MME				
Second Year (Third Semester)				
Sl.No	**Course Code**	**Subject (Theory)**	**Contact Hrs. L-T-P**	**Credit**
1	MA1201	Mathematics–III	3-0-0	3
2	MT1201	Professional Core-1: Metallurgical Thermodynamics & Kinetics	3-0-0	3
3	MT1202	Professional Core-2: Introduction to Physical Metallurgy	3-0-0	3
4	MT1203	Professional Core-3: Transport Phenomena	3-0-0	3
5	CS1204	Advanced Competency Course-1: Programming in Python (PC-4)	3-0-0	2
6	HS1202	Organizational Behaviour	3-0-0	2
Subject (Sessional)				
7	MT1281	Metallurgical Thermodynamics & Kinetics Lab	0-0-3	1.5
8	MT1282	Introduction to Physical Metallurgy Lab	0-0-3	1.5
9	MT1283	Transport Phenomena Lab	0-0-3	1.5
10	CS1284	Programming in Python Lab	0-0-3	1.5
		Total	**18-0-12**	**22**
Second Year (Fourth Semester)				
Sl.No	**Course Code**	**Subject (Theory)**	**Contact Hrs. L-T-P**	**Credit**
1	MT1204	Professional Core-5: Phase Transformation	3-0-0	3
2	MT1205	Professional Core-6: Mineral Processing	3-0-0	3
3	MT1206	Professional Core-7: Unit Process of Extraction	3-0-0	3
4	MT1207	Professional Core-8: Deformation Behavior of Materials	3-0-0	3
5	CS1209	Advanced Competency Course- 2: Artificial Intelligence and Machine Learning (I	3-0-0	2
6	HS1201	Engineering Economics	3-0-0	2
Subject (Sessional)				
7	MT1284	Mineral Processing Lab	0-0-3	1.5
8	MT1285	Process Metallurgy Lab	0-0-3	1.5
9	MT1286	Phase Transformation Lab	0-0-3	1.5
10	MT1287	Fuel Testing Lab	0-0-3	1.5
	Summer Internship and Research Experience (SIRE- I) *			
		Total	**18-0-12**	**22**

METALLURGICAL AND MATERIALS ENGINEERING			
Subject Code	**MA1201**	**Total Contact Hour**	**30**
Semester	**3rd**	**Total Credit**	**3**
Subject Name	**Mathematics–III**		
SYLLABUS			
Module-I	Random variables (Discrete and Continuous. Cumulative Distribution Function (CDF). Variance and standard deviation. Moments. Functions of a random variable. Distributions: Binomial, Poisson, normal, Gaussian, uniform (definitions and examples only). Moment generating function.		6 Hrs
Module-II	Pairs of random variables. Joint probability density function. Joint probability mass function. Marginal distribution. Functions of two random variables, PDF and expected values of the sum of two random variables		6 Hrs
Module-III	Probability Models of n Random Variables. Vector notation. Independence of random variables and random vectors. Functions of random vectors. Expected value vector and correlation matrix.		6 Hrs
Module-IV	Stochastic Processes. Definitions and examples. Types of stochastic processes. Random variables from random processes. The Poisson process.		6 Hrs
Module-V	Markov Chains. Discrete-time Markov chain. Discrete-Time Markov chain dynamics. Limiting state probabilities for a finite Markov chain. State classification.		6 Hrs
Essential Reading	1. Roy D. Yates, Rutgers and David J. Goodman, Stochastic Processes, 2d Edition, John Wiley and Sons, INC. 2. Gregory F Lawler, Introduction to Stochastic Processe, Chapman & Hall/ CRC Press (Taylor Francis Group).		
Course Outcomes	The objective of this course is to familiarize the prospective engineers with techniques in Probability and Statistics. It aims to equip the students to deal with advanced level of Statistics that would be essential for Engineering disciplines. CO1. To apply different distributions in real life problems of industries CO2. To deal with problems that contains multivariable probability distribution. CO3.To enrich knowledge Probability Models of multi-Random Variables CO4. To learn use of stochastic processes in daily life		

Subject Code	**MT1201**	**Total Contact Hour**	**30**
Semester	**3rd**	**Total Credit**	**3**
Subject Name	**Metallurgical Thermodynamics and Kinetics**		
Pre-requisites	**Mathematics-I, Mathematics – II,**		
SYLLABUS			**Contact Hours**
Module-I	Importance of Thermodynamics, Definition of Thermodynamics; concept of state and path functions, Equation of states, thermodynamic processes, Phase diagram of a single component system, Internal energy, heat capacity, enthalpy.		**6 Hrs**
Module-II	First law of thermodynamics, Second law of thermodynamics, entropy, and entropy changes for various processes, free energy and its significance, free energy change as a function of temperature, reversible and irreversible process, criteria of equilibrium, auxiliary functions,		**6 Hrs**
Module-III	Fugacity, activity, equilibrium constant, Concept of Third law of thermodynamics, temperature dependence of entropy, statistical interpretation of entropy, relation between $C_p$and $C_{v,}$ consequences of third law, Ellingham – Richardson diagrams.		**6 Hrs**
Module-IV	Solutions: partial molal quantities, ideal and non-ideal solutions, Roult's law; Henry's law, Gibbs – Duhem equation, regular solution, Chemical potential, Free energy – composition diagrams for binary alloy systems, determination of liquidus, solidus and solvus lines.		**6 Hrs**
Module-V	Introduction of metallurgical kinetics: heterogeneous reaction kinetics: gas-solid, solid-liquid, liquid-liquid and solid-solid systems, Concept of Johnson-Mehl equation, thermal analysis, Thermodynamics of electrochemical cells, solid electrolytes.		**6 Hrs**
Essential Reading	1. Introduction to the Thermodynamics of Materials by D.R. Gaskell; Taylor and Francis. 2. Textbook of Materials and Metallurgical Thermodynamics by A. Ghosh; Prentice Hall of India Pvt. Ltd.		
Supplementary Reading	1. Problems in Metallurgical Thermodynamics and Kinetics by Upadhyaya, G. S., &Dube, R. K.; International Series on Materials Science and Technology, Elsevier. 2. Textbook of Materials and Metallurgical Thermodynamics by A. Ghosh; Prentice Hall of India Pvt. Ltd.		
Course Outcomes	CO1. Analyze and incorporate the modern thermodynamic models for description of chemical reaction and phase transformation in materials CO2. Demonstrate reaction kinetics and stability criteria of different metals based on its energy content and temperature. CO3. Define the use thermodynamic laws in day-to-day applications in both domestic and industrial sector. CO4. Analyze and express the kinetics of the mass transport in solids including the process of surface and interfaces CO5. Work independently with the literature in search, choice and checking of correctness of the necessary information		

Subject Code	**MT1202**	**Total Contact Hour**	**30**
Semester	**3rd**	**Total Credit**	**3**
Subject Name	**Introduction to Physical Metallurgy**		
Pre-requisites	**Chemistry, Physics**		
Syllabus			
Module-I	Introduction, Atomic structure of materials, Symmetry aspects in crystals, crystal systems, crystal planes and directions, atomic packing efficiency, voids in common crystal systems, Solidification of pure metal, Homogeneous and heterogeneous nucleation processes, cooling curve, concept of super cooling, microstructures of pure metals, solidification of metal in ingot mould. Crystal imperfections		**6 Hrs**
Module-II	Mechanical properties of metals, concept of plastic deformation of metals, CRSS, Slip and twinningConcept of equilibrium, Concept of alloy formation, types of alloys, solid solutions, factors governing solid solubility; Unary phase diagram, phase rule, binary phase diagrams:		**6 Hrs**
Module-III	Isomorphous, Eutectic, Peritectic, Eutectoid, Peritectoid, Monotectic and Monotectoid system, Lever rule and its application, interpretation of solidification behavior and microstructure of different alloys belonging to those systems, effect of non-equilibrium cooling, coring and homogenization.		**6 Hrs**
Module-IV	Concept of heat treatment of steels i.e., annealing, normalizing, hardening and tempering; Microstructural effects brought about by these processes and their influences on mechanical properties. Effect of common alloying elements on the Fe-Fe_3C and Fe-C diagrams.		**6 Hrs**
Module-V	Iron cementite and iron- graphite phase diagrams, microstructure and properties of different alloys (both steels and cast irons). Physical metallurgy of non-ferrous alloys Cu-Al, Bronze, and Brass.		**6 Hrs**

Supplementary Reading	1. Physical metallurgy principle by Reza, Lara and Robert E Reed hill 2. Foundations of Materials Science and Engineering; 5th Edition William F. Smith and JavadHashemi 1088 pages; McGraw-Hill Education (April 9, 2009)
Course Outcomes	CO1. After successful completion of the course, the learners would be able to Familiarize themselves with those terms, concepts, and definitions used to describe the properties and processes of common engineering metals. CO2. Students will be reacquainted with fundamental principles of chemistry and physics which predetermine and control behavior of metals in response to external forces, whether mechanical, physical (electrical, magnetic, optical, thermal) or chemical in nature. C03. A fundamental understanding can be developed about the relationships between material composition, structure, and properties resulting from processing or service. CO4. Students can understand the testing procedures used to characterize some of the more common physical properties for engineering metals, and how these properties should be used when specifying conditions where optimum performance without failure can be expected. CO5. Students can get insight idea about atomistic and defect structures, and how they result in the microstructure and influence the properties of metals.

Subject Code	**MT1203**	**Total Contact Hour**	**30**
Semester	**3rd**	**Total Credit**	**3**
Subject Name	**Transport Phenomena**		
Pre-requisites	**Calculus**		
	SYLLABUS		**Contact Hours**
Module-I	Fluid Flow: Classification of fluids, Energy balance, Laminar and Turbulent flows. Flow through pipes and ducts. Flow measurement, Application of dimensional analysis of fluid flow.		**6 Hrs**
Module-II	Steady state and Transient conduction in solids. One-dimensional steady state problems of heat flow through composite walls, Cylinder and Spheres.		**6 Hrs**
Module-III	Convective heat transfer, equation of energy, free and forced convections Concept of boundary layer. Use of Heisler charts and applications.		**6 Hrs**
Module-IV	Radiation, Nature of thermal radiation, Black and Grey bodies, Stefan and Boltzmann law, Kirchhoff's laws, Intensity of radiation, lamberts law, View factor.		**6 Hrs**
Module-V	Heat transfer between two black walls in an enclosure. Combined effect of convection, conduction and radiation. Overall heat transfer coefficient. Mass Transfer and Kinetics: Steady state one-dimensional mass diffusion of component through stationary media. Convective mass transfer in fluids, concept of concentration boundary layer, Mass transfer coefficient.		**6 Hrs**
Essential Reading	1. F.P. Incropera, D. P. Dewitt, T. L. Bergman and A. S. Lavine, Fundamentals of Heat and Mass Transfer, Wiley. 2. H.S. Ray, Kinetics of Metallurgical Reactions		
Supplementary Reading	1. Heat and Mass Transfer: Fundamentals and Applications 5 Edition, Yunus A. Cengel, Afshin J. Ghajar 2. Heat Transfer 10thEdition by JP Holman Mc Graw Hill		
Course Outcomes	CO1. Students will be able to express the different mode of heat transfer and develop heat transfer equipment as per need. CO2. Demonstrate basic equations and Laws for heat transfer problems CO3. Apply heat transfer principles to design and calculate performance of thermal systems related to one dimensional, steady state or transient state for conduction and convection heat transfer. CO4. Evaluate performance of thermal systems related to one dimensional, steady state natural and Forced Convection heat transfer by Theoretically and Experimentally. CO5. Apply the concepts of Heat Transfer theory and application in Industrial and day to day life.		

Subject Code	**CS1204**	**Total Contact Hour**	**30**
Semester	**3rd**	**Total Credit**	**2**
Subject Name	**Programming in Python**		
Course Objective	1: Introduction to Python Language and its features. 2: To understand the concept of Python Program using sequence data and Control statements. 3: To be able to understand and create User Defined Function. 4: To understand the concept of OOPs and its implementation. 5: To understand the concept of strings and file handling		
	SYLLABUS		
Module-I	**Beginning Python Basics:** Introduction to Python Features of Python, Application of Python Data Types, Keywords, Identifiers, Literals, Constants. Python Indentation. Operators and expressions. Naming Conventions with examples, Managing Input and Output, Concept of Indentation. Conditional statement, Looping statements, break and continue, pass & return statements, Nesting of loops.		**6 Hrs**
Module-II	**Modules:** Built-in Modules, Import statement, Packages, Date and Time Modules. Array and its operations, Handling Strings and Characters, List: slicing, bound, cloning, nested list, list and methods, Adding Element: append, extend, count, index and insert). Mutability: Sort, reverse, remove, clear and pop. Map, Filter.		**8 Hrs**
Module-III	Tuple and methods, Sets and methods, Dictionary: Basic operation, iterator and methods. **Function:** Introduction to Functions, passing arguments, Anonymous functions (Lambda Function), Recursive Functions.		**6 Hrs**
Module-IV	**Object Oriented Programming:** Classes and Objects, Class methods. Encapsulation, Data Abstraction, Constructor, Destructor and Inheritance. **Exception Handling:** Handling Exceptions: try-except, try-finally		**6 Hrs**
Module-V	**Strings and Regular Expressions :** Methods of String Objects, Escape Sequence, Iterating Strings, String Module, String Formatting, Regular Expressions: Re-Module. **File Handling:** Introduction to File Handling, File Operations, Directories.		**4 Hrs**
Essential Reading	1. Python Programming for Beginners by Adam Stewart 2. Python Cookbook by David Beazley and Brian K. Jones		
Supplementary Reading	1. Introduction to Python Programming By Gowrishankar S. Veena A 2.Python Programming: Using Problem Solving Approach, Oxford University Press by Reema Thareja		

Course Outcomes	CO1: Understand the Python Language and its features. CO2: Apply sequence data and control statements to solve problem CO3: Able to create user defined functions to solve problems. CO4: Analyze the concept of OOPs and its implementation. CO5: Create the python program using strings and files.		
Subject Code	**HS1202**	**Total Contact Hour**	**30**
Semester	**3rd**	**Total Credit**	**2**
Subject Name	**Organizational Behaviour**		
Course Objective	1: To understand the relevance of organizational behavior concepts and theories in real-life organizational settings & to develop skills in critical thinking, decision –making, problem-solving in applying organizational behavior concepts to practical situations. 2: To provide an understanding of individual behavior in the workplace, including personality, motivation, perception, learning, and attitudes. 3: To understand the impact of team composition, diversity, and communication on team performance & to understand the role of motivation and leadership in managing organization. 4: To explore how organisational culture affects behavior, communication and decision making by enhancing creativity and innovation and give an episteme how to cope with change and stress. 5: To Develop intercultural competence, including awareness, knowledge, and skills for effective communication, negotiation, and collaboration across culture		
	SYLLABUS		
Module-I	**Fundamentals of OB & Understanding the Basic Framework of OB:** Evolution of OB through Quality Management movement, Definitions, Scope & Importance of OB,Challenges (Diversity, Globalisation& Ethical Perspective) and opportunities for OB, models of OB, applying OB to solving problems.		**6 Hrs**
Module-II	**Understanding the Determinants of Individual Behavior:** **Personality:** Determinants of personality, Theories of Personality (Type &Psychoanalytic theory), MBTI, Big five personality traits and other major traits influence workplace behavior. **Perception:** Meaning, Perceptual Process, Application of Perception at Workplace. **Motivation:** Motivation Framework, Content theory (Maslow's need hierarchy & Hertzberg's two factors theory), Process theory (Adam's Equity & Vroom's Expectancy theory), Job Design And motivation, Importance of motivation at Workplace. **Learning:** Theories of learning (Classical Conditioning, Operant Conditioning,& Cognitive Theory), Principles of Learning. Bhavioral modification through learning.		**6 Hrs**
Module-III	**Understanding Group and Team Behavior at Workplace:** **Group & Team:** Defining and classifying groups, the five-stage model of group development Group properties: Roles, norms, status, size and cohesiveness, Group decision making. **Leadership:** Meaning, Definition & types of leadership, Traditional theories of leadership: Trait theories, Behavioral theories, Contingency theories, Contemporary approaches to leadership, importance of leader in organisations.		**6 Hrs**
Module-IV	**Understanding Group and Team Behavior at Workplace:** **Organisational Culture:** Meaning, Definition, Cultural dimensions,effect of Organisational culture **Organisational Change & Development:** Nature, Levels & types of Change, Change Agents: Resistance to Change, Force field theory of Change, Managing the Change.		**6 Hrs**
Module-V	**Conflict & International Organisational Behavior:** **Managing Conflict and Negotiations:** Meaning,views, & levels of Conflict, Process of conflict, Conflict resolution techniques. **Transactional Analysis:** Meaning, Importance of TA, Life position, Ego states And their encounters. **IOB:** Internationalisation of Business, Cultural differences and similarities, Understanding Interpersonal behavior across culture through Hofstede's Cultural Dimensions		**6 Hrs**
Essential Reading	1. "Organizational Behavior: Text, Cases, & Games" by K. Aswathappa .Publisher: Himalaya Publishing House 2. "Essentials of Organizational Behavior" by Stephen P. Robbins and Timothy A. Judge. Publisher: Pearson Education.		
Supplementary Reading	1. "Organizational Behavior: Improving Performance and Commitment in the Workplace" by Jason A. Colquitt, Jeffery A. LePine, and Michael J. Wesson. Publisher: McGraw-Hill Education. 2. "Organizational Behavior: Human Behavior at Work" by John W. Newstrom and Keith Davis. Publisher: McGraw-Hill Education. 3. "Organizational Behavior: An Evidence-Based Approach" by Fred Luthans. Publisher: McGraw-Hill Education. 4. "Organizational Behavior: Emerging Knowledge, Global Reality" by Steven L. McShane and Mary Ann Von Glinow. Publisher: McGraw-Hill Education. 5. "Organizational Behavior and Management" by Ivancevich, Konopaske, and Matteson. Publisher: McGraw-Hill Education. 6. "Organizational Behavior: Theory, Research, and Practice" by John R. Schermerhorn Jr., James G. Hunt, and Richard N. Osborn. Publisher: Wiley		
Course Outcomes	CO1. Explain the importance of organizational behavior in improving individual and organizational effectiveness with Ethical practices. CO2. Evaluate the effectiveness of different leadership styles and their application in different situations. CO3.Develop critical thinking, Creativity& Innovation, problem-solving, and communication skills necessary for success in organisational settings. CO4. Develop strategies for managing organisational change effectively and maintainingsustainability. CO5. Apply organistional behavior concepts and theories to practical organisational situations.		
	SESSIONAL		
Subject Code	**MT1281**	**Total Contact Hour**	**16**
Semester	**3rd**	**Total Credit**	**1.5**
Subject Name	**Metallurgical Thermodynamic & Kinetics Laboratory**		
	List of Experiments		
1	To determine the tumbler and abrasion indices of iron ore, sample.		
2	To determine the micuum indices of cock sample.		
3	To determine the partial molal volume of each component in binary solution		
4	To determine the aquarium constant and free energy change for the C+CO2 =2CO reaction.		
5	Reduction of iron ore pellets by cock powder and calculation of % reduction and % swelling.		
6	Reduction of iron ore by non-coking coal power and calculation of % reduction and % swelling.		
7	To carry out palletization of iron ore fines.		
8	To carry out firing of pellets and measurement of their crushing strength.		

Course Outcomes	CO1. Analyze and demonstrate the transport processes. CO2. Ability to analyze the heat, mass and momentum transfer analysis. CO3. Ability to analyze the industrial problems along with appropriate boundary conditions. CO4. Ability to develop steady and time dependent solutions along with their limitations. CO5. Analyze and demonstrate the pelletization process.		
	SESSIONAL		
Subject Code	MT1282	**Total Contact Hour**	**16**
Semester	**3rd**	**Total Credit**	**1.5**
Subject Name	**Introduction to Physical Metallurgy Laboratory**		
	List of Experiments		
1	To make the crystal structures and to study these systems, with the help of ball models.		
2	To study the principles and operation of metallurgical microscope.		
3	To prepare specimen of some metals and alloys for microstructural examination.		
4	To study the microstructure, grain size of the carbon steels.		
5	To study the microstructure, of the given cast iron samples.		
6	To study the microstructure, grain size of the selected nonferrous alloys.		
7	To find out the grain size number of the given metals and alloys.		
8	Colour metallography of different ferrous metals.		
Course Outcomes	CO1. Demonstrate the different features of optical microscope and their use in metallography. CO2. Develop fundamental skills to prepare best metallographic sample for metallography study. CO3. Develop skills to analyze the microstructure type and evaluate the corresponding property the sample will show. CO4. Define different microstructures and defects seen under a microscope. CO5.Characterize different sample both ferrous and non ferrous with the help of color etching techniques.		
	SESSIONAL		
Subject Code	**MT1283**	**Total Contact Hour**	**20**
Semester	**3rd**	**Total Credit**	**1.5**
Subject Name	**Transport Phenomena Laboratory**		
	List of Experiments		
1	Study the type of flow by Reynolds experiment		
2	Determination of total thermal resistance and thermal conductivity of a composite wall		
3	Determination of thermal conductivity of Asbestos		
4	Determination of thermal conductivity of a given metal rod		
5	Determination of heat transfer coefficient in natural convection		
6	Determination of heat transfer coefficient in forced convection		
7	Determination of emissivity of a given surface		
8	Determination of Stefan Boltzmann constant		
9	Determination of overall heat transfer coefficient in parallel and counter flow runs and obtaining the effectiveness of the given heat exchanger		
10	Determination of exchange capacity of a cationic resin in the softening of water		
Course Outcomes	CO1. Students will be able to classify different types of flow of fluid. CO2. Students will be able to determine thermal conductivity of different materials... CO3. Apply heat transfer principles to design and calculate performance of thermal systems related to one dimensional, steady state or transient state for conduction and convection heat transfer. CO4. Evaluate performance of thermal systems related to one dimensional, steady state natural and Forced Convection heat transfer by Theoretically and Experimentally. CO5. Apply the concepts of Heat Transfer and application in Industrial and day to day life.		
	SESSIONAL		
Subject Code	**CS1284**	**Total Contact Hour**	**20**
Semester	**3rd**	**Total Credit**	**1.5**
Subject Name	**Programming in Python Laboratory**		
Course Objectives	1: Introduction to Python Language and its features. 2: To understand the concept of Python Program using sequence data and Control statements. 3: To be able to understand and create User Defined Function. 4: To understand the concept of OOPs and its implementation. 5: To understand the concept of strings and file handling		
	List of Experiments		
1	Program on basics of python Programming Language.		
2	Program on basic Data Structures in Python.		
3	Program on Conversion from on data type to another.		
4	Program on Functions in Python.		
5	Program using Object Oriented Programming in Python.		
6	Program using Inheritance in Python.		
7	Program using String in Python.		
8	Program using Regular expression in Python.		
9	Program using File Handling in Python.		
10	Program using basics of Pandas and Matplotlib module in Python.		
Course Outcomes	CO1: Understand the Python Language and its features. CO2: Apply sequence data and control statements to solve problem CO3: Able to create user defined functions to solve problems. CO4: Analyze the concept of OOPs and its implementation. CO5: Create the python program using strings and files.		
4TH SEMESTER			
Subject Code	**MT1204**	**Total Contact Hour**	**3**
Semester	**4TH**	**Total Credit**	**30**
Subject Name	**Phase Transformation**		

Module-I	Classification of phase transformations. Thermodynamics and Kinetics: Introduction, Equilibrium, Gibbs free energy change with single component system, Thermodynamic parameters in binary system, Binary phase diagrams, Free energy Vs Composition phase diagrams.	**7 Hrs**
Module-II	Diffusion: Driving force for diffusion, atomic mechanisms of diffusion, interstitial diffusion: steady state diffusion, Non-steady state diffusion, Solutions to the diffusion equation substitutional diffusion, High diffusivity paths. Crystal interfaces: Interfacial free energy, Boundaries in Single-phase solids, Interphase interfaces in solids: interface coherency, interfacial energy effects, misfit strain effects.	**5 Hrs**
Module-III	Nucleation and growth: Homogeneous nucleation, homogeneous nucleation rate, Heterogeneous nucleation, Heterogeneous nucleation rate, Growth of a pure solid, Overall transformation kinetics, Diffusional transformations in solids: TTT diagrams, Effect of alloying elements on TTT & CCT diagrams	**6 Hrs**
Module-IV	Ferrite: Nucleation and growth, Pearlitic transformation: mechanism, nucleation and growth, Bainitic transformation: mechanism, nucleation and growth, precipitation in age hardening alloys, spinodal decomposition, massive transformations, order-disorder transformations.	**6 Hrs**
Module-V	Diffusionless transformations: Martensitic transformations: characteristics, crystallography, theories of Martensitic nucleation, martensite growth. Recovery, Recrystallization and grain growth.	**6 Hrs**
Essential Reading	1. Phase transformations in metals and alloys by D.A. Porter, K.E. Easterling and Sharif, CRC press. 2. Phase transformation in materials by Romesh C Sharma, CBS publishers & Distributors.	
Supplementary Reading	1. Solid State Phase Transformations by V Raghavan, PHI. 2. Materials Science and Engineering by W D Callister and adapted by R Balasubramaniam (New Delhi: Wiley)	
Course Outcomes	CO1. Develop enhanced critical thinking, analytical and problem-solving skills in materials science and engineering based on concepts of metallurgical thermodynamics and kinetics. CO2. Demonstrate the basic principles underlying liquid to solid and solid-state phase transformations in a range of materials. CO3. Implement the importance of phase transformations for controlling microstructure and properties in engineering alloys. CO4. Define the driving forces and kinetic barriers for phase transformations in solid state. CO5.Produce the desired properties of materials which are affected by the atomistic diffusion processes.	

Subject Code	**MT1205**	**Total Contact Hour**	**30**
Semester	**4th**	**Total Credit**	**3**
Subject Name	**Mineral Processing**		
Pre-requisites	**Mathematics-I, Mathematics - II**		
	SYLLABUS		**Contact Hours**
Module-I	Introduction to mineral beneficiation, sampling, liberation studies and its importance. Comminution: Fundamentals of comminution, crushing: construction and operational features of jaw, gyratory, cone and roll crushers.		**6 Hrs**
Module-II	Grinding: Construction and operational features of ball mill, Critical speed of the ball mill, open circuit and closed circuit, Size separation: Sieving and screening, laboratory sizing and its importance, representation and interpretation of size analysis data, industrial screening.		**6 Hrs**
Module-III	Classification: Movement of solids in fluids, free setting and hindered settling of particles, Different types of classifiers, e.g. sizing and sorting classifiers used in mineral industry. Concentration: jigging, tabling, dense media separation.		**6 Hrs**
Module-IV	Froth flotation: Construction and operational features of froth floatation cell, reagents used in floatation processes, Magnetic and electrostatic separation: Theory and application of magnetic and electrostatic separation techniques in mineral industry.		**6 Hrs**
Module-V	Agglomeration techniques: Sintering, palletizing, briquetting and their applications in ferrous and non-ferrous metal industries, testing of agglomerates, important mineral deposits in India.		**6 Hrs**
Essential Reading	1. Principle of Mineral Dressing by A. M. Gaudin. 2. Mineral Processing Technology by Berry A. Willis.		
Supplementary Reading	1. Rate Processes In Metallurgy by Mohanty, A. K.; PHI Learning. 2. Callister W D 2007 Callister's Materials Science and Engineering: Indian Adaptation adapted by R Balasubramaniam (New Delhi: Wiley).		
Course Outcomes	CO1. Analyze and demonstrate the mineral beneficiation process in an economical way. CO2. Evaluate different mineral beneficiation process according to the nature of the minerals and selectively apply the most suitable process of beneficiation. CO3. Develop the technology to use the available low-grade ores and minerals. CO4. Use of wastes and recovery of associated minerals and metals, which will satisfy the “go green slogan”. CO5. Analyze and demonstrate the in-plant studies in order to improve the productivity of mineral beneficiation plants.		

Subject Code	**MT1206**	**Total Contact Hour**	**30**
Semester	**4th**	**Total Credit**	**3**
Subject Name	**Unit Process and Principle of Extraction**		
	SYLLABUS		**Contact Hours**
Module-I	Overview of Extractive Metallurgy processes; Pyro-metallurgy, Hydrometallurgy and Electrometallurgy; Thermodynamic and Kinetic Principles of metal extraction; Ellingham diagrams, Calcinations; Roasting; Predominance Area Diagram, Roasting Practices, Smelting, Formation and function of slag and their calculations,		**6 Hrs**
Module-II	Metallo-thremic and carbothermic reduction of oxides, Smelting Furnaces, Matte Smelting, Pyro metallurgical processes using vacuum Hydrometallurgy: Leaching; Theory of Leaching; Role of oxygen in leaching operation; Bacterial and microbial leaching; Contact reduction of metals in aqueous solutions;		**6 Hrs**
Module-III	Gaseous reduction of metals in aqueous solutions; Ion exchange, Solvent Extraction and Electrolysis, Electrometallurgy: laws of electrolysis, electrolyte Structure of solvent media; Electrolysis of aqueous solution; Electrolysis of fused salts; Cell design; Electro refining.		**6 Hrs**
Module-IV	Halide Metallurgy and Halogenation., Basic approaches of refining, preparation of pure compounds; Purification of crude metals produced in bulk;		**6 Hrs**
Module-V	Concept of activity, chemical potential, fugacity, real and idle solution, and thee significance in metal extraction, Numerical problems relevant to Pyro, Hydro and Electrometallurgical processes		**6 Hrs**

Essential Reading	1. Principles of Extractive Metallurgy: A. Ghosh & H.S. Ray, IIN Publications, Kolkata 1984 2. Principles of Extractive Metallurgy: Rosenquist, T., McGrawhill - Kogakusha International – 1983
Supplementary Reading	1. Mineral Processing and Extractive Metallurgy by Corby G. Anderson (Editor), Robert C. Dunne (Editor), John L. Uhrie (Editor) 2. Metallurgy a Brief Outline of the Modern Processes for Extracting the More Important Metals by W. Borchers.
Course Outcomes	CO1. Illustrate flowsheet of process route for any types of ore. CO2. Student can able to apply thermodynamics principles when dealing with any type of ore. CO3. Students can clearly analyze the proper requirement of different raw materials for metal production. CO4. Student can solve existing issue and new issues which occurs in a plant. CO5. Analyze the best route and techniques for metal extraction and refining economically n profitably.

Subject Code	**MT1207**	**Total Contact Hour**	**30**
Semester	**4th**	**Total Credit**	**3**
Subject Name	**Deformation Behavior of Materials**		
	SYLLABUS		**Contact Hours**
Module-I	Introduction: Scope of the subject, elastic, plastic and visco-elastic deformation. Deformation behavior: Tensile and compression testing, effect of temperature and strain rate Continuum mechanics: Concepts of stress and strain in 3D stress and strain tensor.		**6 Hrs**
Module-II	Principal stresses and strains and principal axes, mean stress, stress deviator, maximum shear, equilibrium of stresses, equations of compatibility. Elastic behavior of materials: Constitutive equations in elasticity for isotropic and anisotropic materials, strain energy, elastic stiffness and compliance tensor.		**6 Hrs**
Module-III	Effect of crystal structure on elastic constants. Plastic response of materials-a continuum approach: classification of stress-strain curves, yield criteria. Microscopic basis of plastic deformation: Elements of dislocation theory, movement of dislocation, elastic properties of dislocation.		**6 Hrs**
Module-IV	Intersection of dislocation, dislocation reactions in different crystal structures, origin and multiplication of dislocations. Plastic deformation of single crystals: Critical resolved shear stress, deformation by twinning, deformation band and kink band, strain hardening of single crystal; stress-strain curves of fcc, bcc and hcp materials.		**6 Hrs**
Module-V	Plastic deformation of polycrystalline materials: Role of grain boundaries in deformation, strengthening by grain boundaries, yield point phenomenon, strain ageing, strengthening by solutes, precipitates, dispersoids and fibres. Deformation in non-metallic materials: structure and deformation of polymers, concept Super lattice dislocations in inter metallics, and concept of charge associated with dislocations in ceramics.		**6 Hrs**
Essential Reading	1. Mechanical Metallurgy, 3rd Ed., McGraw Hill Book Company, New Delhi, 1986 - G.E Dieter. 2. Mechanical Behavior of Materials, McGraw Hill Book Company, New Delhi, 1990 - T.H. Courtney		
Supplementary Reading	1. Mechanical Behaviour of Materials by Norman E. Dowling 2. Mechanical Behaviour and Testing of Materials" by a K Bhargava and C P Sharma		
Course Outcomes	CO1. Calculate and develop the concepts of stress and strain relationships for homogenous, isotropic materials. CO2. Calculate and predict the yielding phenomena occurs in metals and alloys using yield criteria. CO3. Calculate and describe the internal stresses and deformations that result in combined loading conditions CO4. Evaluation of different strengthening mechanism occurs in metals and alloys. CO5. Basic knowledge of deformation mechanism in polymers and intermetallics.		

Subject Code	CS1209	**Total Contact Hour**	3
Semester	4th	**Total Credit**	30
Subject Name	Artificial Intelligence and Machine Learning		
Pre-requisites			
Course Objective	1.To familiarize students with the fundamental concepts, theories, and applications of Artificial intelligence& Machine learning. Students will gain insight into the various subfields of AI& ML. 2.Students will have a clear understanding of the fundamental concepts and terminology of Artificial intelligence& Machine learning, enabling them to discuss and comprehend AI-related topics. 3. Students will have a clear understanding about neural networks, Fuzzy logic. 4. Students will have a clear understanding about Clustering and related techniques. 5. Students will have a clear understanding about Classification and related techniques.		
	SYLLABUS		**Contact Hours**
Module-I	Introduction to Artificial Intelligence, Applications of AI, State-space problem, Problem solving by Intelligent search: BFE, DFS, Iterative Deepening Search, Hill climbing, Heuristic search: A*, AO*, MIN_MAX Algorithm, Alpha-beta cutoff		**8 Hrs**
Module-II	Knowledge representation and reasoning: Formalized symbolic logic, propositional logic, First-order predicate logic, wff conversion to clausal form, inference rules, resolution principle.		**5 Hrs**
Module-III	Unsupervised Learning: K-means, K-Medoids, Hierarchical clustering, Density based clustering, Validation Method: LOO, K-fold cross validation.		**5 Hrs**
Module-IV	Supervised Learning: Decision Tree, Naïve Bayes classifier, K-NN, Introduction to regression. Performance matrix: Confusion matrix, Precision, Recall, Sensitivity, Specificity, MAE, MSE		**6 Hrs**
Module-V	Neural Network Artificial Neuron and its model, activation functions, Neural network architecture: single layer and multilayer feed forward networks, recurrent networks, Training of ANN, Back propagation, RBFNN.		**6 Hrs**
Essential Reading	1.E.Rich and K. Knight, Artificial Intelligence-TMH 2.Neuro Fuzzy and Soft Computing, J. S. R. JANG,C.T. Sun, E. Mitzutani, PHI		
Supplementary Reading	1.Artificial Intelligence, Dan W Patterson, Prentice Hall of India 2.Computational Intelligence Principles, Techniques and Applications, Amit Konar, Springer publication. 3. M. Gopal, Applied Machine Learning, McGraw Hill Education, 2018		

Course Outcomes	CO1:Understand the basics of Search techniques, Knowledge representation and reasoning in Artificial Intelligence. CO2:Understand the Supervised machine learning and Unsupervised machine learning. CO3:Analyzevarious machine learning models. CO4:Implement various Supervised machine learning techniques and analyze them. CO5:Implement various Unsupervised machine learning techniques and analyze them.		
Subject Code	**HS1201**	**Total Contact Hour**	**30**
Semester	**4th**	**Total Credit**	**2**
Subject Name	**Engineering Economics**		
SYLLABUS			
Module-I	**Basic Principles of Economics:** Definition, Nature, Scope and significance of economics for Engineers. Demand & Supply and their Determinants,Elasticity-Government policies and application. Basic Macro economics concept: National income accounting (GDP/GNP/NI/Disposable Income etc) and identities for both closed and open economies.		**6 Hrs**
Module-II	**Utility Analysis:** Cardinal and ordinal measurability of utility, Assumptions of cardinal utility analysis, law of diminishing marginal utility, Consumer's equilibrium: Principle of equi-marginal utility; Indifference curve-Concepts, properties, Budget line, Equilibrium of the consumer, Revealed preference hypothesis, Individual choice under Risk and Uncertainty: St. Petersburg paradox and Bernoulli's hypothesis, Neumann-Morgenstern method of constructing utility index, Friedman-Savage hypothesis		**6 Hrs**
Module-III	**Production, Cost and Market Structure:** Production function: short run production function and law of variable proportion; Long run production function: Isoquants, isocost line, returns to scale, Optimum factor combinations, Cost Analysis: Concepts, Classification- Short run and Long run cost curves, Analytical and accounting cost concepts; Market structure: Market classifications, Perfect competition: Characteristics, price and output determination in Short run and long run, Monopoly market: Price and output determination, price discrimination Modern theories of firms: Baumol's theory of sales revenue maximisation, Bain's limit pricing model.		**6 Hrs**
Module-IV	**Money and Banking:** Money-Function of Money, Demand for Money Theory. Quantity theory of money; Banking: Commercial Banks and their Functions, Central bank's Functions. Role of the Banks in Economic Development, Monetary and Fiscal Policy Tools and their impact on the economy.		**6 Hrs**
Module-V	**Capital Budgeting and Investment Analysis:** Time value of money: use of cash flow diagram, Annual economic worth, present worth, future worth, Internal Rate of Return (IRR), Net Present Value (NPV), Payback period method, Analysis of public projects: Cost-Benefit analysis, Cost effectiveness		**6 Hrs**
Essential Reading	1. Koutsoyiannis, A. (1979). Modern Microeconomics. The Macmillan Press Ltd., London 2. Pindyck, R. S., D. N. Rubinfeld and P. L. Meheta (2009). Microeconomics, Pearson India, New Delhi 3. Panneerselvam, R. (2007). Engineering Economics, Prentice-Hall of India, New Delhi 4. Mankiw Gregory N. (2002). Principles of Economics, Thomson Asia		
Course Outcomes	CO1- Utilise economics principles in consumption process CO2- Describe the utility measurement and measure the utility associated with risk CO3- Efficient use of resources in production and take decision regarding optimum output CO4- Describe market mechanism and analyse product market to take proper decisions CO5- Implement economic principles in company related decision making		
SESSIONAL			
Subject Code	**MT1284**	**Total Contact Hour**	**16**
Semester	**4th**	**Total Credit**	**1.5**
Subject Name	**Mineral Processing Laboratory**		
List of Experiments			
1	To determine and analyze the size distribution of a fixed granular solid by using a test sieve stack and a vibratory shaker		
2	Crushing of ore/coal in the jaw crusher and average size determination by sieving.		
3	To study the jaw crusher and determine the actual capacity and reduction ratio, and verification of Rittinger's law of crushing.		
4	Crushing of ore/coal in a roll crusher and average size determination by sieving.		
5	To study the effect of grinding with grinding time in ball mill.		
6	To separate a mixture of two minerals of different densities by gravity concentration using Wilfley Table and determine the weight and density of each fraction		
7	Beneficiation of ore pulp mix using floatation cell.		
8	Study of magnetic separator and effect of field on the efficiency of the process.		
Course Outcomes	CO1. To analyze and identify different minerals. CO2. To demonstrate the principles of density separation. CO3. To calculate and analyze the role of average size and reduction ratio on mineral beneficiation process. CO4. To demonstrate and analyze different crushing laws to define the relationship between the energy consumption and final product size. CO5. Demonstrate the role of gravity separation using wilfley table.		
	SESSIONAL		
Subject Code	**MT1285**	**Total Contact Hour**	**20**
Semester	**4th**	**Total Credit**	**1.5**
Subject Name	**Process Metallurgy Laboratory**		
List of Experiments			
1	To study the calcination process using carbonate ore and roasting process using sulphide ore.		
2	To find out percentage reduction of given iron ore using coal and coke separately.		
3	To find out percentage swelling of given iron ore using coal and coke separately.		
4	To carryout palletisation of iron ore fines and to measure its green strength and strength after hardening.		
5	To carry out extraction of metals from oxide and sulphide ore using hydrometallurgy route.		
6	To carry cementation process /contact reduction process of copper from leach liquor (copper sulphate).		
7	To carryout electro refining/electro plating of metals like cu/nickel/zinc.		
8	To prepare a sand mould for casting.		
9	To perform casting of low melting point metals and to study the ingot microstructure from different zones.		
10	To carry out purification of two liquid compounds using distillation process.		

Course Outcomes	CO1. Produce a suitable product from carbonate and sulphide ore for subsequent metal production CO2. Evaluate the property of iron ore pellet and lump iron ore so as to select the best raw materials from iron making CO3. Develop skills to produce metal using hydrometallurgy route. CO4. Develop skills to produce metal by melting and casting route and can evaluate the macor structure of ingot. CO5. Develop skills to produce pure metals out of a given ore.		
	SESSIONAL		
Subject Code	**MT1286**	**Total Contact Hour**	**16**
Semester	4th	**Total Credit**	**1.5**
Subject Name	**Phase Transformation Laboratory**		
	List of Experiments		
1	Measurement of volume fraction, surface area in two phase and single-phase materials.		
2	To study the Recovery, Recrystallization and Grain growth behavior of given material.		
3	To study the phase transformation of Pb-Sn eutectic alloy using DSC.		
4	Draw the cooling curves of Pb-Sn alloy with the help of DTA.		
5	To study the precipitation Hardening behavior mechanism in Al-alloys.		
6	Nucleation of Ice from Water: A Modelling Approach.		
7	Study of nucleation and growth in Eutectoid steel.		
8	To study the surface hardening treatments like carburizing/Boronizing on steels.		
Course Outcomes	CO1.Analyze the role of phase transformations on the development of microstructure and properties of metallic materials. CO2. Produce the microstructures resulting from near-equilibrium vs. far-from-equilibrium thermal treatments CO3. Apply the fundamental principles that determine the evolution of structures from liquid melt as well as diffusion processes. CO4. Demonstrate the experimental techniques in correlating the structure with the desired properties. CO5. Implement the mechanism of phase transformation in surface hardening treatments.		
Subject Code	**MT1287**	**Total Contact Hour**	**12**
Semester	**4th**	**Total Credit**	**1.5**
Subject Name	**Fuel Testing Laboratory**		
	List of Experiments		
1	To determine the calorific value of coal and coke using bomb calorimeter.		
2	Proximate analysis of coal and coke.		
3	To determine flash point and fire point of a given sample such as kerosene oil. Diesel and petrol by Pensky- Martins /or other apparatus.		
4	To determine the effect of temperature on kinematic viscosity of glycerin by redwood viscometer.		
5	To determine the bulk and true density of coal sample by using density meter.		
6	To determine the flow rate of oil with the help of flow meter.		
Course Outcomes	CO1. Able to measure the calorific value of solid fuels. CO2. Proximate analysis of coal and coke. CO3. Evaluate the concept of flash and fire point of liquid fuels. CO4. Analyze the kinematic viscosity of different liquid fuels. CO5. Demonstrate the significance of testing of solid and liquid fuels.		