (10+2 level), Mechanical behavior and testing of metals

COURSE OBJECTIVE:

- To provide background on the manufacturing techniques used in metal industries for forming and processing operations.

COURSE OUTCOMES:

CO1	Understand basic manufacturing techniques
CO2	Identify microstructural evolution and property improvements during processing
CO3	Understand the mechanics (forces, strain etc.) during processing

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Introduction: Types of casting, Structure of casting and ingots, Thermodynamics of solidification, Constitutional undercooking, dendritic growth, Heat transfer, Introduction to mechanical working, Principles of mechanical working, classification of working processes.

(No. of lectures - 7)

Unit II Forging: Classification of forging operations, Metallurgical variables associated with forging, Forging equipments and Forging defects.

(No. of lectures - 6)

Unit III Rolling: Forces and geometrical relationship in rolling, classification of rolling mill, Terminology in rolling, variables in rolling, Roll bite conditions. Roll pass design, types of passes, rolling of blooms, billets, slabs, rods, rails, sheets and structural sections. Rolling defects, microstructural changes.

(No. of lectures - 7)

Unit IV Extrusion: Classification of extrusion processes, Variables in extrusion, Flow of metal during extrusion, Extrusion equipment, Hydrostatic extrusion, Defects in extrusion. Microstructural changes.

(No. of lectures - 6)

Unit V Drawing and Forming: Mechanism of drawing, Variables in wiredrawing, Defects in rod and wire products Sheet Metal forming: Classification of forming operations, Forming limit curve, Defects informed products.

(No. of lectures - 6)

Unit VI Advanced Working Processes: Manufacturing of seamless and welded tubes, rail road wheels and tyres, High energy rate forming, Severe plastic deformation techniques like Friction stir processing, Equal channel angular extrusion, High Pressure Torsion, Accumulative Roll Bonding.

(No. of lectures - 8)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Manufacturing Engineering and Technology, Serope Kalpakjian & Steven R. Schmid, Pearson Education, 2018
2. Manufacturing Science, A. Ghosh & A.K. Mallik, East- west press Pvt. Ltd, 2010
3. Mechanical Metallurgy, G. E. Dieter, McGraw- Hill Book Company, 2017
4. Manufacturing Technology, P.N. Rao, McGraw Hill Education, 2018
5. Metal Forming: Processes and Analysis, Betzalel Avitzur, McGraw-Hill Inc., US, 1968
6. Handbook of Metal-forming Processes, Betzalel Avitzur, Wiley, 1983.

ONLINE RESOURCES:

1. https://nptel.ac.in

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT252	**Iron Making**	**4**	**3**	**1**	**0**	**0**

PREREQUISITES: Introduction to Engineering Materials & Physical metallurgy

COURSE OBJECTIVES:

- To develop an in- depth understanding of the iron making process.
- To familiarize the students with BF operations and they will learn how to improve the quality of hot metal.

COURSE OUTCOMES:

CO1	Understand the physicochemical principles involved in iron making.
CO2	Understand the concepts of various modern blast furnace operations.
CO3	Relate the practical aspect of agglomeration process.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following three components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Historical prospects: History of iron making; General overview of iron making across the world; Distribution of iron ores in India; Beneficiation of Indian iron ores.

(No. of lectures - 3)

Unit II Burden preparation: Importance of burden distribution on the performance of blast furnace Agglomeration of iron ores: Sintering and pelletizing, types of sinter, mechanism of bonding in sintering and pelletizing, Testing of burden materials used in BF.

(No. of lectures - 6)

Unit III Blast furnace overview: Design of furnace, different zones, blast furnace refractories, bell- less charging system; Regenerative principles of blast heating- Cowper stoves.

(No. of lectures - 5)

Unit IV Physicochemical processes in blast furnace: blast furnace reactions; physical chemistry of reduction of iron oxide within blast furnace; Reaction in stack, bosh and hearth; indirect and direct reduction in iron making. Slag- metal equilibrium within blast furnace, de-sulphurisation, de-siliconisation.

(No. of lectures - 10)

Unit V Modern trend in the BF: Oxygen enrichment and humidification of air blast- its importance in blast furnace performance; Injection of fuel through tuyers and its impact on blast furnace efficiency; Effect of high top pressure on furnace performance; Preheating of air blast in iron production.

(No. of lectures - 8)

Unit VI Blast furnace irregularities: hanging, scaffolding etc., remedial measures to Control of blast furnace operation. Modeling and simulation as tool to improve the performance of blast furnace. Modern iron making practices. Plant practice for green iron making processes.

(No. of lectures - 8)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Iron Making and Steelmaking: Theory and Practice, Ghosh, and A. Chatterjee, PHI Learning (P) Ltd., 2008.
2. Introduction to Physical chemistry of iron and steel making, R. G. Ward, ELBS, 1962.
3. Physical Chemistry of Iron & Steel Manufacturer, Bodsworth C., CBS Publishers, 2014.
4. Principles of blast furnace Iron Making, A. K. Biswas, SBA Pub., Kolkata, 1984.

ONLINE/E RESOURCES:

1. https://nptel.ac.in

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT255	**Phase Transformations**	**4**	**3**	**1**	**0**	**0**

PREREQUISITE: Basic understanding of thermodynamics

COURSE OBJECTIVES:

- To make the students understand the significance of phase transformation and diffusion.
- To familiarize the students with different kind of phase transformations, commonly seen in alloys systems.
- To understand the basic correlation of thermodynamics and kinetics of phase transformation.
- To impart knowledge on dependence of properties on phase transformation.

COURSE OUTCOMES:

CO1	Understand the phase transformation in different alloy systems and their microstructure.
CO2	Understand fundamental knowledge about the thermodynamics and kinetics of phase transformation.
CO3	Compare the phase transformation of steels, aluminium etc. which are the most commercially exploitable materials for our society.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following four components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Introduction: Classification of phase transformations, Concept of Equilibrium. Thermodynamics and kinetics of phase transformation: Free energy of elemental crystal and solid solutions. Nature of inter- phase interfaces and their energies. Theory of nucleation, homogeneous and heterogeneous. Strain energy effect. Diffusion in solids: Steady state diffusion, non-steady state diffusion, solution of Fick's second law.

(No. of lectures - 8)

Unit II Grain Growth: Theory of thermally activated growth, interface- controlled growth (polymorphic and massive), diffusion- controlled growth (one and three dimensional), coupled growth (eutectoid and discontinuous precipitation). Overall transformation kinetics Empirical equations, Johnson-Mehl and Avrami models. Isothermal Transformation diagrams.

(No. of lectures - 7)

Unit III Liquid-solid transformation: Nucleation, homogeneous and heterogeneous, growth continuous and lateral, interface stability, alloy solidification cellular and dendritic, eutectic, off-eutectic, peritectic solidification, welding, casting and rapid solidification.

(No. of lectures - 6)

Unit IV Solid state transformation: Classification, nucleation and growth - homogeneous and heterogeneous mechanism, precipitate growth under different conditions, age hardening, spinodal decomposition, precipitate coarsening, transformation with short range diffusion, moving boundary transformations recrystallization, grain growth, eutectoid transformation, discontinuous reactions.

(No. of lectures - 7)

Unit V Diffusive transformation: Factors influencing pearlitic transformation, mechanism of transformation, nucleation and growth, orientation relationship, degenerate pearlite. Bainite mechanism of transformation, nucleation and growth, orientation relationships, surface relief, classical and non-classical morphology, effect of alloying elements.

(No. of lectures - 7)

Unit VI Non-diffusive transformation: Martensitic transformation, thermodynamics and kinetics, nucleation and growth, morphology, crystallography, stabilization, strengthening mechanisms, nonferrous martensite, shape memory effect/alloys.

(No. of lectures - 5)

TEXT BOOKS (Title, Authors, Publisher & Year):

1. Solid State Phase transformation: V. Raghavan, Prentice Hall India, 1987.
2. Phase Transformation in Metals and Alloys, D.A. Porter and K. Easterling, 3rd Ed., CRC Press, 2009.

REFERENCE BOOKS:

1. Physical Metallurgy Principles, Robert E. Reed- Hill, Affiliated East- West Press, 2008.
2. Physical Metallurgy, Vijender Singh, Standard Publishers Distributors, 2010.
3. Introduction to Physical Metallurgy, Sidney H. Avner, Tata McGraw- Hill, 2004.

ONLINE/E RESOURCES:

1. https://nptel.ac.in

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT254	**NDT and Evaluation**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE: Introduction to Engineering Materials

COURSE OBJECTIVE:

- To introduce the concept of non- destructive testing among the students and teach them the working principles.
- To make awareness on how NDT techniques shall be applied for inspecting materials in accordance with industry specifications and standards.

COURSE OUTCOMES:

CO1	Identify appropriate NDT techniques as per requirement.
CO2	Understand various process parameters and control the NDT process for the desired output parameters.
CO3	Identify the internal flaws in the material by NDT and take measures to eliminate them.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following four components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I: Need for inspection, types of inspection system, quality of inspection, reliability of defect detection and benefits of NDT examination.

(No. of lectures - 4)

Unit II Visual Inspection: Basic principles, physical aids used for visual inspection and applications. Liquid Penetrant Inspection: Physical principles, procedures of testing, penetrant testing materials, penetrant testing methods, applications and limitations.

(No. of lectures - 6)

Unit III Magnetic Particle Testing: Principle of MPT, Magnetization techniques, procedure used for testing a component, equipment used for MPT, sensitivity, precautions, limitations, residual magnetism, need for demagnetization.

(No. of lectures - 6)

Unit IV Eddy current testing: Basic principles, techniques used for ECT, Applications and limitations. Radiography: Basic principles, electromagnetic radiation sources, effect of radiation in film, radiographic imaging, inspection techniques, applications and limitations.

(No. of lectures - 10)

Unit V Ultrasonic Testing: Basic principles of sound beam, ultrasonic transducers, type of display, inspection methods A, B and C scanning modes, identification of defects, immersion testing, applications and limitations.

(No. of lectures - 6)

Unit VI Acoustic Emission Testing (AET): Principles, technique, Instrumentation and applications. Miscellaneous tests. Reliability in NDT, statistical methods for quality control. Leak testing: Basic principles and application. In situ metallographic examination, sulphur printing.

(No. of lectures - 8)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Testing of metallic materials, A.V.K. Suryanarayana, 2nd edition, BSP Books Private Limited, 2018.
2. Non- destructive test and evaluation of materials, J. Prasad, and C.G.K. Nair, 2nd edition, Tata McGraw- Hill Education, 2011.
3. Practical non- destructive testing, B. Raj, T. Jayakumar, and M. Thavasimuthu, 3rd edition, Alpha Science International Limited, 2007.
4. Non-destructive evaluation: Theory, techniques, and applications, P.J. Shull, 1st Edition, CRC Press, 2002.
5. Non- destructive examination and quality control, 9th edition, ASM International, Vol.17, 1989.
6. Treatise on non- destructive testing and evaluation, T. Rangachari, J. Prasad and B.N.S. Murthy, Navbharath Enterprises, Vol.3, 1983.

ONLINE/E RESOURCES:

1. https://nptel.ac.in

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT251	**Basics of Transport Phenomena**	**4**	**3**	**1**	**0**	**0**

PREREQUISITE: Thermodynamics of Materials

COURSE OBJECTIVE:

- To provide to the student a sufficient background and understanding about the fundamental phenomena, governing equations and assumptions used in the analysis of transport processes.
- To make aware of the core scientific connections and will be encouraged to solve problems based on relevant analogies.

COURSE OUTCOMES:

CO1	Understanding about three fundamental transport processes, momentum, heat and mass, including conservation and constitutive equations.
CO2	Understand the knowledge about a non- steady- state physical process related to a given conduction or diffusion equation with corresponding initial and boundary conditions.
CO3	Understand the theoretical basis of convective heat- transfer and mass- transfer.
CO4	Analyse the analogies between momentum, heat, and mass transfer to interrelate rate constants.
CO5	Solve coupled heat, mass and momentum transfer problems based on analogy.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Fluid Behaviour: Newton's Law of viscosity, Momentum flux, Generalization of Newton's Law of viscosity, Pressure and temperature dependence of viscosity, shell balance, Differential mass balance (Continuity equation), Differential momentum balance (Equation of Motion), Navier-Stokes equation and its applications, solutions of momentum transfer problems in different geometries, flow past plane surfaces and through pipes, Overall Mass

balance and overall momentum balance. Euler's equations and its integration to obtain Bernoulli's equation (Energy Equation).

(No. of lectures - 12)

Unit II Heat Transfer: Modes of heat transfer, Thermal property of matter, Heat conduction equation and its application, Boundary conditions, concept of heat transfer coefficient, 1D steady state conduction, Forced and free convection, Heat transfer coefficient relations for forced convection Thermal conduction with internal heat sources, Heat transfer under change of phase, Transient conduction - lumped capacitance, Boundary Layer concepts**.**

(No. of lectures - 12)

Unit III Radiation: Aspects of radiative heat transfer, Black body radiation, Stefan-Boltzmann Law, Kirchhoff's Law, Concept of Gray body, Heat transfer between finite surfaces by radiation and view factor.

(**No. of lectures - 8)**

Unit IV Mass transfer: Diffusion and convective mass transfer, General differential equation for convective mass transfer, concept of mass transfer coefficient. **Dimensional analysis:** Buckingham Pi theorem, Significance of dimensionless numbers. Mathematical treatment of the similarities between heat, mass and momentum transfer.

(No. of lectures - 8)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Transport Phenomena 2nd Edition by Bird, Stewart and Lightfoot, Wiley India Pvt. Ltd., 2018.
2. Rate Processes in Metallurgy by A.K. Mohan, PHI Learning Pvt. Ltd., 2012
3. Fundamentals of Heat and Mass Transfer Sixth Edition by Incropera, Wiley, 2007
4. Heat and Mass Transfer by R.C. Patel, Acharya Book Depot., 1964
5. Transport phenomena in materials processing by D.R. Poirier and G.H. Geiger, TMS, 2016

ONLINE/E RESOURCES:

1. https://nptel.ac.in

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Scheme/Specialization: B.Tech. (Metallurgical and Materials Engineering)

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTP258	**Metallography & Structural Characterization lab**	**1**	**0**	**0**	**2**	**0**

PREREQUISITE: Introduction to Physical Metallurgy

COURSE OBJECTIVE:

To familiarize the students with basic knowledge metallographic practices and study the various microstructures of various steels, cast iron and other alloys.

COURSE OUTCOMES:

CO1	Understanding different metallographic practices
CO2	Demonstrate the use of microscope.
CO3	Correlate the microstructure of various steels, cast iron and other alloys
CO4	Identify different phases in the given alloy sample

COURSE ASSESSMENT:

The Lab Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	PRS (Practical Sessionals)	60%
b)	PRM (Practical Mid Term Exam)	20%
c)	PRE (Practical End Term Exam)	20%

COURSE CONTENT:

1. Study of optical microscope and image formation.
2. Metallographic specimen preparation and etching reagents for various metals and alloys
3. Microstructural study of mild steel.
4. Microstructural study of stainless steel.
5. Microstructural study of grey cast iron
6. Microstructural study of nodular cast iron
7. Microstructural study of non- ferrous alloys
8. Determination of grain size
9. Study of sulphur print/ phosphorus print
10. Quantitative metallography: volume fraction measurement

11. Study of stereographic projection: Fundamental Principles

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Lab Manual

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Scheme/Specialization: B.Tech. (Metallurgical and Materials Engineering)

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTP256	**Electrometallurgy and Corrosion Lab**	**1**	**0**	**0**	**2**	**0**

PREREQUISITES: Electrometallurgy and Corrosion

COURSE OBJECTIVES:

- This lab course is mainly designed to conduct the practical's like electro- deposition, verification of Faraday's laws, and evaluation of factors affecting corrosion

COURSE OUTCOMES:

CO1	Apply the concept of electrochemical and electrolytic processes
CO2	Design hands on equipment to evaluate corrosion studies.
CO3	Analyze the corrosion phenomenon in a given practical application.

COURSE ASSESSMENT:

The Course assessment (culminating to the final grade), will be made up of the following three components.

S. No.	Component	Weightage
a)	PRS (Practical Sessionals)	60%
b)	PRM (Practical Mid Term Exam)	20%
c)	PRE (Practical End Term Exam)	20%

COURSE CONTENT:

1. Anodizing of Al utilizing H_2SO_4 and Oxalic acid bath
2. Electroless deposition of Ni/ Cu
3. Electroplating and thickness measurement of Ni/Cu coatings
4. Corrosion rate determination using Weight loss measurement in acidic media
5. Corrosion rate determination using Weight loss measurement in alkaline media
6. Polarization experiment/ Study of Tafel's plot
7. Basic study of electrochemical Impedance Spectroscopy
8. Use of inhibitors and study of their effect
9. Study of Cathodic protection
10. To study the intergranular corrosion of Austenitic stainless steels
11. Microarc oxidation of Al/Mg
12. Electrowinning of copper

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Lab Manuals

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Scheme/Specialization: B.Tech. (Metallurgical and Materials Engineering)

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTP259	**Non Destructive Testing & Metallurgical Analysis Lab**	**1**	**0**	**0**	**2**	**0**

PREREQUISITE: Engineering Materials

COURSE OBJECTIVES:

To familiarize and equip the students with basic knowledge of non destructive testing and metallurgical analysis.

COURSE OUTCOMES:

CO1	Distinguish different NDT devices
CO2	Select the suitable NDT equipment for analysis
CO3	Calculate and determine the percentage of element present through metallurgical analysis.

COURSE ASSESSMENT:

The Course assessment (culminating to the final grade), will be made up of the following three components.

S. No.	Component	Weightage
a)	PRS (Practical Sessionals)	60%
b)	PRM (Practical Mid Term Exam)	20%
c)	PRE (Practical End Term Exam)	20%

COURSE CONTENT:

1. Inspect and evaluate the surface imperfections using penetrant testing method
2. Inspect subsurface defects by magnetic particle
3. Inspect subsurface defects by eddy current testing method
4. Familiarization and calibration of eddy current equipment.
5. Inspection of non magnetic/magnetic materials by eddy current method.
6. Familiarization of ultrasonic flaw detectors
7. Familiarization and calibration of reference blocks using ultrasonic flaw detector.
8. To determine total iron in iron ore.
9. Estimation of carbon in plain carbon steel by Column/Matching tube method.
10. To estimate the percentage of manganese in cast iron.

11. Estimation of copper by Iodometric method.
12. To estimate the concentration of a given $KMnO_4$ solution using colorimeter

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Lab Manuals
2. Elemental Analysis in Geochemistry, A. Volborth, Elsevier, 2012

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Scheme/Specialization: B.Tech. (Metallurgical and Materials Engineering)

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTP257	**Metal Working Lab**	**1**	**0**	**0**	**2**	**0**

PREREQUISITE: Engineering Materials

COURSE OBJECTIVES:

To familiarize and equip the students with basic knowledge of metal working and metallurgical analysis.

COURSE OUTCOMES:

CO1	Understand different metal working processes
CO2	Select the suitable metal working process
CO3	Calculate and determine the percentage of deformation in different metals and alloys

COURSE ASSESSMENT:

The Course assessment (culminating to the final grade), will be made up of the following three components.

S. No.	Component	Weightage
a)	PRS (Practical Sessionals)	60%
b)	PRM (Practical Mid Term Exam)	20%
c)	PRE (Practical End Term Exam)	20%

COURSE CONTENT:

1. To study the lathe machine & materials for various components and prepare tensile specimen
2. To study the wire drawing machine and calculate drawability of wire
3. To study quick return mechanism of shaper & prepare surface finish of forged product
4. To study about the spinning lathe and form a sheet metal of required shape
5. To study the operation of forging hammer & determination of metal losses in forging
6. To study cold rolling process of mild steel strip
7. To perform bend test on cold rolled & annealed mild steel strips
8. To study hot rolling of process of mild steel billets
9. To study about the recrystallization of brass

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Lab manuals

SEMESTER V

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT302	**Materials Characterization**	**3**	**3**	**0**	**0**	**0**

PREREQUISITES: Basic Sciences, Introduction to Engineering materials

COURSE OBJECTIVES:

- To provide the knowledge regarding different material characterization techniques
- To provide basic understanding on correlation of structures and properties of materials

COURSE OUTCOMES:

CO1	Understand different materials characterization techniques
CO2	Understand the scientific principles behind the characterization techniques
CO3	Differentiate the information obtained from different techniques
CO4	Interpret the information obtained from different characterization tools

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following three components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Introduction to materials characterization

(No of Lecture - 3)

Unit II X- Ray Diffraction: Production and properties of x- rays, Absorption of x- rays and filters, diffraction of x- rays through crystals. Bragg's law, structure factor of cubic crystal structures, Laue and powder methods, indexing of x- ray diffraction pattern, determination of phases, lattice parameters, crystallite size and residual stresses.

(No of Lecture - 6)

Unit III Principles of electron microscopy: electron beam- specimen interaction, electron optics of SEM & TEM. Scanning electron microscope (SEM): image formation modes: backscattered electrons (BSEs), secondary electrons (SEs). Fractography, EBSD and other important applications of SEM. Transmission electron microscope (TEM): image formation, contrast mechanism, bright- field image and dark- field image, electron energy loss

spectroscopy (EELS), selected area diffraction (SAD), Indexing of SAD pattern, specimen preparation techniques, and applications of TEM.

(No of Lecture - 11)

Unit IV Micro & Surface analysis: Principle and applications of X- ray photoelectron spectroscopy (XPS), Auger electron Spectroscopy (AES), Field ion microscopy, Energy dispersive spectroscopy (EDS), and wavelength dispersive spectroscopy (WDS).

(No of Lecture - 6)

Unit V Scanning probe microscopy: Principles of Scanning Probe microscopy techniques, Scanning Tunneling Microscopy, Atom Force Microscopy.

(No of Lecture - 6)

Unit VI Thermal analysis techniques; Basic principles, and applications of thermogravimetry analyzer (TGA), differential thermal analyzer (DTA), differential scanning calorimeter (DSC), principles of mechanical and optical dilatometers, differential optical dilatometers, determination of thermal expansion and phase transformation using dilatometry methods. Interpretation of curves obtained from TGA/DSC/dilatometers for various materials etc.

(No of Lecture - 8)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Microstructural characterization of materials, David Brandon and Wayne D. Kaplan, Wiley Second Edition, 2008
2. Experimental Techniques in Physical Metallurgy, V.T. Cherepin and A.K.Malik, Asia Pub. House, 1967.
3. Elements of Diffraction, B D Cullity and S R Stock, 3rd Ed. (Indian), Pearson, Noida, India, 2016.
4. Electron Microscopy and analysis, Peter J Goodhew, John Humphreys, and Richard Beanlan, 3rd Ed., Tailor & Francis, London, 2001.
5. Thermal Analysis of Materials, Robert F. Speyer, Marcel Dekker, Inc., New York, 1993.
6. Materials Characterization Techniques, Sam Zhang, Lin Li, Ashok Kumar, CRC Press, New York, 2009.
7. Transmission electron microscopy of metals, Gareth Thomas, John Wiley & Sons, Inc. N.Y., 1962

ONLINE RESOURCES:

1. https://nptel.ac.in

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT305	**Production of Sponge Iron and Ferroalloys**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE: Iron Making, Metallurgical Thermodynamics and Kinetics.

COURSE OBJECTIVE:

To provide basic understanding on various DRI making and Ferro-alloy making processes.

COURSE OUTCOMES:

CO1	Understand fundamentals of physic- chemical principles involved in iron ore reduction in solid and liquid state.
CO2	Understand the design & operational aspects of various coals and gas based DRI making technologies.
CO3	Identify the use of ferroalloys in the production of steel.
CO4	Discuss various reaction mechanisms during the production of ferroalloys.
CO5	Discuss the technology of production of ferroalloys.

COURSE ASSESSMENT:

The Course assessment (culminating to the final grade), will be made up of the following components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I: Introduction to iron making routes, approaches towards alternative routes. Classification of advanced processes. Thermodynamic and kinetic aspects of iron ore reduction in solid state using solid/gaseous reductants. Iron making by mini blast furnace and electro thermal processes.

(No. of lectures - 8)

Unit II: Direct reduction processes, their classification, commercially available coal and gas-based processes: shaft, kiln, retort and rotary hearth type reactors. Raw materials preparation. selection of reductants, heat and mass transfer, energy consumption and operating problems.

Storage, transportation and utilization of sponge iron in India. HBI making and Iron carbide making.

(No. of lectures - 16)

Unit III: Introduction to Ferroalloys: History and development of ferroalloys, classification of ferroalloys, classification of ferroalloy processes and overview of Indian ferro alloy sector.

(No. of lectures - 6)

Unit IV: Theory of Ferro alloys production: Concepts, thermodynamic and kinetic principles, Ferroalloy Processing: techniques, electrical and thermal processes, existing production process of various important Ferro alloys (Fr-Si, Fe-Mn, Fe-Cr, Fe-V, etc.).

(No. of lectures - 6)

Unit V: Recent advances in DRI & ferroallys, uses of ferro-alloys in iron and steel industry.

(No. of lectures - 4)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Alternative routes to iron making, A. Sarangi and B. Sarangi, 2nd edition, PHI Learning Private Limited, 2015.
2. Sponge iron production by direct reduction of iron oxide, A. Chatterjee, 2nd edition, PHI Learning Private Limited, 2012.
3. An introduction to modern iron making, R.H. Tupkary and V.R. Tupkary, 3rd edition, Khanna publishers, 2010.
4. Ferroalloys: theory and practice, M. Gasik, V. Dashevskii, A. Bizhanov, 1st edition, Springer, 2020.
5. The complete book on ferroalloys, B.P. Bhardwaj, 1st edition, NIIR Project Consultancy Services, 2008.
6. Handbook of ferroalloys: Theory and technology, M. Gasik, 1st edition, Elsevier, 2013.

ONLINE/E RESOURCES:

1. https://nptel.ac.in

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT301	**Introduction to Nanomaterials and Technology**	**3**	**3**	**0**	**0**	**0**

PREREQUISITES: Basic Sciences, Introduction to Engineering Materials

COURSE OBJECTIVES:

- To provide the scientific principles of nanomaterials and technology
- To make the student aware of the importance of nonmaterial's and technology in present technological world.

COURSE OUTCOMES:

CO1	Understand the applications of nonmaterial's and nanotechnology in the present technological world.
CO2	Understand the basic scientific principles of nonmaterial's and nanotechnology
CO3	Compare various naturally occurring nonmaterial's and artificially made

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following three components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Introduction to nanomaterials: Introduction to nanomaterials, Nature inspired nanomaterials and historical nanomaterials, Classification of nanomaterials, Length scales, surface area/volume ratio of micron to nanoscale materials.

(No of Lectures - 5)

Unit II Properties of Nanomaterials: Effect of particle size on thermal properties, electrical properties, mechanical properties, magnetic properties, optical properties and chemical sensitivity. nanowires, nanoclusters, nanobelts, quantum dots/wells. Polymer/Metal/Ceramic matrix nanocomposites.

(No. of Lectures - 7)

Unit III Synthesis of Nanomaterials: Top down and bottom up approaches, Top- down approaches- lithography, mechanical alloying, severe plastic deformation, Sonication,

Bottom- up approaches- physical vapour deposition, chemical vapour deposition, molecular beam epitaxy, colloidal or wet chemical route, green chemistry route, sol- gel method, atomic layer deposition. Synthesis, purification, properties and applications of carbon nanotubes (CNT).

(No. of Lectures - 7)

Unit IV Characterization of Nanomaterials: Basic principle and applications of X-ray diffraction (XRD), Optical spectroscopy, Surface area analysis (BET method), Light scattering method, Scanning electron microscope (SEM), Transmission Electron Microscope (TEM), Scanning probe microscopy- Atomic force microscope (AFM) and scanning tunneling microscope (STM), X-ray photoelectron spectroscopy.

(No. of Lectures - 6)

Unit V Applications and challenges of nanomaterials: nanofluids, hydrogen storage, solar energy, antibacterial coating, self- cleaning coating, nanotextiles, biomedical field, water treatment, automotive sector, catalysts. Challenges of nanomaterials, Risks and toxicity from metallic and oxide nanoparticles, Recent advances in nanoscience and nanotechnology.

(No. of Lectures - 5)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Nanomaterials, Nanotechnologies and Design: An Introduction for Engineers and Architects, Michael F. Ashby, Butterworth-Heinemann, 2009.
2. Nanomaterials and Nanocomposites: Synthesis, Properties, Characterization Techniques and Applications, R.K Goyal, CRC Press, 2017.
3. Textbook of Nanoscience and Nanotechnology , B.S. Murty, P. Shankar, Baldev Raj, B. B. Rath, James Murday, Springer- Verlag Berlin ,Co- publication with Universities Press (India) Pvt. Ltd., 1st Ed., 2013
4. Introduction to nanoscience and nanotechnology, Gábor Louis Hornyak, Harry F. Tibbals, Joydeep Dutta, CRC Press, 2013
5. Introduction to Nanotechnology, Charles P. Poole, Jr. and Frank J. Owens, Wiley, 2003.

REFERENCE BOOKS:

1. An introduction to synthesis, properties and applications, Dieter Vollath, Nanomaterials: Wiley, 2nd Edition, 2013
2. Nanoscale Materials in Chemistry, Kenneth J. Klabunde, Wiley-Interscience, 2003.

ONLINE RESOURCES:

1. https://nptel.ac.in

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT303	**Powder Metallurgy**	**3**	**3**	**0**	**0**	**0**

PREREQUISITES: Manufacturing, Physical Metallurgy

COURSE OBJECTIVES:

- To learn and get an in depth understanding of powder metallurgical processes and characterization in a scientific and systematic manner

COURSE OUTCOMES:

CO1	Understand the key concepts and terminology in the field of powder metallurgy
CO2	Describe and explain different powder production techniques
CO3	Correlate the microstructure and mechanical properties of powder metallurgy components in relation to their applications

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Introduction: Introduction and historical background of powder metallurgy, significance and advantages of powder metallurgy technique over other manufacturing processes. Methods of powder production and general principles involved in mechanical, chemical, atomization and electrolytic methods of metal and alloy powder production.

(No. of Lectures - 8)

Unit II Powder Characterization: Chemical composition, microstructure, size and size distribution, shape, surface area, flow rate, apparent and tap density. Compressibility, pyrophoricity and toxicity of metallic powders.

(No. of Lectures - 8)

Unit III Powder Processing: Mechanical alloying of powders involving high energy mechanical milling and its mechanism, heat treatment of powders, cold compaction involving

uniaxial and biaxial compaction with mechanical and hydraulic presses using rigid dies, cold isostatic pressing of green compacts, warm compaction.

(No. of Lectures - 8)

Unit IV Hot Consolidation techniques: Sintering: Stages of sintering and bonding mechanisms involved, liquid phase sintering, solid state sintering, spark plasma sintering, reactive sintering, sintering furnaces, sintering atmospheres, pressurized sintering, hot pressing, powder compact extrusion, powder compact forging, hot isostatic pressing (HIP), Sinter- HIP process, powder compact rolling, powder injection molding, additive manufacturing.

(No. of Lectures - 8)

Unit V Powder Metallurgy parts and applications: Design considerations of powder metallurgy parts, near net shape technology, applications in aerospace and automobiles, Porous parts viz. bushes, filters, bioimplants, dispersion strengthened materials, cemented carbides, bearing materials, sintered friction materials- clutches, brake linings.

(No. of Lectures - 8)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Introduction to Powder Metallurgy, J.S. Hirschoron-American Powder Metallurgy Institute, 1st Edition 1969.
2. Powder Metallurgy Science, R.M. German –Metal Powder Industry; Subsequent edition, 1994.
3. Powder Metallurgy: Principles & Applications, F.V. Lenel - Metal Powder Industry; First edition, 1980.
4. Powder Metallurgy, P.C. Angelo & R. Subramanian, PHI Learning Pvt. Ltd., Eastern economy edition, 2008.
5. Powder Metallurgy for Engg. (Brighton), R.H.T. Dixon & A. Clayton –Machinery Publishing, 2011.
6. Powder Metallurgy, K. Sinha, Dhanpat Rai Publications, New Delhi, 2nd edition, 2016.
7. ASM Hand Book, Volume 7, Powder Metallurgy, 2015.

ONLINE/E RESOURCES:

1. https://nptel.ac.in

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Scheme/Specialization: B.Tech. (Metallurgical and Materials Engineering)

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT304	**Principles of Heat Treatment**	**4**	**3**	**1**	**0**	**0**

PREREQUISITE: Introduction to physical metallurgy

COURSE OBJECTIVE:

- To introduce the importance of heat treatment techniques

COURSE OUTCOMES:

CO1	Understand the microstructure evolution during the heat treatment
CO2	Sketch the heat treatment routes to control the microstructure
CO3	Understand different phase transformations

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following four components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

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

(No. of lectures - 10)

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

(No. of lectures - 10)

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

(No. of lectures - 10)

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

(No. of lectures - 3)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Introduction to Physical Metallurgy, Avner, Sidney H., Tata McGraw Hill, New York, 2008
2. Physical Metallurgy: Principles and Practice, V. Raghavan, PHI Learning, Delhi, 2008.
3. ASM, Metals Handbook: Heat treating, Vol. 4, 9th Ed., 1991.

ONLINE/E RESOURCES:

1. https://nptel.ac.in

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

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Scheme/Specialization: B.Tech. (Metallurgical and Materials Engineering)

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTP308	**Material Characterization Lab**	**1**	**0**	**0**	**2**	**0**

PREREQUISITES: Basic Knowledge of Physics, Chemistry & Mathematics

COURSE OBJECTIVE:

- To acquire the knowledge of characterization techniques for studying material's properties.

COURSE OUTCOMES:

CO1	Understand different characterization techniques.
CO2	Analyze the investigating causes of materials failure.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following three components.

S. No.	Component	Weightage
a)	PRS (Practical Sessionals)	60%
b)	PRM (Practical Mid Term Exam)	20%
c)	PRE (Practical End Term Exam)	20%

COURSE CONTENTS:

1. Review of optical microscope, types of optical microscope, resolution, magnification, limitations etc.
2. Determination of experimental density of metals, plastics and composites
3. Grain size determination
4. Inclusion rating of the steel samples
5. Fractography study using Electron Microscope/Energy Dispersive Spectroscopy
6. Miller Indexing of the X- ray diffraction pattern of ferrous and non- ferrous metals.
7. Identification of crystalline phases using X- ray diffraction
8. To identify an unknown sample by x- ray diffraction procedures
9. Crystallite size determination of nanocrystalline materials using XRD peak broadening.
10. Determination of coefficient of thermal expansion using dilatometer

11. Study of transition temperatures using differential scanning calorimeter

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. X- Ray Diffraction**:** A Practical Approach, C. Suryanarayana , M. Grant Norton, Springer New York, NY, 1988.
2. ASM handbook, Volume 9: Metallography and Microstructures, 2020
3. ASM handbook, Volume 10: Materials Characterization, 2020
4. Lab Manual

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTP306	**Extractive Metallurgy and Thermodynamics Lab**	**1**	**0**	**0**	**2**	**0**

PREREQUISITE: Introduction to extractive metallurgy

COURSE OBJECTIVES:

- To provide practical knowledge on extractive metallurgy techniques
- To demonstrate various aspects of extractive metallurgy techniques

COURSE OUTCOMES:

CO1	Understand the engineering knowledge of extraction of metals
CO2	Apply and integrate the knowledge of extractive metallurgy to the processing of different alloys

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following three components.

S. No.	Component	Weightage
a)	PRS (Practical Sessionals)	60%
b)	PRM (Practical Mid Term Exam)	20%
c)	PRE (Practical End Term Exam)	20%

COURSE CONTENTS:

1. To study the effect of time on roasting of Zinc Sulphide
2. To study the effect of temperature on roasting of Zinc Sulphide
3. To determine Heat Transfer Coefficient
4. To find viscosity of molten metal/ slag by inclined plane method
5. To find viscosity of molten metal/ slag by Brookfield viscometer
6. To find the efficiency of electrolyte cell for copper refining
7. To study the effect of time & temperature on leaching of copper oxide
8. To study the effect of time on cementation of copper
9. To study the effect of time on reduction of mill scale by coal
10. To study the effect of temperature on reduction of mill scale by coal

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Lab Manuals

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTP309	**Powder Metallurgy Lab**	**1**	**0**	**0**	**2**	**0**

PREREQUISITE: Powder Metallurgy

COURSE OBJECTIVES:

- To provide practical knowledge on powder metallurgy techniques like powder compaction and sintering
- To demonstrate various aspects of metal powder handling and processing of powder metallurgy specimen

COURSE OUTCOMES:

CO1	Understand the engineering knowledge of powder processing and specimen preparation
CO2	Apply and integrate knowledge of powder metallurgy to the processing of engineering components

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following three components.

S. No.	Component	Weightage
a)	PRS (Practical Sessionals)	60%
b)	PRM (Practical Mid Term Exam)	20%
c)	PRE (Practical End Term Exam)	20%

COURSE CONTENTS:

1. Sampling of metal powder
2. Determination of hydrogen loss for metal powder
3. Determination of acid insoluble in Cu powder
4. Determination of sieve analysis of metal powders
5. Determination of flow rate of free flowing metal powders using Hall flow meter
6. Determination of apparent density of free flowing metal powders using Hall Flow Meter
7. Determination of green strength for un- sintered P/M compact
8. Determination of compressibility of metal powder

9. Determination of density of sintered P/M product
10. Determination of hardness of P/M product

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Lab Manuals

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTP307	**Heat Treatment and Thermodynamics Lab**	**1**	**0**	**0**	**2**	**0**

PREREQUISITE: Principles of heat treatment

COURSE OBJECTIVE:

- To study various heat treatment techniques of alloys

COURSE OUTCOMES:

CO1	Understand the microstructure evolution during the heat treatment
CO2	Understand the variation of properties with the microstructure evolution
CO3	Compare phase transformations in different alloys during heat treatment

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following.

S. No.	Component	Weightage
a)	PRS (Practical Sessionals)	60%
b)	PRM (Practical Mid Term Exam)	20%
c)	PRE (Practical End Term Exam)	20%

COURSE CONTENTS:

1. Study various heat treatment process, such as normalizing, annealing, hardening.
2. Effect of annealing temperature on properties of steel
3. Austempering of steel
4. Effect of various quenching media on properties of steel
5. Effect of tempering temperature on properties of steel/Al based alloys
6. Jominy end quench testing of steel
7. Cooling curve of pure metal and alloys
8. Plotting of CCT curves
9. Study of precipitation hardening of Al-Cu alloy
10. Effect of temperature of cold worked structure

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

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

SEMESTER VI

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT311	**Joining of Materials**	**4**	**3**	**1**	**0**	**0**

PREREQUISITE: Foundry Technology

COURSE OBJECTIVE:

- To impart knowledge about various metal joining techniques, their principles and applicability for various ferrous and non- ferrous metals.

COURSE OUTCOMES:

CO1	Understand the principle of metal joining.
CO2	Familiarize with different welding techniques
CO3	Compare and contrast welding, brazing, and soldering processes.
CO4	Correlate weldability, welding stresses, and welding defects.
CO5	Select and design welding materials, processes and inspection techniques based on application, fabrication and service conditions

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Introduction of joining processes: Mechanical joining (mechanical fasteners, integral attachments, and other mechanical joining methods), adhesive joining (types of adhesives, wettability, surface preparation, and joint design), and welding (fusion and solid state). Surface requirements for joining.

(No. of lectures - 6)

Unit II Fusion welding processes: Gas welding, thermit welding, arc welding (SMAW, GTAW, GMAW, SAW). Plasma arc welding, laser beam welding, and electron beam welding. Shielding gases. Electrodes. Welding design.

(No. of lectures - 10)

Unit III Solid state welding processes: friction welding, friction- stir welding, diffusion bonding, explosive welding, forge welding, etc. resistance welding processes. surface cladding. Brazing and soldering (filler materials and fluxes, heating methods, wettability, and joint design).

(No. of lectures - 10)

Unit IV Responses of materials to welding: Structure of the welded joint, solidification modes, welding stresses and distortion, heat treatment of parent metals and welds, solidification cracking, reheat cracking, welding defects and detection techniques.

(No. of lectures - 8)

Unit V Joining of specific materials and structures: (Metals & alloys, ceramics & glasses, polymers, composite materials and dissimilar material combinations).

(No. of lectures - 6)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Welding Engineering and Technology, R.S. Parmar, 3rd Edition, Khanna Publishers, 2013.
2. Welding: Principles and Application, L. Jeffus, 8th Edition, Delmar Cengage Learning, 2016.
3. Welding Metallurgy, S. Kou, 2nd Edition, Wiley and Sons, 2005.
4. Modern Welding Technology, H. Cary and S. Helzar, 6th Ed., Pearson Prentice Hall, 2004.
5. Joining of Materials and Structures, R.W. Messler, Elsevier, 2004.
6. Metallurgy of Welding, J. F. Lancaster, Springer, 1980.

ONLINE/E RESOURCES:

1. https://nptel.ac.in

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT314	**Steel Making**	**4**	**3**	**1**	**0**	**0**

PREREQUISITE: Metallurgical Thermodynamics and Kinetics, Iron Making

COURSE OBJECTIVE:

- This course will provide the knowledge of production of steel through various technologies, current challenges in the steel industry and help the students in understanding the importance of steel making.

COURSE OUTCOMES:

CO1	Analyze various physicochemical principles involved in steelmaking.
CO2	Understand different steelmaking processes and their design related developments.
CO3	Correlate various secondary steelmaking operations and their importance for producing clean steel.
CO4	Describe continuous casting of liquid steel and its related developments.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following four components:

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I: Evolution of modern steel making. Steel plant layouts. Status of steelmaking in India vis-a-vis global scenario. Basic thermodynamics of solution. Physic-chemical principles of steel making; slag metal equilibrium involved in steel making. Ionic slag theory as applied to slag- metal reaction in hearth steel making; slag- metal and gas- metal reaction in pneumatic steel melting processes.

(No. of lectures - 10)

Unit II: Introduction to practices, pretreatment of hot metal. Basic oxygen furnace: Design and operation. Modern trends in BOF technology. Genesis of modern combined blowing technique of steel production. Refining mechanism in oxygen steel making process.

(No. of lectures - 8)

Unit III: Electric arc furnace steel making for high alloy steels. Use of Ultra high power electric arc furnace in steel making. DRI as a source for steelmaking. Production of high alloy steels. New steelmaking technologies: CONARC and EOF processes.

(No. of lectures - 8)

Unit IV: De- oxidation- precipitation and diffusion deoxidation. Production of clean steel. Degasification and decarburization- different techniques of vacuum degassing, AOD, VOD, CLU and MRP processes. Ladle metallurgy- synthetic slag practice. Secondary refining of steel by vacuum remelting techniques. Deep desulphurization and deep dephosphorization in secondary steel making.

(No. of lectures - 10)

Unit V: Continuous casting of steel: Advantages, types of machines, Mould lubrication and reciprocation, Developments in technology with respect to productivity, quality and energy conservation. semi continuous casting, near-net-shape casting. Strip casting.

(No. of lectures - 4)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. A First Course in Iron and Steel Making, D. Mazumdar, 1st Edition, Orient Blackswan Private Limited, 2015.
2. An Introduction to Modern Steel Making, R.H. Tupkray and V.R. Tupkray, 7th Edition, Khanna Publishers, 2008.
3. Iron Making and Steel Making: Theory and Practice, A. Chatterjee and A. Ghosh, 1st Edition, PHI Learning Pvt. Ltd. Delhi, 2008.
4. Steel Making, A. K. Chakraborty, 1st Edition, PHI Learning Pvt. Ltd. Delhi, 2006.
5. Extractive Metallurgy, Joseph Newton,John Wiley & Sons Inc., 1959.
6. Extractive Metallurgy, 2nd edition, J.D. Gilchrist, Pergamon Press, 1979.

ONLINE/E RESOURCES:

1. https://nptel.ac.in

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Scheme/Specialization: B.Tech. (Metallurgical and Materials Engineering)

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT313	**Non- Ferrous Extractive Metallurgy**	**4**	**3**	**1**	**0**	**0**

PREREQUISITE: Mineral Processing, Introduction to Extractive Metallurgy

COURSE OBJECTIVE:

- To familiarize the students with basic knowledge about various non- ferrous metals and their route of extraction

COURSE OUTCOMES:

CO1	Differentiate Pyrometallurgical, Hydrometallurgical & Electrometallurgical methods of extraction of Non- ferrous Metals.
CO2	Identify suitable processes of extraction depending on Non- Ferrous Metals to be extracted.
CO3	Apply knowledge of various extraction processes to get the final product.
CO4	Suggest proper non- ferrous metals for various applications

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following four components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Aluminium: Occurrence of bauxite, Bayer's process for production of alumina. Alternatives to Bayer's Process. Hall-Heroult Process- Conventional and New Materials for construction of aluminium reduction cell, Nature of electrolyte, Electrolysis of alumina with emphasis on physicochemical principles and secondary- reactions. Factors affecting current efficiency. Alternatives to Hall-Heroult Process. Refining of aluminium. Advances in the extraction of aluminium, Methods to treat low grade ores.

(No. of lectures - 12)

Unit II Copper: Occurrence of copper ores. Roasting, Matte smelting, converting and refining process as applied to copper production and their physico-chemical aspects. Single step and multistep continuous processes. Hydrometallurgical process for production of

primary copper. Recovery of copper from copper slag. Treatment of refractory copper ores. Newer processes in the extraction of copper

(No. of lectures - 12)

Unit III Lead, Zinc and Cadmium: Occurrence of Lead and Zinc ores. Pyrometallurgical and Hydrometallurgical Processes for lead and zinc production and their physico-chemical aspects. Refining of lead and zinc, Recovery of by- products. Imperial smelting process, Recovery of cadmium as a by- product

(No. of lectures - 12)

Unit IV Recent Advances: Advanced processes currently employed in the Industry

(No. of lectures - 4)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Extraction of Non- ferrous Metals, H.S. Ray, R. Sridhar and K.P. Abraham, Affiliated East West Press (P) Ltd., 2015.
2. Extractive Metallurgy of Non- ferrous Metals, R. Raghvan, V. N. Publication, 2016.
3. Non- ferrous Production Metallurgy, John L Bray, John Wiley &Sons; First Edition, 1941
4. Principles of Extractive Metallurgy, Rosenquist, Terkel, Techbooks; Reprint Edition, 1991
5. Lead-Zinc-Tin '80: Proceedings of a World Symposium on Metallurgy and Environmental Control, John M. Cigan, Thomas S. Mackey, Thomas J. O'Keefe, Metallurgical Society of AIME, 1979.

ONLINE/E RESOURCES:

1. https://nptel.ac.in
2. Expert lectures from the industry

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Scheme/Specialization: B.Tech. (Metallurgical and Materials Engineering)

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT310	**Composite Materials**	**4**	**3**	**1**	**0**	**0**

PREREQUISITE: Introduction to Engineering Materials

COURSE OBJECTIVE:

- To familiarize and equip the students with basic knowledge about composite materials

COURSE OUTCOMES:

CO1	Understand various basic concepts related to composite materials
CO2	Compare various types of composite materials
CO3	Analyze role of each component of the composite materials
CO4	Identify various fabrication processes of composite materials
CO5	Understand how to reuse the composite materials after their service life is over

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following four components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Introduction: Definition of composite materials. Advanced composites, importance of composites over other materials. Advantages and general characteristics of composite materials, General requirements of composite materials.

(No. of lectures - 5)

Unit II Matrix, reinforcement, and interface: Classification of composites on the basis of reinforcement and matrix, Form and functions of reinforcement, Functions of matrices. Dispersion strengthened, particle strengthened and fibre- reinforced composites. Strengthening mechanisms-discontinuous and continuous fibre composites. Comparison of above composites. Characteristics and materials of reinforcements and matrices. Testing for interfacial bond strength.

(No. of lectures - 10)

Unit III Major composite classes: polymer matrix, metal matrix, ceramic matrix, carbon-carbon, and intermetallic composites. hybrid composites, laminated composites. Examples of

each class of composites. Role of interfaces in composites, toughening mechanisms in PMCs, MMCs, and CMCs.

(No. of lectures - 10)

Unit IV Micromechanics and fabrication methods: Micromechanics. Fabrication methods of PMCs, MMCs and CMCs, Reuse of composites after their service life.

(No. of lectures - 10)

Unit V Recent Advances: Nanocomposites, challenges & applications in the field of composites, challenges and applications.

(No. of lectures - 5)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Composite Materials: Properties, Non- destructive testing and Repair, Mel M. Schwartz, Prentice Hall, New Jersey, 1996
2. Composite Materials – Science & Engineering, K.K. Chawla., Springer- Veslag, New York, 3rd Ed, 2012
3. Industrial Materials: Polymers, Ceramics and Composites, David A. Colling & Thomas Vasilos, vol. 2, Prentice Hall, N. Jersey, 1995.
4. Composite Materials: Engineering and Science, F.L. Matthews and R. D. Rawlings, Chapman and Hall, London, 1994

ONLINE/E RESOURCES:

1. https://nptel.ac.in

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTP312	**Joining of Materials Lab**	**1**	**0**	**0**	**2**	**0**

PREREQUISITE: Basic Sciences (10+2 level), Physical Metallurgy

COURSE OBJECTIVE:

- To impart knowledge about various metal joining techniques, their principles and applicability for various ferrous and non- ferrous metals.

COURSE OUTCOMES:

CO1	Design and fabricate weldments using various fusion welding processes.
CO2	Design and fabricate weldments using various solid- state welding processes.
CO3	Fabricate joints using the brazing and soldering process.
CO4	Evaluate the quality of welded joints using non- destructive testing methods
CO5	Analyze the metallurgical changes in welded joints.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following four components.

S. No.	Component	Weightage
a)	PRS (Practical Sessionals)	60%
b)	PRM (Practical Mid Term Exam)	20%
c)	PRE (Practical End Term Exam)	20%

COURSE CONTENTS:

1. To study about welding processes, weld joint designs and welding symbols.
2. To fabricate a butt joint using the Oxy- Acetylene gas Welding (OAW) process from the given samples.
3. To fabricate a lap joint using the Shielded Metal Arc Welding (SMAW) process from the given samples.
4. To fabricate a corner joint using the Gas Metal Arc Welding (GMAW) process from the given samples.
5. To fabricate an autogenously butt joint using the Gas Tungsten Arc Welding (GTAW) process from the given samples.
6. To fabricate a joint using the brazing process (Torch brazing) from the given samples

7. To fabricate a job by soldering two copper wires using Pb-Sn solder.
8. To fabricate a joint using the friction welding process from the given samples.
9. To fabricate a joint using the resistance spot welding process from the given samples.
10. To fabricate a joint using the friction- stir welding (FSW) process from the given samples.
11. To study about the weld section.

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Manufacturing Technology: Foundry, Forming and Welding, P.N. Rao, 2nd Edition, Tata McGraw- Hill Education, 2017.
2. Manufacturing Science, A. Ghosh and A.K. Mallick, 2nd Edition, East- West Press Pvt. Ltd. 2010.

ONLINE/E RESOURCES:

1. https://nptel.ac.in

SEMESTER VII

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTD402	**Minor Project**	**3**	**0**	**0**	**6**	**0**

PREREQUISITE: Understanding of Engineering materials, material processing and analysis

COURSE OBJECTIVES:

- To develop ability in the students to apply some of the metallurgical engineering techniques/principles have been taught, in real life engineering problems.

COURSE OUTCOME:

CO1	Identify an open ended problem in area of metallurgical engineering which requires further investigation
CO2	Identify the methods and materials required for the project work.
CO3	Manage the work with team members.
CO4	Formulate and implement innovative ideas for social and environmental benefits.
CO5	Analyze the results to come out with concrete solutions.
CO6	Write technical report of the project apart from developing a presentation.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following components. The assessment panel consists of faculty members of the department.

S. No.	Component	Weightage
a)	Mid- Semester assessment	50%
b)	End Semester assessment	50%

COURSE CONTENTS: (No of periods 30)

A student is required to carry out the project work related to metallurgical and materials engineering, under the guidance of a faculty member. Student group consists of 3- 4 members. The project must cover at least any one area suggested below:

• Design, analysis and/or fabrication of materials, alloys, composites etc,
• Experimentation,
• Product design and development in metallurgical and materials engineering,
• Industry needs based basic survey or Testing or Analysis etc.

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTS401	**Training Seminar**	**2**	**0**	**0**	**4**	**0**

PREREQUISITE: Fundamental knowledge in metallurgical and materials engineering

COURSE OBJECTIVE:

- To impart experience and knowledge to the students about working in industries or in academic institutes/ research labs.

COURSE OUTCOMES:

CO1	Identify and analyze problems related to industries/research within a given timeframe.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following components.

S. No.	Component	Weightage
a)	Seminar Presentation	50%
b)	Report Submission	50%

COURSE CONTENTS:

1. To work in a team for a project/ or to be able to work independently for a project
2. To collect the relevant data
3. To analyze the data, interpret the results and present it in an articulate manner
4. To collate all the data, observations, analysis, and results
5. To write a proper structured report

ONLINE/E RESOURCES:

1. https://nptel.ac.in

SEMESTER VIII

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTD403	**Major Project**	**9**	**0**	**0**	**18**	**0**

PREREQUISITE: Understanding of Engineering materials, material processing and analysis

COURSE OBJECTIVES:

- To develop ability in the students to apply some of the metallurgical engineering techniques/principles have been taught, in real life engineering problems.

COURSE OUTCOME:

CO1	Identify an open ended problem in area of metallurgical engineering which requires further investigation
CO2	Identify the methods and materials required for the project work.
CO3	Manage the work with team members.
CO4	Formulate and implement innovative ideas for social and environmental benefits.
CO5	Analyze the results to come out with concrete solutions.
CO6	Write technical report of the project apart from developing a presentation.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following components. The assessment panel consists of faculty members of the department.

S. No.	Component	Weightage
a)	Mid- Semester assessment	50%
b)	End- Semester assessment	50%

COURSE CONTENTS: (No of periods 60)

A student is required to carry out the project work related to metallurgical and materials engineering, under the guidance of a faculty member. Student group consists of 3- 4 members. The project must cover at least any one area suggested below:

• Design, analysis and/or fabrication of materials, alloys, composites etc,
• Experimentation,
• Product design and development in metallurgical and materials engineering,
• Industry needs based basic survey or Testing or Analysis etc.

ELECTIVES

EXTRACTIVE METALLURGY

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT802	**Alternative Routes of Iron making**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE: Iron Making, Production of Sponge Iron and Ferroalloys.

COURSE OBJECTIVE:

- To provide basic understanding on various alternative iron making routes such as coal and gas based DRI making and smelting reduction processes.

COURSE OUTCOMES:

CO1	Sketch operational aspects of various coal and gas based DRI making technologies.
CO2	Understand various storage, transportation and operational issues with respect to DRIs.
CO3	Understand the development in various smelting reduction processes.
CO4	Understand the fundamentals of physic- chemical principles involved in iron ore reduction in solid and liquid state.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I: Need for the development of alternative routes, approaches towards new techniques. Classification of advanced processes. Thermodynamic and kinetic aspects of iron ore reduction in solid and liquid state using solid/gaseous reductants.

(No. of Lectures - 8)

Unit II: Sponge iron production using shaft, kiln, retort and rotary hearth reactors. Raw materials preparation. Selection of reductants. Heat and mass transfer. Energy consumption and operating problems. Storage, transportation and utilization of sponge iron in India.

(No. of Lectures - 12)

Unit III: Pre- reduced iron ore pellets for blast furnace applications, concept of composite pellets and its feasibility. Iron powder and iron carbide preparation from fluidized bed reactor and other processes. Operating/ storage problems.

(No. of Lectures - 10)

Unit IV: Smelting- Reduction Processes: Principles, classification, merits and limitations. COREX process and electric smelting processes.

(No. of Lectures - 10)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Alternative Routes to Iron Making, A. Sarangi and B. Sarangi, 2nd edition, PHI Learning Private Limited, 2015.
2. Sponge iron production by direct reduction of iron oxide, A. Chatterjee, 2nd edition, PHI Learning Private Limited, 2012.
3. An introduction to modern iron making, R.H. Tupkary and V.R. Tupkary, 3rd edition, Khanna publishers, 2010.
4. Hot metal production by smelting reduction of iron oxide, A. Chatterjee, 1st edition, PHI Learning Private Limited, 2009.

ONLINE/E RESOURCES:

1. https: //nptel.ac.in

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Scheme/Specialization: B.Tech. (Metallurgical and Materials Engineering)

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT814	**Secondary Steel Making**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE: Courses: Iron making, Steel making, Metallurgical thermodynamics and kinetics

COURSE OBJECTIVE:

- To teach the students about the importance, theories and practices of producing secondary steel.

COURSE OUTCOMES:

CO1	Understand the importance of secondary refining of steel.
CO2	Anlayse about inclusion control in steel.
CO3	Understand different theories behind secondary steel making.
CO4	Compare different processes of secondary steel making.
CO5	Understand recent advances in secondary steel making.

COURSE ASSESSMENT:

The Course assessment (culminating to the final grade), will be made up of the following components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I: Brief Review of primary steel making processes, limitation of primary steelmaking & importance of secondary steel making, objectives of secondary steel making processes, secondary steel making reactor.

(No. of lectures- 7)

Unit II: Furnace tapping operations, prevention of slag carryover, principles of deoxidation, desulphurization and inclusion control, injection metallurgy and its usefulness, ladle refining technique with synthetic slag practice.

(No. of lectures- 8)

Unit III: Effect of agitation of bath in ladle metallurgy operation- different processes of argon stirring and their relative merits, vacuum metallurgy – Sievert's law, vacuum carbon deoxidation; vacuum oxygen decarburization, argon oxygen decarburization, vacuum degassing of steel, tank degassing, stream degassing, recirculation degassing- RH and DH processes.

(No. of lectures- 10)

Unit IV: Refining of steel by remelting under vacuum: CEVAM process, electro slag refining technique, advantages of the process and their limitations, ladle metallurgy as secondary refining process - vacuum arc degassing, ASEA- SKF process, evaluation of ladle metallurgy from the view point of production high quality ultraclean steel.

(No. of lectures- 10)

Unit V: Recent advances in secondary steel making.

(No. of lectures- 5)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Secondary Steelmaking: Principles and Applications, A. Ghosh, CRC Press, 2000.
2. Iron Making and Steelmaking: Theory and Practice, A. Chatterjee and A. Ghosh, PHI Learning Pvt. Ltd., 2008.
3. A First Course in Iron and Steel Making, D. Mazumdar, Universities Press, Hyderabad, 2015.

OTHER RESOURCES:

1. Recent journal papers
2. Expert lecture from industry persons

ONLINE RESOURCES

1. https://nptel.ac.in

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT806	**Extraction of Mg, Sn, Ferro- Alloying Elements, Ni, Ti**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE: Mineral Processing, Introduction to Extractive Metallurgy

COURSE OBJECTIVE:

- To familiarize the students with basic knowledge about various non- ferrous metals and their route of extraction

COURSE OUTCOMES:

CO1	Select Pyrometallurgical, Hydrometallurgical & Electrometallurgical methods of extraction of Non- ferrous Metals.
CO2	Identify suitable processes of extraction depending on Non Ferrous Metals to be extracted.
CO3	Apply knowledge of various extraction processes to get final product.
CO4	Suggest proper non- ferrous metals for various applications

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Extraction of Magnesium and Tin: Ores, methods of Mg extraction, Pidgeon process, Mg production in India, Concentration of Sn ores, smelting of Sn concentrate, refining of Sn.

(No. of lectures- 10)

Unit II Extraction of Ferro alloying Elements: Extraction of Chromium, Manganese, Silicon, Tungsten, Vanadium, Molybdenum, Tantalum.

(No. of lectures- 15)

Unit III Extraction of Nickel: Extraction of Ni by pyrometallurgy, Extraction of Ni from oxide ores, hydrometallurgy of nickel sulphide concentrates.

(No. of lectures- 8)

Unit IV Extraction of Titanium: Ores, treatment of Ilmenite for upgradation, chlorination of TiO_2, production of metallic Ti by reduction of titanium tetrachloride.

(No. of lectures- 7)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Extraction of Non- ferrous Metals, H.S. Ray, R. Sridhar and K.P. Abraham, Affiliated East West Press (P) Ltd., 2015
2. Extractive Metallurgy of Non- ferrous Metals, R. Raghvan, V. N. Publication, 2016
3. Non-ferrous Production Metallurgy – John L Bray John Wiley & Sons; First Edition, 1941

ONLINE/E RESOURCES:

1. https://nptel.ac.in
2. Expert lectures from the industry

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT805	**Environment and Waste Management in Metallurgical Industries**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE: Basic Sciences Basics in Metallurgical engineering processes and extractive metallurgy

COURSE OBJECTIVE:

- To provide background and details of the various waste management techniques applied in metallurgical engineering industries

COURSE OUTCOMES:

CO1	Understand the working principles of waste management techniques in metallurgical industries
CO2	Analyse the root cause of the pollution created in metallurgical industries by metallurgical wastes

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I: Sources and classification of pollutants, Metallurgical factors influencing air, water and soil pollution

(No. of Lectures - 10)

Unit II: Control of pollution by equipments. Cleaner Production (Pollution Control) in Metallurgical Industries

(No. of Lectures - 10)

Unit III: Iron and Steel and Non- ferrous Metals (Cu, Al, Zn, and Pb), Pollution Control in ferrous & non-ferrous foundries, effluent treatment and recycling of metals from ferrous and Non-ferrous industry and e-waste.

(No. of Lectures - 8)

Unit IV: Introduction to need of environmental management. Policies, procedures and resources for implementing and maintaining effective environmental management in the organization. ISO: 14000, of waste & its disposal and light weighting in transport.

(No. of Lectures - 12)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Dust & Fume Generation in the Iron & Steel Industries, S. Andoneyev, O. Filipyev.
2. Air Pollution, M.N. Rao, HVN Rao
3. Environmental Engineering, G.N.Pandey.

ONLINE RESOURCES

1. https://nptel.ac.in

PROCESS METALLURGY

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

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Scheme/Specialization: B.Tech. (Metallurgical and Materials Engineering)

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT810	**Metallurgy of Additive Manufacturing**	**3**	**3**	**0**	**0**	**0**

PREREQUISITES: Introduction to Physical Metallurgy

COURSE OBJECTIVES:

- To educate students the microstructural changes that take place during Additive manufacturing.

COURSE OUTCOMES:

CO1	Understand physical metallurgy of strengthening mechanism of metals.
CO2	Understand the solidification of metals and segregation mechanism
CO3	Familiarize various cracking and fracture during solidification
CO4	Analyze the microstructure evolution, solidification and issues during 3D printing

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following three components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

UNIT I Introduction to Physical Metallurgy: Mechanical properties of metals, dislocations and strengthening mechanisms, failure, grain structure and recrystallization, phase diagrams, phase transformations: development of microstructure and alteration of mechanical properties, strengthening mechanisms.

(No. of lectures- 6)

UNIT II Solidification of Metals: Solidification of metals, interface stability, microscopic aspects of solidification, solute redistribution: macroscopic and microscopic, segregation mechanism, recrystallization and grain growth, allotropic transformation, precipitation reactions, Fracture toughness, Solidification cracking, reheat cracking, liquation cracking, cold cracking, strain- age, and ductility dip cracking.

(No. of lectures- 8)

UNIT III Metallurgy of Steel: Introduction of additive manufacturing of steel, physical and mechanical metallurgy of austenitic and PH steels solidification mode in austenitic and PH steels, processing issues with 3D printing of steel, case study on metallurgical aspects using laser based process.

(No. of lectures- 7)

UNIT IV Metallurgy of Nickel based alloys: Nickel base alloy classification, physical and mechanical properties of precipitation based- strengthened Nickel based alloys, solidification and microstructure evolution, processing issues, case study on metallurgical aspects using arc based process.

(No. of lectures- 7)

UNIT V Metallurgy of Titanium based alloys: Titanium base alloy classification, physical and mechanical properties of alpha beta titanium alloys, solidification and microstructure evolution, processing issues, case study on metallurgical aspects using electron beam based process

(No. of lectures- 6)

UNIT VI Post Processing treatment for property improvement: Thermal post processing, hot isostatic pressing, recrystallization, stress relieving, solution treatment and aging.

(No. of lectures- 6)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Metallurgy and mechanics of welding: processes and industrial applications. Blondeau, Régis, John Wiley & Sons, 2013.
2. Welding Metallurgy and Weldability of Stainless Steels, by J. C. Lippold, D.J. Kotecki, Wiley, 2005.
3. ASM Hand book – Surface Engineering, ASM International, Vol. 5, 1994.
4. Welding metallurgy and weldability of nickel- base alloys, Lippold, J.C., Kiser, S. D., & DuPont, J.N, John Wiley & Sons, 2011.

ONLINE/E- RESOURCES

1. https: //www.coursera.org/learn/additive- technologies- in- metallurgy- - mechanical-engineering
2. https://nptel.ac.in

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT828	**Particulate Materials**	**4**	**3**	**1**	**0**	**0**

PREREQUISITES: Manufacturing, Physical Metallurgy

COURSE OBJECTIVES:

- To learn and get an in depth understanding in a scientific and systematic manner, which includes understanding various powder metallurgy principles
- To provide with knowledge about the field of powder metallurgy and teach them generic principles associated with creating powders and fabricating engineering shapes from those powders.

COURSE OUTCOMES:

CO1	Understand the key concepts and terminology in the field of powder metallurgy
CO2	Describe and explain different powder production techniques, compaction and shaping, sintering and finishing of the powder metallurgical components
CO3	Relate the microstructure and mechanical properties of powder metallurgy components in relation to their applications

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Introduction: Introduction to powder metallurgy. Powder Production: General principles of mechanical, chemical, atomization and electrolytic method of metal and alloy powders production.

(No. of lectures - 8)

Unit II Powder Characterization: Chemical composition, Microstructure, size and size distribution, shape, surface area, flow rate, apparent and tap density. Compressibility, pyrophoricity and toxicity of metallic powders, powder annealing.

(No. of lectures - 8)

Unit III Powder Processing: Mixing and blending and their mechanics, powder mixers, mechanical alloying. Cold compaction: Compaction in rigid dies, uniaxial and biaxial compaction, mechanical and hydraulic presses.

(No. of lectures - 8)

Unit IV Sintering and Hot Compaction: Sintering: Basic stages of sintering and mechanisms involved, liquid phase sintering, solid state sintering, sintering furnaces, sintering atmospheres. Hot pressing, powder compact extrusion, powder compact forging, powder compact rolling. Powder injection moulding, hot isostatic pressing, additive manufacturing.

(No. of lectures - 10)

Unit V Applications: Near net shape technology, Cemented carbides, bearing materials, sintered friction materials- clutches, brake linings, Bushes, filters, and bioimplants, dispersion strengthened materials, cemented carbides.

(No. of lectures - 6)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Introduction to Powder Metallurgy, J.S. Hirschoron, American Powder Metallurgy Institute, 1st Edition 1969
2. Powder Metallurgy Science, R.M. German, Metal Powder Industry; Subsequent edition,1994
3. Powder Metallurgy: Principles & Applications, F.V.Lenel –Metal Powder Industry; 1st Ed., 1980
4. Powder Metallurgy, P.C. Angelo & R. Subramaniam, PHI Learning Pvt. Ltd., Eastern economy Edition, 2008
5. Powder Metallurgy for Engg., R.H.T. Dixon & A. Clayton, Machinery Publishing, 2011.
6. Powder Metallurgy, K. Sinha, Dhanpat Rai Publications, New Delhi, 2nd edition, 2016.
7. Powder Metallurgy, ASM Hand Book, Volume 7, 2015.

ONLINE/E RESOURCES

1. Powder Metallurgy (NPTEL Course) by Ranjit Bauri (IITM)
2. https://onlinecourses.nptel.ac.in/

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Scheme/Specialization: B.Tech. (Metallurgical and Materials Engineering)

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT817	**Welding Metallurgy**	**4**	**3**	**1**	**0**	**0**

PREREQUISITE: Joining of metals

COURSE OBJECTIVE:

To gain knowledge about welding techniques and the associated metallurgy of steel weld

COURSE OUTCOMES:

CO1	Understand the importance of the welding in structural applications
CO2	Acquire knowledge of welding microstructures and properties of steel

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I: Overview of welding, Importance of welding in structural applications, joining efficiency

(No. of lectures - 2)

Unit II: Fusion welding techniques such as submerged arc welding, flux core arc welding, tungsten inert gas welding, Metal inert gas welding, plasma arc welding, electron beam welding, laser beam welding. Solid state welding, Heat Source, Heat flow in welding, Analysis of Heat Flow in Welding, Effect of Welding Parameters, Chemical Reactions in Welding, Gas–Metal Reactions, Slag–Metal Reactions

(No. of lectures - 15)

Unit III: Fluid Flow and Metal Evaporation in Welding, Residual Stresses, Distortion, and Fatigue, Weld Metal Solidification, Grain Structure, Microstructure within Grains, Post-Solidification Phase Transformations, Weld Metal Chemical In homogeneities

(No. of lectures –13)

Unit IV: Weld Metal Solidification Cracking, Characteristics, Cause, and Testing, Metallurgical Factors, Mechanical Factors, Reducing Solidification Cracking, Formation of the Partially Melted Zone, Difficulties Associated with the Partially Melted Zone, Case studies .

(No. of lectures - 10)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Welding Metallurgy, Sindo Kou, A. John Wiley and Sons, Inc., 2003.
2. Welding Metallurgy and Weldability, J. C. Lippold, John Willey and Sons, New Jersey, United States 2015

ONLINE/E RESOURCES:

1. https://nptel.ac.in

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT801	**Advanced Casting Technology**	**3**	**3**	**0**	**0**	**0**

PREREQUISITES: Foundry Technology, Physical metallurgy

COURSE OBJECTIVES:

- To provide the knowledge and practice regarding different foundry processes and their industrial importance
- To provide knowledge on efficient design of casting runner, riser and gating system with minimal casting defects and solidification process

COURSE OUTCOMES:

CO1	Understand the fundamental knowledge on the casting systems
CO2	Analyze gating and riser design and the metallurgical aspects of the solidified metals
CO3	Sketch castability- process friendly design
CO4	Describe the inspection and testing of different castings

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following components:

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quizzes	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I: Casting Processes, classification, characteristics of sand casting processes, metal mould casting processes and casting processes using other mould/core materials, Pattern materials, types of patterns, Mould and core making materials and their characteristics.

(No of Lecture - 5)

Unit II: Technology of Selected Casting Processes, Sand mould casting processes, Metal mould casting processes, centrifugal casting, continuous casting processes, Direct Chill casting, High Pressure and low pressure casting

(No of Lecture - 8)

Unit III: Casting for heterogeneous materials- Fiber Reinforcement Plastics, quick casting, full mould casting, evaporative pattern casting

(No of Lecture - 7)

Unit IV: Solidification, gating and risering design and analysis, nucleation and grain growth, solidification of pure metals, short and long freezing range alloys. Rate of solidification, macrostructure and microstructure. Solidification contraction, fluidity and its measurement. Mould-metal interface reactions, Directional solidification.

(No of Lecture - 10)

Unit V: Melting and quality control of various steels and non- ferrous alloys - casting defects - fettling, inspection and testing of castings Design for castability - process friendly design, castability analysis, repair & salvage, advancement in casting.

(No. of Lectures - 10)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Complete Casting Handbook: Metal Casting Processes, Metallurgy, Techniques and Design, John Campbell, Butterworth- Heinemann, 2015
2. Manufacturing processes for Engineering Materials, Serope Kalpakjian, Addision, Wesley, 1997.
3. Fundamentals of metal casting technology, P.C. Mukherjee, Oxford & IBH Publishing Company, 1988
4. Casting properties of metals and alloys, A.M. Korolkov Consultants Bureau, 1963
5. Casting, ASM Handbook Volume 15, 2008

ONLINE RESOURCES:

1. https://nptel.ac.in

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT818	**Additive Manufacturing Process**	**3**	**3**	**0**	**0**	**0**

PREREQUISITES: Basics of engineering materials, manufacturing process

COURSE OBJECTIVES:

- To educate students with fundamental and advanced knowledge in the field of Additive manufacturing technology

COURSE OUTCOMES:

CO1	Understand the working principles and process parameters of additive manufacturing processes
CO2	Distinguish different additive manufacturing processes and suggest suitable methods for building a particular component
CO3	Design and develop a working model using additive manufacturing processes

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Weekly submissions/ assignments/ quizzes	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Introduction to Additive Manufacturing: Introduction to AM, AM evolution, Distinction between AM & CNC machining, Steps in AM, Classification of AM processes, Advantages of AM and types of materials for AM.

(No. of lectures - 4)

Unit II Additive Manufacturing Methods: Vat Photo- polymerization: Material Jetting: Material extrusion: Binder Jetting: Sheet Lamination: Powder Bed fusion: Direct Energy Deposition: discuss on process mechanism, process parameters, advantages, limitations, applications, recent advances; other similar Processes: thermal spray direct writing, beam deposition, liquid phase deposition, hybrid techniques

(No. of lectures - 16)

Unit III Additive Manufacturing Equipment and Sub- systems: Laser: Laser fundamentals, construction of laser systems, laser properties, laser material interaction, types of laser; Electron Beam: Fundamentals, electron beam –metal interaction, electron beam based additive manufacturing systems Arc- based AM: process mechanism, process parameters, advantages, limitations, applications, recent advances Beam, Material Feeding and Job Manipulation System: laser beam scanning, laser optics, fibre delivery system, job manipulation, electron beam manipulation, process chambers, sensors, material feeding systems, co- axial and lateral nozzles, powder spreading, multi- material spreading.

(No. of lectures - 7)

Unit IV Additive Manufacturing Materials: Types of materials, Polymer, Metals, Ceramics, recent advances in materials, forms of raw materials, support materials, powder production techniques, and powder characterization.

(No. of lectures - 3)

Unit V Post-Processing: Support material removal, surface texture improvement, accuracy improvement, aesthetic improvement, preparation for use as a pattern, property enhancements using non- thermal and thermal techniques.

(No. of lectures - 6)

Unit VI Guidelines for Process Selection: Selection methods for a part, challenges of selection, example system for preliminary selection, process planning and control.

(No. of lectures - 4)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Additive Manufacturing: Principles, Technologies and Applications, C.P Paul, A.N Junoop, McGraw-Hill, 2021
2. Additive Manufacturing, Second Edition, Amit Bandyopadhyay Susmita Bose, CRC Press Taylor & Francis Group, 2020.
3. Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, Ian Gibson, David W Rosen, Brent Stucker, Springer, 2015, 2nd Edition.
4. 3D Printing and Additive Manufacturing: Principles & Applications, Chua Chee Kai, Leong Kah Fai, World Scientific, 2015, 4th Edition.
5. Rapid Prototyping: Laser- based and Other Technologies, Patri K. Venu Vinod and Weiyin Ma, Springer, 2004.

ONLINE/E RESOURCES

1. https://www.nist.gov/additive- manufacturing
2. http://additivemanufacturing.com/basics/
3. https://nptel.co.in

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

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Scheme/Specialization: B.Tech. (Metallurgical and Materials Engineering)

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT811	**Non-Equilibrium Processing of Materials**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE: Basic of thermodynamics, manufacturing processes

COURSE OBJECTIVE:

- To familiarize and equip the students with knowledge of principles and techniques of non- equilibrium processes those are on the threshold of development of materials for the new millennium.

COURSE OUTCOMES:

CO1	Understand the rapid technological developments during recent decades.
CO2	Understand the development of materials that are stronger and capable of use at high temperature and are less expensive.
CO3	Identify the potentials and limitation of the processes and techniques that enable the prospective scientists who wish to enter into the area of non- equilibrium processing

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following components.

S. No.	Component	Weightage
a)	Weekly submissions/ assignments/ quizzes	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I: Thermodynamics and Kinetics of Metastable Phase Transformation: Free energy of elements and alloys. Free energy determination of metastable phases. Supersaturated phases and their lattice parameters. Kinetics of Metastable Phase Formation – Nucleation and Growth.

(No. of lectures - 7)

Unit II: Introduction to non- equilibrium materials processing route: rapid solidification, spray forming, mechanical alloying, ion mixing, vapour deposition, laser processing, plasma processing Sputtering systems, ECAPs, Roll bonding, Friction based processes like friction welding, friction stir processing, friction surfacing.

(No. of lectures - 7)

Unit III: Basic principles of the processes: Basic thermodynamic and kinetic aspects related to the microstructure development during non- equilibrium processing. Effect of fine structures on equilibrium, suppressing of equilibrium structures.

(No. of lectures - 6)

Unit IV: Nanostructured Materials: Preparation, Structure, Stability, Particle consolidation, Properties, Applications – present and potentials, Powder Consolidation.

(No. of lectures - 6)

Unit V: Bulk Amorphous Alloys, Quasicrystals, High entropy alloys. atomic crystals and their reactivity. Non- equilibrium phases in Fe based, Cu based, Al based alloys.

(No. of lectures - 10)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Non- equilibrium Processing of Materials, C. Suryanarayana, Elsevier publications, 1st Edition - July 22, 1999 ISBN: 9780080426976
2. Friction stir processing and Applications, Rajiv Mishra, Elsevier publications, 2005.
3. Tribology in manufacturing technology, D. J. Paulo, Springer, 2012.
4. Laser surface processing and model studies, B. S. Yilbas, S Z Shuja Springer, 2013.
5. An introduction to surface alloying of metals, S. Hosamani 2011.

ONLINE/E RESOURCES:

1. https://nptel.co.in

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT815	**Surface Engineering**	**3**	**3**	**0**	**0**	**0**

PREREQUISITES: Introduction to Engineering Materials

COURSE OBJECTIVES:

- To establish a fundamental understanding of materials and their roles in surface selection for target applications.
- To introduce the concept of surface engineering and its importance

COURSE OUTCOMES:

CO1	Analyze the factors responsible for surface damage by corrosion, wear, and wear mechanisms.
CO2	Apply the fundamentals of surface engineering.
CO3	Apply the knowledge and grasp of coating deposition concepts.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following three components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quizzes	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Introduction: General introduction to surface and bulk, microstructure, properties, interfaces, defects, importance of substrate, current status of surface engineering, introduction to tribology, surface degradation by wear and corrosion.

(No. of Lectures - 5)

Unit II Surface Degradation by Wear: Friction, wear, lubrication, roles of friction and lubrication, categories of wear, wear and lubrication mechanisms, wear and lubrication mode, an overview of lubrication.

(No. of Lectures - 6)

Unit III Surface Degradation by Corrosion: Corrosion mechanisms, oxidation and related concepts, the interaction between wear and corrosion.

(No. of Lectures - 6)

Unit IV Surface Coating Processes: Gaseous state processes – chemical vapor deposition, physical vapor deposition, Ion and laser beam- assisted deposition and surface treatment; solution state processes – chemical solution deposition, electrochemical deposition, sol- gel processing, plasma electrolysis; molten and semi- molten processes – laser surface treatment, thermal spraying, welding; surface hardening treatment.

(No. of Lectures - 10)

Unit V Surface Characterizations: Coating characteristics: surface, thickness, adhesion, morphology, composition, wettability, residual stress, Property characterization and evaluation: roughness, thickness, Microhardness & nanoindentation, tribological evaluation, visual and metallurgical examinations, optical and electron microscopy.

(No. of Lectures - 8)

Unit VI Industrial Applications: Sliding bearings, rolling contact bearings, gears, tools for cutting, tool forming, erosion and scratch- resistant surfaces, magnetic recording devices, etc.

(No. of Lectures - 5)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Coatings Tribology: Properties, Mechanisms, Techniques, and Applications in Surface Engineering, K. Holmberg and A. Matthews, Elsevier, UK, 2009.
2. Corrosion Engineering, M.G. Fontana, Tata McGraw- Hill, 3rd ed. (seventh reprint), 2008.
3. Principles and Prevention of Corrosion, D. A. Jones, Prentice- Hall, 1996.

ONLINE/E RESOURCES

1. https://nptel.ac.in

ENGINEERING METALS

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT809	**Light Metals and Alloys**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE: Introduction to Physical Metallurgy, Principles of Heat Treatment, Mechanical Working of Metals

COURSE OBJECTIVE:

- To impart knowledge on processing, microstructure and properties of various important light metals and alloys being used by mankind today.

COURSE OUTCOMES:

CO1	Understand the importance of light metals and alloys.
CO2	Correlate the processing, properties and applications of Al and its alloys.
CO3	Distinguish the processing, properties and applications of Mg and its alloys.
CO4	Understand the processing, properties and applications of Ti and its alloys.
CO5	Understand the processing and properties of Be and Li alloys.

COURSE ASSESSMENT:

The Course assessment (culminating to the final grade), will be made up of the following components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I: General introduction, production, processing, and properties of light metals and alloys, applications.

(No. of Lectures - 6)

Unit II: Physical and mechanical metallurgy of aluminium and aluminium alloys, Nomenclature of Al alloys, Classification of aluminium alloys, Wrought and cast aluminium alloys, Work hardening, Annealing and age hardening of aluminium alloys.

(No. of Lectures - 9)

Unit III: Physical and mechanical metallurgy of magnesium and magnesium alloys, Alloying behaviour, Classification, Deformation behaviour, Effect of crystallographic texture on properties.

(No. of Lectures - 9)

Unit IV: Physical and mechanical metallurgy of titanium and titanium alloys, Classification of titanium alloys such as near α, α alloys, α/β alloys, β alloys, Titanium aluminides.

(No. of Lectures - 9)

Unit V: Beryllium and Li alloys, Rapid solidification, Future aspects and challenges.

(No. of Lectures - 7)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Light alloys: From Traditional Alloys to Nanocrystals, I. J. Polmear, 4th edition, Elsevier, 2006.
2. Physical Foundations of Materials Science, G. Gottstein, 1st edition, Springer, 2004.
3. Engineering Materials and Processes: Titanium, G. Lütjering and J. Williams, 2nd edition, Springer, 2007.
4. Magnesium Alloys and Technology, K. U. Kainer, 1st edition, Wiley, 2003.
5. ASM Handbook, Volume 9: Metallography and Microstructures, 2020.
6. ASM Handbook, Volume 2A: Aluminium Science and Technology, 2020.
7. ASM Handbook, Volume 2: Properties and Selection: Nonferrous Alloys and Special-Purpose Materials, 2020.

ONLINE RESOURCES

1. https://nptel.ac.in

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT804	**Design and Development of Steels**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE: Basic Knowledge of Physical and Mechanical Metallurgy

COURSE OBJECTIVE:

To know various types of steels, their microstructure and properties.

COURSE OUTCOMES:

CO1	Identify various types of steel
CO2	Sketch the heat treatment routes to control microstructures

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I: Design rationales of steels for various engineering applications. Factors influencing the design of steels. Microstructural aspects of steel for use at low temperatures, high temperatures, and under corrosive atmosphere.

(No. of Lectures - 12)

Unit II: Development of steels for high strength, and high toughness applications requiring high ballistic properties.

(No. of Lectures - 5)

Unit III: Development strategies for cryogenic steels, creep resistant steels. Design of steels for wear resistant applications, cold-rolled grain-oriented steel (CRGO) & Cold Rolled Non-Oriented Coil (CRNO).

(No. of Lectures - 10)

Unit IV: Development of high performance steels e.g. TRIP steel and TWIP steels, interstitial free steels, nitrogen steels and extra low carbon precipitation hardenable steels. Additive strengthening and toughening of steels. Design of nano grained steels.

(No. of Lectures - 13)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Principles of Heat Treatment of Steels, G. Krauss, American Society for Metals,1980
2. Advanced steels - The recent Scenario in Steels Science & Technology, Y. Weng, H. Dong, Springer- Verlag Berlin Heidelberg, 2011.
3. Physical Metallurgy and Design of Steels, F.B. Pickering, Applied Science Publishers, 1978
4. Heat Treatment, ASM, Metals Handbook: Vol. 4, 9th Ed.
5. ASM, Metals Handbook: Properties and selection, Vol. 1, 10th Ed.
6. The Physical Metallurgy of Steels, William C. Leslie, Hempisphere Publishing Corporation, 1981.

ONLINE/E RESOURCES:

1. https://nptel.ac.in

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT816	**Theory of Alloy Design**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE: Introduction to Physical Metallurgy, Principles of Heat Treatment

COURSE OBJECTIVE:

- To provide the students with the knowledge of requirements and theory behind alloy design.

COURSE OUTCOMES:

CO1	Understand the requirements of alloy design.
CO2	Analyze different strengthening methods and their applicability.
CO3	Analyze the roles of matrix and second phase on overall properties of a material.
CO4	Understand the theory of alloy design for different applications.
CO5	Identify various technologically important alloys.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I: Significance of alloy design, Steps in alloy design and toughening, comparative study of different strengthening methods (Substructure and interface modification, solution strengthening, precipitation strengthening, dispersion strengthening, composite strengthening).

(No. of Lectures - 7)

Unit II: Single phase, dual phase and multiphase alloys, Effect of matrix on properties of alloys, Effect of size, shape and distribution of second phase on mechanical properties of alloys

(No. of Lectures - 7)

Unit III: Microstructural engineering and alloy design for improvement of tensile strength, ductility, toughness, design of high toughness alloys for high temperature and low temperature applications, Alloys for onshore and off shore applications, Alloys for wear applications, Alloy for chemical industry.

(No. of Lectures - 7)

Unit IV: Alloy design for fatigue strength, creep strength, fracture strength and corrosion resistance (Aqueous, Stress).

(No. of Lectures - 14)

Unit V: Technologically important alloys: high strength low alloy steel, stainless steel, high speed steel, maraging steel, and Hadfield manganese steel.

(No. of Lectures - 5)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Alloy and Microstructural Design, John K. Tien and George S. Ansell (Eds.), Academic Press, 1st Edition, 1976.
2. Alloy Design, S. Ranganathan, V.S. Arunachalam and R.W. Cahn (Eds.), Indian Academy of Science, Bangalore, 1981.
3. ASM Handbook, Vo. 1 & 2, Properties and selection: Metals Park, Ohio, 1990.
4. Selection of Materials for Component Design: Source Book, H.E. Boyer (Ed.), American Society for Metals, Metals Park, Ohio, 1984.
5. Material Selection in Mechanical Design, M.F. Ashby, Pergamon, New York, 1992.

ONLINE RESOURCES:

1. https://nptel.ac.in

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

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Scheme/Specialization: B.Tech. (Metallurgical and Materials Engineering)

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT813	**Physical Metallurgy of Alloy Steels**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE: Introduction to Physical Metallurgy

COURSE OBJECTIVE:

- To understand the structure- property relationship of alloy steels for engineering applications

COURSE OUTCOMES:

CO1	Understand various types of alloy steel
CO2	Sketch heat treatment routes to control alloy steel microstructures that will provide customizable properties to the component for specific engineering applications
CO3	Classify different phase transformations involved in alloy steel

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I: Advantages of alloy steels over plain carbon steels, classification of alloy steels, Composition, properties and applications of some low alloy steels. Composition, properties and applications of some high alloy steels. Strengthening mechanisms in steels. Heat treatment of alloy steels.

(No. of Lectures - 12)

Unit II: Physical metallurgy of alloy tool steels of different varieties, microstructural variation with heat treatment and its impact on properties and application of steels such as cold work tool steel, hot work tool steels, water hardening tool steels, shock- resisting tool steels, and high- speed steels. Physical metallurgy of advanced steel e.g. dual- phase steel, IF steel, high manganese steel, TRIP steel.

(No. of lectures - 15)

Unit III: Physical metallurgy of stainless steel and their classification, embrittlement in ferritic stainless steel, sensitization, and stabilization in austenitic stainless steel; stabilized austenitic alloys.

(No. of lectures - 10)

Unit IV: Composition, properties and applications of some alloy cast irons.

(No. of Lectures - 3)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Physical Metallurgy of Steels, William C. Leslie, McGraw Hill, 1981
2. ASM, Metals Handbook: Properties and selection, Volume 1
3. Introduction to Physical Metallurgy, Sidney H. Avner, McGraw Hill, 2017
4. Engineering Physical Metallurgy and Heat Treatment, Yu M. Lakhtin, Mir Publishers, 1980
5. Physical Metallurgy and The Design of Steels, F.B. Pickering, Applied Science Publishers Ltd., 1978
6. Cast Iron – Physical and Engineering Properties, H.T. Angus, Butterworths, 2013

ONLINE/E RESOURCES:

1. https://nptel.ac.in

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT826	**High Temperature Corrosion**	**3**	**3**	**0**	**0**	**0**

PREREQUISITES: Electrometallurgy and Corrosion

COURSE OBJECTIVES:

To introduce the concept of high- temperature corrosion.

COURSE OUTCOMES:

CO1	Understand the fundamental aspects of high- temperature corrosion.
CO2	Select materials based on the high- temperature service conditions and application region.
CO3	Understand high- temperature oxidation behavior of pure metals and alloys.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following three components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Introduction: General introduction to corrosion, definition of high- temperature corrosion, high- temperature corrosion phenomena, high- temperature materials, corrosive environments, high- temperature corrosion encountered in different application areas.

(No of Lectures - 5)

Unit II High- Temperature Electrochemistry: Electrochemical nature of molten salt corrosion, single potential of an electrode, equilibrium diagrams, Tafel relationship, polarization, electrochemical nature of metal oxidation, current- potential measurements on solid electrodes.

(No of Lectures - 8)

Unit III Oxidation of Metals and Alloys: Oxidation of pure metals at high temperatures, kinetics of oxide scale formation, systems with significant oxygen solubility's in the metal,

and crack- forming systems, growth law – linear and parabolic, Pilling-Bed worth ratio. Oxidation of alloys, classification of reaction types, noble parent with base alloying elements, base parent with base alloying elements, protective oxide forming alloys (iron and nickel-based).

(No of Lectures - 10)

Unit IV Corrosion in Various Environments: High- temperature corrosion in sulfur-containing environments: metal- sulfur reactions, sulfidation kinetics, hot corrosion, type 1 and type II hot corrosion, basic and acidic fluxing. High- temperature corrosion in alkali and halogen- containing environments: metal- alkali and halogen reactions, cyclic chlorine corrosion, corrosion in molten salts and carbonates. High- temperature corrosion in carbon and nitrogen- containing environments: alloy resistance to carburization, metal dusting, mechanisms of metal dusting, and prevention mechanisms against metal dusting, internal nitridation, and the effect of internal nitridation on mechanical properties. Effect of hydrogen and water vapor on high- temperature corrosion of metals.

(No of Lectures - 12)

Unit V Case Studies: Metallurgical Industries.

(No of Lectures - 5)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. High Temperature Corrosion, P. Kofstad, Elsevier Applied Science, 1988.
2. Corrosion and Oxidation of Metals, U. R. Evans, Arnold Publ., London, 1981.
3. Corrosion Engineering, M.G. Fontana, Tata McGraw- Hill, 3rd ed. (seventh reprint), 2008.
4. Introduction to High Temperature Oxidation and Corrosion, A.S. Khanna, ASM International, Materials Park, Ohio, 2002.

ONLINE/E RESOURCES

1. https://nptel.ac.in

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Scheme/Specialization: B.Tech. (Metallurgical and Materials Engineering)

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT808	**Fracture and Failure**	**3**	**3**	**0**	**0**	**0**

PREREQUISITES: Mechanical behavior of materials

COURSE OBJECTIVES:

- To develop an in- depth understanding of the fundamentals of fracture mechanics and their historical prospects.
- To familiarize the students with various tools used to characterize the fracture behaviour of materials.

COURSE OUTCOMES:

CO1	Understand fracture and failure modes and their significance in materials evaluation.
CO2	Analyze the crack behaviour in different loading conditions.
CO3	Understand the practical aspect of failure analysis.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following three components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Introduction: Basic Concepts in Fracture Mechanics - The geometry of stress and strain, elastic deformation, plastic, and elasto-plastic deformation, the concept of catastrophic failure.

(No. of Lectures - 8)

Unit II Failure: Definition and explanation of the term failure, Fundamental causes of failure, type- I and type- II failure, stress- concentration factor, defect tolerance approach.

(No. of Lectures - 6)

Unit III Fracture parameters: LEFM, Types of fracture, Modes of fracture, Fracture toughness, concept of stress intensity factor, KI_C, J Integral, factors influencing fracture toughness of engineering alloys.

(No. of Lectures - 12)

Unit IV Fractographic examinations: Fractography, trans-granular and inter-granular fracture, modes of fracture.

(No. of Lectures - 4)

Unit V Modes of fracture and failure: Failure by fatigue, creep, and corrosion, Stress corrosion cracking. Failure due to faulty selection of materials, heat treatment, nonmetallic inclusions, and casting defects.

(No. of Lectures - 10)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Analysis of Metallurgical Failures, Colangelo, V.J., Heiser, F.A., John Wiley & Sons, Singapore.2012
2. Strength and Fracture of Engineering Solids, Felbeck, David K., Atkins, Anthony G., Prentice Hall, Inc., Englewood Cliffs.2008
3. Mechanical Metallurgy, Dieter, George E., Jr; McGraw Hill Book Co., New York. 2017
4. Failure Analysis- Case Histories and Methodology, Naumann, F.K., ASM, Metals Park, Ohio.2020
5. Failure and its Prevention, American Society for Metals, Metals Handbook, 8th Ed., Vol. 10, ASM, Metals Park, Ohio. 2001
6. Fundamentals of Fracture Mechanics, Knott, J.E., Butterworths,London.2003

ONLINE/E RESOURCES:

1. Engineering Fracture Mechanics (NPTEL course) by Prof. K. Ramesh, IITM.
2. Fracture, Fatigue and Failure (NPTEL course) by Prof. I. Sen, IIT Kharagpur

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT807	**Fatigue, Fracture and Creep**	**3**	**3**	**0**	**0**	**0**

PREREQUISITES: Mechanical behavior of Materials

COURSE OBJECTIVES:

- To develop an understanding of the fundamentals of fatigue, fracture and creep.
- To familiarized with the deformation aspect of engineering components.

COURSE OUTCOMES:

CO1	Understand fatigue, fracture and creep and their significance in materials design.
CO2	Evaluate critically the relevance of S- N curve, C- M plot, KIC, J- integral and LMP parameters.
CO3	Understand damage mechanisms under both cyclic and creep loading.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following three components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Introduction: Cyclic loading, stress- concentration, high cycle fatigue (HCF), Basquin equation, S- N curve, effect of stress ratio and mean stress on HCF damage, design against HCF, low cycle fatigue (LCF).

(No. of Lectures - 8)

Unit II Cyclic deformation mechanisms: C-M relationship, significance of C-M plot, cyclic hardening and softening mechanisms, cyclic stress- strain curve, fatigue damage mechanisms, Paris law of fatigue crack growth, fretting.

(No. of Lectures - 8)

Unit III Fundamental of fracture: Different modes of fracture, Griffith theory of fracture, stress- concentration factor, Linear elastic fracture mechanics (LEFM), concept of fracture toughness, KI_C, J Integral, factors influencing fracture toughness of engineering alloys.

(No. of Lectures - 12)

Unit IV Creep and related damage mechanisms: Creep of crystalline solids, role of temperature and stress on creep, Equi- cohesive temperature, creep and creep rate curves, Creep testing of engineering alloys, creep- deformation mechanisms, Nabarro- Herring and Coble creep, deformation mechanism maps, LMP parameter, Super plasticity.

(No. of Lectures - 12)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Mechanical Metallurgy, Dieter, George E., Jr; McGraw Hill Book Co., New York., 2017
2. Failure and its Prevention, American Society for Metals, Metals Handbook, 8th Ed., Vol. 10, ASM, Metals Park, Ohio,1998.
3. Fundamentals of Fracture Mechanics, Knott, J.E., Butterworths,London.,2002
4. The utilization of creep test data in engineering design, Bailey, R. W. Proceedings of the Institution of Mechanical Engineers, 1935.
5. Callister's Materials Science and Engienering, William D Callister, Wiley India (P) Ltd., 2007.

ONLINE/E RESOURCES

1. https://nptel.ac.in

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Scheme/Specialization: B.Tech. (Metallurgical and Materials Engineering)

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT803	**Defects and Diffusion in Crystalline solids**	**3**	**3**	**0**	**0**	**0**

PREREQUISITES: Mechanical behaviour of materials

COURSE OBJECTIVES:

- To familiarize with different types of defects, their interactions and their influence on properties.
- A survey of various means of characterizing (quantity and quality) defects

COURSE OUTCOMES:

CO1	Understand the properties of individual defects.
CO2	Understand about defect interactions.
CO3	Understand about defects in materials and their role in determining properties.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following three components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Basic Introduction: Origin and classification of defects, Basics of crystallography, crystal structures, crystal symmetry, thermodynamics and mechanics.

(No. of Lectures - 6)

Unit II Point Defects: Introduction, origin of point defects, Equilibrium Concentration, Point defects in metallic and ionic crystals and their interaction, Effects of point defect on properties with more emphasis on diffusion.

(No. of Lectures - 8)

Unit III Line Defects: Introduction, observation of dislocations, Burger vector, dislocation theory: atomistic, forces between dislocations, energy of dislocations, Jogs, dislocations in metallic and intermetallic systems, effects of dislocation on properties: focus on plasticity, Point- line defects interaction.

(No. of Lectures - 12)

Unit IV Planar Defects: Interface thermodynamics, interface structure, classification of interfaces, glissile / sessile interface, interface migration, grain boundaries and geometrical relationships, stacking faults, APBs, special boundaries, etc., effects of interfaces on mechanical and other properties.

(No. of Lectures - 10)

Unit V Characterization: Characterization tools used to identify the defects in the materials.

(No. of Lectures - 4)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Solid State Physics, C. Kittel, Intro to 3rd Ed., Wiley, 1968
2. Point Defects in Metals, C. Damask and G. J. Dienes; 1st ed., Gordon and Breach, 1963
3. Diffusion in Solids, P.G. Shewmon; 2nd ed., TMS, 1989
4. Introduction to dislocations, D. Hull and D. J. Bacon: 4th ed., Butterworth- Heinemann, 2001.
5. Interfaces in Crystalline Interfaces, P. Sutton and R. W. Balluffi; 1st ed., Oxford Univeristy Press, 1995
6. Mechanical Metallurgy, George E. Dieter: Mechanical Metallurgy, McGraw- Hill Book Company, 2017.

ONLINE/E RESOURCES:

1. Defects in crystalline solids (NPTEL course) by Prof. S Shekhar, IIT Kanpur

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT827	**Introduction to Computational Materials Science**	**3**	**3**	**0**	**0**	**0**

PREREQUISITES: Introduction to Physical Metallurgy

COURSE OBJECTIVES:

- Introduce students to materials modeling and simulation techniques that cover a wide time and length scales.
- Show how these modeling methods can be used to understand fundamental material structure, material defects and the relationships between material structure and material behavior; and
- Develop an understanding of the assumptions and approximations that are involved in the modeling frameworks at the various time and length scales.

COURSE OUTCOMES:

CO1	Understand the basis for the simulation techniques, learn how to use computational modeling, and how to present and interpret the results of simulations
CO2	Understand theories and applications of atomistic scale modeling techniques to simulate, understand, and predict the properties of materials
CO3	Solve problems in materials science and engineering.

COURSE ASSESSMENT

The course assessment (culminating to the final grade), will be made up of the following three components

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Introduction to materials modeling and simulation: Modelling and simulation, scales in materials structure and behavior, how to develop models.

(No. of Lectures - 4)

Unit II Basics: Random- walk model of diffusion, bulk diffusion, random walk simulation, random- walk model for materials. Simulation of finite systems: sum of interacting pairs, perfect crystals, cutoffs, periodic boundary condition, implementation, long- ranged potentials.

(No. of Lectures - 6)

Unit III Atoms and Molecules: Electronic structure methods, interatomic potentials, molecular dynamics, Monte Carlo method, molecular and macromolecular systems, Dislocation dynamics and Crystal plasticity.

(No. of Lectures - 10)

Unit IV Mesoscopic Methods: Kinetic Monte Carlo, Monte Carlo methods at mesoscale, cellular automata, phase-fields methods, mesoscale dynamics.

(No. of Lectures - 12)

Unit V Materials selection and design: Integrated computational materials engineering, concurrent material design, and material informatics.

(No. of Lectures - 8)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Introduction to Computational Materials Science; Richard Lesar, Material Research Society, Cambridge University Press, 2018.
2. Handbook of Materials Modelling, S. Yip, Springer, 2005.
3. Numerical Methods for Engineers, Santosh K. Gupta, New Age International (P) Limited, New Delhi, 1998.

ONLINE RESOURCE

1. www.cambridge.org/laser
2. https://nptel.ac.in

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ENGINEERING MATERIALS

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

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Scheme/Specialization: B.Tech. (Metallurgical and Materials Engineering)

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT310	**Composite Materials**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE: Introduction to Engineering Materials

COURSE OBJECTIVE:

- Familiarize and equip the students with basic knowledge about composite materials

COURSE OUTCOMES:

CO1	Understand various basic concepts related to composite materials
CO2	Acquire ideas about the various types of composite materials
CO3	Understand role of each component of the composite materials
CO4	Identify various fabrication processes of composite materials
CO5	Understand how to reuse the composite materials after their service life is over

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following three components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Introduction: Definition of composite materials. Advanced composites, Importance of composites over other materials. Advantages and general characteristics of composite materials, General requirements of composite materials.

(No. of Lectures - 5)

Unit II Matrix, Reinforcement, and Interface: Classification of composites on the basis of reinforcement and matrix, Form and functions of reinforcement, Functions of matrices. Dispersion strengthened, particle strengthened and fibre- reinforced composites. Strengthening mechanisms-discontinuous and continuous fibre composites. Comparison of above composites. Characteristics and materials of reinforcements and matrices. Testing for interfacial bond strength.

(No. of Lectures - 10)

Unit III Major composite classes: polymer matrix, metal matrix, ceramic matrix, carbon-carbon, and intermetallic composites, hybrid composites, laminated composites. Examples of each class of composites. Role of interfaces in composites, toughening mechanisms in PMCs, MMCs, and CMCs.

(No. of Lectures - 10)

Unit IV Micromechanics and fabrication methods: Micromechanics. Fabrication methods of PMCs, MMCs and CMCs, Reuse of composites after their service life.

(No. of Lectures - 10)

Unit V Recent Advances: Nanocomposites, challenges in the field of composites.

(No. of Lectures - 5)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Composite Materials: Properties, Non- destructive testing and Repair, Mel M. Schwartz, Prentice Hall, New Jersey, 1996
2. Composite Materials – Science & Engineering, K.K. Chawla., Springer- Veslag, New York, 3rd Ed, 2012
3. Industrial Materials: Polymers, Ceramics and Composites, David A. Colling & Thomas Vasilos, vol. 2, Prentice Hall, N. Jersey, 1995.
4. Composite Materials: Engineering and Science, F.L. Matthews and R. D. Rawlings, Chapman and Hall, London, 1994

ONLINE/E RESOURCES:

1. https://nptel.ac.in

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT821	**Automotive and Aerospace Materials**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE: Introduction to Physical Metallurgy

COURSE OBJECTIVE:

Provide background on the various types of Materials used in the Automotive and Aerospace industries

COURSE OUTCOMES:

CO1	Familiarize various types of materials used in automotive and aerospace applications
CO2	Correlate the properties and applications of various lightweight materials used in the automotive and aerospace industries

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Introduction: Introduction to applications of automotive materials, Aluminium alloys and Steel for automotive applications, High strength to weight ratio materials for chasis and body etc., Materials for piston and cylinder assembly, materials for transmission gears, shaft, cams and valves, materials for heavy duty springs, materials for different types of bearing, materials for radiator assembly

(No. of Lectures - 10)

Unit II Aerospace Materials: Aluminium alloys, Properties, Applications, Titanium alloys, Properties, Applications, High Strength Steels, Properties, Applications, Additive manufacturing for fabrication of Aerospace components**.**

(No. of Lectures - 10)

Unit III Composites: Introduction and Classification of Composites, Metal matrix composites, Polymer matrix composites, Fiber reinforcements, Basic Mechanics of Composites, Composites for aerospace applications: Fiber reinforced polymer and fiber

metal laminates (FML), Carbon fiber reinforced polymer (CFRP), Glass fiber reinforced polymer (GFRP), Materials for Aerospace components- propeller blades, turbine blades, space applications.

(No. of Lectures - 10)

Unit IV Superalloys: Introduction to Superalloys, Applications, Classification, Nickel based superalloys, Iron Based superalloys, Cobalt based superalloys, Different phases in superalloys.

(No. of Lectures - 10)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Physical Metallurgy of Steels, W.C. Laslie, McGraw Hill, 1981
2. Introduction to Physical Metallurgy, Sidney H. Avner, McGraw Hill, 2017
3. Fundamentals of Composite Materials, A.K. Shrivastava, Sankalp Publication, 2021
4. Composite Materials: Science and Engineering, Krishan K. Chawla, Springer, 2012
5. Light Alloys: Metallurgy of the Light Metals, I J Polmear, Butterworth- Heinemann, 2017
6. The Superalloys: Fundamentals and Applications, Roger C. Reed, Cambridge University Press, 2008

ONLINE RESOURCES:

1. https://nptel.ac.in

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT829	**Properties and Processing of Polymers**	**3**	**3**	**0**	**0**	**0**

PREREQUISITES: Basic Knowledge of Physics and Chemistry and basics of engineering materials

COURSE OBJECTIVE:

- Acquire the knowledge about structures, properties, processing and applications of engineering polymers.

COURSE OUTCOMES:

CO1	Understand different types of polymers.
CO2	Correlate the structure, properties and applications of polymers.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following three components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Introduction to Polymers: Thermoplastics, Thermosets, High- Performance Polymers, Liquid crystal polymers, Polymer blends & alloys, Shape memory polymers, Thermoplastic Elastomers, Thermoset Elastomers, Molecular Weight Distributions, roles of additives, Glass transition temperature.

(No. of Lectures - 8)

Unit II Factors Affecting Properties: Effect of chemical composition, types of bonds and structures on mechanical, thermal, electrical, barrier and rheological properties of polymers. Effect of molecular weight, cross linking, filler, and additives on transitions temperatures.

(No. of Lectures - 8)

Unit III Processing Techniques: Injection Molding**,** Special Injection Molding Processes (multi- component Injection Molding, Co- Injection Molding, Gas- Assisted Injection Molding, Injection- Compression Molding, Reaction Injection Molding, Liquid Silicone Rubber Injection Molding), Extrusion, Blow Molding, Rotational Molding, Thermoforming, Calendering, Foaming.

(No. of Lectures - 8)

Unit IV Additive Manufacturing Techniques: Stereo lithography, fused filament fabrication, Selective laser sintering, other 3D printing techniques etc.

(No. of Lectures - 8)

Unit V Applications: Applications of polymers, blends and their composites/ nanocomposites/hybrids for structural, tribology, electronics, aerospace, biomedical field etc.

(No. of Lectures - 8)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Introduction to Plastics Engineering, Vijay K. Stokes, John Wiley & Sons Ltd, UK, 2020.
2. Plastics Engineering, 4th Edition, R. J Crawford and P. J Martin. Elsevier, UK. 2020.
3. Material Science of Polymers for Engineers, 3rd Edition, Tim A. Oswald and Georg Menges., Hanser Publications, Cincinnati, USA, 2012.

ONLINE RESOURCES

1. https://nptel.ac.in

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DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT830	**Tribological Engineering Materials**	**3**	**3**	**0**	**0**	**0**

PREREQUISITES: Basic knowledge in material science and engineering

COURSE OBJECTIVES:

- Provide knowledge on the tribology in material science and engineering
- Provide the knowledge on the importance of material design in tribology

COURSE OUTCOMES:

CO1	Understand the scientific and engineering principles underlying tribology of engineering materials
CO2	Apply and integrate knowledge of material structure and property on the design of materials suitable for tribological applications
CO3	Understand the engineering principles of surface treatment and lubricants in tribology

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following three components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I: Introduction to tribological processes and tribologically relevant properties of materials, friction materials and their application. Antifriction/conventional bearing materials, wear resistant materials. An overview of engineering materials having potential for tribological application.

(No. of Lectures - 8)

Unit II: Characterization of Ferrous and non-Ferrous materials for tribological requirements/applications. Surface treatment techniques with applications such as carburizing, nitriding, induction hardening, hard facing and laser surface treatments.

(No. of Lectures - 8)

Unit III: Surface coating techniques such as electrochemical depositions, anodizing, thermal spraying, Chemical vapour deposition.

(No. of Lectures - 7)

Unit IV: Materials for specific applications e.g. seals, hydraulic components and high temperature & low temperature (freezing conditions) applications. Evolution and characteristics of Nano-materials, functionally graded materials and nanocomposites for tribological applications.

(No. of Lectures - 8)

Unit V: Lubricants and lubrication types: types and properties, additives and their role; Grease, solid lubricants. Standards, evaluation, testing and selection of lubricants. Hydrodynamic Lubrication - Elasto hydrodynamic lubrication, Boundary Lubrication - Solid Lubrication Hydrostatic Lubrication Salvaging and re-use of lubricants. Critical environmental problems related to use of lubricants and possible control measures.

(No. of Lectures - 9)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Engineering Tribology, G.W. Stachowiak, A. W. Batchelor, Butterworth- Heinemann Ltd; 2nd edition, 2000.
2. Handbook of Micro/Nano Tribology (Mechanics and Materials Science Series) 2nd Edition, by Bharat Bushan (Editor)CRC Press; 2nd edition, 2020.
3. Principles of Tribology, Shizhu Wen, Ping Huang, Wiley, November 2011.
4. Tribology Friction and Wear of Engineering Materials, Ian Hutchings and Philip Shipway, Elsevier Science, 2017.

ONLINE RESOURCES

1. https://nptel.ac.in

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

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Scheme/Specialization: B.Tech. (Metallurgical and Materials Engineering)

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT820	**Advanced Solar Photovoltaic Materials and Technologies**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE: Engineering Materials

COURSE OBJECTIVE:

- To familiarize and equip the students with basic knowledge about different types 3rd generation solar cells

COURSE OUTCOMES:

CO1	Understand various basic aspects of solar photovoltaic technology
CO2	Acquire ideas about the solar cells characterizations
CO3	Understand constructional and working principles of different types of 3rd generation solar cells

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following three components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Introduction: Review and basics of Semiconductor physics, Metallurgy of silicon, Production of metallurgical and electronic grade Si, Principle of solar energy conversion, Device Physics of Solar Cells.

(No. of Lectures - 8)

Unit II Basics: Solar irradiation measurements, Evaluation of solar cells, Solar cell modules, Electrical and optical losses, Introduction to 1st and 2nd generations of solar cells and their advantages and limitations, Potential and drawbacks of current manufacturing technologies, Economic aspects, Introduction to 3rd generation solar cells.

(No. of Lectures - 10)

Unit III Organic solar cells: Fundamentals of organic semiconductors (Bonding, Conjugation, Hybridization, Electronic structure), Introduction to Organic solar cells, various

device architectures, Physics of Bulk Hetero-junction (BHJ) solar cells, Morphology and charge separation in BHJ.

(No. of Lectures - 7)

Unit IV Dye- sensitized solar cells: Introduction to Dye- sensitized solar cells (DSSCs), Fabrication of DSSCs, Design and selection of novel dyes and solid electrolytes materials, Counter electrode engineering.

(No. of Lectures - 7)

Unit V Perovskite solar cells and Recent Advances: Introduction, Fabrication of perovskite solar cells, Photo physics in perovskite solar cells, Stability in perovskite solar cells, Lead- free perovskite solar cells, Multiple exciton generation and Quantum dot solar cells.

(No. of Lectures - 8)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Solar Photovoltaics: Fundamentals, Technologies and Applications, Chetan Singh Solanki, PHI Publications, 3rd Edition, 2015
2. Solar Energy, S.P. Sukhatme, Tata McGraw Hill, 2008
3. Solar Cell Device Physics, Stephen Fonash, Elsevier, 2nd Edition, 2009

ONLINE/E RESOURCES/ Suggested Readings:

1. https://nptel.ac.in
2. Semiconductor Devices: Basic Principles, J. Singh, Wiley, 2000
3. Organic Electronics: Materials, Processing, Devices and Applications, CRC Press, 2009

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT823	**Ceramics and Glasses**	**3**	**3**	**0**	**0**	**0**

PREREQUISITES: Introduction to Engineering Materials

COURSE OBJECTIVES:

Provide the basic knowledge of the processing and design of ceramic materials, glass, glass-ceramic materials, and binders in terms of both science and engineering

COURSE OUTCOMES:

CO1	Identify technically important ceramic and glass materials.
CO2	Understand the basics of the properties of ceramic and glass materials.
CO3	Infer a material with the required properties using characterization techniques.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following three components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Ceramics: Definition and scope of ceramics and ceramic materials, classification of ceramic materials, areas of applications, bonding and structure of various ceramic materials, crystal structure and defects, polymorphic transformations, raw materials, and defects in ceramics.

(No. of Lectures - 6)

Unit II Glass: Definition, glass structure, difference between glass and crystalline materials, types and composition of glass, fundamentals of glass formation, Zachariasen rules, viscosity-based transition points, de-vitrification, glass forming methods, major glass industries in India and the world, market scenario of the glass industry.

(No. of Lectures - 7)

Unit III Glass-Ceramics: Definition, production of glass- ceramics, application of glass ceramics, types of glass ceramics, photosensitive lithium aluminum silicate, magnesium aluminum silicate, machinable glass ceramics, bio- active glass ceramics, sintered glass ceramics, nanoceramics, electronic ceramics, electro- optic ceramics, magnetic ceramics, ceramic superconductors.

(No. of Lectures - 8)

Unit IV Processing: Powder processing, pre- consolidation, shape forming processes, fundamental sintering mechanisms, and various advanced sintering techniques.

(No. of Lectures - 6)

Unit V Properties: Electrical conductivity, dielectric properties, magnetic properties, optical properties, thermal properties, and mechanical properties, emphasis on the effects of composition, microstructure, processing, temperature and atmosphere on these properties.

(No. of Lectures - 6)

Unit VI Testing of Ceramics and Glasses: Porosity testing, creep and rupture testing, cryogenic testing, electrical testing, high temp performance testing, mechanical testing, metallurgical evaluation, microbiology testing, microstructural analysis, mineralogical analysis, refractory materials testing, surface analysis.

(No. of Lectures - 7)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Fundamentals of ceramics, M. W. Barsoum, 2nd edition, CRC Press, 2020.
2. Ceramic Processing, M. N. Rahaman, 2nd edition, CRC Press, 2017.
3. Materials Characterization Techniques, S. Zhang, L. Li and A. Kumar, CRC Press, 2008.
4. Introduction to Ceramics, 2nd edition, W. David Kingery, H. K. Bowen, Donald R. Uhlmann, Wiley, 1976.

ONLINE/E RESOURCES

1. https://nptel.ac.in/
2. www.lucideon.com

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT822	**Biomaterials**	**3**	**3**	**0**	**0**	**0**

PREREQUISITES: Basic Sciences

COURSE OBJECTIVES:

- Learn characteristics and classification of Biomaterials
- Understand different metals, ceramics and its nanomaterials characteristics as biomaterials
- Learn polymeric materials and its combinations that could be used as a tissue replacement implants
- Get familiarized with the concepts of Nano Science and Technology
- Understand the concept of biocompatibility and the methods for biomaterials testing

COURSE OUTCOMES:

CO1	Understand common use of biomaterials as metals, ceramics and polymers and its chemical structure, properties, and morphology.
CO2	Identify significant gap required to overcome challenges and further development in metallic and ceramic materials, polymeric materials
CO3	Create combinations of materials that could be used to replace different organs & tissues of human body.
CO4	Understand the testing standards applied for biomaterials.

COURSE ASSESSMENT:

The Course assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Weekly submissions/ assignments/ quizzes	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Introduction to Biomaterials: Introduction, historical developments, impact of biomaterials, biological tissue, implants, safety and efficacy testing. Bulk properties and surface properties of materials, characterization methods of surface properties of Biomaterials.

(No. of Lectures - 6)

Unit II Metallic and Ceramic Materials: Metallic implants – stainless steels, Co- based alloys, Ti- based alloys, shape memory alloy, nanostructure metallic implants, degradation

and corrosion, Ceramics – carbons, alumina, yttria based zirconia, resorbable ceramics, bioactive ceramics, nanostructured bio ceramics.

(No. of Lectures - 12)

Unit III Polymeric Materials: polymers as biomaterials, biodegradable polymers, Bio polymers: collagen, elastin and chitin. Soft tissue application, medical textiles, materials for ophthalmology: contact lens, intraocular lens. Membranes for plasma separation and blood oxygenation. Biological functional materials, grafts and other materials.

(No. of Lectures - 10)

Unit IV Testing of Biomaterials: Biocompatibility, blood compatibility and tissue compatibility tests, Toxicity tests, sensitization, carcinogenicity, mutagenicity and special tests, Invitro and Invivo testing; sterilisation of implants and devices: ETO, gamma radiation, autoclaving, effects of sterilization.

(No. of lectures - 6)

Unit V Application of Biomaterials: Cardiovascular Applications; Dental implants; Adhesives and Sealants; Ophthalmologic Applications; Orthopedic Applications; Drug Delivery System; Sutures; Bioelectrodes; Biomedical Sensors and Biosensors. Materials used In Medicine: Metals; Polymers; Hydrogels, Bioresorbable and Biodegradable Materials.

(No. of Lectures - 6)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Biomaterials, Second Edition, Sujata V. Bhatt, Narosa Publishing House, 2005.
2. Functional Materials: Electrical, Dielectric, Electromagnetic, Optical and applications, Deborah D. L. Chung, World Scientific Pub., Vol. 2, 2010.
3. Functional Materials: Preparation, Processing and Applications, S Banerjee and A. K. Tyagi, 1st Edition, Elsevier, USA, 2012.
4. Biomaterials Science: An Introduction to Materials in Medicine, Schoen, F. J., Ratner, B. D., Hoffman, A. S., Lemons, J. E, Netherlands: Elsevier Science, 2004.
5. Biomaterials: an interfacial approach; Hench, LL, Ethridge, EC, Academic Press, 1982.
6. The Biomedical Engineering Handbook, Bronzino, J.D., CRC Press, Germany, 2000.

ONLINE/E RESOURCES

1. https://nptel.ac.in

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT812	**Nuclear Materials**	**3**	**3**	**0**	**0**	**0**

PREREQUISITES: Mineral Processing, Introduction to Extractive Metallurgy

COURSE OBJECTIVES:

- To provide enough background in nuclear materials and their properties, applications and safety precautions.
- To gain a working knowledge of the extraction of nuclear materials from their ores.

COURSE OUTCOMES:

CO1	Understand about different types of materials used in nuclear reactors.
CO2	Understand the extraction process of nuclear materials.
CO3	Correlate the properties of nuclear materials and their applications.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following three components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Introduction: Brief outlines of essential requirements of metals for nuclear energy programs - Structural, fissile, moderator and control, materials for canning, control rods, moderators, coolants, pressure vessels, heat exchanging tubing, and shielding, materials selection, types of reactors, nuclear fission and fusion, radioactive fuel, Indian reactors, and atomic energy programs.

(No. of Lectures - 12)

Unit II Extraction of Nuclear Fuels: Introduction, metallic fuels – Uranium, Plutonium, Thorium; Minerals and their occurrence in India, extraction of nuclear fuels, properties, applications, brief introduction of ceramic fuels.

(No. of Lectures - 15)

Unit III Extraction of Zirconium and Hafnium: Minerals and their occurrence in India, preparation of zirconium oxide and hafnium oxide, Kroll process, bimetal reduction, properties, application, Van-Arkel process.

(No. of Lectures - 5)

Unit IV Extraction of Beryllium: Minerals and their occurrence in India, purification, properties, applications.

(No. of Lectures - 5)

Unit V Safety Measurements: Radioactive wastage, hazardous, and preventions.

(No. of Lectures - 3)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Extraction and Metallurgy of Uranium, Thorium and Beryllium, RG & Hill, NA Bellamy, Pergamon Press, 1963.
2. Uranium Production Technology, C. D. Harigton & A.D. Ruchle, Van Nostrand Publication. Krieger Publishing Company; First Edition, 1959.
3. Extraction of Nuclear and Non- ferrous Metals, S. K. Dutta and D. R. Lodhari, Springer, 2018.

ONLINE/E RESOURCES:

1. https://nptel.ac.in

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT824	**Design and selection of materials**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE: Engineering materials, Mechanical behavior and testing.

COURSE OBJECTIVE:

- The subject exposes students to the basic parameters for selection of materials and different classes of materials, manufacturing processes and their properties, applications of materials.

COURSE OUTCOMES:

CO1	Understand the importance of materials selection.
CO2	Describe the process flow of manufacturing process.
CO3	Distinguish different design criteria for manufacturing process.
CO4	Describe the case study on design.
CO5	Sketch different failure criteria for safe design of components.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Material Selection in Design: General criteria for material selection, performance characteristics of materials, materials selection process, design process and materials selection, economics of materials, recycling and materials selection.

(No. of Lectures - 4)

Unit II Materials Properties and Design: Role of crystal structure. Stress – Strain diagram, design for strength, rigidity. Effect of static strength, stiffness, fracture toughness. Design for yielding and fracture toughness, fatigue, creep and wear resistance, brittle fracture, corrosion resistance. Designing with plastics, brittle materials.

(No. of Lectures - 10)

Unit III Manufacturing Considerations in Design: Surface finish, texture and dimensional tolerances in fitting, interchangeability, selective assembly and geometric tolerance. Selection of fits and tolerances.

(No. of Lectures - 4)

Unit IV Types of design, Design Tools and Materials Data: Design under static loading, variable loading, eccentric loading, stress concentration. Design examples with shaft design, spring design and C- frames, Materials and shape – microscopic and microstructural shape factors – limit to shape efficiency. Comparison of structural sections and materials indices – case studies.

(No. of Lectures - 8)

Unit V Materials Selection: Ashby Method, Case Studies, Multiple Constraints in materials selection, Multiple Objectives, Role of Materials in Shaping the Product Character.

(No. of Lectures - 4)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Engineering Design: A materials and processing approach, G.E. Dieter, 4th Edition, McGraw Hill, 2008.
2. Design of Machine Elements, V.B. Bhandari, 4th Edition, Tata McGraw- Hill Education, 2017.
3. Materials Science and Engineering: An Introduction, W.D. Callister, D.G. Rethwisch, 9th edition, John Wiley, 2013.
4. Engineering Materials: Properties and Selection, K. Budinski, M. Budinski, 9th edition, PHI Learning Private Limited, 2009.
5. Materials Selection and Design, M.A. Maleque, M.S. Salit, Springer, 2013.
6. Materials Selection in Mechanical Design, M. F. Ashby, Elsevier Science, 2016.

ONLINE/E RESOURCES:

1. https://nptel.ac.in

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT825	**Electronic and Magnetic Materials**	**3**	**3**	**0**	**0**	**0**

PREREQUISITES: Introduction to Engineering Materials

COURSE OBJECTIVES:

- To provide a fundamental understanding of the electronic and magnetic properties of materials and to use that understanding in the selection and development of materials for various engineering applications.

COURSE OUTCOMES:

CO1	Understand electronic and magnetic materials.
CO2	Apply the knowledge in manufacturing the ICs based on lithography.
CO3	Describe the magnetic properties of materials.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following three components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Electronic Materials: Review of electronic materials, types of electronic materials, application, intrinsic semiconductors, electron and hole concentrations, Fermi energy level, effect of temperature on Fermi energy, carrier mobility, direct vs. indirect band gap materials, elemental vs. compound semiconductors, extrinsic semiconductors, doping – p and n- type semiconductors, carrier concentration and Fermi level as a function of temperature, drift mobility, light and heavy doping.

(No. of Lectures - 9)

Unit II Manufacturing Process of the electronic materials and Wafer Technology: Crystal growth methods for bulk single crystals - zone melting- refining, leveling - synthesis of epitaxial films by VPE, PVD, MBE and MOCVD techniques, semiconductor materials, lithography – wafer technology, basic patterning and surface preparation to exposure, photo masking, photo resist and their performance factors, etching, dry and wet etching, resistor stripping, production of silicon - starting applications, antireflective coatings.

(No. of Lectures - 9)

Unit III Specific Electronic Materials: LEDs and solar cell materials, transistors – MOSFETs, band diagram and channel formation, threshold voltage, I- V characteristics.

(No. of Lectures - 6)

Unit IV Magnetic Materials: History of magnetism and magnetic materials, magnetic Unit s, concepts and terminology, classification of magnetic materials, magnetic domains and domain structure, magnetic hysteresis, magnetic anisotropy and magnetostriction, theories of diamagnetism, paramagnetism, theories of ordered magnetism, hard and soft magnetic materials.

(No. of Lectures - 9)

Unit V Specific Magnetic Materials: Magneto- resistive materials, magneto- electric materials, magneto- elastic materials, materials with shape memory, materials for magnetic recording, magnetic refrigerant materials, magnetic materials in electric vehicles and hyper loop trains.

(No. of Lectures - 7)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Magnetism and Magnetic Materials, J. M. D. Coey, Cambridge University Press, 2010.
2. Introduction to Magnetic Materials, B. D. Cullity and C. D. Graham, NY: Wiley- IEEE Press, 2008.
3. Principles of Electronic Materials and Devices, S. O. Kasap, McGraw Hill Education, 2017
4. Semiconductor Materials, Devices and Fabrication, Parasuraman Swaminathan, Wiley 2017

ONLINE/E RESOURCES:

1. https://nptel.ac.in

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT819	**Advanced Microscopic Techniques**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE: Material characterization techniques

COURSE OBJECTIVE:

- To provide background and details of the various advanced microscopic techniques used in materials and metallurgical research.

COURSE OUTCOMES:

CO1	Understand the working principles of the various microscopic techniques
CO2	Analyse the output from the techniques and correlate with the structure of materials

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Light Optical Microscopy: Polarization microscopy, Phase contrast microscopy, DIC Microscopy and confocal microscopy, Resolution, Magnification

(No. of Lectures - 6)

Unit II Diffraction Techniques: X- Ray Diffraction, Electron Diffraction, Ewald Sphere, Reciprocal space, Stereographic Projections

(No. of Lectures - 8)

Unit III Electron Microscopy: Scanning electron microscopy (SEM), Energy dispersive X-ray spectroscopy (EDS), Wavelength dispersive X- ray spectroscopy (WDS), Electron Back Scatter Diffraction (EBSD), Transmission electron microscopy (TEM)

(No. of Lectures - 12)

Unit IV Scanning Probe Microscopy: Scanning tunneling microscopy (STM) & atomic force microscopy (AFM)

(No. of Lectures - 6)

Unit V Spectroscopic Characterization: X- ray photoelectron spectroscopy (XPS), X- ray fluorescence (XRF), Fourier- transform infrared spectroscopy (FTIR) and Raman spectroscopy

(No. of Lectures - 8)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Electron Microscopy and Analysis, Peter J Goodhew, John Humphreys, Richard Beanland, Taylor and Francis, 2000
2. Microstructural Characterization of Materials, David Brandon and Wayne D. Kaplan, Wiley, 2008
3. Scanning Electron Microscopy and X- ray Microanalysis, Joseph I Goldstein, Springer, 2003
4. Crystallographic Texture of Materials, Satyam Suwas, R K Ray, Springer, 2016

ONLINE RESOURCES

1. https://nptel.ac.in