VIJAYANAGARA SRI KRISHNADEVARAYA UNIVERSITY

JNANASAGARA CAMPUS, BALLARI-583105

Department of Studies in

Mineral Processing

SYLLABUS

Master of Science
(III Semester)

With effect from
2021-22

VIJAYANAGARA SRI KRISHNADEVARAYA UNIVERSITY

Department of Mineral Processing

Jnana Sagara, Ballari - 583105

Distribution of Courses/Papers in Postgraduate Programme I to IV Semester as per Choice Based Credit System (CBCS) Proposed for PG Programs

III – SEMESTER

With Practical

Semester	Category	Subject code	Title of the Paper	Marks			Teaching hours/week			Credit	Duration of exams (Hrs)
				IA	SEE	Total	L	T	P		
THIRD	DSC9	21MNP3C9L	Magnetic and Electrostatic Separation Technology	30	70	100	4	-	-	4	3
	DSC10	21MNP3C10L	Froth Flotation	30	70	100	4	-	-	4	3
	DSE1	21MNP3E1AL	A. Non Ferrous Extractive Metallurgy	30	70	100	4	-	-	4	3
		21MNP3E1BL	B. Elements of Mining Technology								
		21MNP3E1CL	C. Heat and Mass Transfer								
	DSE2	21MNP3E2AL	A. Surface Chemistry	30	70	100	4	-	-	4	3
		21MNP3E2BL	B. Bio Processing								
		21MNP3E2CL	C. Dynamics of Machine								
	GEC1	21MNP3G1AL	A. Basic Techniques of Mineral Dressing	20	30	50	2	-	-	2	1
		21MNP3G1BL	B. Principles of Iron Making								
		21MNP3G1CL	C. Environmental Management								
	SEC3	21MNP3S3LP	Research Methodology	20	30	50	1	-	2	2	1
	DSCL	21MNP3C8P	Magnetic and Electrostatic Separation Technology Lab	20	30	50	-	-	4	2	4
	DSCL	21MNP3C9P	Froth Flotation Lab	20	30	50	-	-	4	2	4
Total Marks for III Semester						**600**				**24**	

Course Title: Magnetic and Electrostatic Separation Technology	**Course code:** 21MNP3C9L
Total Contact Hours: 52	**Course Credits: 04**
Formative Assessment Marks: 30	**Duration of ESA/Exam: 3 Hours**
Summative Assessment Marks: 70	

Objective: The prime objective of this course is to acquire the knowledge exploiting the differences in magnetic and Electrical properties of different minerals in order to recover valuable minerals from the gangue minerals.

Course Outcome:

1. Student can perform the Magnetic separation studies on given ore Samples and generate the products.
2. Discuss the performance of the magnetic separation
3. Present the analysis report for magnetic and electrical separation.

UNIT – I **09 Hours**

Principles of magnetic separation, types of magnetic materials, different forces involved in dry and wet magnetic separation. Construction, operation and performance factors of Dry, wet, low and high intensity separators, drum separators, induced roll separator, cross belt separator, WHIMS, HGMS,etc. applications of magnetic separators.

UNIT-II **10 Hours**

Electrical Separation: Principles of electrostatic separation. Electrical properties of materials. Lifting and pinning effect, corona discharge. Construction, operation, and performance factors of different electrical separators: high-tension separators. Multi roll separator, plate and screen separators, and tribo-electric separators. Applications of electrical separators. Auxiliary equipment and circuits for electrical separation. Dry methods of Beneficiation and Sorting: Principles, equipment and circuits.

UNIT- III **12 Hours**

Introduction to dewatering and drying. Flocculation and Dispersion, principles of flocculation and dispersion phenomena. Different types of flocculants used in dewatering techniques, selective flocculation and their applications.

UNIT –IV **10 Hours**

Dewatering by gravity sedimentation: Thickening principles and practices. Derivation of thickener diameter using Coe and Clevenger equation and Kynche Model. Design of a thickener, factors affecting thickeners operation and control. Different types of thickeners used in mineral industries such as conventional thickener (Bridge support and Column support type), Hi-rate thickener, lamella thickener, and tray thickener etc., Dewatering Using Screens.

UNIT- V **11 Hours**

Filtration: Principles of filtration, factors affecting the filtration, different type's industrial filters,cake filtration.

Centrifuging and drying different types of thermal dryers and their application, centrifugal sedimentation. Application and practices of dewatering processes in mineral industries.

Tailing Disposal: Tailing ponds and Design & construction, Types, Industrial applications andwater reclamation

Course: **FROTH FLOTATION**	**Course Code:** 21MNP3C10L
Total Contact Hours: 52	**Course Credits: 04**
Formative Assessment Marks: 30	**Duration of ESA/Exam: 3 Hours**
Summative Assessment Marks: 70	

Objective: The separation of minerals based on interfacial properties and processing slimes byaggregation and interfacial differential properties are studied. This is followed by a detailed discussion on application in material processing also.

Course Outcome:

1. Students can operate Flotation Machines and can able to identify basic machine parts and student can perform the flotation operations.
2. Discuss the role of reagents in flotation systems
3. Prepare the regents and optimize the flotation operations

UNIT – I **10 Hours**

Flotation fundamentals: Introduction, History. Physical aspects of Flotation – Surface Energy and surface tension, Interfacial tension, Cohesion, adhesion and Contact angle. Types of interfaces, Electro-kinetic Phenomenon, Electrical Double Layer at the Solid-Liquid interface. Alteration of Solid surfaces caused by mechanical forces. Adsorption and its characteristics, pH, Solid/Liquid ratio.

UNIT-II **10 Hours**

Flotation Machines**:** Basic machine features and function. Classification of flotation machines. Bubble generation. Design features of different machines. Like Denver flotation cell, Fagergren flotation cell. Flotation cell, Column flotation, Jameson cell and Dual Extraction Column etc,. Study of Flotation circuits like roughing, scavenging and cleaning etc.,

UNIT- III **11 Hours**

Chemical Aspects of Flotation systems – Flotation reagents and their Classification. Functions of each class of reagents. Dissociation and hydrolysis, Kraft point and Cloud point. Mechanism of Adsorption of reagents and characteristics. Attachment of reagents to minerals as surface compounds, principles of attachment of reagents to air bubble surface.

UNIT –IV **10 Hours**

Types of flotation systems – Selective flotation, Skin flotation, Reverse flotation, Floc-flotation, Electro-flotation, ion flotation, and Differential flotation. Micro flotation tests, Laboratory flotation tests, Flotation Kinetics and Factors affecting flotation. Froth analysis: Mineralized froths and their stability

UNIT- V **11 Hours**

Plant practices: Flotation circuits for flotation of iron, copper, lead-zinc sulphide,fluorspar, rockphosphate, limestone, oxidized and mixed non-ferrous ores.
Flotation performance analysis, working exercises of flotation circuit optimization.

Books:

1. A.M.Gaudin - Flotation
2. R.P.King - Flotation
3. A.K.Finch & G.S.Dobby - Column Flotation.
4. S.Venkatachalam & Degaleeson - Laboratory Experiments in Mineral Processing
5. A.Z.M. Abouzeid - Mineral Processing Laboratory Manual

6. T.Allen - Particle Size Measurement
7. A.K.Matis - Flotation Science and Engineering
8. Flotation: Theory, Reagents and Testing R.D.Crozier
9. Flotation of sulphide Minerals K.S.E. Forssberg (Ed)

Course: NON FERROUS EXTRACTIVE METALLURGY	**Course Code:** 21MNP3E1AL
Total Contact Hours: 52	**Course Credits: 04**
Formative Assessment Marks: 30	**Duration of ESA/Exam: 3 Hours**
Summative Assessment Marks: 70	

Objective: The objective of this course is to impart the knowledge of unit processes of metallurgy for extraction of non- ferrous metals from the ores.

Out Comes

1. Discuss the routes of non ferrous extractive metallurgy
2. Perform the laboratory pyrometallurgical operations
3. Stud the thermodynamics of the metallurgical operations.

UNIT – I **09 Hours**

Introduction to Thermodynamics, and Kinetics of Metallurgical Reactions. Sources of Metals. Pyrometallurgy:Principles, Fuels and types of Combustion furnaces.

UNIT- II **12 Hours**

Unit processes of pyro-metallurgy – Drying, Calcining, Roasting, Sintering, Smelting, and Refining. Extraction of Copper, Nickel, Lead, Zinc, Aluminum, Gold, Silver, Titanium, Magnesium, Nuclear, Reactive metals. Use of Halides in non-ferrous extraction processes.

UNIT- III **12 Hours**

Hydrometallurgy: Principles, Chemical and Electrochemical Principles of Leaching, Precipitation, Solvent Extraction, Ion Exchange, Extraction, E_h-pH Diagrams, Metal Extractionunder atmospheric pressure, high pressure and temperature.

UNIT –IV **10 Hours**

Bioleaching- Concepts and principles, E_h -pH Diagrams, Extraction of common metals, Microbes, Characteristics and their utility. Extraction of metals: Gold, Silver, Uranium,Copper, Zinc, and Nuclear metals.

UNIT- V **11 Hours**

Electrometallurgy: Principles, Electro winning and Electro refining of metals like Copper, Nickel, Lead, Gold, Silver, Zinc etc., Electroplating. Powder Metallurgy: Principles and applications

Books:

1. H.S.Ray, R.Sridhar& K.P.Abraham, Extraction of Non Ferrous Metals
2. T.Rosenqvist, :Principles of Extractive Metallurgy
3. H.S.Ray & A.Ghosh, :Principles of Extractive Metallurgy
4. R.H.Tupkari, :Introduction to Modern Iron Making

Course: ELEMENTS OF MINING TECHNOLOGY	Course Code: 21MNP3E1BL
Total Contact Hours: 52	Course Credits: 04
Formative Assessment Marks: 30	Duration of ESA/Exam: 3 Hours
Summative Assessment Marks: 70	

Objective: Learn the Basics of Mining, Importance of Underground and Surface Mining, Method of Opening a Deposit with various Means of Entry, Special and various Conditions and their Accessories.

Out Come: After the completion of the course, student is expected to have skills in:

1. Understanding of different unit operations in mining.
2. Understanding of environmental impacts of mining and their remediation.
3. Understanding of different mining methods used for metallic and non-metallic mineral extraction.
4. Understanding of mine safety aspects.

UNIT – I **09 Hours**

Introduction to mining engineering: Significance to mining industry in national economy and infrastructure building, basic mining terminologies, geo-technical investigations, classification of mining methods, selection criteria for underground or opencast mining methods. Opening up of deposits: Types, size and location of entries into underground coal and other minerals.

UNIT- II **12 Hours**

Unit operations in Mining: Drilling, Blasting, Loading, and Transportation. Safety, Ventilation and illumination in underground mines. Mines support. Hazards in underground mines and their control. Impact of mining on environment. Reclamation. Legislation & Safety..

UNIT- III **12 Hours**

Development of workings: Drivage of cross cuts, drifts, inclines and rises by conventional and mechanized methods. Arrangements for ventilation, supports, lighting, transportation, and drainage; Drilling patterns for underground coalmines and hard rock mines.

UNIT –IV **10 Hours**

Mine supports: Types of support: timber, prop, chock/cog, and cross bar, concrete, steel, and hydraulic supports. Yielding and rigid supports. Fore poling, roof stitching, roof bolting, applicability, advantages, and limitations of various supports.

UNIT- V **11 Hours**

Conventional method: drilling and blasting method, types of drill patterns, blasting, and transportation of muck. Mechanized method: construction and working principle of tunnelboring machine, applicability, advantages, and limitations of tunnel boring machine. Shield tunneling method: construction and working principle, applicability, advantages, and limitations.

BOOKS FOR REFERENCE :

1.R.N.P.Arogyaswamy A Course in Mining
Geology2.Mackinstry Mining Geology
3.D.J.Deshmukh Elements of Mining Technology Vol. I & II
4. Hartman H.L., Introductory Mining Engineering, Wiley Interscience, New York,
1987.5.Mishra, G.B, Surface Mining Dhanbad Publishers, Dhanbad, 1994
6.Peele Robert Mining Engineers Hand Book Vol. I & II

Course: **HEAT AND MASS TRANSFER**	**Course Code:** 21MNP3E1CL
Total Contact Hours: 52	**Course Credits: 04**
Formative Assessment Marks: 30	**Duration of ESA/Exam: 3 Hours**
Summative Assessment Marks: 70	

Objective: Learn the principles of heat transfer by various modes, and their applications in metallurgical sectors. To study and understand the fundamentals of mass transfer

Out Comes : After completion of the Course, Students can be able to

1. Solve the heat transfer problems
2. Discuss the cause and effects of heat transfer
3. Critically analyze the heat transfer related

UNIT – I **10 Hours**

Introduction to Heat Transfer**:** Importance of heat transfer. Modes of heat transfer. Mechanism of thermal conduction in Solids, thermal conduction in Liquids and thermal conduction in gases. Thermal conductivity. Heat transfer at the interface of two solids. Convection and heat transfer coefficient. Radiation, study of conduction, convection and radiation.

UNIT- II **10 Hours**

Steady State Unidirectional Heat Conduction: Three –dimensional Fourier conduction equation. Transformation of Fourier equation into polar co-ordination. Derivation of Fourier equation in polar co-ordinates. Derivation of Fourier equation in spherical co- ordinate. Steady state unidirectional heat flow through Slab, Cylinder and sphere through at uniform and non-uniform conductivity without heat generation. Electrical analogy for solving the conduction heat transfer problems. Heat flow through composite slabs, composite cylinders and composite spheres with consideration of heat transfer coefficients. Logmean area.

UNIT- III **12 Hours**

Dimensional analysis and model testing: introduction, criteria of similitude .fundamental dimensions, Buckingham theorem, shear force in the flowing fluid. Frictional loss in pipes. Forced convection, natural or free convection. Advantages of dimensional analysis, Limitations of dimensional analysis physical significance of different non-dimensional numbers. Equivalent diameter.

UNIT –IV **10 Hours**

Introduction to radiation: introduction. Basic theories of radiant heat transfer. Spectrum of electromagnetic radiation. Reflection absorption and transmission of radiation. Emission of radiation. Black body and monochromatic Radiation. Planck law of radiation. Total emissive power and Stefan Boltzmann law. Greybody and emissive power of greybody. Kirchhoff's law of radiation. Weins displacement law. Solid angle and intensity of radiation. Lambert cosine law radiation from real surfaces.

UNIT- V **10 Hours**

Mass transfer: Introduction. Ficks law of diffusion .steady state diffusion of gases and liquids through solids. Equi-molal diffusion. Isothermal evaporation of water into air. The mass transfer coefficient. Thermometry: introductions. Fluid thermometers. Thermoelectric thermometers. Pyrometers. Possible errors in measurements.

BOOKS FOR REFERENCE :

1. S.Domkundwar -A course in Heat & mass transfer
2. Jacob & Hawkins -Elements of Heat & mass transfer
3. ERG.Eckart & Robert,M -Heat nad Mass Transfer
4. Brown -Introduction to Heat Transfer

Course: SURFACE CHEMISTRY	**Course Code:** 21MNP3E2AL
Total Contact Hours: 52	**Course Credits: 04**
Formative Assessment Marks: 30	**Duration of ESA/Exam: 3 Hours**
Summative Assessment Marks: 70	

Objective: the objective of this course is to understand the property of minerals, and the interfacial chemical properties of minerals with surrounding environment like water and air etc.,

Course Outcome:

1. Student can able to identify the molecular structure and surface properties of the mineral as well as flotation reagents by various methods.
2. Suggest the group of reagents for mineral separation by flotation and other separation technique.

UNIT – I **09 Hours**

Chemical Bonding: Ionic bond- Properties of Ionic solids, Covalent bond- Properties of covalent compounds, Polarity in covalent bonds, Hydrogen bond, Metallic bond. Colloids: Classification,Preparation, Properties and Application of colloids

UNIT-II **10 Hours**

Adsorption: Types of adsorption and its characteristics. Thermodynamic models of isotherms. Fraundlich Adsorption Isotherm, Langmuir's Adsorption Isotherm, BET theory of multiplayer adsorption isotherm, Henry's law and Polany's potential theory, Mechanical effects of adsorption. Chemisorptions

UNIT- III **12 Hours**

Physical Chemistry of Surface and Interfaces: Liquid-Gas Interface: Surface tension and its measurement, Surface tension values, surface tension and temperature and other properties. Surface tension and chemical composition. Thermodynamics of surface tension, surface tension of solutions,Mono-layers and their effects.

UNIT –IV **10 Hours**

Liquid-Liquid Interface: Interfacial tension and its values, Multi-component system, Spreading of liquid over liquid, Films at interfaces, Emulsions. Solid-Liquid-Gas Interface: Contact angle and its measurement and characteristics, Solid particles in liquid surfaceSolid-Liquid Interface: Interfacial energy, Stagnant layer at solid-liquid interfaces, Adsorption of liquids, Heat of wetting, Adsorption from solutions, Importance of adsorption and its utilization, Corrosion by liquids.

UNIT- V **11 Hours**

Electrical characteristics on Interfaces: Static electricity, Conductance of solid-gas interfaces, Electro-kinetic phenomenon, theory and its measurements, Effects of composition of liquid phases and solid on electro-kinetic phenomenon. Electrical Double Layer, mutual repulsion of EDL's, utilization of electro-kinetic phenomenon.

Books For Reference:

1. O.Kubaschewski and C.B.Alcoc - Metallurgical Thermodynamics
2. Jan Leja - Surface Chemistry of Froth Flotation
3. Puri & Sharma - Principles of Physical Chemistry
4. Maron & Prutton - Principles of Physical Chemistry
5. Samuel Glasstone - Physical Chemistry
6. J.J.Bikerman - Surface Chemistry, Theory and Applications
7. Lloyd.I.Osipov - Surface Chemistry, Theory & Industrial Applications.
8. Duncan.J.Shaw Introduction to Colloid & Surface Chemistry.

Course: BIO PROCESSING	**Course Code:** 21MNP3E2BL
Total Contact Hours: 52	**Course Credits: 04**
Formative Assessment Marks: 30	**Duration of ESA/Exam: 3 Hours**
Summative Assessment Marks: 70	

Objective: The objective of this course is to know the scope of bio mineral processing and develop the processes for recovery of valuable minerals from very low grades using microbes

Course Outcome:

1. Student can able to discuss the role of microbes in leaching of minerals
2. Discuss the process involved in bio processing
3. Discuss the Microbes and their utility in bio hydrometallurgy

UNIT – I **09 Hours**

Concept and scope of bio-mineral processing. Utility of Microbes for beneficiation and selective dissolution of minerals/metals. Types of microbes & their genesis. Culturing and identification of microbes with reference to bioprocessing. Acid mine drainage its impact and control. Bio-flotation and flocculation. Application of Bio-processing and dissolution

UNIT-II **10 Hours**

Classification of microorganisms, Prokaryotic, and Eukaryotic cells; general properties, distribution of microbes, applied fields of microbiology. Enumeration of microbes; microscopic techniques, staining. Bacteria - cell structure, spore, morphology, classifications, and reproductions. Culture characteristics, growth, nutrition requirements, morphology and reproduction of Fungi, Algae, Protozoa and Actinomycetes**.**

UNIT- III **12 Hours**

Growth of microbes: batch culture, specific growth rate and doubling time; continuous culture; synchronous growth.Effects of environmental factors on growth. Microbial nutrition; culture media and culture characteristics. Handling of microbes; identification and staining.Control of microbes by physical agents and chemical methods.

UNIT –IV **10 Hours**

Microbial metabolisms -Anabolism/catabolism; Central metabolism: glycolysis and the TCA cycle; Metabolic pathways of contaminant biodegradation; Metabolic regulation Stoichiometry and Bacterial Energetics – Mass balances, Redox reactions: electron donor/electron acceptor; Redox half-reactions; Energy balances (_G) – Growth, Substrate Partitioning and theoretical yield, Electron acceptors, fermentation. Monod and Halden kinetics. Bio processing of sulphides ore (bio leaching and bio-oxidation). Mineral bio- processing mechanisms; engineering process. Degradation of natural substances.

UNIT- V **11 Hours**

Concept and principles of bio leaching . Eh-pH diagrams and their importance in prediction of leaching systems. Common metals extracted through bio leaching and bio hydrometallurgy. Characteristics of different microbes used in mineral processing, Direct and indirect attachment of microbes on mineral surfaces, Variation of surface charges in presence and absence of microbes, Use of microbes in mineral operations, Bio flotation, Bio flocculation some case studies. Microbes and their utility in bio hydrometallurgy. Isolation and identification microbes used. Application of bio hydrometallurgy, some case studies.

Books for Reference:

1. Agate. A.D., Basic principles of Geo-Chemistry
2. Venkatechalam. S., Hydrometallurgy
3. Ehrlich, H.L. and Brierley, C.L., Microbiological Mineral Recovery
4. Karavaiko. G.I and Kaznetsor, S.I., The Bactrial leaching of metals Iron Ores.
5. Murr, L.E., Torma, A.E and Brierly. A.J.(eds) Metallurgical applications of bacterial leaching and relatedMicrobiological phenomena.
6. Ross,G., Biohydrometallurgy.

Course Title: DYNAMICS OF MACHINES	**Course code:** 21MNP3E2CL
Total Contact Hours: 52	**Course Credits: 04**
Formative Assessment Marks: 30	**Duration of ESA/Exam: 3 Hours**
Summative Assessment Marks: 70	

Objective: This course is designed to understand fundamental and applied aspects of machines dynamics and power transmitting elements.

Course Outcome: After the completion of courses the students can able to

1. Explain the basic kinematics concepts
2. Solve the mechanical power transmission problems
3. Discuss the role of force balances in machines

UNIT – I **10 Hours**

Basic Kinematic concepts and definitions, Degrees of freedom, Elementary Mechanism: Link, joint, Kinematic Pair, Classification of kinematic pairs, Kinematic chain and mechanism, Gruebler's criterion, Inversion of mechanism, Grashof criteria, Four bar linkage and their inversions, Single slider crank mechanism, Double slider crank mechanism and their inversion. Transmission angle and toggle position, Mechanical advantage.

UNIT-II **10 Hours**

Gear and Gear Trains: Gear Terminology and definitions, Analysis of mechanism Trains: Simple Train, Compound train, Reverted train, Epicyclic train and their applications.

Turning Moment Diagram and Flywheel: Turning moment diagram. Turning moment diagrams for different types of engines, Fluctuation of energy and fluctuation of speed. Dynamic theory of Flywheel, Flywheel of an internal combustion engine. Determination of flywheel size from Turning Moment Diagram

UNIT- III **12 Hours**

Combined Static and Inertia Force Analysis: Inertia forces analysis, velocity and acceleration of slider crank mechanism by analytical method, engine force analysis - piston effort, force acting along the connecting rod, crank effort. Dynamically equivalent system, compound pendulum, correction couple.

UNIT –IV **10 Hours**

Friction Effects: Screw jack, friction between pivot and collars, single, multi-plate and cone clutches. Flexible Mechanical Elements: Belt, rope and chain drives, initial tension, effect of centrifugal tension on power transmission, maximum power transmission capacity, belt creep and slip.

UNIT- V **10 Hours**

Brakes & Dynamometers: Classification of brakes, Analysis of simple block, Band and internal expanding shoe brake, Braking of a vehicle. Absorption and transmission dynamometers, Prony brake, Rope brake dynamometer, belt transmission, epicyclic train, torsion dynamometer.

Course Title: BASIC TECHNIQUES OF MINERAL DRESSING	**Course code:** 21MNP3G1AL
Total Contact Hours: 30	**Course Credits: 02**
Formative Assessment Marks: 20	**Duration of ESA/Exam: 1 Hour**
Summative Assessment Marks: 30	

Objective:

The Objective of the course is to understand various aspects pertaining mineral origin, occurrence and enhancement of grade & yields and also the appropriate methods/techniques for eco friendly exploitation of different ore deposits.

Outcome:

After completion of this course the students will able to

1. Understand the fundamental aspects of mineral processing
2. Express the importance of mineral processing
3. Identify the machineries used in mineral processing

UNIT – I **10 Hours**

Definition, Scope and necessity of Mineral Beneficiation, Historical developments and Economics. Physical Properties of Ores and their importance in Mineral beneficiation.

UNIT-II **10 Hours**

Definition of terms – Concentrate, Tailing, Middling, Recovery and Ratio of concentration. Unit operations. Sampling: Definition, purpose, methods, measurements of accuracy of sampling. **Crushing:** Purposes, Mechanism of crushing, types of crushers and their salient features. Grinding tumbling mills, Types of tumbling mills, open and closed circuit grinding operation. **Liberation:** Definition and importance of liberation studies and its analysis. Laboratory sizing, Industrial screens.

UNIT- III **10 Hours**

Different techniques used in Mineral Processing –Brief study on Gravity Concentration, Floatation, Magnetic Separation, Electro static Separation and Agglomeration.

Textbook:

1. Ore deposits of India -their distribution and processing by K.V.G.K. Gokhale and T.C.Rao
2. The Practice of Mineral Dressing by F.B Michell, Class notes and Mining & MineralDressing Journals.

Course Title: PRINCIPLES OF IRON MAKING	**Course code:** 21MNP3G1BL
Total Contact Hours: 30	**Course Credits: 02**
Formative Assessment Marks: 20	**Duration of ESA/Exam: 1 Hour**
Summative Assessment Marks: 30	

Objectives of the course : This course introduces the principles and practices in iron making.

Course Outcomes:

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

1. Describe the physical and chemical processes that take place during iron making
2. Analyze the effect of change in process parameters in iron making
3. Describe the methods for control of quality in iron production
4. Solve numerical problems involving reaction kinetics and composition control

UNIT – I **10 Hours**

Raw materials and their properties: Iron ores, Limestone, Agglomerates, and Coke. Preparation of ores: sintering and palletizing, blast furnace burdening and distribution, testing of raw materials for blast furnace. Iron Making: The blast furnace plant and its accessories. Raw material and their preparation. Sintering and Pelletization. Blast furnace reactions.

UNIT – II **10 Hours**

Pig Iron Production: Construction of Blast-Furnace, refractories, Cooling systems. Blast furnace parts and its aerodynamics, reactions in different zones, composition of slag and its effects on quality of metal produced. Parameters affecting the productivity of Blast-Furnace. Irregularities in blast furnaces, de-sulphurization and de-phosphorization of Pig-Iron..

UNIT-III **10Hours**

Alternate route of Iron Making : D.R Processes: Raw material preparation. Quality requirement and consumption norms Different methods of Sponge Iron Production. Scope of the process under Indian condition. **S-R Processes:** Production of liquid iron by SR process – such as COREX, ROMELT, Mini Blast Furnaces and Electric Furnaces.

Textbooks

1. Ahindra Ghosh and Amit Chatterjee: Iron making and Steelmaking Theory and Practice, Prentice-Hall of India Private Limited, 2008.
2. Dipak Mazumdar, A First Course in Iron and Steel Making, University Press-IIM-2015Suggested
3. An introduction to modern steel making, R. H. Tupkary, Khanna Publishers (2000)
4. An introduction to modern iron making, R. H. Tupkary, Khanna Publishers (2004)

Course Title: ENVIRONMENTAL MANGEMENT	**Course code:** 21MNP3G1CL
Total Contact Hours: 30	**Course Credits: 02**
Formative Assessment Marks: 20	**Duration of ESA/Exam: 1 Hour**
Summative Assessment Marks: 30	

Objectives of the course 1. This course introduces the principles and practices in iron making.

Course Outcomes:

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

1. Classify the industrial pollutants and appraise its storage
2. Suggest the new concepts to control and avoid the pollution caused by mineral industries.
3. Propose pollution free environment by addressing the safe disposal of hazardous elements

UNIT – I **10 Hours**

Introduction: Impact on environment and Ecology due to mining and mineral processing, Biosphere, Natural cycle, Concept of sustainable development, Life Cycle Assessment, Environmental Impact Assessment, definition of Pollution, Origin of Pollution, Pollutants, Classification of Pollutants, Types of Pollution, Source of Pollution, Effects of Pollution on the Environment.

UNIT – II **10 Hours**

Air Pollution: Introduction, Sources of Air pollution, Classification of Air Pollution and Pollutants, according to air origin and state of materials. Measurement of air quality, units, sampling devices and methods of sampling, control of air pollution and equipments.

Water Pollution: Characteristics of water, Types of water pollution, sources of water pollution, Classification of water pollutants, Wastewater sampling and analysis, Waste water treatment, control of water pollution, water management – Industrial wastes and treatment processes.

UNIT – II **10 Hours**

Soil pollution: Introduction to soil chemistry, soil pollution, soil erosion, control of land degradation, control of soil pollution, solid waste management. Soil pollution by Industrial wastes, Soil pollution by, Chemical and metallic pollutants, Radioactive pollution. Soil pollution by industrial waste and remedial measures.

Noise Pollution: Definition, Sources, and Classification of Noise pollution, Measurement of Noise, Units of sound, Noise level, Measuring noise level, Industrial noise pollution, Prevention.

Textbooks

1. Ahindra Ghosh and Amit Chatterjee: Iron making and Steelmaking Theory and Practice,Prentice-Hall of India Private Limited, 2008.
2. Dipak Mazumdar, A First Course in Iron and Steel Making, University Press-IIM-2015 Suggested
3. An introduction to modern steel making, R. H. Tupkary, Khanna Publishers (2000)
4. An introduction to modern iron making, R. H. Tupkary, Khanna Publishers (2004)

Course Title: **RESEARCH METHODOLOGY**	**Course code:** 21MNP3S3L
Total Contact Hours: 27	**Course Credits: 02**
Formative Assessment Marks: 20	**Duration of ESA/Exam: 1 Hour**
Summative Assessment Marks: 30	

Objective: The objectives of this course are to identify the problem statement and review theliterature and analyse the data.

Course out Come

1. Disseminate the Knowledge by Reading research articles
2. Abel to draft the research objectives and set the scope of the work
3. Discuss the research reports

UNIT-I **9Hours**

Nature and importance of research- Aims, Objectives and Principles: Fundamental research vs. applied research with examples: Qualitative vs Quantitative research: Theoretical research vs. experimental research with examples: Selection of a research problem and Sources of literature – Journals, Conferences, Books. Types of sources: Literature Survey engines- Scopus, web of Science, Google Scholar, PubMed, NCBI, Scihub, etc. Science citation index: Citations, h-index, i10 index, impact factor.

UNIT-II **9Hours**

Data Collection Methods- Framing a hypothesis, designing controlled experiments, choosing the sample-size, sampling bias, importance of independent replicates, conducting an experiment, maintaining a lab-notebook to record observations: Identifying experimental errors. Case studies on well-designed experiments vs. poorly designed experiments. Fundamentals of MINITAB, Designing of experiments and analysis using MINTAB .

UNIT-III **9Hours**

Data Presentation and Writing: Technical presentation, technical writing, Formatting citations; MS Excel for plotting the data (pie chart, plots, bar charts)

Analysis using software tools:

Descriptive Statistics: Mean, standard deviation, variance, plotting data and understanding error-bars. Curve Fitting: Correlation and Regression. Distributions: Normal Distribution, Gaussian distribution, skewed distributions. Inferential Statistics: Hypothesis testing and understanding p-value. Parametric tests: Student's t-test, ANOVA. Tests to analyze categorical data: Chi-square test.

References (indicative)

1. C.R. Kothari, Research Methodology: Methods and Techniques, II Ed. New AgeInternational Publishers, (2009).
2. Shanthibhushan Mishra, Shashi Alok, Handbook of Research Methodology, I Ed, 2017,Educreation Publishers.
3. Basic Statistical Tools in Research and Data Analysis (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5037948/).

Course: Magnetic and ElectrostaticSeparation Technology Lab	**Course Code:** 21MNP3C8P
Formative Assessment Marks: 20	**Course Credits: 02**
Summative Assessment Marks: 30	**Duration of ESA/Exam: 4 Hours**

Course Objectives: To classify and separate the ore and gangue minerals based on theirMagnetic property.

Course Outcome: after completion of this course the students can able to

1. Prepare the feed samples for the magnetic separation studies
2. Perform the magnetic separators for recovery of minerals
3. Evaluate the performance of the magnetic separator
4. Discuss the results of separation studies

List of Experiments:

- Amenability test by bar magnetic separation
- Magnetic separation of ore samples using dry drum magnetic separator.
- Magnetic separation by Wet Low Intensity Magnetic Separator (LIMS)
- Magnetic separation of ore by Wet High Intensity magnetic Separator (WHIMS)
- Magnetic separation by varying operating parameters like variation of MOG, Intensity, size of the matrix. etc
- Amenability studies of given ore using Davis test tube for analysis of percent Manetics in an samples
- Experiments to understand the Roughing , Cleaning and scavenging effects in the concentration of ores
- Theory of electrical separation and study of beach sand mineral processing flowsheet using electrical separation

Course: **Froth Flotation Lab**	**Course Code:** 21MNP3C9P
Formative Assessment Marks: 20	**Course Credits: 02**
Summative Assessment Marks: 30	**Duration of ESA/Exam: 4 Hours**

Course Objectives: The objective of this course is to carry out the flotation experiments on low-grade mineralsusing Chemical reagents in order to recover the valuable minerals.

Course Outcome: after completion of this course the students can able to

1. Prepare the feed samples for the Flotation studies
2. Perform the Flotation operation on samples for recovery of minerals
3. Evaluate the performance of the Flotation tests
4. Discuss the results of separation studies

List of Experiments

- Study of Flotation Machine: different parts and their importance
- Demonstration of Simple flotation experiments to understand the bubble loading
- Flotation reagent Preparations
- Flotation feed preparation
- Experiments of Direction flotation of Iron ore, Manganese, Lime stone (any Two)
- Experiments on Reverse Flotation of Iron ore, Copper, Lime stone (Any two)
- Demonstration of Bulk and Sequential Flotation
- Demonstration of process control studies (Optimization of Flotation parameters)
- Flotation Kinetic Studies
- Determination of Forth Factor
- Studies to find out Air Flow Number of a cell