I Year **I Semester**

S. No	Course Code	Course Title	L	T	P	Credits
1	HS	Communicative English	3			3
2	BS	Calculus	3			3
3	BS	Engineering Chemistry	3			3
4	ES	Basic Electrical and Electronics Engineering	3			3
5	ES	Engineering Graphics and Drafting	1		3	2.5
6	HS	English communication skills lab-I			3	1.5
7	BS	Engineering Chemistry lab			3	1.5
8	ES	Mechanical workshop practice			3	1.5
9	ES	Basic Electrical & Electronics Engineering			3	1.5
10	MC	Constitution of India	3			0
11	MC	Physical Fitness Activities/ Yoga				
		Total Credits				20.5

I Year **II Semester**

S. No	Course Code	Course Title	L	T	P	Credits
1	BS	Linear Algebra and Numerical Methods	3			3
2	BS	Engineering Physics	3			3
3	ES	Engineering Mechanics	3			3
4	ES	Problem Solving and Programming using C	3			3
5	ES	Computer-Aided Engineering Drawing	1		3	2.5
6	HS	English Communication Skills lab-II			3	1.5
7	BS	Engineering Physics lab			3	1.5
8	BS	Engineering Physics Virtual lab			2	0
9	ES	Problem Solving and Programming using C - lab			3	1.5
10	PR	Engineering Exploration Project – Design Thinking (15 hrs per semester)				0.5
11	MC	Professional Ethics and Human Values	3			0
		Total Credits				19.5

II Year **I Semester**

S. No	Course Code	Course Title	L	T	P	Credits
1	PCC	Mineral Processing	3	0	0	3
2	PCC	Physical Metallurgy	3	0	0	3
3	BS	Vector calculus, Transformations and Partial Differential Equations	3	0	0	3
4	PCC	Thermodynamics and Kinetics	3	1	0	4
5	PCC	Metallurgical Analysis	3	0	0	3
6	PCC	Mineral Processing lab	0	0	3	1.5
7	LC	Physical Metallurgy Lab	0	0	3	1.5
8	LC	Metallurgical Analysis Lab	0	0	3	1.5
		Total Credits				**20.5**

II Year **II Semester**

S. No	Course Code	Course Title	L	T	P	Credits
1	PCC	Iron Making	3	0	0	3
2	ES	Elements of Mechanical Engineering	3	0	0	3
3	BS	Complex Variables and statistical Methods	3	0	0	3
4	PCC	Phase Transformation and Heat Treatment	3	0	0	3
5	PE	Professional Elective-I: 1. Fuels, Furnaces and Refractories 2. Light Metal Technology 3. Computational Materials Engineering	3	0	0	3
6	PCC	Foundry Technology	3	0	0	3
7	LC	Phase Transformation and Heat Treatment Lab	0	0	3	1.5
8	LC	Foundry Technology Lab	0	0	3	1.5
		Total Credits				**21**

III Year **I Semester**

S. No	Course Code	Course Title	L	T	P	Credits
1	PCC	Mechanical Behaviour of Materials	3	0	0	3
2	PCC	Steel Making	3	0	0	3
3	PCC	Corrosion Engineering	3	0	0	3
4	PCC	Non-ferrous Extractive Metallurgy	3	0	0	3
5	PE	Professional Elective-II: 1. Magnetic and Electronic Materials 2. Nuclear Materials 3. Advanced Manufacturing Technology	3	0	0	3
6	OE	Open Elective-I: 1. Introduction to Materials Engineering 2. Basics of Crystallography 3. Metallurgical Process Modelling	3	0	0	3
7	LC	Corrosion Lab	0	0	3	1.5
8	LC	Mechanical Testing Lab	0	0	3	1.5
		Total Credits				**21**

III Year **II Semester**

S. No	Course Code	Course Title	L	T	P	Credits
1	PCC	Materials Characterization	3	0	0	3
2	PCC	Non-destructive Testing	3	0	0	3
3	PCC	Powder Metallurgy	3	0	0	3
4	PE	Professional Elective-III: 1. Surface Engineering and Tribology 2. Transport Phenomenon 3. Alternative routes of iron and steel making	3	0	0	3
5	OE	Open Elective-II: 1. Materials Testing 2. Chemical Analysis of Metals 3. Materials for Extreme Environment	3	0	0	3
6	PCC	Ferro Alloy Technology	3	0	0	3

7	LC	Materials Characterization Lab	0	0	3	1.5
8	LC	Non-destructive Testing Lab	0	0	3	1.5
		Total Credits				**21**

IV Year **I Semester**

S. No	Course Code	Course Title	L	T	P	Credits
1	PCC	Materials Joining Technology	3	0	0	3
2	PCC	Composite Materials	3	0	0	3
3	PE	Professional Elective-IV: 1. Solidification Processing 2. Metallurgical Failure Analysis 3. Polymer Science and Technology	3	0	0	3
4	OE	Open Elective-III: 1. Functional Materials 2. High Temperature Materials 3. Biomaterials	3	0	0	3
5	PR	Project Work (Phase-I)	0	0	0	2.5
6	PR	Internship Followed by Seminar	0	0	0	1
7	LC	Materials Joining Lab	0	0	3	1.5
8	LC	Composite Materials Lab	0	0	3	1.5
		Total Credits				**18.5**

IV Year **II Semester**

S. No	Course Code	Course Title	L	T	P	Credits
1	HSSMS	Introduction to Industrial Management	3	0	0	3
2	PCC	Nanomaterials	3	0	0	3
3	PE	Professional Elective-V: 1. Fatigue and Fracture Mechanics 2. Energy Materials 3. Ceramic Science and Technology	3	0	0	3
4	LC	Nano Materials Lab	0	0	2	1
4	PR	Project Work (Phase-II)	0	0	0	8
		Total Credits				**18**

		L	T	P	C
II- Year I-Semester	**MINERAL PROCESSING**	**3**	**0**	**0**	**3**

Course objective: The course presents the principles and methods of beneficiation of minerals from their ores. It covers the theory and working of various crushers, classifiers and other mineral beneficiation equipment to meet the industrial needs.

UNIT I

(Learning objective: To study the scope of ore dressing and to describe the various crushers used in ore dressing, To understand the theory, principle and working of various ball mills used for size reduction)

Scope and objective of ore dressing, Sampling of ores by different methods. Theory of liberation of minerals. Crushers: -Jaw, Gyratory, Cone, Rolls, and toothed roll crushers.
Types of grinding operations like batch and continuous dry and wet grinding, open circuit and closed circuit grinding. Grinding Mills: Ball mills, theory of ball mill operation, rod and tube mills. Comminution laws: - Rittinger's laws, Kick's law and Bond's law.

UNIT II

(Learning objective: To explain the theory and principles of various sizing techniques. It also describes the movement of solids in fluids by explaining the effect of various parameters on the movement of solids.)

Sizing: Study of laboratory sizing techniques and reporting of sizing data. Industrial sizing units: Types of screen surfaces. Grizzlies, trommels, vibrating and shaking screens. Movement of solids in fluids: Stokes and Newton's laws. Terminal velocity and its relation with size. Relation between time and velocity. Relation between distance travelled and velocity. Equal settling ratio, Free and hindered settling ratios. Quantifying concentrating operations: Ratio of concentration, recovery, selectivity index and economic recovery.

UNIT III

(Learning objectives: To understand the principles and working of classifiers. The student should also understand various heavy media separation methods.)

Classification of classifiers, study of settling cones, rake classifier, spiral classifier, and cyclones. Heavy media separation: Principles, flow chart, different media used. Heavy media separation using heavy liquids and heavy suspensions. Washability curves for easy, normal and difficult coal.

UNIT IV

(Learning objectives: The basic concepts involved in jigging and tabling will be detailed to understand the working of various jigging machines and other equipment involved with tabling.)

Jigging: Theory of jigging. Jigging machines: hand jig, Harz jig, Denver jig, Baum jig, Hancock jig, James coal jig, and halkyn jig. Design considerations in a jig. Tabling: -study of stratification on a table. Shaking tables, wilfley table. Humphrey's spiral classifier.

UNIT V

(Learning objectives: To understand the principles and applications of flotation and other separation processes and to be getting acquainted with the working of equipment used for floatation process.)

Flotation: Principles of flotation, Factors affecting flotation. Classification of collectors and frothers. Regulators factors affecting their efficiency. Flotation machines: -Pneumatic and mechanical flotation cells. Application of flotation process for Cu, Pb and Zn ores. Magnetic separation processes and electrostatic separation process.

(*Assessment: The student should be evaluated based on the assignments and objective tests. The student's analytical abilities (with special focus on academically weak students) should be tested periodically in classes by giving problems). Emphasis should be given by conducting tutorial classes at the end of each unit.*

TEXTBOOK:

1. Principles of Mineral Dressing by A.M. Gaudin.

REFERENCES:

1. Elements of Ore Dressing by A.F. Taggart
2. Mineral processing technology-.A. Wills
3. Ore dressing practices-S.K.Jain.

		L	T	P	C
II- Year I-Semester	**PHYSICAL METALLURGY**	**3**	**0**	**0**	**3**

(Course Objective: It is an introductory course for the students of Metallurgical Engineering and the subject deals with the fundamental concepts about the crystal structures, phase diagrams, and their applications.)

UNIT – I

(Learning objective: To understand the basic crystal structures of various materials which forms the basis for the subsequent study of properties of materials.)

Structure of Metals, Hume-Rothery's classification of metals, metallic bond-crystal structure of metals, coordination number, relationship between lattice parameter and atomic radius, packing factor and density calculations, interstitials, polymorphism, plane and directional indices, transformation of indices.

UNIT – II

(Learning objective: To understand the constitution and necessity of alloy formation. To study the associated Hume Rothery rules for the formation of alloys.)

Constitution of Alloys: Necessity of alloying; types of solid solutions, Hume-Rothery's rules. Intermediate alloy phases, electro-chemical compounds, size factor, compounds, and electron phases.

UNIT – III

(Learning objective: The chapter outlines the various experimental methods of construction of phase diagrams. The unit also outlines the solidification behaviour of materials during cooling.)

Equilibrium Diagrams: Experimental methods for construction of equilibrium diagrams, Isomorphous alloy systems, eutectic and partial eutectic systems.

Solidification: Types of Nucleation, determination of the size of critical nucleus, equilibrium cooling and heating of alloys, lever rule, coring, miscibility gaps. Simple problems using lever rule.

UNIT – IV

(Learning objective: The unit intended to describe various phase diagrams and phase transformations)

Transformation in solid-state, allotropy, order-disorder transformation, eutectoid, peritectoid reactions and complex phase diagrams, relation between equilibrium diagrams and physical properties of alloys. Study of important binary phase diagrams like Fe-Fe_3 C, Cu-Zn, Cu-Sn, and Al-Cu.

UNIT – V

(Learning objectives: To provide the detailed explanation of phase transformations in steels and to understand the importance of isothermal diagrams)

Phase transformations in steels pearlitic, martensitic and bainitic transformations cooling curves. Isothermal transformation diagrams, transformations on continuous cooling.

(Assessment: The student should be evaluated based on the assignments and objective tests. The student's analytical abilities with special focus on academically weak students) should be tested periodically in classes by giving problems with respect to Phase diagrams and others. Unit tests are to be conducted at the end of each unit).

TEXTBOOK:

1. Introduction to Physical Metallurgy – S.H. Avner- McGraw-Hill publishers
2. Physical Metallurgy – Viajyendra Singh, Standard Publishers Distributors, 2005

REFERENCES:

1. Physical Metallurgy principles-Reed Hill – CENGAGE Learning Publishers
2. Engineering Physical Metallurgy and Heat Treatment – Y. Laktin.
3. Elements of Physical Metallurgy – A.Guy
4. Metallographic laboratory practice – Kehl
5. Principles of Physical Metallurgy – Smith. M.
6. Introduction to Metallurgy – A.H. Cottrell
7. Metallurgy for Engineers-Clark and Varney.
8. Physical Foundations of Materials Science – G. Gottstein
9. The Science and Engineering of Materials – Askeland et. al.
10. Physical Metallurgy – William F Hasford – CRC Press
11. Callister's Materials Science and Engineering, Adapted by R.Balasubramaniam, second edition, Wiley, 2015

II- Year I-Semester	THERMODYNAMICS AND KINETICS	L	T	P	C
		3	0	0	3

Course Objective: To provide comprehensive coverage of the laws of thermodynamics, reaction Kinetics, and their applications so as to prepare the student for professional practice.)

UNIT-I

(Learning Objectives: The student can understand the basic concepts of the properties of a system to help them to get a clear understanding of reversible and irreversible processes.)

Objectives and limitations to thermodynamics, concepts of system and state, heterogeneous and homogeneous systems, extensive and intensive properties of system, thermodynamic variables, thermodynamic equilibrium. Reversible and irreversible processes.

UNIT-II

(Learning Objectives: The student can understand the clear concept of enthalpy and internal energy. It also helps in understanding the classification of work. These basic concepts will make the student to understand systems concept of manufacturing processes. It helps the student to identify, formulate and solve engineering problems.)

First and Second laws Law of thermodynamics: Nature of first law, relationship between heat and work, internal energy and the first law of thermodynamics, calculations of work, constant capacity, reversible adiabatic processes, reversible isothermal pressure or volume changes of an ideal gas, enthalpy change with temperature, Kirchhoff's equation. Second law of thermodynamics: Efficiency of a cyclic process, Carnot cycle, Carnot theorem, second law of thermodynamics, concept of entropy

UNIT-III

(Learning Objectives: To understand the concepts of free energy and entropy. To understand the relationship between these functions and their applications in various thermodynamic processes. It helps the student to identify, formulate and solve engineering problems.)

Third law of thermodynamics: Background of third law deductions from third law, applications of third law, and other methods of obtaining ΔS^0 for a reaction. Free energy functions: Purposes of the new functions, definition of Helmholtz and Gibbs free energy change, meaning of thermodynamically possible process, determination of ΔG from thermal data useful relationships between free energies and other thermodynamic functions, Maxwell's equation and Gibbs-Helmholtz equation.

UNIT-IV

(Learning Objectives: To know the concepts of activity and equilibrium constants. It helps the student to identify, formulate and solve engineering problems.)

Fugacity, activity and equilibrium constant: Concepts of fugacity, activity and equilibrium constant variation of the equilibrium constant with temperature, Calculation of equilibrium constant from free energy changes, derivation of the Clausius – Clapeyron equation for single substance, Duhriges rule for the estimation of the vapour pressures of an element, Integration of Clausius – Clapeyron equation. Problems.

UNIT –V

(Learning Objectives: To understand the kinetics of chemical processes and simultaneous reactions. It helps the student to identify, formulate and solve engineering problems.)

Kinetics: Kinetics of chemical process, Molecularity, and order of a reaction, zero-order reactions, first-order, second-order reactions, Determination of order of reaction, collision theory, theory of absolute reaction rates, consecutive and simultaneous reactions, catalysis in chemical reactions.

TEXTBOOK:

1. Introduction to the thermodynamics of materials 5th Edition– D.R. Gaskell – CRC Press
2. Principles of metallurgical thermodynamics- S. K. Bose and S.K. Roy, University Press 2014

REFERENCES:

1. Thermodynamics of solids-R.S.Swalin
2. Physical chemistry of metals-L.S.Darken & Gurry
3. Physical Metallurgy Principles – RH Reed hill.
4. Thermodynamics An Engineering Approach – Cengel – Mcgraw-Hill – 7th Edition
5. Fundamentals of thermodynamics-Sonntag et al
6. An Introduction to thermodynamics-Y.V.C.Rao
7. Chemical and Metallurgical thermodynamics – Prasad Krishnakanth – New Age Publications
8. Text Book of Materials and Metallurgical Thermodynamics: Ahindra Ghosh (PHI)

		L	T	P	C
II- Year I-Semester	**METALLURGICAL ANALYSIS**	**3**	**0**	**0**	**3**

Course objective: To study the methods of analysis of various metals and alloys quantitatively and qualitatively.

UNIT-I:
(Learning objective: To know the importance of various methods of Metallurgical analysis.)

Importance of chemical analysis, scope of metallurgical analysis, classification of various methods used in metallurgical analysis. Solution preparations, normality, molarity, molality, Equivalent weight. Dissolution of ores in general, dissolution of metals and alloys.

Chemical Analysis - Basic Principles - theory of indicators –Conventional solution methods for qualitative analysis of ores, fluxes, slags, metals, and refractories.

UNIT-II:
(Learning objective: To know the various methods of qualitative analysis of a few ferrous and non-ferrous metals and alloys)

Qualitative analysis of common non-ferrous alloys such as brasses, bronzes, and solders. Estimation of C, S, Si, Mn, and P in cast iron and steel.

UNIT-III:
(Learning objective: To estimate various elements present in various ores)

Estimation of Cr, Ni, Mo, W, and V in alloy steels. Determination of iron in iron ore, manganese in manganese ores, lime in limestone, fire-assay of precious metals.

UNIT-IV:
(Learning objective: To describe various instrumental methods of analysis and to compare the results with different wet methods)

Instrumental analysis: Importance of instrumental analysis –Comparison with standard wet chemical methods - Fundamental Physicochemical principles involved and equipment required in absorptiometry i.e., colorimetry and spectrophotometry, colorimetric titration.

UNIT-V:
(Learning objective: To describe various advanced instrumental methods of analysis)

Spectroscopy, potentiometry, amperometric titration. Calorimetric titrations, polarography, conductometry, electro-analysis, and flame photometry.

(Assessment: The student should be evaluated based on the assignments and objective tests. Emphasis should be given by conducting tutorial classes (with a special focus on academically weak students) at the end of each unit).

TEXTBOOK:

1. S.K.Jain-Metallurgical analysis.

REFERENCES:

1. Iyer V.G., Metallurgical Analysis: BHU Press, Varanasi.
2. Agarwal, B.C. and Jain S.P., A Text Book of Metallurgical Analysis, Khanna Publishers, Delhi -1963.
3. Snell Foster D and Frank M Biffen: Commercial methods.of analysis / Che. Publishing Co.,1964
4. Vogel Al., A Text Book of Quantitative Inorganic Analysis Longman ELBS 1962.
5. Willard H.H.etal: Instrumental Methods of analysis Van Nostrand.

		L	T	P	C
II- Year I-Semester	**METALLURGICAL ANALYSIS LAB**	**0**	**0**	**3**	**1.5**

Learning objective: Design the sequence of operations in a logical order. The relevant tabular forms are to be prepared. Experiments are to be conducted taking the necessary precautions. The data should be recorded and the results need to be interpreted using the necessary mathematical expressions. The graphs are to be drawn where ever required and the appropriate conclusions should be presented.

1. Estimation of Iron in Iron ore. - To determine the percentage of Iron in Iron Ore by KMnO4 method and K2Cr2O7 method.
2. Estimation of Silicon in Cast Iron.
3. Estimation of Carbon in Steel by Strohlein apparatus method.
4. Estimation of Copper in Brass by Electrolytic method.
5. Estimation of manganese in cast iron.
6. Estimation of Chromium in Steel.
7. Estimation of Sodium and Potassium in Chloride Salts by Flame Photometry.
8. Estimation of lime in Limestone.
9. Estimation of the concentration of KMnO4 in the solution using Digital Spectrophotometer.
10. Estimation of Sulphur and Phosphorus in cast irons.
11. Estimation of Chromium in Stainless steels.
12. Estimation of Mn, Cr, and Si in Ferro-Alloys

EQUIPMENT:

1. Optical emission spectrometer
2. Flame Photometer
3. Digital Spectrophotometer
4. Electronic digital balances – 2 No's

(Assessment: The student's performance should be evaluated at the end of each class based on the following parameters:
I.

1. *observation book,*

2. *Record.*
3. *Conduct of the experiment successfully*
4. *Interpretation of the data*
5. *Drawing the graphs where ever necessary*
6. *Viva-voce.*

II.

1. *At the end of each cycle of experiments internal exams should be conducted in addition to the end examination)*

		L	T	P	C
II- Year I-Semester	**MINERAL PROCESSING LAB**	**0**	**0**	**3**	**1.5**

(Learning objective: Design the sequence of operations in a logical order. The relevant tabular forms are to be prepared. Experiments are to be conducted taking the necessary precautions. The data should be recorded and the results need to be interpreted using the necessary mathematical expressions. The graphs are to be drawn where ever required and the appropriate conclusions should be presented.)

List of Experiments

1. Sampling of ore from the bulk by
   1. Coning and quartering method
   ii) Riffle sampler methods
2. Sizing by Sieve analysis of crushed ore
3. Verification of Stoke's Law.
4. Determining the reduction ratio of a jaw crusher.
5. Study of the variation of reduction ratio with process variables in Rolls crusher.
6. Study of the process variables on reduction ratio and particle size distribution in ball mill.
7. To find the grindability index of ores.
8. Verification of Laws of Comminution.
9. Determination of the efficiency of a magnetic separator.
10. Determination of the efficiency of a jig.
11. Study of the particle separation by fluid flow using wilfley table.
12. Determination of the efficiency of a pneumatic separator.
13. To study the concentration of metallic and non-metallic ores by Froth-Flotation process.

Equipment:

1. Riffle Sampler
2. Sieve Shakar with Sieves
3. Stokes' Apparatus
4. Jaw Crusher
5. Roll Crusher
6. Ball Mill
7. Grindability Index Apparatus
8. Magnetic Separator
9. Jig
10. Wilfly's Table
11. Pneumatic Separator
12. Froth – Floatation Equipment
13. Balances

		L	T	P	C
II- Year I-Semester	**PHYSICAL METALLURGY LAB**	**0**	**0**	**3**	**1.5**

Learning objective: Design the sequence of operations in a logical order. Experiments are to be conducted taking the necessary precautions. The microstructures should be observed at various magnifications and the structure should be interpreted and conclusions should be presented.

LIST OF EXPERIMENTS

1. Preparation and study of Crystal models.
2. Study of: Specimen cutting machine Specimen mounting press Grinding and polishing equipment
3. Study of various Metallurgical Microscopes and use of levelling press
4. Metallographic preparation of ferrous specimens for Microscopic examination
5. Preparation of non-ferrous specimens for Metallographic examination
6. Preparation and Metallographic study of pure metals like Iron, Copper, Aluminium, etc..
7. Measurement of lattice parameters of various crystal structures and calculation of packing factors and size of vacancies.
8. Identification of Microstructures of steels

Equipment:

1. Specimen Cutting Machine
2. Specimen Mounting Press
3. Belt Grinding Machine
4. Disc Polishing Machines
5. Metallurgical Microscopes
6. Specimen Leveller.
7. Image analyser
8. Standard samples with their microstructures

		L	T	P	C
II- Year II-Semester	**IRON MAKING**	**3**	**0**	**0**	**3**

***(Course objective:** The subject deals with preparation of various types of iron ores, agglomeration methods and operation of Blast Furnace)*

UNIT-I

(Learning Objectives: To know the availability and preparation of iron ores. To understand various agglomeration techniques of iron ores and their importance)

Occurrence and distribution of iron ores in India and in the world, Preparation of iron ores.
Sintering: Principles, raw materials, and DL. machine. Mechanism of sintering. sintering bonds. Factors affecting sintering efficiency. Pelletisation: Theory of pellatisation, Water-particles system. Production of green pellets: disk and drum pelletisers, Induration of pellets: Shaft, traveling grate.

UNIT-II
*(Learning Objectives**:** Study of BF coke, BF gases, and their cleaning*.)

Blast furnace coke: Functions, properties and uses, BF profile and design considerations. Furnace lining. Furnace cooling system. Hoisting equipment. B.F. Stoves. BF gas cleaning system and gas use.

UNIT-III
(Learning Objectives: Study of Physical Chemistry of reduction of ores, and uses and properties of slags.)

Physical chemistry of reduction of iron ores: Physical and chemical factors affecting the reduction of ores. Relevant CO/CO2 and H2/H2O diagram. Controls of C, Si, S, P in metals and slags.

Blast furnace slags: Its constitution. Effect of CaO, SiO2, Al2O3, and MgO on fluidity of slags. Uses of slags.

UNIT-IV
(Learning Objective: To understand the design and operation of Blast Furnace, blast furnace irregularities and methods of increasing productivity)

Blast Furnace Operation: Blowing in, blowing out, fanning and draughting. BF irregularities and their control/remedies. Development of BF: HTP, humidification of blast. O2 enrichment, hot blast temperature, BF additives, and top charging systems.

UNIT-V

(Learning Objective: BF Burden calculations and study of alternate routes of iron making including wrought iron.)

BF Burden calculations: Raceways parameters. Factors affecting it. Alternative routes of iron making: Electric pig iron smelting, low shaft and small shaft B.F. Classification of sponge iron making. HYL, Kiln Krupp-Renn, Midrex process. Production of wrought iron.

(Assessment: The student should be evaluated based on the assignments and objective tests. The student's analytical abilities (with special focus on academically weak students) should be tested periodically in classes by giving problems). Emphasis should be given by conducting tutorial classes at the end of each unit.

TEXTBOOK

Modern Iron making Dr. R.H. Tupkary

REFERENCE BOOKS

1. Blast furnace theory and practice Vol. 1 and 2 edited by Julius H. Strass burger.
2. Principles of blast furnace Iron Making A.K. Biswas.

		L	T	P	C
II- Year II-Semester	**PHASE TRANSFORMATIONS AND HEAT-TREATMENT**	**3**	**0**	**0**	**3**

Course Objective: *This subject deals with Principles of heat treatment of steels, Alloy steels, and some non-ferrous alloys and different heat treatment methods.*

UNIT-I

Learning Objective: *This unit deals with principles of heat treatment, and different hardenability methods.*

Principles Of Heat Treatment: Austenitic Transformation, Pearlitic Transformation, Bainitic Transformation, Martensitic Transformation, Annealing, Normalizing, Hardening, mechanism of heat removal during quenching, quenching media, size and mass effect, hardenability, tempering, austempering, manufacturing, deep freezing. Heat treatment furnaces and their design, atmosphere control vacuum heat treatment, etc.

UNIT-II

Learning Objective: *To learn about different surface hardening methods.*

Surface heat treatment, carburizing, cyaniding, flame and induction hardening, residual stresses, deep freezing, thermomechanical treatments: HTMT, LTMT, Ausforming, Isoforming, Cryoforming.

UNIT-III

Learning Objective: *This topic throws light on TTT Curves and the effect of alloying elements on Fe-Fe_3C system.*

Effect Of Alloy Elements: Purpose of alloying, effect of alloying elements on ferrite, cementite, Fe- Fe_3C system, tempering, and TTT Curves.

UNIT-IV

Learning Objective: *This topic explains heat treatment of various types of tool, die steels and cast irons.*

Alloy Steels: Structural and constructional steels, maraging steels, tool and die steels. Corrosion and heat resistant steels, Hadfield steels, magnetic steels and alloys, free machining steels.

Cast Irons: White cast iron, grey cast iron, spheroidal graphite iron, malleable cast iron, alloy cast iron.

UNIT-V

Learning Objective: *To understand the principles of heat treatment of various non-ferrous alloys.*

Non-Ferrous Metals And Alloys: Precipitation hardening, aging treatment, the study of copper and its alloys, aluminium and its alloys, nickel and its alloys.

(Assessment: The student should be evaluated based on the assignments and objective tests. The student's analytical abilities (with grinding focus on academically weak students) should be tested

periodically in classes by giving problems). Emphasis should be given by conducting tutorial classes at the end of each unit.

TEXTBOOK

1. Heat Treatment Principle and Techniques-Rajan & Sharma
2. Heat treatment of metals- Vijayendra Singh, 2nd edition, Standard Publishers Distributors, 2006

REFERENCES

1. Heat Treatment of metals-Zakharv-Mir Publishers
2. Physical Metallurgy Lakhtin-Mir Publishers
3. Physical Metallurgy - Clark and Varney
4. Physical Metallurgy Principles - Reed Hill
5. Physical metallurgy-Raghavan
6. Materials Science and Engineering, Adapted by R.Balasubramaniam, second edition, Wiley, 2015

		L	T	P	C
II- Year II-Semester	**FOUNDRY TECHNOLOGY**	**3**	**0**	**0**	**3**

Course objective: *The course deals with various types of Foundries, patterns, moulding materials and different types of casting methods including modern methods.*

UNIT I

Learning Objectives: *To know about various types of foundries and know the patterns and moulding sands and additives used for getting good moulds.*

Scope and development of Foundry. Types of foundries. PATTERNS: Materials for patterns, types of patterns; functions and pattern allowance. MOULDING MATERIALS: Moulding sands, properties and selection of materials and additives used.

UNIT II

Learning Objectives: *To know in detail about various casting processes and properties in moulds. Gating and risering in moulds.*

CASTING PROCESSES AND EQUIPMENT: Green and dry sand moulding; shell moulding, CO2 moulding. Core moulds and cores. Plaster mould casting, composite mould casting, Investment casting.
GATING AND RISERING: Gate nomenclature, gate types and types of risers.

UNIT III

Learning Objectives: *Study of different moulding processes and their equipment*

Permanent mould casting, pressure die-casting, Gravity die-casting and centrifugal casting, Types of moulding equipment.

UNIT IV
Learning Objectives: *Solidification of metals and alloys and melting practices to be studied*

SOLIDIFICATION OF METALS: Nucleation crystal growth. Freezing of metals and alloys. Dendritic freezing. Coring and segregation, ingot defects, Flow of metals in moulds.
MELTING OF FERROUS ALLOYS: ‘Melting of Gray iron and cupola. Cupola operation and control. Effect on chemical composition, carbon equivalent, and effect of alloying elements on foundry characteristics. Melting of non-ferrous alloys: Melting of Aluminium and copper alloys production processes: Production of Gray Iron, ductile iron. Malleable iron castings

UNIT V
Learning Objectives: *Various casting defects and their prevention to be studied*

Continuous casting and casting defects: Casting defects arising due to moulding, coring melting, and poring practice.

(Assessment: The student should be evaluated based on the assignments and objective tests. The student's analytical abilities (with special focus on academically weak students) should be tested periodically in classes by giving problems). Emphasis should be given by conducting tutorial classes at the end of each unit.

TEXTBOOKS

1. Principles of Metal casting by Heine, Loper, and Rosenthal.
2. Foundry Technology – Dhuvendra Kumar & S.K.Jain

REFERENCE BOOKS

1. Metals Handbook Vol. 5 published by ASM, Ohio.
2. Foundry Technology-Jain
3. Foundry Technology Principles-T.V.Ramana Rao

		L	T	P	C
II- Year II-Semester	**PHASE TRANSFORMATIONS AND HEAT-TREATMENT LAB**	**0**	**0**	**3**	**1.5**

Learning objective: Design the sequence of operations in a logical order. The relevant tabular forms are to be prepared. Experiments are to be conducted taking the necessary precautions. The data should be recorded and the results need to be interpreted using the necessary mathematical expressions. The graphs are to be drawn where ever required and the appropriate conclusions should be presented.

List of Experiments:

1. Annealing of medium carbon steel and observation of microstructure.
2. Normalizing of medium carbon steel and observation of microstructure.
3. Hardening of medium carbon steel and observation of microstructure.
4. Study of tempering characteristics of water quenched steel.
5. Study of age hardening phenomena in duralumin.
6. Spheroidizing of given high carbon steel.
7. Determination of hardenability of medium carbon steel by Jominy end Quench Test.
8. To conduct Re-crystallization studies on cold-worked copper.

Equipment:

1. Muffle Furnaces 1000^0c – 2 No's
2. Muffle Furnaces 300^0c – 2 No's
3. Muffle Furnaces 120^0c – 1 No's
4. Hardenability Apparatus
5. Micro Scopes
6. Vickers Hardness Tester

(Assessment: The student's performance should be evaluated at the end of each class based on the following parameters:

I.

2. *observation book,*
3. *Record.*
4. *Conduct of the experiment successfully*
5. *Interpretation of the data*
6. *Drawing the graphs where ever necessary*
7. *Viva-voce.*

II.

1. *At the end of each cycle of experiments internal exams should be conducted in addition to the end examination)*

		L	T	P	C
II- Year II-Semester	**FOUNDRY TECHNOLOGY LAB**	**0**	**0**	**3**	**1.5**

(Learning objective: Design the sequence of operations in a logical order. The relevant tabular forms are to be prepared. Experiments are to be conducted taking the necessary precautions. The data should be recorded and the results need to be interpreted using the necessary mathematical expressions. The graphs are to be drawn where ever required and the appropriate conclusions should be presented.)

LIST OF EXPERIMENTS:

1. Preparation of gating system using green sand.
2. Study of the particle size distribution of the sand.
3. Study of the variation of permeability of the green sand with clay and water.
4. Determination of the variation of sand properties like green hardness, green compact strength with additives in sands.
5. Determination of the variation of hot compact hardness and hot shear strength with additives in sands.
6. Determination of clay content in sand.
7. Determination of the shatter index of green sand.
8. Founding of Al and Cu alloys in a pit furnace and casting into light components.
9. Study Charge calculations and melting practice of cast iron in a cupola.
10. Preparation of a shell-by-shell moulding process.
11. Non-destructive testing of a few cast-iron components.

Equipment:

1. Mould Boxes, Patterns, Cove Boxes, Tool Boxes.
2. Rotap Sieve Shaker with Sieves
3. Permeability Apparatus.
4. Universal Sand Testing Machine with Accessories.
5. Sand Hardness tester.
6. Clay Content Apparatus
7. Shatter Index test.
8. For Melting: Pit Furnace, Electric Furnace
9. Shell Moulding Machine
10. Centrifugal Casting Machine
11. Ultra Sonic Tester
12. Ladles, Crucibles and other Accessories
13. Muffle Furnace 1000^0c

(Assessment: The student's performance should be evaluated at the end of each class based on the following parameters:

I.

1. *observation book,*
2. *Record.*
3. *Conduct of the experiment successfully*
4. *Interpretation of the data*
5. *Drawing the graphs where ever necessary*
6. *Viva-voce.*

II.

4. *At the end of each cycle of experiments internal exams should be conducted in addition to the end examination)*

		L	T	P	C
II- Year II-Semester	**FUELS, FURNACES AAND REFRACTORIES (PE-I)**	**3**	**0**	**0**	**3**

***(Course objective:** The subject deals with various types of fuels, their origin, classification, and their properties. It also deals with various types of furnaces, their working principle, the types of Refractories used in them and various types of temperature measuring instruments.)*

UNIT I

***(Learning Objectives:** To study the origin, classification, and analysis of industrial fuels. Manufacture and testing of metallurgical coke along with the properties are to be studied))*

Introduction to Fuels technology Classification of fuels Origin and classification of coal Analysis of Coal Proximate and ultimate analysis.

Pulverized fuels Principle of Carbonization Manufacture of Metallurgical coke Properties of Metallurgical Coke Testing of Coke.

UNIT II

***(Learning Objectives:** Study of fuel oil production and fuel gases production and their uses)*

Principles of production of fuel oils from crude. Manufacture, properties and uses of
a) Producer gas
b) Water-gas Properties and uses of Blast furnace gas and coke oven gas; cleaning of Blast furnace gas.

UNIT III

***(Learning Objectives:** Study of heat transfer through various bodies. Solving problems pertaining to them. Study of different furnaces*.)

Steady-State Heat Transfer: Importance of Heat transfer, conduction through a plane, cylindrical, Spherical and compound walls, shape factor and effect of variable thermal conductivity
Furnaces: Characteristic features of vertical shaft furnaces, reverberatory furnaces, Arc and Induction furnaces. Tube and muffle type resistance furnaces, continuous furnaces. Sources of heat losses in furnaces and heat balance.

UNIT-IV

***(Learning Objectives:** To study various types of pyrometers used in the industry.)*

Pyrometry: Thermoelectric pyrometry- Peltier and Thomas e.m.f's. Thermo-electric power of thermocouples. Required properties of thermocouples. Noble and base metal thermocouples. Thermo-pile. Measurement of e.m.f by Milli-voltmeters and potentiometers. Thermometer; optical and radiation pyrometer.

UNIT V

***Learning Objectives:** To study different types of Refractories, their manufacturer, properties and industrial users*.

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. Testing of Refractories. Applications of refractories in the metallurgical industries.

(Assessment: The student should be evaluated based on the assignments and objective tests. The student's analytical abilities (with special focus on academically weak students) should be tested periodically in classes by giving problems). Emphasis should be given by conducting tutorial classes at the end of each unit.

TEXTBOOK:

1. Furnaces, Fuels, and Refractories by O.P. Gupta, Khanna Publishers.

REFERENCE BOOKS:

1. Elements of fuel technology -HIMUS
2. Refractories Norton
3. Refractories-R.Chisti.
4. Furances-J.D.Gilchrist
5. Pyrometry-W.P.wood& J.M.corck
6. Fuels Furnaces, Refractories& Pyrometry-A.V.K.Surya Narayana.
7. Elements of heat transfer- Jakob&Hawikns.
8. Elements of thermodynamics& heat transfer- Obert & Young.
9. Control systems & Instrumentation S.Bhasker.

II- Year II-Semester	LIGHT METAL TECHNOLOGY (PE-I)	L	T	P	C
		3	0	0	3

(Course Objective: To study the importance, properties, and applications of various wrought and cast light metals and their alloys)

UNIT-I

Learning Objective: To learn the extraction process, properties, and applications of Al and its alloys.

Aluminium and its alloys: Extraction – Properties – Applications. Wrought and Casting Alloys (Al-Cu, Al-Mn, Al-Si, Al-Mg, Al-Si-Mg, Al-Zn, Al-Li) – Corrosion resistance of Al alloys.

UNIT – II

(Learning Objective: To learn the properties and applications of Be and its alloys. Ti and its alloys)

Properties of light metals – properties and applications of Beryllium

Properties and applications of titanium and its alloys.

UNIT-III

Learning Objective: To learn the properties and applications of Mg and its alloys

Magnesium – Classification – Casting alloys – Wrought alloys-properties and applications of Mg alloys.

UNIT-IV

Learning Objective: To learn the properties and applications of Zn and its alloys

Properties and applications of Zn and its alloys

UNIT-V

Learning Objective: To learn the properties and applications of Zr and its alloys

Extraction, Properties, and applications of Zr and its alloys

(Assessment: The student should be evaluated based on the assignments and objective tests. Emphasis should be given by conducting tutorial classes (With a focus on academically weak students) at the end of each unit.

TEXTBOOK

1. Light alloys: Metallurgy of light metals, I. J. Polmear, 2nd edition, Edward Arnold Publishers, 1989

REFERENCES

1. Light alloys: from traditional alloys to nanocrystals, I. J. Polmear and David St. John, BH-Elsevier, 4th edition 2006
2. ASM Metals Handbook Vol-1 & 2

		L	T	P	C
II- Year II-Semester	**COMPUTATIONAL MATERIALS ENGINEERING (PE-I)**	**3**	**0**	**0**	**3**

Course objective: This course introduces computational methods in the domain of metallurgical engineering. , To understand the structure-property correlations in materials engineering.
To understand the evolution of materials structure and to control material properties. , To calculate the miscellaneous problems by using computational techniques.

UNIT- I

The C programming language, GNU plot – the plotting freeware, GNU Octave for computations and plotting, Introduction to FEM, FDM, FVM and Computer packages: MATLAB, Sci Lab. Plotting, Fitting, Interpolation, Numerical integration,

UNIT-II

Structure and thermodynamics

Basics of Mathematical Modelling-Deterministic and stochastic/probabilistic models. Computing free energy of common metallurgical systems from enthalpy and entropy or heat capacity and determination of the temperature of reduction of metal

UNIT-III

The mathematical formulation of Solid-state processes of Heat treatment & Microstructure evolution, Diffusion and precipitate growth kinetics. Transport phenomena based Modelling: model formulation based on heat, mass and momentum transfer, governing equations and boundary conditions. Classical Molecular Dynamics Modelling and simulations and its applications in materials, Monte Carlo simulations: phase separation and ordering

UNIT-IV

Phase-field and heat-mass transfer mathematical formulation of Liquid state Metallurgical Processes of Iron Making, Primary Steel Making and Secondary Steel Making using Momentum, Mass and Energy Balance. Principles of Computational Fluid flow and setting up the governing equation with boundary conditions. Formulation of Laminar and Turbulent flows. Case Studies of Tapping of Liquid steel, melting behaviour of additions, IGP. Computation of % CO/CO2 at different heights with a given function of temperature profile along with the height of BF and Simulations of Blast furnace reduction reactions at various heights. Mathematical Modelling of Solidification of Steel in Sand Moulds, Ingot Moulds & Comcast.

UNIT-V

Optimization and control. Elements of modern artificial intelligence (AI) related techniques. Introduction to Genetic Algorithm and Artificial Neural Nets. Dis-criticized Methods of Taylor's series expansion, polynomial Interpolation and least square approximation for numerical computation of Non-linear algebraic equations, ODE & PDE. Statistical methods for validating models.

Course Outcomes:

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

1. Analyse a metallurgical problem to create a well posed numerical problem.
2. Identify initial and boundary conditions of a problem relevant to the materials domain.
3. Propose a solution procedure for a numerical problem in the domain of materials engineering.
4. Demonstrate the ability to quantify a materials engineering problem through numerical analysis.
5. Select materials for specific applications and also to design advanced materials for new applications.
6. To use preferred tools at electronic, continuum and structural levels.

Text Books:

1. Introduction to Computational Materials Science – Richard LeSar, Cambridge University Press (2013).
2. Applied numerical methods for engineering using Mat lab and C – R.J. Schilling and S.L. Harris, Cengage Learning (2007).

Reference Books:

1. Mathematical Methods for Physics and Engineering, 3rd Edition – R.F. Riley, M.P. Hobson, S.J. Bence, Cambridge University Press (2012).
2. Modelling in materials processing – J.A. Dantzig and C.L. Tucker III, Cambridge University Press (2001).
3. V Raghavan, “Materials Science and Engineering”, Prentice-Hall India, 2004.
4. E Kreyzig, “Advanced Engineering Mathematics”, Wiley-India,1999.
5. Dipak Mazumdar, James W. Evans, “Modelling of Steel Making Processes”, CRC Publication,1st Edition, 2010.
6. H.K.Versteeg, W.Malalsekera, “An Introduction to Computational Fluid Dynamics”, Longman Scientific and Technical, 1st Edition 1995.
7. S.C.Chapra, R.P.Canale, “Numerical Methods for Engineers”, McGraw Hill India Pvt. Ltd.,5th Edition, 2002.
8. S. Yip (Ed.): Handbook of Materials Modelling, Springer, 2005.
9. Santosh K. Gupta: Numerical Methods for Engineers, New Age International (P) Limited, New Delhi, 1998.