VIJAYANAGARA SRI KRISHNADEVARAYA UNIVERSITY

JNANASAGARA CAMPUS, BALLARI-583105

DEPARTMENT OF STUDIES IN MINERAL PROCESSING

M.Tech (Mineral Processing)

SYLLUBUS

Effective From

2024-25

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VIJAYANAGARA SRI KRISHNADEVARAYA UNIVERSITY

JNANASAGARA CAMPUS, BALLARI-583105

Department of Studies in Mineral Processing

Programme: Master of Technology (M. Tech) in Mineral Processing

Programme Overview:

Duration: 3 Years (6 semesters)

Master of Technology (M.Tech) in Mineral processing programme is designed to prepare students for a career in Mineral and Metallurgical Research and related Industry by introducing them to a concepts in Mineral Processing. The programme aims to provide basic understanding of principles, concepts and field based knowledge of Mineral Processing through well-structured curriculum and experimentation to understand the mineral and metallurgical industrial challenges.

Programme Educational Objectives (PEOs):

After 3-4 years of completion of the programme, the graduates will be able to:

1. Hold positions in mineral-based academic, research institutions, and industry.
2. Design various circuit configurations for processing low-grade ferrous and non-ferrous ores.
3. Implement ecological and environmentally friendly processes for mineral industry to achieve sustainable growth.
4. Execute professional leadership and organizational goals towards conservation of mineral resources.

Programme Outcomes (POs):

At the end of the programme, the students will be able to:

1. Identify the minerals and their end applications in industry
2. Formulate a separation system, or process to meet the desired needs of Metallurgical engineers within economic, Environmental and social constraints
3. Demonstrate separation of sizing, classification, Minerals and separation of valuable minerals from gangue in the ores by various mineral processing methods etc.
4. To collaborate with multidisciplinary sciences and its application to mineral engineering
5. Identify and formulate the scheme to solve technical problems in mineral based plants
6. Demonstrate Sizing, Classification, Separation of minerals from one another and from gangue in the ore by various mineral processing methods
7. Recognize the need of conservation of mineral reserves and development of safe and zero waste technology in global environment.
8. 8. Use the techniques, skills, and modern engineering tools necessary for mineral engineering practices.
9. Understand engineering and management principles and its application through post rational approaches for the extraction of minerals and metals.
10. Understand professional responsibility and skill.

VIJAYANAGARA SRI KRISHNADEVARAYA UNIVERSITY

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

PG Program in Mineral Processing

M.Tech I – SEMESTER

Semester	Category	Subject code	Title of the Paper	Marks			Teaching hours/week			Credit	Duration of exams (Hrs)
				IA	SEE	Total	L	T	P		
FIRST	DSC1	24MNP1C1L	Mineralogy	30	70	100	4	-	-	4	3
	DSC2	24MNP1C2L	**Petrology**	30	70	100	4	-	-	4	3
	DSC3	24MNP1C3L	Analysis of Ores and Minerals	30	70	100	4	-	-	4	3
	DSC4	24MNP1C4L	**Applied Mathematics and Experimental Design**	30	70	100	4	-	-	4	3
	SEC1	24MNP1S1L	**Elements of Mechanical Engineering**	20	30	50	2	-	-	2	1
	DSC3P1	24MNP1C1P	Mineralogy Lab	20	30	50	-	-	4	2	4
	DSC4P2	24MNP1C2P	Petrology Lab	20	30	50	-	-	4	2	4
	DSC1T1	24MNP1C3P	Analysis of Ores and Mineral Lab	20	30	50	-	-	4	2	4
Total Marks for I Semester						**600**				**24**	

M.Tech (Mineral Processing) II-SEMESTER

Category	Subject code	Title of the Paper	Marks			Teaching hours/week			Credit	Duration ofexams (Hrs)
			IA	SEE	Total	L	T	P		
DSC5	24MNP2C5L	Ore Genesis and Ore Microscopy	30	70	100	4	-	-	4	3
DSC6	24MNP2C6L	**Comminution and Sizing**	30	70	100	4	-	-	4	3
DSC7	24MNP2C7L	**Ore Classification and Gravity Separation Processes Technology**	30	70	100	4	-	-	4	3
DSC8	24MNP2C8L	Indian Mineral Deposits	30	70	100	4	-	-	4	3
SEC2	24MNP2S2	**Computational Techniques in Mineral Processing**	20	30	50	1	2	-	2	2
DSCL	24MNP2C4P	Ore Microscopy Lab	20	30	50	-	-	4	2	4
DSCL	24MNP2C5P	Comminution and Sizing Lab	20	30	50	-	-	4	2	4
DSCL	24MNP2C6P	Ore Classification and Gravity Separation Processes Lab	20	30	50	-	-	4	2	4
Total Marks					600				24	

M.Tech (Mineral Processing) III-SEMESTER

Category	Subject code	Title of the Paper	Marks			Teaching hours/week			Credit	Duration of exams (Hrs)
			IA	SEE	Total	L	T	P		
DSC9	24MNP3C9L	**Magnetic and Electrostatic Separation Technology**	30	70	100	4	-	-	4	3
DSC10	24MNP3C10L	**Froth Flotation**	30	70	100	4	-	-	4	3
DSE1	24MNP3E1L	Non Ferrous Extractive Metallurgy Elements of Mining Technology Heat and Mass Transfer	30	70	100	4	-	-	4	3
DSE2	24MNP3E2L	Surface Chemistry Bio Processing **Dynamics of Machine**	30	70	100	4	-	-	4	3
GEC1	24MNP3G1L	Basic Techniques of Mineral Dressing **Principles of Iron Making** Environmental Management	20	30	50	2	-	-	2	2
SEC3	24MNP3S3	**Research Methodology**	20	30	50	2	-	-	2	4
DSCL	24MNP3C7P	Magnetic and Electrostatic Separation Technology Lab	20	30	50	-	-	4	2	4
DSCL	24MNP3C8P	Froth Flotation Lab	20	30	50	-	-	4	2	4
Total Marks					600				24	

M.Tech(Mineral Processing) IV-SEMESTER

Category	Subject code	Title of the Paper	Marks			Teaching hours/week			Credit	Duration of exams (Hrs)
			IA	SEE	Total	L	T	P		
DSC11	24MNP4C11L	**Mineral Processing Plant Design**	30	70	100	4	-	-	4	3
DSC12	24MNP4C12L	Ferrous extractive Metallurgy	30	70	100	4	-	-	4	3
DSE3	24MNP4E3L	**Cement Technology**	30	70	100	4	-	-	4	3
		Industrial Engineering and Management								
		Pollution control and Eco-System Management								
DSE4	24MNP4E4L	Dewatering and Tailing Management	30	70	100	4	-	-	4	3
		Advanced Foundry Technology								
		Mineral Engineering Economics								
GEC2	24MNP4G2L	Indian Mineral Resources	**20**	30	50	1		2	2	2
		Fundamentals of Computer and Office Automation								
		Waste Recycling								
DSCL	24MNP4C9P	Metallurgy Lab	20	30	50	-	-	4	2	4
Project	24MNP4C1R	Project	30	70	100			8	4	4
Total Marks					600				24	

M.Tech (Mineral Processing) V-SEMESTER

Category	Subject code	Title of the Paper	Marks		Teaching hours/week				Credit	Duration of exams (Hrs)
			IA	Sem. Exam	Total	L	T	P		
DSC13	24MNP5C13L	Coal Preparation and Fuel Technology	30	70	100	4	-	-	4	3
DSC14	24MNP5C14L	Agglomeration Techniques	30	70	100	4	-	-	4	3
DSC15	24MNP5C15L	Process Control and Automation	30	70	100	4	-	-	4	3
DSC16	24MNP5C16L	Modelling and Simulation of Mineral ProcessingUnit Operations	30	70	100	4	-	-	4	3
SEC4	24MNP5S4P	**VISIT to Mineral/ Metallurgical Plants**	20	30	50	-	-	4	2	2
DSCL	24MNP5C10P	Coal Preparation and Fuel Technology Lab	20	30	50	-	-	4	2	4
DSCL	24MNP5C11P	Agglomeration Lab	20	30	50	-	-	4	2	4
DSCL	24MNP5C12P	Modelling and Simulation Lab	20	30	50	-		4	2	4
Total Marks				**600**					**24**	

M.Tech (Mineral Processing) VI-SEMESTER

Category	Subject code	Title of the Paper	Marks		Teaching hours/week				Credit	Duration of exams (Hrs)
			IA	Sem. Exam	Total	L	T	P		
DSC13	24MNP6CR2	Project Report and Viva - Voce		250	250	-	-	10	10	3
DSC14	24MNP6C13P	Industrial Training report		50	50	-	-	2	2	3
Total Marks				**300**					**12**	

(I-IV semester)- Total Marks: 2400 Total credits 96

DSC – Department Specific Core, DSE – Discipline Specific Elective, SEC – Skill Enhancement Course, GEC – Generic Elective Course, IA – Internal Assessment, SEE – Semester End Examination, L – Lecture, T – Tutorial, P – Practical.

Regulations/ Guide lines:

1. M.Tech in Mineral processing Programme is of 3 years (6 Semester) duration. Candidates with B.Sc degree having studied Mathematics and Physics at PUC level are eligible for admission to this programme and candidates with **B.E. / B.Tech**. Degree in Mineral engineering, Mining Engineering, Chemical Engineering, Civil Engineering, Metallurgy, Materials Engineering, Mechanical Engineering, Industrial Production and Electrical Engineering are also eligible for admission. However, the students can have optional exit after completion of first four semesters (02 years) and they will be awarded M.Sc Degree in Mineral Processing.

2. Hard Core Subjects are Compulsory. Candidates have to select any **Two** Soft-Core subjects in very semester.

3. **One Open Elective** subject shall be chosen by the students from the subject offered by the other Departments during **II & III Semesters.**

4. Students are not permitted to take the practical examination without the submission of the Certified Laboratory Records.

5. After the completion of **II & IV Semester**, students are sent for Plant Visits and Industrial Training/s respectively. **One or Two** Faculty members may accompany the students for plant visit or visit the work place at least once during the training period for supervision. TA/DA has to be paid for the faculty members for their visit as per the University norms. Plant visits and Industrial training are compulsory.

6. The students of ***V Semester (M.Tech Programme)*** have to undertake the Industrial Tour for a period of 15 days. Two Faculty members and one non teaching staff member have to accompany the students for tour. TA/DA has to be paid for the faculty members and non teaching staff for their visit as per the University norms Industrial tour is compulsory.

7. Candidate should present the dissertation/Project work before the Viva-Voce Committee consisting of BOE Chairman and members, Chairman of the Department and their respective Guides.

8. Two seats may be reserved for industrial sponsored candidates

9. All other conditions are as per the University Rules and Regulations promulgated from time to time.

10. The grade and the grade point earned by the candidate in the subject will be as given below:

P	**G**	**GP = V x G**
90 – 100	9 (A++)	V x 9
80 – 89	8 (A+)	V x 8
70 – 79	7 (A)	V x 7
60 – 69	6 (B+)	V x 6
50 – 59	5 (B)	V x 5
00 – 49	0 (C)	V x 0

Here, P is the percentage of marks secured by a candidate in a course which isrounded tonearest integer. V is the credit value of the course. G is the grade and GP is the grade point.

If G=0(C), (GP=0) then the candidate is assumed to have automatically dropped the course. He/she is not said to have failed in the course.

Question paper pattern

Question paper pattern for DSC Courses for 70 Marks of 3 Hours duration

There are total of 8 question

____ Semester PG Degree Examinations _____

MINERAL PROCESSING

Paper Code/ Title:_____/_____

Time: 3Hours **Max Marks: 70**

Instruction to the candidates:

- **Question number 1 is compulsory**
- **Answer any 5 of the following**

Q.No		Total Marks
01	_____	14
02	_____	14
03	_____	14
04	_____	14
05	_____	14
06	_____	14
07	_____	14
08	_____	14

All the 8 Questions are drawn from each unit, and 1 question is drawn compulsorily from first unit. There Shall be sub questions in the main question with equal distribution of marks with total marks not exceeding 14

Question paper pattern for SEC Courses for 30 Marks of 1 Hours duration

There are total of 8 question

____ Semester PG Degree Examinations _____

MINERAL PROCESSING

Paper Code/ Title:_____/_____

Time: 1 Hours **Max Marks: 30**

Instruction to the candidates: Mark the correct answer in OMR sheet

Q.No		Total Marks
01	_____	01
02	_____	01
03	_____	01
04	_____	01
….	…..	
….	……	
30	……	01

There shall be 30 Multiple Choice Question covering entire syllabus and each carries equal marks , Each questions shall be given 4 choices to choose correct option

M.Tech (Mineral Processing) First Semester

Course: Mineralogy	**Course Code: 24MNP1C1L**
Teaching Hours/Week (L-T-P): 4 - 0 - 0	**No. of Credits:** 04
Internal Assessment: 30 Marks	**Semester End Examination:** 70 Marks

Course Objectives:

1. To Identify and study the properties of different minerals both in hand Specimen and under the microscope.
2. To Prepare the mineral sample for microscopic studies.

UNIT – I 11 Hours

Introduction, Elements of Crystals, Crystal morphology, Euler's formula. Goniometry: Interfacial angle, law of constancy of interfacial angles, Contact and Optical Goniometers. Symmetry characters– Plane of Symmetry, Axis of Symmetry and Centre of Symmetry. Crystallographic Axes, Parameters and Indices, Weiss and Muller's Notations. Classification of Crystals into six systems. Crystal.Forms: Simple, Open, Combination and Closed forms. Holohedrons, Hemihedrons, Tetrahedrons and Hemi morphs. Study of crystals of Normal classes. Twins: Definition, characters and types. A brief introduction to X-ray crystallography.

UNIT-II 9 Hours

Definition of Mineral, crystalline and amorphous states, Crystalline aggregates – Columnar, Bladed, Acicular, Fibrous, Tabular, Foliated, Granular and Imitative forms. Properties depending upon light: Colour Pleochroism. Play of colours, Opalescence, Fluorescence, Phosphorescence, Streak, Luster and Diaphaneity.

UNIT-III 10 Hours

Properties depending upon cohesion and elasticity: Cleavage, Fracture, Hardness and Tenacity. Properties depending upon electricity: Electrical conductivity, Frictional and thermoelectricity, Pyroelectricity and Piezoelectricity. Properties depending upon Heat and Magnetism: Fusibility, Thermal conductivity, Specific heat, Para and Diamagnetism. Determination of specific gravity by balance, Pychnometer, Jolly's spring balance, Walker's steel yard and Heavy liquids. Solid solution, interstitial and defect solid solution. Isomorphism, Polymorphism and Pseudomorphism.

UNIT- IV 11 Hours

Classification of silicate structures: Brief study of feldspars, olivine, garnet, pyroxene, amphiboles, mica and silica group of minerals. Description of non- silicate group of minerals: Native elements, Carbonates, Oxides and Hydroxides , Sulfates and Sulfosalts.

UNIT – V 11 Hours

Optical Mineralogy: Preparation of thin sections of minerals and rocks. Petrological microscope: Its mechanical and optical parts. Nicol prism and its construction. Accessory plates – construction and use of Quartz wedge, Gypsum and Mica plates.Microscopic examination of minerals under plane polarized and crossed nicols-Colour, Pleochroism, Relief, Isotropism and Anisotropism, Interference colors, Birefringence, Extinction (causes and types only), and Optic sign (Types and determinations only).

References:

1. H.H. Read - Rutley's Elements of Mineralogy
2. M.H.Battey - Mineralogy For students
3. E.S.Dana & W.E.Ford - A Text Book of Mineralogy
4. C.S.Hurlbut Dana's - Manual of Mineralogy.
5. William E. Ford Dana's - Textbook of Mineralogy
6. Pramod O Alexander - A Hand Book of Minerals, Crystals, Rocks and Ores
7. C. Hammond, The Basics of Crystallography and Diffraction, Oxford University Press, 2009
8. Maureen M. Julian, Foundations of Crystallography, Taylor & Francis Group (2008)
9. W. A. Deer (Editor), R. A. Howie (Editor), J. Zussman (Editor) - Introduction to the Rock-forming Minerals Paperback –2013
10. Klein, C and Hurlbut, Jr., C.S. 1993; Manual of Mineralogy. John Wiley.
11. Krauskopf, K. B. and D. K. Bird. 1995. Introduction to Geochemistry. New York: McGraw-Hill.
12. William M. White, Geochemistry, 2013, Wiley-Blackwell

Course Out Come: After completion of this course, students will be able to

CO	Statement
CO1	To identify and differentiate the minerals based on appearance and their properties.
CO2	Suggest the application of Minerals for different end uses
CO3	Appreciate the mineral property by identifying its application useful to mineral separation

M.Tech (Mineral Processing) First Semester

Course: PETROLOGY	**Course Code: 24MNP1C2L**
Teaching Hours/Week (L-T-P): 4 - 0 - 0	**No. of Credits:** 04
Internal Assessment: 30 Marks	**Semester End Examination:** 70 Marks

Course Objectives:

1. To Identify and study the different minerals present in the rocks both in hand specimen and thin sections of the rocks under the microscope.

12 Hours

UNIT – I :

Introduction : The Origin of Planets, Early Earth and Formation of a Layered Planet, Earth as a System of Interacting Components, Earth Through Geologic Time. Concept of heat and temperature inside the Earth. Melting and crystallization. Magma and magmatic processes. Concept of intrusion and extrusion.

UNIT-II : 09Hours

Igneous Petrology : Forms and types of igneous bodies:- extrusive bodies- Flood basalts, Volcanoes and types of volcanoes. Pyroclastic deposits. Intrusive bodies:- concept of concordant and discordant intrusion, Dikes and sills and types of dikes, breccia pipes, Laccoliths, Lopoliths, Stocks and Batholiths.

UNIT-III : 09Hours

Structure and textures of igneous rocks. Classification of igneous rocks- concept of mode and norm. Phase rule and concept of phase diagrams. Mineralogical and chemical description and significance of important igneous rocks of continental and oceanic association

UNIT- IV : 11 Hours

Metamorphic Petrology: Concept of metamorphism- Changes in pressure and temperature. Equilibrium and non-equilibrium reactions. Agents of metamorphism. Types of metamorphism, metamorphic grade and facies of metamorphism. Texture, structure and classification of metamorphic rocks. Pressure-temperature composition diagrams for paragenitic studies. Metamorphism and deformation.

UNIT – V : 11 Hours

Sedimentary Petrology: Introduction to the Processes and factors influencing genesis of sediments.Weathering, soil formation, erosion and transport of debris and their deposition and conversion to rocks. Sedimentary structure and texture for petrography of clastic and non-clastic Rocks. Methods of description and classification of sediments and sedimentary rocks: Siliciclastic, Carbonate, and Chemical deposits and brief introduction to their origin. Depositional environment of sedimentary rocks, Burial and lithification

Course Out Come: After completion of this course, students will be able to

CO	Statement
CO1	Identify and know the essential and accessory minerals present in the rocks.
CO2	Explain the process involved in the formation of different types of rocks.
CO3	Appreciate different texture and structures present in rocks.
CO4	Recommend the rocks for different purposes depending upon the properties possessed.

Books Recommended

1. Frank Press Raymond Siever: Understanding Earth (3rd ed). W.H. Freeman and Company. New York . 2000
2. B. J. Skinner and S.C. Porter: The Dynamic Earth – An Introduction to Physical Geology 3rd edition. John Wiley & Sons, New York. 1995.
3. Best, M.G., 2002, Igneous and metamorphic petrology, 2nd Edition, Blackwell Publishers
4. Philpots A.R., 1990, Principles of Igneous and metamorphic petrology, Prentice Hall
5. Yardley, B.W., 1989, An introduction to metamorphic petrology, Longman
6. Sengupta, S.M. (1994) Introduction to Sedimentology, Oxford & IBH
7. Tucker, M.E. (1981) Sedimentary Petrology: an introduction. John Willey & Sons, New York
8. Blatt, Middleton & Murray (1980) Origin of sedimentary rocks. Printice Hall Inc
9. Pettijohn, F.J. (1975) Sedimentary rocks. Harper and Row Publ., New Delhi
10. Prothero, D.R., Schwab, F., (2003) Sedimentary Geology. W. H. Freeman; 2nd edition

M.Tech (Mineral Processing) First Semester

Course: ANALYSIS OF ORES AND MINERALS	**Course Code: 24MNP1C3L**
Teaching Hours/Week (L-T-P): 4 - 0 - 0	**No. of Credits:** 04
Internal Assessment: 30 Marks	**Semester End Examination:** 70 Marks

Course Objective:

This course is designed to understand the methods of estimation of metal content in the feed and products produced by various mineral separation processes

UNIT – I 11 Hours

Introduction, Sampling, Common apparatus and techniques, Accuracy and Precision. Separation techniques: Solvent extraction, Ion-exchange and brief idea about Chromatography

UNIT-II 09 Hours

Titrimetric Analysis: Theory and classification. Redox and Complex metric titrations. Gravimetry: Theory-methods-super saturation co-precipitation and post-precipitation. Precipitation from homogeneous solutions, Washing, drying and Ignition of the precipitate.

UNIT-III 09 Hours

Electrogravimetry: Principles and applications in the electrolytic separation of metals. Fire Assaying: Analysis of Gold and Silver. Proximate analysis of solid, liquid and gaseous fuels

UNIT- IV 11 Hours

Spectral Methods of Analysis: Principles, Instrumentation and application of Colorimetry and Spectro photometry, Flame photometry, Atomic Absorption Spectrometry and Flame emission spectroscopy

UNIT- IV 13 Hours

Thermal Analysis: Thermo Gravimetric Analysis (TGA) and Differential Thermal Analysis (DTA). A brief review of Electron Spectroscopy for Chemical Analysis (ESCA), X-ray diffraction, Electron Microprobe Analyser, (EMPA), X-ray Fluorescence and Inductively Coupled Plasma (ICP). Analysis of common ores like – Haematite, Pyrolusite, Magnetite, Chromite, Dolomite, Limestone, Bauxite, Magnesite, Chalcopyrite, Sphalerite, Baryte and Graphite.

Course Outcome: After completion of this course, students will be able to

CO	**Statement**
CO1	Perform the Chemical analysis of the ore sample and products.
CO2	Analyze the ore products for precious metals.
CO3	Do the characterization of the products obtained by mineral processing operations
CO4	Estimate the errors in results and quantify the results with standards
CO5	Use different equipment's for characterization

Reference books:

1. Chatwal & Anand - Instrumental Methods of Chemical Analysis
2. G.W. Ewing - Instrumental Methods of Chemical Analysis
3. B.K.Sharma - Instrumental Methods of Chemical Analysis
4. P.J.Potts - A Hand book of Silicate Rock Analysis
5. F.J.Welcher - Standard Methods of Chemical Analysis
6. N.H.Furman - Standard Methods of Chemical Analysis
7. A.I.Vogel - Text Book of Quantitative Inorganic Analysis
8. Jain & Agarwal - Metallurgical Analysis

M.Tech (Mineral Processing) First Semester

Course: APPLIED MATHEMATICS AND EXPERIMENTAL DESIGN	**Course Code: 24MNP1C3L**
Teaching Hours/Week (L-T-P): 4 - 0 - 0	**No. of Credits:** 04
Internal Assessment: 30 Marks	**Semester End Examination:** 70 Marks

Course Objective:
This course is focused to develop the mathematical calculations and the statistical analysis ability for optimization of processes and to enhance the equipment performance.

Course Outcome: After completion of this course, students will be able to

CO	Statement
CO1	Student is able to design the experiments and develop statistical models for solving mineral processing problems
CO2	Formulate the laboratory experiments with minimum trials
CO3	Identify the key variables of the experiments

09 Hours

UNIT – I

Equations: Linear equations of first degree, quadratic equations, solutions by factorizing, Systems of simultaneous equations, analytical solutions of a equation, remainder theorem and synthetic division.

09Hours

UNIT-II

Linear Differential Equations: Ordinary differential equations of second order, homogeneous, non-homogeneous with constant and variable coefficient, solving technique of linear differential equations

UNIT-III 11 Hours

Laplace transformation and PDE: Laplace transform of simple functions first and second shifting theorems, Laplace transforms of derivatives integrals and periodic functions. Inverse Laplace transforms and convolution property. Solution of ordinary differential equations related to engineering problems.

UNIT- IV 11 Hours

Frequency distribution: Construction of frequency distribution table and cumulative frequency table. **Graphical representation:** Histogram, frequency polygon and cumulative frequency curve. **Measure of central tendency**: Mean, Median, partition values, Mode, Measurement of dispersion, Quartile deviation, Mean deviation, Standard deviation.

UNIT- IV 12 Hours

Measures of variability, Ranking method, Column effect method & Plotting method, Analysis of variance (ANOVA) in Factorial Experiments: YATE's algorithm for ANOVA, Regression analysis, Mathematical models from experimental data. Illustration through Numerical examples. Factorial Experiments: Terminology: factors, levels, interactions, treatment combination, randomization, Two-level experimental designs for two factors and three factors. Central composite designs. Illustration through Numerical examples.

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Reference books:

1. Kreyzic - Advanced Engineering Mathematics
2. Mallik and Gupta - Numerical Analysis
3. Mallik and Mallik - do -
4. S.S.Sastry - do -
5. M.Shantkumar - Computer based Numerical Analysis
6. F. Ayres (Schaum series) - Differential equations
7. Scield (Schaum series) - Numerical Analysis.
8. V.Rajaraman - Computer oriented Numerical Analysis
9. Samuel D.Counte & Carl - Elementary Numerical Analysis An algorithmic approach.
10. Ronald E, Walpol and Raymond H.Myers - Probability and Statistics for Engineers and Scientists
11. R.Lowell Wine - Statistics for Scientists and Engineers
12. Etwod.G.Kirkpatrick - Introductory Statistics and Probability for Engineering, Science and Technology
13. John.B.Kennedy and Adam.M. Neville - Basic Statistical Methods for Engineers and Scientists
14. Umargi - Probability and Statistical Methods.
15. A.Polland - Introductory Statistics.

M.Tech (Mineral Processing) First Semester

Course Title : Elements of Mechanical Engineering	**Course Code: 24MNP1S1L**
Teaching Hours/Week (L-T-P): 2 - 0 - 0	**No. of Credits:** 02
Internal Assessment: 20 Marks	**Semester End Examination:** 30 Marks

Objective: This course is designed to impart the knowledge of driving force of machines, elements of machines and working principles of machines.	
Unit – I Prime Movers: Types of prime movers. Definition of terms - Pressure, Work, Temperature, Heat, Power, Units of heat, Specific heat, Mechanical equivalent heat. Belt Drive – Types - Open and Cross belt drive, Velocity ratio, Slip and creep, Guide Pulley, Jackey pulley, Stepped cone pulley, crowning of pulleys, Fast and Loose pulley. Belt Drive - Advantages. Chain Drive. Gear Drive. Types of Gears, Velocity ratio of Gear Drive, Gear train Simple problems on Belt and Gear Drive. Pumps: Definition, Classification of pumps, Reciprocating pump, Centrifugal pumps, Gear pump, Priming of pumps, Air vessels, Simple problems.	10 Hours
Unit – II Different types of wears – Abrasion, Corrosion, Scoring, Scuffing, Pitting, Scaling. Minimization of wear with examples. Definition, necessity, types and properties of lubricants. Methods of lubrication. Lubricators - Screw cap lubricator, Drop feed lubricator and Splash lubricator Lathes: Types of lathes, description and functions of Lathe parts, Accessories and attachments, Lathe operations – Turning, Taper turning and their methods. Thread cutting, Knurling, Problems on taper cutting and thread cutting.	11 Hours

Course outcome:

- Student will able to discuss the fundamental aspects mechanics of machines and machine elements with their usage in the assembly of machines.
- They are also able to read the drawing of the machine and their maintenance during their use in mineral processing industry.

M.Tech (Mineral Processing) First Semester

Course: Mineralogy Lab	**Course Code:** 24MNP1C1P
Teaching Hours/Week (L-T-P): 0- 0 - 4	**No. of Credits:** 02
Internal Assessment: 20 Marks	**Semester End Examination:** 30 Marks

Course Objective:

1. To Identify and study the properties of different minerals both in hand Specimen and under the microscope.
2. To Prepare the mineral sample for microscopic studies.

List of experiments

Mineralogy: Megascopic and Microscopic identification of the following Minerals:

Quartz group: : Important varieties

Felslpars : Orthoclase, Microcline, Plagioclase, Labradorite

Mica group: Muscovite, Biotite

Pyroxenes: Augite, Diopside, Hypersthene

Amphiboles: Hornblende, Tremolite, Actinolite, Anthophyllite

Other Minerals: Olivine, Serpentine, Chlorite, Garnet, Talc, Tourmaline, Sillimanite Andalusite, Sillimanite, Kyanite, Corundum, Asbestos, Calcite, Dolomite, Baryte, Magnesite, Fluorite, Gypsum

Course Outcome: after completion of the course, student will be able to

CO	**Statement**
CO1	To identify and differentiate the minerals based on appearance and their properties.
CO2	Suggest the application of Minerals for different end uses
CO3	Appreciate the mineral property by identifying its application useful to mineral separation

M.Tech (Mineral Processing) First Semester

Course: Petrology Lab	**Course Code:** 24MNP1C2P
Teaching Hours/Week (L-T-P): 0- 0 - 4	**No. of Credits:** 02
Internal Assessment: 20 Marks	**Semester End Examination:** 30 Marks

Course Objective:
To Identify and study the different minerals present in the rocks both in hand specimen and thin sections of the rocks under the microscope.

List of Experiments

Petrology: Megascopic Identification of following Rocks

Igneous: Granite, Syenites, Pegmatites, Aplite,
Diorite, Gabbro, Anorthosite, Dolerties,Rhyolites,Basalts, Ultramafic Rocks: Dunite, Pyroxenite, Peridotite, Komatiite

Sedimentary: Conglomerates, Breccias, Sandstones, Limestones, Dolomite, Shale, Laterites and Bauxites.

Metamorphic: Schists, Gneisses, Marble, Quartzite, Slate, Phyllite, Amphibolite and Charnockite, Banded Iron Formations

Course Out Come : After completion of this course, students will be able to

CO	**Statement**
CO1	Appreciate different texture and structures present in rocks.
CO2	Recommend the rocks for different purposes depending upon the properties possessed.

M.Tech (Mineral Processing) First Semester

Course: ANALYSIS OF ORES AND MINERALS LAB	**Course Code:** 24MNP1C3P
Teaching Hours/Week (L-T-P): 0- 0 - 4	**No. of Credits:** 02
Internal Assessment: 20 Marks	**Semester End Examination:** 30 Marks

List of experiments
Analysis of various elements like
Fe, Mn, Mg, Ca, Pb, Cu, Ni, Ti, V by titrimetric, gravimetric and colorimetric methods

M.Tech (Mineral Processing) Second Semester

Course: Ore Genesis and Ore Microscopy	**Course Code:** 24MNP1C5L
Teaching Hours/Week (L-T-P): 4- 0 - 0	**No. of Credits:** 04
Internal Assessment: 30 Marks	**Semester End Examination:** 70 Marks

Objective: The Prime objective of this course is to study the various processes of ore formation and their classification and to study the optical properties of different minerals under the reflected light with the help of ore microscope.

UNIT – I 09 Hours

Introduction to ore geology: magmas and magmatic ore formations – differentiation, concentration, magma mixing, sublimation etc.

Hydrothermal process – cavity filling, contact metasomatism, replacement; wall rock alteration, mineral paragenesis and zoning in mineral deposits. Geological thermometers.

UNIT – II 09 Hours

Ore deposits associated with acidic, mafic and ultramafic rocks layered intrusive and the associated ore deposits mineral deposits associated with kimberlites, komatites and carbonatites. Classification of ore deposits.

UNIT-III 11 Hours

Ore deposits formed by sedimentary processes: Iron, Manganese, Carbonates, Phosphates, Sulphates, and Clay deposits. Uranium and Vanadium deposits and Non-Ferrous ores. Evaporation, Residual and Mechanical concentration, factors controlling residual concentration. Process of formation of residual deposits- Bauxite and Nickel.

UNIT-IV 11 Hours

Ore Deposits formed by Oxidation and Supergene enrichment-factors controlling supergene enrichment. Mode of formation of placer deposits.

Ore deposits associated with metamorphism: Graphite, Asbestos, Talc, Soapstone, Andulasite, Sillimanite, Kyanite and Garnet.

Metallogenic epochs and provinces. Ore deposits related to plate tectonics, control of Ore localization.

UNIT- V 12 Hours

Introduction to Ore Microscopy: Preparation of samples for Ore microscopic studies: Qualitative properties – Colour, Reflectance, Bireflectance and Reflection pleochroism. Isotropism and Anisotropism, Internal reflection, Rotation properties, Polishing hardness, Scratch hardness, Crystal form and habit, cleavage and parting, twinning etc. Quantitative properties – Micro indentation hardness and Reflectivity. Microchemical techniques, Modal analysis. Textures of Ore minerals, assemblages and paragenesis. Application of Ore microscopic studies in mineral technology

Course outcome: **After completion of this course students will be able to**

CO	**Statement**
CO1	Know the various geological processes responsible for formation of ore and about textures and structures present in the ore.
CO2	Device the best way of separation of minerals with the knowledge of texture and structure
CO3	Operate the ore microscope to characterize the ore minerals.
CO4	Identify the minerals, textures, and structures present in the ore sample.

Books

1. Jensen and Bateman, A.M. - Economic Mineral Deposits
2. K.V.G.K. Gokhale & T.C.Rao - Ore Deposits of India
3. R.L.Stanton - Ore Petrology
4. C.F.Park (Jr) and Mac Diarmid - Ore Deposits
5. W. Lindgren - Mineral Deposits
6. E.N.Cameron - Ore Microscopy
7. J.R.Craig & Vaughan - Ore Microscopy and Ore Petrology
8. P.Ramdohr - The Ore Minerals and their Inter growths

Course: Comminution and Sizing	Course Code: 24MNP1C6L
Teaching Hours/Week (L-T-P): 4- 0 - 0	No. of Credits: 04
Internal Assessment: 30 Marks	Semester End Examination: 70 Marks

Objective: The objective is to study the size reduction operations in mineral processing. And also to understand the screening operations.

UNIT – I 10 Hours

Definition, Scope and necessity of Mineral Processing, Historical developments and Economics. Physical Properties of Ores and their importance in Mineral Processing.
Sampling: Definition, purpose, types of sampling and measurements of accuracy of sampling. Definition of terms – Concentrate, Tailing, Middling, Recovery and Ratio of concentration. Unit operations. Simple problems on estimation of recovery and ratio of concentration. Efficiency and Selectivity index.

UNIT-II 09 Hours

Comminution: Definition and basic laws of Comminution, Simple problems on energy estimations. Crushing Purpose, Mechanism of crushing, types of crushers and their salient features, major parts and maintenance of crushers.

UNIT-III 09 Hours

Grinding: Tumbling mills, Importance of cascading and cataracting, estimation of critical speed of tumbling mills. Types of tumbling mills, grinding practice, open, closed circuit grinding operations, and related problems.

UNIT- IV 12 Hours

Laboratory Sizing: Definition of particle size, measurement of particle size, Sizing by screening and sub- sieve sizing. Definition of sieve, screen, mesh. Advantages of wet and dry sieving. Graphical representation of size analysis data, size distribution functions and their applications.

UNIT- IV 12 Hours

Industrial screens and their efficiency. Liberation: Definition, importance and application of ore microscopy in liberation studies and its analysis. Methods of liberation and behavior of locked particles. Instrumental analysis of liberation of minerals. Working problems on screen performances.

Course Outcome: After completion of this course, students will be able to

CO	Statement
CO1	Perform the sampling of ore for various treatments
CO2	Demonstrate the crushing operation and produce products
CO3	Identify the various parts of crushers and grinding mills
CO4	Perform the sieve analysis of feed and products of any equipments used in mineral industries
CO5	Draw the separation curves and infer the results

Reference books:

1. A.M.Gaudin - Principles of Mineral Dressing
2. S.K.Jain - Ore Processing
3. A.K.Lynch - Crushing and Grinding Circuits
4. B.A.Wills - Mineral Processing Technology
5. E.J.Pryor - Mineral Processing
6. A.F.Taggart - Text Book of Ore Dressing
7. A.F.Taggart - Hand Book of Mineral Dressing

8. Robert.H.Richards, Charles Lock & R.Schumann - A Text Book of Ore Dressing
9. Pradeep & Rakesh Kumar - Selected Topics in Mineral Processing
10. S.P.Mehrotra & P.Sarkar - Mineral Processing – Recent advances and future trends.
11. T.Allen - Practicle Size Measurement

M.Tech (Mineral Processing) Second Semester

Course: Ore Classification and Gravity	**Course Code:** 24MNP1C7L

Separation technology	
Teaching Hours/Week (L-T-P): 4- 0 - 0	**No. of Credits:** 04
Internal Assessment: 30 Marks	**Semester End Examination:** 70 Marks

Objective: The prime objective of this course is to acquire the knowledge for exploiting the differences in physical properties of different minerals in different media in order to recover valuable minerals.

UNIT – I 09 Hours

Movement of Solids in fluids : Free settling, Hindered settling , equal settling, Factors affecting the settling of particles, Laminar flow , Turbulent flow, Derivation of various laws , Reynolds number , Free settling ratio and Hindered settling ratio and numerical problems.

UNIT-II 10 Hours

Classification: Principles, Mechanism of classification, Types of sorting classifiers, Performance of hindered settling classifiers, Operation and efficiency of sorting hindered settling, classifiers as concentration devices and simple problems. Reflux classifiers, Stub cyclones, Autogenous media cyclones: Sorting classifiers; Principles, Operation and efficiency , types and their industrial application

UNIT- III 12 Hours

Introduction to Physical Methods of Separation: Principles, Types of processes and Ore characteristics.

Gravity Separation: Separation in Vertical currents–Jigging–Theory and principles, differenttypes of jigs, operation of jigs, performance and efficiency, Jig circuits. Separation in Streaming currents – Theory of thin film concentration and flowing film concentration. Tabling- factors affecting the performance of tables, different types of tables.

UNIT -IV 10 Hours

Spiral concentrators – principles, types of spirals, application of spiral concentrators, performance and their efficiency. Reichert cones, Enhanced Gravity concentration: Brief introduction of principles and operation – Multigravity separator, Floatex density separator, knelson concentrator, Falcon separator, Kelsey Jig, Apic Jig etc.

UNIT- V 11 Hours

Dense Medium separation : Principles, media preparation and stability of media, regeneration of media, Classification of DMS, types of dense medium separators and their Operation , typical DMS circuits efficiency and construction of partition curves.

Simple Problems on calculations of Recovery, Yield, Enrichment ratio and grade in gravity separation units. analysis of gravity separation flow sheets.

Course Outcome: **After completion of this course, students will be able to**

CO	**Statement**
CO1	Differentiate the free settling and hindered settling phenomenon's
CO2	Identify the parts of mineral classifiers
CO3	Use classification as a method of concentration
CO4	Perform the gravity separation of minerals.
CO5	Draw the separation curves and appreciate the mineral separation by gravity methods

Books

1. A.F.Taggart - Text Book of Ore Dressing
2. A.F.Taggart - Hand Book of Mineral Dressing
3. Robert.H.Richards, Charles Lock & R.Schumann - A Text Book of Ore Dressing

4. Pradeep & Rakesh Kumar - Selected Topics in Mineral Processing
5. S.P.Mehrotra & P.Sarkar - Mineral Processing – Recent advances and future trends.
6. T.Allen - Practicle Size Measurement

Course: Indian Mineral Deposits	Course Code: 24MNP1C8L
Teaching Hours/Week (L-T-P): 4- 0 - 0	No. of Credits: 04
Internal Assessment: 30 Marks	Semester End Examination: 70 Marks

Objective: The objective of this course is to impart knowledge on distribution of different mineral deposits across India along with their contribution in national economy.

UNIT – I 10 Hours

Importance of Mineral Resources for the Industry and Economy of a Nation. Mineral Resources, Expendable and Non-expendable minerals. Conservation of minerals. Metallic and non-metallic minerals, Essential, Critical and Strategic minerals.

UNIT-II 09 Hours

Study of important Metallic and Non-metallic Mineral Deposits of India with reference to Origin, Mode of occurrence, Mineralogy, Distribution, Production, Process Flow-sheets, Uses and Trades in India.

UNIT-III 09 Hours

Metallic deposits: Iron, Manganese, Chromium, Copper, Lead and Zinc, Bauxite, Gold and other precious metals

UNIT-IV 12 Hours

Refractory minerals, Diamond, Beach sands. Minerals used in Glass, Cement and Ceramic industries. Minerals used in fertilizer industry, Minerals used as insulators, Structural and Building materials including Pigments and Fillers, Minerals used in chemical industry, Abrasive minerals, Industrial and manufacturing materials

UNIT- IV 12 Hours

Fuel Minerals: Oil and Gas, Coal & Lignite. Definition, Composition, types and Ranks of Coals, Macerals and Lithotypes and their distribution. Distribution and Mode of Occurrence of Radioactive Minerals

Course Outcome: **After completion of this course, students will be able to**

CO	Statement
CO1	Discuss the Metallic and Non-metallic Mineral Deposits of India
CO2	Distinguish refractory minerals, Diamond, Beach sands. Minerals used in Glass, Cement and Ceramic industries. Minerals used in fertilizer industry,
CO3	Locate the occurrence of Oil and Gas, Coal & Lignite deposits of India.

Book References:

1. K.V.G.K.Gokhale & T.C.Rao - Ore Deposits of India
2. S.Krishnaswamy - Indian Mineral Resources
3. S.Deb - Industrial Minerals and Rocks of India
4. W.Seely & S.Mudd Serie - Industrial Minerals and Rocks
5. B.P.Radhakrishna - Mineral Resources of Karnataka
6. R.N.P.Arogyaswamy - A Course in Mining Geology
7. Roshan Bappu & Mular - Mineral Processing Plant Design
8. Weiss (Editor)S.M.E. - Hand Book of Mineral Processing Vol. I & II.

Course: Computational Techniques in Mineral Processing	**Course Code:** 24MNP2S2LT
Teaching Hours/Week (L-T-P): 1- 2 - 0	**No. of Credits:** 02
Internal Assessment: 20 Marks	**Semester End Examination:** 30 Marks

Objective: The prime objective of this course is to develop the computational skills to optimize the mineral beneficiation plants for effective utilization of resources.

UNIT – I 13 Hours

Introduction: Material balancing, simple problems on material balancing of closed circuit crushing and grinding.

Mass balancing of complex circuits: Mass balancing of complex circuits. Concepts of connection matrix and its applications. Estimation of recovery and separation efficiencies for beneficiation unit operations with multiple product streams with numerical examples.

UNIT-II 13 Hours

Reconciliation of excess data for minimizing of errors involved in yield and recovery calculations.

Error analysis: Computation of errors involved in size and chemical analysis of feed and product streams for estimation of accurate yield in the plant operations. Application of Lagrangian Multipliers for error minimization. Use of machine learning algorithms for mineral processing plant optimizations

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

CO	**Statement**
CO1	Perform the mass balancing of unit operations in mineral processing
CO2	Perform the reconciliation of data for minimizing the errors
CO3	Estimate the recovery and circuit efficiency

M.Tech (Mineral Processing) Second Semester

Course: Ore Microscopy Lab	**Course Code:** 24MNP1C4P

Teaching Hours/Week (L-T-P): 0- 0 - 4	**No. of Credits:** 02
Internal Assessment: 20 Marks	**Semester End Examination:** 30 Marks

- **Study of metallic and non-metallic ores: -** iron, manganese, copper, bauxite, lead and zinc ores etc.,
- **Microscopic studies of ores –** Important textures, Reflectance, Bireflectance, Microhardness and etch test.

Course: Comminution and Sizing Lab	**Course Code:** 24MNP1C5P
Teaching Hours/Week (L-T-P): 0- 0 - 4	**No. of Credits:** 02
Internal Assessment: 20 Marks	**Semester End Examination:** 30 Marks

LIST OF EXPERIMENTS TO BE CARRIED OUT

- Experiments on Sampling techniques and error estimation.
- Verification of Gy's law of sampling
- Determination of physical characteristics of ore sample like specific gravity, bulk density, and angle of repose.
- **Crushing experiments:** Jaw crusher and roll crusher. Verify basic energy laws and the Denver grindability test. Work index, Bond, and HGI work index.
- Demonstration of Ball Mill and Rod Mill Grinding.
- Determination of Particle Size by Size analysis, wet & dry sieve analysis, Sub-sieve analysis – Beaker decantation and Andresen Pipette method.
- Determination of Specific Gravity by pychnometer method.
- Separation of sample by size and calculation of head and distribution of values. Validation of data using determinant methods.

Course: Ore classification and Gravity Separation Processes Lab	**Course Code:** 24MNP1C6P
Teaching Hours/Week (L-T-P): 0- 0 - 4	**No. of Credits:** 02
Internal Assessment: 20 Marks	**Semester End Examination:** 30 Marks

LIST OF EXPERIMENTS TO BE CARRIED OUT

- Determination of terminal velocity - Free settling test, Hindered settling test
- Estimation of % solids both by weight and volume methods.
- Laboratory Screening Operations
- Sink and float tests
- Demonstration Experiments in Jigging.
- Shaking Table
- Demonstration of Hydrocyclone
- Demonstration of Air Classification
- Demonstration of Spiral concentrator
- Plotting of Tromp Curves

Course Title: Magnetic and Electrostatic Separation Technology	**Course code:** 24MNP3C9L
Total Contact Hours: 52	**Course Credits: 04**
Formative Assessment Marks: 30	**Duration of ESA/Exam: 3**
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 and water reclamation

M.Tech (Mineral Processing) Third Semester

Course Title: FROTH FLOTATION	**Course Code:** 24MNP3C10L
Total Contact Hours: 52	**Course Credits: 04**
Formative Assessment Marks: 30	**Duration of ESA/Exam: 3**
Summative Assessment Marks: 70	

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

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.

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 Prepare the regents and optimize the flotation operations

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)

M.Tech (Mineral Processing) Third Semester

Course: NON-FERROUS EXTRACTIVE METALLURGY	**Course Code:** 24MNP3E1AL
Total Contact Hours: 52	**Course Credits: 04**
Formative Assessment Marks: 30	**Duration of ESA/Exam: 3**
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.

1.

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, Eh-pH Diagrams, Metal Extraction under atmospheric pressure, high pressure and temperature.

UNIT –IV **10 Hours**

Bioleaching- Concepts and principles, Eh -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

Course 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.

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

M.Tech (Mineral Processing) Third Semester

Course: ELEMENTS OF MINING TECHNOLOGY	**Course Code:** 24MNP3E1BL
Total Contact Hours: 52	**Course Credits: 04**
Formative Assessment Marks: 30	**Duration of ESA/Exam: 3**
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.

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 tunnel boring machine, applicability, advantages, and limitations of tunnel boring machine. Shield tunneling method: construction and working principle, applicability, advantages, and limitations.

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.

BOOKS FOR REFERENCE :

1.R.N.P.Arogyaswamy A Course in Mining Geology
2.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:** 24MNP3E1CL
Total Contact Hours: 52	**Course Credits: 04**
Formative Assessment Marks: 30	**Duration of ESA/Exam: 3**
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

1.

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.

Course 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

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

M.Tech (Mineral Processing) Third Semester

Course: SURFACE CHEMISTRY	**Course Code:** 24MNP3E2AL
Total Contact Hours: 52	**Course Credits: 04**
Formative Assessment Marks: 30	**Duration of ESA/Exam: 3**
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.,

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.

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.

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.

M.Tech (Mineral Processing) Third Semester

Course: BIO PROCESSING	**Course Code:** 24MNP3E2BL
Total Contact Hours: 52	**Course Credits: 04**
Formative Assessment Marks: 30	**Duration of ESA/Exam: 3**
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

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.

Course Outcome: **after completion of this course student can able to**

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

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 related Microbiological phenomena.
6. Ross,G., Biohydrometallurgy.

M.Tech (Mineral Processing) Third Semester

Course Title: DYNAMICS OF MACHINES	**Course code:** 24MNP3E2CL
Total Contact Hours: 52	**Course Credits: 04**
Formative Assessment Marks: 30	**Duration of ESA/Exam: 3**
Summative Assessment Marks: 70	

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

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 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

Course Title: BASIC TECHNIQUES OF MINERAL DRESSING	**Course code:** 24MNP3G1AL
Total Contact Hours: 30	**Course Credits: 02**
Formative Assessment Marks: 20	**Duration of ESA/Exam: 2**
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.

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.

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

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 & Mineral Dressing Journals.

M.Tech (Mineral Processing) Third Semester

Course Title: PRINCIPLES OF IRON MAKING	**Course code:** 24MNP3G1BL
Total Contact Hours: 30	**Course Credits: 02**
Formative Assessment Marks: 20	**Duration of ESA/Exam: 2**
Summative Assessment Marks: 30	

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

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.

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

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)

M.Tech (Mineral Processing) Third Semester

Course Title: ENVIRONMENTAL MANGEMENT	**Course code:** 24MNP3G1CL
Total Contact Hours: 30	**Course Credits: 02**
Formative Assessment Marks: 20	**Duration of ESA/Exam: 2**
Summative Assessment Marks: 30	

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

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 – III **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.

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

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)

M.Tech (Mineral Processing) Third Semester

Course Title: RESEARCH METHODOLOGY	**Course code:** 24MNP3S3L
Total Contact Hours: 27	**Course Credits: 02**
Formative Assessment Marks: 20	**Duration of ESA/Exam: 1**
Summative Assessment Marks: 30	

Objective: 1. the objectives of this course are to identify the problem statement nd review the literature and analyse the data.

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.

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

References (indicative)

1. C.R. Kothari, Research Methodology: Methods and Techniques, II Ed. New Age International 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/).

M.Tech (Mineral Processing) Third Semester

Course Title: Magnetic and Electrostatic Separation Technology Lab	**Course Code:** 24MNP3C7P
Formative Assessment Marks: 20	**Course Credits: 02**
Summative Assessment Marks: 30	**Duration of ESA/Exam: 4**

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

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 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

M.Tech (Mineral Processing) Third Semester

Course: Froth Flotation Lab	**Course Code:** 24MNP3C8P
Formative Assessment Marks: 20	**Course Credits: 02**
Summative Assessment Marks: 30	**Duration of ESA/Exam: 4**

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

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

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

M.Tech (Mineral Processing) Fourth Semester

Course Tilte : MINERAL PROCESSING PLANT DESIGN	**Course Code:** 21MNP4C11L
Contact Hours : 52	**No. of Credits:** 04
Formative Assessment: 30 Marks	**SEE Hours: 3 Hours**
Summative Assessments: 70 marks	

Objective: The objective of this course is to design and selection of equipments for separation of minerals based on magnetic, electrical conductivity and processing of slimes by aggregation and interfacial differential properties are studied followed by a detailed discussion on dewatering and tailing plant design and disposal.

UNIT – I **09 Hours**

Sampling and Testing: Sampling a mineral deposit for feasibility studies and metallurgical testing. Metallurgical testing procedures. Metallurgical flow sheet development. Selection and design features of Crushing and Grinding Equipments: Primary, Secondary & Tertiary Crushers. Rod and Ball mills. Autogenous grinding from Test work.

UNIT-II **10 Hours**

Flowsheet types: Different types of flowsheets and their definitions; Flowsheet symbols as per BIS norms. Different types of information required for flowsheet development and plant design Site selection; Gravity Separation: Application and selection of Spiral Classifiers, Selection of cyclone classifiers. Equipment symbols: Standard Process equipment symbols as per BIS norms.

UNIT- III **12 Hours**

Magnetic and Electrostatic separation: Types, Process, and Plant design of Magnetic and Electrostatic separators. Flow sheets

Flotation: Basic functions and sizing and Selection of flotation machines, Flotation machine families, Selection of chemical reagents, Conceptual design of flotation circuits

UNIT –IV **10 Hours**

Solid-Liquid separation: Thickeners – Mill design for thickeners, thickener tanks, Mechanism of operation and control. Filters – Types and theory of continuous filtration, Concentrate drying, Handling and storage.

UNIT- V **11 Hours**

Belt conveyers: Design, Selection, Stackers and Reclaimers. Slurry transportation Operations: Design and Application of Centrifugal slurry pump Design and construction of Tailing ponds and water Reclamation facilities. Environmental considerations in mill sites. Dust collection systems

Course Outcome:

1. Student will able to give valuable input for designing of Belt conveyers: Design, Selection, Stackers and Reclaimers.
2. Design and Application of Centrifugal slurry pump, Design and construction of Tailing ponds and water Reclamation facilities.
3. Design and construction of Modern Mineral Processing Plant and Flow Sheets.

M.Tech (Mineral Processing) Fourth Semester

Course Title: FERROUS EXTRACTIVE METALLURGY	**Course Code:** 24MNP4C12L
Total Contact Hours/Week (L-T-P):52	**No. of Credits:** 04
Internal Assessment: 30Marks	**Semester End Examination:70** Marks

Objective:

The extraction of ferrous metals and steel from ferrous metallic ores and industrial wastes is studied in ferrous extractive metallurgy.

UNIT – I **09 Hours**

Principles of Extractive-Metallurgy: Iron ore quality w.r.t. size, chemistry and other properties, types of fluxes used and the importance of coke-quality for iron making. Requirement of Raw-materials per tonne of Liquid Iron Production. Sintering of Iron-ore fines and usage of Sinter, Iron-bearing burden and its importance..

UNIT-II **10 Hours**

Pelletization – principles, mechanisms, fundamental forces of cohesion between particles, surface tension, forces between micro assemblies, pore size distribution, additives, pre-heating & indurations, quality of agglomerates, effect of parameters, like, size, moisture, binder concentration, effect of drying and autoclave curing, fluxed pellets, composite pre -reduced pellets and cold bonded pellets. Compaction by piston/ roll press – effect of machine and material parameters.

UNIT- III **12 Hours**

Iron Making : Recent developments in Blast furnace operations like, Bell-less top charging system, High top pressure, Humidified & Oxygen enriched blast and Auxiliary fuel injection through tuyers. Alternative routes of iron making: Introduction, Processes of Sponge Iron production; SL/RN, MIDREX, HyL processes. Smelting Reduction Processes; COREX, ROMELT, Hismelt.

UNIT –IV **10 Hours**

Steel Making: Thermodynamics of refining – Carbon, Silicon, Manganese, Phosphorous and Sulphur reactions. Deoxidization of steel – Raw materials for steel making. Steel making by L.D.Process. case Studies on advanced processes in steel making.

UNIT- V **11 Hours**

Steel making by Oxygen bottom blowing and combined blowing. Other recent processes. Secondary steel making processes. Electric arc furnace process, Casting pit practice , continuous casting of steel, Production of ferro alloys

Course Outcome:

1. Student can able to perform the raw material tests for blast furnace for iron making
2. Identify the basic parts and auxiliaries of blast furnace and their
3. Discuss the various routes of iron making

Books:

1. R D Pehlke, Unit Processes in Extractive Metallurgy- American Elsevier pub.Co.,Michigan, 1973.
2. J. J. Moore- Chemical metallurgy, Butterworth-Heineman,1981.
3. J. D. Gilchrist- Extractive metallurgy- Pergamon Press, 1989.
4. Iron making by R.H Tupkary
5. Steel Making by R H Tupkary

M.Tech (Mineral Processing) Fourth Semester

Course: CEMENT TECHNOLOGY	**Course Code:** 24MNP4E3AL
Total Contact Hours: 52	**No. of Credits:** 04
Formative Assessment: 30 Marks	Exam hours : 3
Summative Assessment :70 Marks	

Objective: The objective of the course to understand chemical aspect of cement, its composition, manufacturing Processes and its influence on performance...

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UNIT – I **09 Hours**

Introduction to Cement and Binding materials : History of binding materials and Cement, Classification of Cement Binders, Lime as Binder, cement and its importance in construction, Cement and its Raw Mill Composition, History of Cement manufacturing process, material composition of cement, various unit operation of cement manufacture, the present status and future of cement industry in India

UNIT-II **10 Hours**

Calcareous Raw Materials: Source of Lime, Limestone, Chalk, Marl, Industrial wastes as cement Raw materials Unit-V Argillaceous Raw Materials: Source of Silica, Alumina, Iron Oxide, Shale and effect of coal ash and additives use as corrective materials, Fly ash , Slag, sludge as cement raw materials. Additives and Gypsum : Origin and occurrences and distribution of various additive in India such as Bauxite, Iron Ore , Laterite, and gypsum.

UNIT- III **12 Hours**

Sampling and pre blending of cement raw materials, estimation of Silica Modulus, Alumina Modulus, Hydraulic Modulus, Lime saturation Factor, Liquid Content, method proportioning, 2,3 and 4 component mixes, impact of moduli values on cement manufacturing process and quality of clinker.

UNIT –IV **10 Hours**

Cement manufacturing process, chemical composition of various types cement, cement component and their phase relation, Binary and ternary compounds of cement and formation of eutectic. Mineralizer, Role of additive in clinker formation, various mineralizer and fluxes, their role in manufacture of clinker,

UNIT- V **11 Hours**

Hydration of clinker minerals, role of gypsum in cement hydration process, hydration of Portland cement and strength of Portland cement

Unit process calculations in cement manufacturing

Out Comes: after attending the course, students will be able to

1. Identify the different types of cements
2. Understand the cement manufacturing process
3. Explain the role of minerals and admixtures in cement manufacturing

Books

1. F. M. Lea, Chemistry of Cement and Concrete, Arnold, London.
2. Cement Data Book: W. H Duda , Verlag G m Bh,Berlin
3. R. H. Bouge, Chemistry of Portland Cement, Reinhold, New York
4. Process Calculations: A Cement Process Handbook by V D Chari

M.Tech (Mineral Processing) Fourth Semester

Course: INDUSTRIAL ENGINEERING AND MNAGEMENT	**Course Code:** 24MNP4E3BL
Total Contact Hours: 52	**No. of Credits:** 04
Formative Assessment: 30 Marks	Exam hours : 3
Summative Assessment :70 Marks	

Objective: The objective of the industrial engineering is to decipher the knowledge of engineering management from inception to implementation of a project.

UNIT – I **09 Hours**

Growth and concept of Industry: - Basic and scientific factory systems, types of ownership, Principles of management. Organization- Types of organizations, role of executives, elements of co-ordination Functions of management: Planning, organizing directing, co-ordination, controlling and decision making

UNIT-II **10 Hours**

Personal Management:- Functions of personal management, recruitment, selection and training of Workers and supervisors. Production Management:- Plant location, layout of plants, depreciation and valuation of machinery, production planning and control. Quality productivity movement in India. Automation in India, its advantages and disadvantages. Functions of production control and planning control, material control.

UNIT- III **12 Hours**

Marketing: Functions of marketing, Market research, sales, organizational planning, advertising and sales promotion, duties of sales personnel.

UNIT –IV **10 Hours**

Human Relations: Job specification and morale, Employer and Employee relations, Health and Wealth of workers. Effects of physical conditions like noise, lighting, ventilation on output, fatigue and reduction of fatigue.

UNIT- V **11 Hours**

Industrial safety: Accidents and their reduction. Settlement of individual disputes, ILO, workers participation in management.

Out Comes: after attending the course, students will be able to

1. Discuss the mineral economics in projects
2. Inculcate the Managerial skills
3. Discuss and implement the good administration at work place

Books

1. Barthwal. B.R. Industrial Economics- An introductory Text Wiley Eastern Ltd., New Delhi, 1984.
2. Mehta.P.L Managerial Economics Sultan Chand & Sons, New Delhi – 1988.
3. Dwivedi **Text book of Managerial Economics** Vikas Publishing House, New Delhi 1998.
4. Minor.J.B. & Miner.M.G. **: Personnel and Industrial Relations:** A Managerial approach Mac Millan Publihsing Co.1997

M.Tech (Mineral Processing) Fourth Semester

Course: POLLUTION CONTROL AND ECO SYSTEM MANAGEMENT	**Course Code:** 21MNP4E3CL
Total Contact Hours: 52	**No. of Credits:** 04
Formative Assessment: 30 Marks	Exam hours : 3
Summative Assessment :70 Marks	

Objective: The objectives of this course are to understand the importance of eco system and its management by pollution control.

UNIT – I **09 Hours**

Natural Resources: Definition, Resource, types, perpetual and non perpetual, renewable and non renewable, Fuel and Energy Resources, Wildlife resources, their exploitation and impacts on environment, mineral resources and reserves, water, energy, soil, wildlife resources, oceanic resource, mineral resources, exploitation, recycling.

UNIT-II **10 Hours**

Use of natural resources, conventional use of resources, overuse, abuse, exploitation of resources, unequal distribution of natural resources, resource crunch, protection, conservation and sustainable use of natural resources.

UNIT- III **12 Hours**

Concept and objectives, general guidelines for environmental audit, audit procedure, merits and demerits, water audit, social audit and energy audit, carbon footprint, water footprint

UNIT –IV **10 Hours**

Nature of industrial effluents, gaseous effluents, methods of gas analysis, analysis of natural water, analysis of waste water for BOD, free acids and basic; dissolved organic and inorganic compounds like alkali and alkaline salt. Industrial effluent treatment recovery and recycle techniques.

UNIT- V **11 Hours**

Methods for removal of pollutants from gaseous effluents; particulate matter, waste water treatment Activated sludge process. Removal of Nitrogenous pollution, Removal of nitrogen; physico-chemical processes; biological method of pollution control. Analytical methods of small amount of the metal pollutants; removal and recovery techniques of heavy metals

Out Come: Students will be able to:

1. Relate the concept of major conflicts of development and environment
2. Learn the sources of air pollution and its control.
3. Comprehend the term water pollution with its classification and impacts.
4. Understand regulatory aspects of pollution control.
5. Analyze the hazardous waste with its management.

Books

1. Waste water engineering, Met Calf and Eddy, INC, Tata Mc Graw Hill
2. Fundamentals of Environmental Pollution, Krishnan Khannan, S. Chand and Company Ltd.,1994.
3. Environmental Pollution Control, C.S.Rao, Wiley Eastern Ltd.,1993
4. Air Pollution Control and Engineering, De Nevers, Mc Graw Hills, 1993.

M.Tech (Mineral Processing) Fourth Semester

Course: DEWATERING AND TAILING MANAGEMENT	**Course Code:** 24MNP4E4AL
Total Contact Hours: 52	**No. of Credits:** 04
Formative Assessment: 30 Marks	Exam hours : 3
Summative Assessment :70 Marks	

Objective: The prime objective of this course is to understand the various dewatering systems. In addition, to practice the safe disposal of mine/mineral wastes by adopting reuse, recycle and reduce concepts.

UNIT – I **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 f diameter using Coe and Clevenger equation and Kynche Model. Design of a thickener, flocculation, and their applications.

UNIT-II **10 Hours**

Dewatering by gravity sedimentation: Thickening principles and practices. Derivation of 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, tray thickener, Dewatering using Screens.

UNIT- III **9 Hours**

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

UNIT –IV **12 Hours**

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

UNIT- V **9 Hours**

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

Out Come: Students will be able to:

1. Operate the thickeners for water recovery
2. Perform the flocculation studies for treatment of water .
3. Perform the filtration studies and shall find out the moisture levels

M.Tech (Mineral Processing) Fourth Semester

Course: ADVANCED FOUNDRY TECHNOLOGY	**Course Code:** 21MNP4E4BL
Total Contact Hours: 52	**No. of Credits:** 04
Formative Assessment: 30 Marks	Exam hours : 3
Summative Assessment :70 Marks	

Objective: The prime objective of this course is to acquire the knowledge on foundry Technology

UNIT – I **12 Hours**

Concept of solidification of metals. Homogenous and heterogeneous nucleation.Growth mechanism. Solidification of pure metals and alloys. Mechanism of columnar and dendrites growth.Coring or Segregation. Solidification time and Chvorinov's rule. Concept of progressive and directional solidifications

UNIT-II **10 Hours**

Purpose of the gating system. Components of the gating System and its functions. Design of the gating System. Different types of gates. Gating ratio and its functions. Definition and functions of the riser. Types of risers and their application. Design of the riser - its shape. Size and location. Use of insulating material and exothermic compounds in risers.

UNIT- III **9 Hours**

Factors to be considered in casting design. Design consideration in pattern making, molding techniques and core making and assembly. Cooling stresses and hot spots in casting and modification in casting geometry to overcome them.

UNIT –IV **12 Hours**

Casting defects and factors responsible for them. Different inspection and testing methods to evaluate the casting. Quality control activities in a foundry. Salvaging methods of defective casting. Furnace Technology: Study of various furnaces used in foundry, construction, and operation of crucible and hearth furnaces. Resistance, Arc and Induction furnaces-their construction. Operation and application. Heat treatment furnaces and drying ovens used in foundry.

UNIT- V **9 Hours**

Introduction to modernization. Mechanization of foundry and its advantages. Mechanization of sand plant, molding, and core making mechanization in melting, pouring, and shakeout units. Material handling equipments and conveyor systems. Brief sketches and description of layouts of job. Captive and mechanized foundries.

Course out Come: Students will be able to:

1. Discuss foundry practices
2. Perform the quality check of the casting product.
3. Discuss the process improvements in the foundry

M.Tech (Mineral Processing) Fourth Semester

Course: MINERAL ENGINEERING ECONOMICS	**Course Code:** 24MNP4E4CL
Total Contact Hours: 52	**No. of Credits:** 04
Formative Assessment: 30 Marks	Exam hours : 3
Summative Assessment :70 Marks	

Objective: The objective of this course is to strengthen the knowledge on managerial skills and industrial economics by fundamental studies

UNIT – I **12 Hours**

Role of mineral industry in National Economy. Economics- Definition, Wealth, cost, prices, Elements of economic activities – production and Productivity. Demand, Supply and Distribution of Income.

UNIT-II **10 Hours**

Economic organization of industry, Private and Public sector, Costs and cost accounting. Capital interest and annual charges, obsolescence, depreciation and valuation. International Trade related to Mineral Industry.

UNIT- III **9 Hours**

Economic selection of equipment, estimating the cost of equipment. Capital and operative cost. Milling calculations and Mill reports. Analysis of economic benefit

UNIT –IV **12 Hours**

Mineral Market Analysis – types of markets, short run and long run equilibrium in each market; Pricing Strategies - price discrimination; Public Goods and Externalities;

UNIT- V **9 Hours**

Asymmetric Information – adverse selection and moral hazard; Economics of Uncertainty and Risk; Inflation: Measures, Causes and Remedies..

Course out Come: Students will be able to:

1. Discuss economics of the process
2. Perform the economic feasibility analysis.
3. Discuss the improvements in the plant practices for economic benefits

Course: INDIAN MINERAL RESOURES	**Course Code:** 24MNP4G2AL
Total Contact Hours: 27	**No. of Credits:** 02
Formative Assessment: 20 Marks	Exam hours : 2
Summative Assessment :30 Marks	

M.Tech (Mineral Processing) Fourth Semester

Objective: The objective of this course is to impart knowledge on distribution of different mineral deposits across India along with their contribution in national economy.

UNIT – I **09 Hours**

Importance of Mineral Resources for the Industry and Economy of a Nation. Mineral Resources, Expendable and Non-expendable minerals. Conservation of minerals. Metallic and non-metallic minerals, Essential, Critical and Strategic minerals.

UNIT-II **09 Hours**

Study of important Metallic and Non-metallic Mineral Deposits of India with reference to Origin, Mode of occurrence, Mineralogy, Distribution, Production, Process Flow sheets, Uses and Trades in India.

UNIT-III **09 Hours**

Metallic deposits: Iron, Manganese, Chromium, Copper, Lead and Zinc, Bauxite, Gold and other precious metals: Distribution and Mode of Occurrence of Fuel Minerals: Oil and Gas, Coal & Lignite.

Course Outcome: **After completion of this course, students will be able to**

1. Discuss the Metallic and Non-metallic Mineral Deposits of India
2. Distinguish metallic and non metallic minerals
3. Locate the occurrence of Oil and Gas, Coal & Lignite deposits of India.

Reference Book:

1. K.V.G.K.Gokhale & T.C.Rao - Ore Deposits of India
2. S.Krishnaswamy - Indian Mineral Resources
3. S.Deb - Industrial Minerals and Rocks of India
4. W.Seely & S.Mudd Serie - Industrial Minerals and Rocks
5. B.P.Radhakrishna - Mineral Resources of Karnataka

M.Tech (Mineral Processing) Fourth Semester

Course: FUNDAMENTALS OF COMPUTER AND OFFICE AUTOMATION	**Course Code:** 24MNP4G2BL
Total Contact Hours: 27	**No. of Credits:** 02
Formative Assessment: 20 Marks	Exam hours: 2
Summative Assessment :30 Marks	

Objective: To provide an in-depth training in use of office automation, internet, and internet tools. The course also helps the candidates to be acquainted with IT.

. **UNIT – I** **09 Hours**

Introduction to Computer Fundamentals: Introduction to Computer, Computer System Hardware Computer Memory, Input and Output Devices, Interaction between User and Computer, Introduction to Free and Open Source Software, Definition of Computer Virus, Types of Viruses, Use of Antivirus software

UNIT-II **09 Hours**

User Interface, New Features of Windows, Desk Top Graphical Device, Interface Dynamic Data Exchange Object Linking & Embedding Net Working. Files & Folders Configuring Printers Installing Programs System Tools

UNIT-III **10 Hours**

Features of MS-Word, Components of Word Window, Creating Document, Typing Text, Saving and Closing Opening Existing, Printing & Previewing Documents, Switch between Multiple Documents Quitting Word. Working With Work Sheets Working With Ranges Types Of References Working With Formulas, Power Point tools, Creating Presentation, Using Design Templates, Creating Blank ,Presentation, Inserting Objects ,PowerPoint Views, Saving & Printing Your Works, Working With Colours & Transitions, About Slide Show Timings, Navigating During Presentation

Out Comes: Students would be able to

1. create word documents on specific topics,
2. create and manage the spreadsheets.
3. Make presentations and would be acquainted with internet.

M.Tech (Mineral Processing) Fourth Semester

Course: WASTE RECYCLING	**Course Code:** 21MNP4G2CL
Total Contact Hours: 30	**No. of Credits:** 02
Formative Assessment: 20 Marks	Exam hours : 2
Summative Assessment :30 Marks	

Objective: The objective of this course is to impart knowledge on different types of waste in mining and mineral industries and their further utilizations for sustainable developments

Course Outcome: **After completion of this course, students will be able to**

1. Differentiate the wastes
2. Perform the recovery analysis from the wastes
3. Discuss the possible routes of processing of wastes
4. Discuss the regulatory norms for safe disposal of mining wastes

UNIT – I **10 Hours**

Mining wastes: Types of waste, utilization of waste dumps, separation of valuable metals from waste products of mining using primary separation methods, recovery of iron ore, manganese ore, coal and other ferrous metals from mining wastes, recovery of radioactive minerals from gold mining wastes, a case study of individual metals collection of mining waste model check dams and dumps

UNIT-II **10 Hours**

Processing waste: Types of processing waste, waste slurry treatment using thickeners, cyclones, sedimentation, settling techniques, solid waste recovery of valuable metals by simple separation methods, waste disposal, tailing dumps, ponds.

UNIT-III **10 Hours**

Metallurgical waste: Types of metallurgical wastes, iron ore fines, coal fines, coke breeze, dolomite fines, sinter fines, pellet fines and sludge etc.Uses of fines in pellet plants , coke fines , sinter plants , briquette making & recycling using sinter plants Sludge treatment , segregation and separation of sludge constituents using primary separation methods , iron ore ,coke, and coal fines separation

Books:

1. S.Ramachandra Rao (Ed):- Waste processing and recycling in mineral and metallurgical industries Vol. II: proceedings of the International Symposium on Waste Processing and Recycling in Mineral and Metallurgical Industries II, Vancouver, British Columbia, August 20-24, 1995
2. McHarry, Jan, Reuse Repair Recycle, Gaia Books Ltd. 1993.
3. SME HAND BOOK OF MINERAL PROCESSING : vol I and II

M.Tech (Mineral Processing) Fourth Semester

Course: METALLURGY LAB	**Course Code:** 21MNP4C10P
Formative Assessment: 20 Marks	**No. of Credits:** 02
Summative Assessment :30 Marks	Exam hours : 4

Course Objectives: To exercise the metallurgical processes in the laboratory by imitating the Industrial practices

List of Experiments

1. Tests on raw material testing like tumbler, shatter index etc.,
2. Calcinations of limestone and dolomite;
3. Roasting of sulphide minerals of lead, zinc, copper, etc.;
4. Roast leaching of sulphides;
5. Leaching of oxides and silicates; Acid leaching of various minerals;
6. Recovery of dissolved metals by hydroxide precipitation, sulphide
7. precipitation and reductive precipitation;
8. Reduction of iron ores by using coal/coke;
9. Microbial leaching – development of culture, application of microbial
10. Leaching for extraction of metals.

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

1. Perform the roasting experiments for enrichment of ores
2. Analyze the leaching experiments
3. Discuss the laboratory results.

M.Tech (Mineral Processing) Fourth Semester

Course: PROJECT	**Course Code:** 24MNP4CF
Formative Assessment: 20 Marks	**No. of Credits:** 04
Summative Assessment :30 Marks	

Course Objectives: The objective of this course is t develop problem-solving skills on real industrial problems and to develop report-writing skills

The student has to undertake a Project Work in the Departmental laboratory or any mineral/metallurgical industry of local for a period of 4 months and has to submit the project report, Assessment is done by presentation of project work during end of semester. Bi-monthly progress shall be considered for Formative assessment

M.Tech (Mineral Processing) Fifth Semester

Course: Coal Preparation and Fuel Technology	**Course Code:** 24MNP5C13L
Total Contact Hours: 52	**No. of Credits:** 04
Formative Assessment: 30 Marks	Exam hours : 3
Summative Assessment :70 Marks	

Objective: Advances in fuel technology in reducing emission levels and costs, besides Meeting the demands of increasing population is sine-qua-none for mineral processing Engineers who don the role of fuel engineers. Removal of dirt from coal mostly by Physical separation like gravity is a preceding part of Fuel technology.

UNIT – I **09 Hours**

Coal preparation: Scope, objectives and applications. Types and properties of coals in general, industrial uses, characteristics of coals, coking and non-coking coals. Washability studies sink and float analysis of coals. Standard washability curves, tromp Curves, Mayer curves, probable error, washability index. Efficiency of coal washing.

UNIT-II **10 Hours**

Gravity separation process**:** Jigging: jig types and applications. Comparison of mineral and coal jigs. Baum and Batac jigs. Heavy media Separation: Types, application and operation. Heavy Media (Commercial) , Media Recovery circuit. Heavy Media cyclones-operating principles, applications, performance, efficiency, and Design calculations. Preparation of non-coking coals.

UNIT- III **12 Hours**

Fine coal washing : Modern trends. Froth flotation , Oil agglomeration , Water only cyclones and their applications in coal washing, Typical coal washing flow sheets with reference to Indian coal washeries, coal washery equipments and their selection. Factors of Designing a Modern coal washery

UNIT –IV **10 Hours**

Fuel Technology: Scope, objectives, and applications. Types of fuels: solid, liquid, gaseous fuels with examples. Primary, secondary, & tertiary fuels. Advantages of solid, liquid &gaseous fuels. Properties of fuels & their tests. Calorific value of fuels, Oxygen bomb calorimeter. Combustion ofcoal & their types. Boudouard reactions and other relevant reactions

UNIT- V **11 Hours**

Carbonization: Theory of carbonization, types of carbonization, advantages of carbonization, Gasification of coal, smelter gasifier and corex gas. standard metallurgical coke making process, properties of coke, Micum Test, Shatter Test, Haven test, Roga Index, Swelling Index, Gray king assay value, free swelling number. plastic properties of coals,High temperature properties of coke, byproducts of a coke oven, waste heat and flue gas recovery. Coal slurry injection to blast furnace

Course Outcome: Student can able to

1. perform the proximate and ultimate analysis of coal samples
2. Distinguish different types of coal
3. Discuss the beneficiation of low grade coal
4. Perform the quality tests like gray king index , micum index and roga index

M.Tech (Mineral Processing) Fifth Semester

Course Title: Agglomeration Techniques	**Course Code:** 24MNP5C14L
Total Contact Hours: 52	**No. of Credits:** 04
Formative Assessment: 30 Marks	Exam hours: 3
Summative Assessment :70 Marks	

Objective: The objective of this course is to understand the Size enlargement process for use especially in metal extraction.

UNIT – I **09 Hours**

Necessity and scope of agglomeration, Different types of agglomeration techniques. Pelletization. Raw material preparation, Characteristics of raw materials for pelletzation like Iron –ore, additives, binders etc.

UNIT-II **10 Hours**

Green-ball formation, effect of process parameters on size and strength of green-pellet, testing of Green-balls. Drying and firing of Green Balls, testing of indurated pellets like Tumbler-test, Reducibility, Swelling index, Reduction Degradation Index, Compressive strength etc.

UNIT- III **12 Hours**

Pelletization Equipments _ Construction and operation of Disc and Drum-Pelletizers, Different types of pellet-firing system, Shaft-furnace, Grate-system and Grate Kiln System. Uses of pellets for Iron-making.

UNIT –IV **10 Hours**

Sintering: various raw materials used for production of sinter. Preparation of fuel and flux and its effect on the process of sintering. Calculation of charge-components for producing desired quality of sinter to be used in Blast-Furnace Iron making.

UNIT- V **11 Hours**

Proportioning of Raw-materials, Primary and secondary mixing together with Moisturing, Sintering-Mineralogy, its effect on strength of sinter, Productivity of sintering M/C, Control of various parameters for improving quality of the product. Cooling, screening of sinter before use in blast furnace. Design of sintering plants and pelletisation plants.

Course Outcome:

1. Student can able to perform the Pelletization ,
2. Briquetting and sintering of ore samples to produce respective products
3. Dsicuss the importance of size enragement processes
4. Select the suitable methods for agglomerations

M.Tech (Mineral Processing) Fifth Semester

Course Title: Process Control and Automation	**Course Code:** 24MNP5C15L
Total Contact Hours: 52	**No. of Credits:** 04
Formative Assessment: 30 Marks	Exam hours: 3
Summative Assessment :70 Marks	

Objective: The objective of this course is to understand the logic systems in Mineral processing for stable operation despite heterogeneity and fluctuations of the ore and shift in specifications and market.

UNIT – I **09 Hours**

Introduction – Static performance characteristics, Dynamic characteristics – Transducer elements –Intermediate elements. Temperature – Temperature measurements, various methods – column change – softening type. Instruments on expansion concept. Resistance thermometers, Thermocouples – Radiation type pyrometers, Ionization principle – recent methods. Liquid level measurement – various types.

UNIT-II **10 Hours**

Pressure – Pressure measurement – Manometers. Elastic properties utilization – Bourdon guage – Diaphragm guage. Force balancing concept. Bellow type – vaccum guage- McLead, Pirani Ionization gauge, High pressure measurements. Electrical type instruments. Density measurements – various types.

UNIT- III **12 Hours**

Flow: Flow measurement, both weight and volumetric flow measurements. Usage of Bernoulli's principle – orifice plates, venturi, elbow flow meter, nozzle – weirs – notch rotameters, laminarflow meter, obstruction less flow meter – positive displacement type – vane type. analysis

UNIT –IV **10 Hours**

Viscosity measurements: various methods, Rheometers, Moisture and humidity measurements, various methods. Conductivity meter – pH meter. Particle size measurement using Image analysis.

UNIT- V **11 Hours**

Introduction to feed back control P, PI & PID controllers, Liquid level, mixing tank, interacting and non-interaction systems. Control of Crushing plants, wet grinding circuits, and Flotation columns: Control objectives, Disturbances, Sensing techniques, Case studies of various advanced automatic control systems for different mineral processing plants.

Course Outcome: after completion of this course student can able to

1. Handle the control and optimization tools
2. Discuss the various control devices for process parameters
3. Suggest the right control device for process control

M.Tech (Mineral Processing) Fifth Semester

Course: Modeling and Simulation of Mineral Processing Unit Operations	**Course Code:** 24MNP5C16L
Total Contact Hours: 52	**No. of Credits:** 04
Formative Assessment: 30 Marks	Exam hours : 3
Summative Assessment :70 Marks	

Objective: The prime objective of this course is to acquire the knowledge for exploiting the differences in physical properties of different minerals indifferent media in order to recover valuable minerals.

UNIT – I **09 Hours**

Introduction: Introduction to mathematical modelling, need of mathematical models, methodologies and types of mathematical models including role of simulators, types simulators and description on features of simulators available.

UNIT-II **10 Hours**

Modelling of Comminution and classification units: Modelling of size reduction units Using matrix and kinetic approaches, calculations on breakage function, selection function and classification functions. Modelling of size classifiers using partition value concepts, Application of Lynch and Rao models..

UNIT- III **12 Hours**

Modelling of Beneficiation units: Modelling of gravity separators such as jigs, heavy media separators, spirals, water-only cyclones including modern centrifugal gravity separators. Application of different models their relative merits and de-merits. Modelling flotation processes, different types of models, use RTD theorems for modelling and numerical examples.

UNIT –IV **10 Hours**

Modelling of other process: Modelling of dewatering units such as thickeners and filters. Modelling of size enlargement processes.

UNIT- V **11 Hours**

Simulation: Introduction, types of standard simulators available in the market and their features. Development of simulation of packages involving mineral characterization files, feed composition files and other data bases required for the plant flow sheet, computations. Software for the development of the flow sheet matrices; simulation of unit operations and recycle calculations. Graphic display and error traps for computer program to simulate beneficiation plant flow sheets.

References Book:

1. R.P.King; Butterwort Heinemann 2001 Modeling & simulation of Mineral Processing Systems
2. Bennette (Barrol) Particulate technology
3. PrasherGrinding Hand book

M.Tech (Mineral Processing) Fifth Semester

Course: Visit to Mineral/Metallurgical Plants	**Course Code:** 24MNP5S4P
Teaching Hours/Week (L-T-P): 0 - 0 - 4	**No. of Credits:** 04
Internal Assessment: 20 Marks	**Semester End Examination:30** Marks

Objective: The prime objective of this course is to acquire the real industrial set up for treating low grade ores and discuss the industrial practice with plant engineers

Student has to undergo plant visit as prescribed in the time table (minimum 4 industries in a semester). The industrial visit report and industrial training report has to be submitted along with dissertation for evaluation.

M.Tech (Mineral Processing) Fifth Semester

Course: Coal Preparation and Fuel Technology Lab	**Course Code:** 24MNP5C11P
Teaching Hours/Week (L-T-P): 0 - 0 - 4	**No. of Credits:** 04
Formative Assessment: 30 Marks	Exam hours : 3
Summative Assessment :70 Marks	

Objective: The objective of this course is to assess the coal quality parameters by laboratory methods

1. Sampling of coal, Study of washability curves,
2. sink and float analysis.
3. Preparation of Laboratory liquids,
4. Study of washability index.
5. Proximate analysis of coal,
6. Hard grove grindability index.
7. calorific value of coals using oxygen bomb calorimeter.
8. Study of typical Indian coal washery flow sheets.
9. Experiments on Jigging, Heavy. Media. Separation, froth flotation and oil agglomeration of coal.
10. Study of coking and non-coking coals.

Out Come: After completion of this course students are ables to

1. Perform the sampling of coal
2. Perform the bench scale beneficiation of coal
3. Perform the grinding of coal
4. Discuss the importance of coal beneficiation

M.Tech (Mineral Processing) Fifth Semester

Course: Agglomeration Lab	**Course Code:** 24MNP5C12P
Teaching Hours/Week (L-T-P): 0 - 0 - 4	**No. of Credits:** 02
Internal Assessment: 20 Marks	**Semester End Examination:30** Marks

Course Objectives: To study the size enlargement techniques for iron making

LIST OF EXPERIMENTS

- Pelletization studies: effect of size, moisture and binder concentration, drying, preheating and induration.
- Sintering of iron ores – effect of fluxes, moisture and fuel. Roast
- sintering of pyrite concentrate. Compaction by piston / roll press.
- Study of processing and development of flow sheets for Iron Ores, Manganese ores, Copper, Lead & Zinc, Bauxite, Graphite, Limestone & Dolerite, Baryte, Magnesite and Clay

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

1. discuss the importance of agglomeration techniques
2. perform the laboratory studies on pellets
3. Infer the results of agglomeration

M.Tech (Mineral Processing) Fifth Semester

Course: Modeling and Simulation of Mineral Processing Unit OperationsLab	**Course Code:** 21MNP5C13P
Teaching Hours/Week (L-T-P): 0 - 0 - 4	**No. of Credits:** 02
Internal Assessment: 20 Marks	**Semester End Examination:30** Marks

Course Objectives: To learn the simulation software (MODSIM) for Dynamic Mineral processing flowsheets and data Interpretation

Simulation Exercises using Ore Dressing Plant Simulator (e.g. MODSIM) on:
(Not less than 10 Exercises from the following)

1. Drawing Flow-sheet of Ore Dressing Plants
2. Simulation of crushing and grinding plants, Models for vibrating screens.
3. Simulation of gravity separation plants.
4. Dense medium separations - baths and cyclones.
5. Autogenous gravity separations - jigs, sluices, Riechert cones, water-only cyclones and spiral concentrators.
6. Simulation of flotation plants.
7. Models for flotation systems.
8. Comminution plants.
9. Models for SAG and FAG mills.
10. Models for ball and rod mills.
11. Models for classifiers.
12. Simulation of open and closed loop milling circuits.
13. Mineral liberation and comminution.
14. Simulation of combined comminution and concentration plants including regrinding.
15. Simulating complex plants.
16. Designing new plants.
17. Assessment of existing plants.
18. Calibration of models against plant data

Course Out Come : After Completion of theis couse student can able to

1. Ananyse the Flowsheet and do the simulation
2. Interpretation of simulation results
3. Compare the simulation results with the real values, and sugeest the changes for the mineral processing industry.

Course Title: Project Report and Viva - Voce	**Course Code:** 24MNP6CR2
Teaching Hours/Week (L-T-P): 0 - 0 - 10	**No. of Credits:** 10
Internal Assessment: ****	**Semester End Examination:250** Marks

Course Objective

1. To enhance the practical knowledge and result analysis skills.
2. To enable the students, experience a real-life problem solving under the supervision of faculty members.
3. To prepare the students perform functions that demand higher competence in national/international organizations.
4. To train the students in scientific research.
5. Develop research/ experimentation skills as well as enhancing project writing and oral presentation skills
6. Inculcate team spirit and time management.

Course Outcomes

CO1. Able to develop analytical skill.
CO2. Cultivate the understanding of problem, study design, methodology/ experimentation, significance of reproducibility of results.
CO3. Understanding of ethics of science and research for supporting higher studies.
CO4. Learn effective project organizational skills along with discussions, result interpretation and paper writing. CO5. Able to analyses the results.
CO6. Enhance the research skills.
CO7 Course Description This course will help to develop knowledge and research skills applicable to a career in environmental science.

Components for evaluation of project/dissertation and visit to Factory /Institution

Sl.No	Main Components Marks	Max Marks
1	Project Report/Dissertation (Introduction, Materials and Methods, Results and discussion, Conclusion and References)	100
2	Presentation (Clarity, understanding and Time Management)-	75
3	Viva-Voce	75
	TOTAL	250

Course Title: Industrial Training report	**Course Code:** 24MNP6C13P
Teaching Hours/Week (L-T-P): 0 - 0 - 4	**No. of Credits:** 02
Internal Assessment: ***	**Semester End Examination: 50Marks**

Course Objective

1. To train the students in scientific research.
2. Develop research/ experimentation skills as well as enhancing project writing and oral presentation skills
3. Inculcate team spirit and time management.

Course Outcomes

CO1. Able to develop analytical skill.

CO2. Cultivate the understanding of problem, study design, methodology/ experimentation, significance of reproducibility of results.

CO3. Understanding of ethics of science and research for supporting higher studies.

Components for evaluation of visit to /Industry /Factory /Institution

Sl.No	Main Components Marks	Max Marks
1	Training Report	30
2	Viva-Voce	20
	TOTAL	50