Scheme of Instruction, Evaluation

and

Syllabi of

M.E. MINING ENGINEERING
(Regular & CEEP)

With effect from Academic Year 2023-24

Estd. 1917

DEPARTMENT OF MINING ENGINEERING
UNIVERSITY COLLEGE OF ENGINEERING
(Autonomous)
Osmania University
Hyderabad – 500 007, TS, INDIA

Estd. 1929

INSTITUTION

The University College of Engineering (UCE) has the distinction of being the oldest and the biggest among the Engineering Colleges of the State of erstwhile Andhra Pradesh. Established in the year 1929, eleven years after the formation of Osmania University, it was the 6th Engineering College to be established in the whole of British India. The College moved to its present permanent building in the year 1947. Today it is the biggest among the campus colleges of Osmania University. The Golden Jubilee of the College was celebrated in 1979, the Diamond Jubilee in 1989 and the Platinum Jubilee in 2004. The College was made autonomous in 1994.
The Institute offers eight UG programmes (AI&ML, Biomedical, Civil, Computer Science, Electrical and Electronics, Electronics and Communications, Mechanical and Mining Engineering) and 22 PG programmes in various specializations. The University College of Engineering (A) is the first Engineering College to get ISO: 9001 Certification in Rank by NIRF, MHRD. The College also offers Ph.D., programmes in various areas of specialization in the various branches of Engineering. Part-time courses are also being offered at postgraduate levels.

Vision

The Vision of the institute is to generate and disseminate knowledge through harmonious blending of science, engineering and technology. To serve the society by developing a modern technology in students' heightened intellectual, cultural, ethical and humane sensitivities, fostering a scientific temper and promoting professional and technological expertise.

Mission

- To achieve excellence in Teaching and Research
- To generate, disseminate and preserve knowledge
- To enable empowerment through knowledge and information
- Advancement of knowledge in Engineering, Science and Technology
- Promote learning in free thinking and innovative environment
- Cultivate skills, attitudes to promote knowledge creation
- Rendering socially relevant technical services to the community
- To impart new skills of technology development
- To inculcate entrepreneurial talents and technology appreciation programmes
- Technology transfer and incubation

DEPARTMENT

The Department of Mining Engineering was established in 1956 at University College of Engineering, Osmania University, Hyderabad. Later, with a view to impart hands on field experience and very good exposure to the mining industry, the Department of Mining Engineering, was relocated to Kothagudem in 1978 amidst the coalfields of The Singareni Collieries Company Ltd. and rechristened as The Kothagudem School of Mines (KSM). In 1994, the Kothagudem School of Mines was handed over to Kakatiya University and is being called as UCE, KU.
The Department of Mining Engineering was re-started during 2018-19 in OUCE during Osmania University Centenary Celebrations with M.E. in Mining Engineering, Subsequently B.E in Mining Engineering was started from the academic year 2021-22. Establishment of this department is well supported by Industry and Alumni of Mining Engineers.

Vision

To be as a leading academic department on pace with global standards and contribute to the development of economic, technically viable and useful to societal problems and challenges of Mining engineering profession and also contribute to the regional and country's developmental activities.

Mission

- To produce highly competent and capable professionals to face the challenges and provide viable solutions to Mining Engineering problems
- Integration of their knowledge and skills to excel in the profession through continuous learning and contribute to the well being of the society.
- To enhance the technical knowledge, research aptitude to serve the society in highly competent manner.

Programme Educational Objectives (PEO):

PEO1: Impart basic knowledge in the field of Mining Engineering.
PEO2: Develop skills to analyse and provide viable solutions to various Mining Engineering problems.
PEO3: Enhance communication skills and encourage team work.
PEO4: Prepare Mining Engineering professionals with zeal for research, life-long learning, and work for sustainable development of society with ethics.

PROGRAM OUTCOMES (POs)

POs	Engineering Graduates will be able to:
PO1	**Engineering Knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	**Problem Analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct investigations of complex problems:** Use research based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and

	norms of the engineering practice.
PO9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Lifelong learning:** Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change.
	PROGRAM SPECIFIC OUTCOMES (PSOs)
PSO1	**Analytical Skill :** Ability to plan, execute, manage and rehabilitate Mining Engineering systems and processes
PSO2	**Entrepreneurial Skill :** Ability to become independent practitioners, consultant and entrepreneurs in the field of Mining Engineering

MAPPING OF PEO'S WITH PO'S

S.No.	PEO Statement	M1	M2	M3
PEO 1	Impart basic knowledge in the field of Mining Engineering	3	2	2
PEO 2	Develop skills to analyse and provide viable solutions to various Mining Engineering problems.	3	3	2
PEO 3	Enhance communication skills and encourage team work.	2	2	1
PEO 4	Prepare Mining Engineering professionals with zeal for research, life-long learning, and work for sustainable development of society with ethics.	3	3	3

Rubrics

1 : Weakly mapped

2 : Moderately mapped

3 : Strongly mapped

PEO	Justification and rationale of the mapping
PEO 1	Mainly focuses on imparting basic knowledge in Mining Engineering to produce highly competent and capable professionals. Accordingly, the correlations are assigned.
PEO 2	Emphasis is on training to inculcate analytical skills to design various Mining Engineering problems. Hence, the correlations are allotted.
PEO 3	Focuses on personality development, character building and to work with peers. Therefore, the correlations are justified.
PEO 4	Equip with required skills to effectively tackle the real life problems of Mining Engineering in sustainable manner. Therefore, M1 to M3 are in good agreement.

Mapping of PEOs with POs

PROGRAMME EDUCATIONAL OBJECTIVES	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
PEO-1	3				3				1	1		1	1	
PEO-2	3				3				1	1		1	1	
PEO-3	3				3				1	1		1	1	
PEO-4	3				3				1	1		1	1	
PEO-5														

DEPARTMENT OF MINING ENGINEERING, U.C.E., O.U
M. E. MINING ENGINEERING

Type of course	Course Code	Course Name	Contact hours per week		Scheme of Evaluation		Credits
			L	P	CIE	SEE	
SEMESTER-I							
Core-I	MN 101	Surface Mine Planning and Design	3		40	60	3
Core-II	MN 102	Rock Mechanics and Ground Control	3		40	60	3
Core-III	MN 103	Numerical Modelling in Mining	3		40	60	3
Program Elective-I	MN 111	Instrumentation in Mining	3		40	60	3
	MN 112	Advanced Exploration Techniques					
	MN 113	Mineral Economics and Investment					
Program Elective-II	MN 121	Advanced Metal Mining and Mechanization	3		40	60	3
	MN 122	Geo-Environmental Engineering					
	MN 123	Hydraulics and Hydraulic Equipment in Mining					
Program Elective-III	MN 131	Advanced Coal Mining and Mechanization	3		40	60	3
	MN 132	Applied Geology for Mining Engineering					
	CE 215	Models of Air and Water Quality					
Lab-I	MN 151	Applied Geology Lab for Mining Engineering	0	2	50	-	1
Seminar	MN 161	Seminar	0	2	50	-	1
		Total	**18**	**4**	**340**	**360**	**20**

Type of course	Course Code	Course Name	Contact hours per week		Scheme of Evaluation		Credits
			L	P	CIE	SEE	
SEMESTER-II							
Core-IV	MN 201	Mine Waste Management	3		40	60	3
Core-V	MN 202	Rock Excavation Engineering	3		40	60	3
Core-VI	MN 203	Rock Slope Engineering	3		40	60	3
Program Elective-IV	MN 241	Geo-Statistics	3		40	60	3
	MN 242	Mine Systems Engineering					
	MN 243	Modern Surveying Techniques					
	MN 244	Surface Mine Environmental Engineering					
Program Elective-V	CE 305	Ground Improvement Techniques	3		40	60	3
	MN 251	Reliability Engineering					
	MN 252	Finite Element Analysis					
Open Elective	OE941CE	Green Building Technology	3		40	60	3
	OE942CE	Cost Management of Engineering Projects					
	OE941ME	Operations Research					
	OE942ME	Composite Materials					
	OE943ME	Industrial Safety					
	OE941CS	Business Analytics					
	OE941LA	Intellectual Property Rights					
	OE941BM	Medical Assistive Devices					
	OE942BM	Medical Imaging Techniques					
	OE941EE	Waste to Energy					
	OE942EE	Power plant control and instrumentation					
	OE941EC	Elements of Embedded System					
	MN 162	Mini Project		4	50	-	2
Lab-II	MN 152	Computer Applications in Mining		2	50	-	1
Lab-III	CE 351	Geo-Technical Engineering Laboratory		2	50	-	1
		Total	**18**	**8**	**390**	**360**	**22**

Type of course	Course Code	Course Name	Contact hours per week		Scheme of Evaluation		Credits
			L	**P**	**CIE**	**SEE**	
SEMESTER-III							
Audit Course - I	MN 301	Engineering Research Methodology.	2		40	60	0
Audit Course - II	AC 031	English for Research Paper Writing	2		40	60	0
	AC 032	Disaster Mitigation and Management					
	AC 033	Sanskrit for Technical Knowledge					
	AC 034	Value Education					
	AC 035	Stress Management by Yoga					
	AC 036	Personality Development through Life Enhancement Skills					
	AC 037	Constitution of India					
	AC 038	Pedagogy Studies					
	MN 181	Dissertation Phase -I	-	20*	100	-	10
		Total	**4**	**20**	**180**	**120**	**10**

Type of course	Course Code	Course Name	Contact hours per week		Scheme of Evaluation		Credits
			L	**P**	**CIE**	**SEE**	
SEMESTER-IV							
	MN 182	Dissertation Phase -II	-	32*	**100**	**100**	**16**
		Grand Total	**40**	**64**	**1010**	**940**	**68**

CIE: Continuous Internal Evaluation
SEE: Semester End Examination

Note:

a. Dissertation Phase -II has two parts, CIE - I and CIE – II, at the end of 8th week and 16th week respectively for evaluation of 50 marks each.
b. Audit Courses will be offered in ONLINE/OFFLINE/HYBRID mode and SEE will be conducted in Written/Computer Based Test Mode.
c. Research Methodology and IPR will be offered as an Audit Course for all PG Programs.

* The student has to work a minimum of 20 hours/week and 32 hours/week at Dissertation Phase – I & II respectively.

SEMESTER-I

MN 101	SURFACE MINE PLANNING & DESIGN					
(CORE - I)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To introduce the various techniques for mine planning,
2	Geotechnical investigation and equipment management.
3	To appreciate the modern trends in opencast mines, safety and environment

Course Outcomes:	
On completion of this course, the student will be able to :	
CO-1	Understand mine development phases, feasibility report preparation, economic mine planning, and equipment management techniques
CO-2	Acquire skills in geotechnical investigation, slope design, and mine closure planning for safe and efficient operations
CO-3	Develop proficiency in highwall slope stability, haul road design, and drainage system planning for optimized mining operations
CO-4	Understand safety considerations, pollution control, and environmental aspects in opencast mining to ensure sustainable and safe practices
CO-5	Stay updated on advancements like in-pit crushing, continuous surface mining, and diverse extraction methods, enhancing knowledge of modern mining techniques

Unit – I

PLANNING: Mine development phases: Stages/Phases of mine life; Preliminary evaluation of surface mining prospects. Quality control and conservation. Output and manpower planning; calendar planning, mine scheduling, production scheduling, design of sumps and pumping systems and drainage.

Feasibility Report - Contents and preparation. Mine planning and its importance; Mining revenues and costs, and their estimation; Mine planning components, planning steps and planning inputs. Development of economic block model; Floating cone technique method.

Production planning: Necessity of Production Planning, new trends in Production planning, Determination of optimum mine size; Introduction to production scheduling.

EQUIPMENT MANAGEMENT: Selection of mining system vis-à-vis equipment system. Machine availability, productivity, maintenance, maintenance scheduling, preventive maintenance, control and monitoring inventory. Workshops for HEMM. Power supply arrangements in opencast mines.

Unit – II

GEOTECHNICAL PARAMETERS: Application of geotechnical investigation for design of ultimate pit slope and other design parameter, slope failure, types of slope failure, factors effecting slope failures. Selection of initial mine cuts, location of surface structures, division of mining area into blocks, mine design, bench drainage, geometry, slope stability; open pit limits and optimization, Mine Closure plan and its importance, Mine Closure plan contents.

Unit – III

ANALYSIS AND DESIGN OF HIGHWALL SLOPES AND WASTE DUMPS :
Influence of pit slope on mine economics; Highwall slope stability analysis and design methodology.
Design of haul roads: Design of road cross section; Design of road width, curves and gradient; Haul road safety features and their design. Design of drainage system.

Unit – IV

SAFETY AND ENVIRONMENT
Safety aspects in opencast mines regarding height, width and slope of benches, drilling and blasting, fly rock, nearby dwellings, mine illumination, gradient and other aspects of haul roads, formation of spoil dumps, tailings management etc. pollution due to noise, vibrations due to machinery and blasting, water pollution, measurement monitoring and control measures for the same, land reclamation and afforestation, environmental audit.

Unit –V

MODERN TRENDS IN OPENCAST MINES
Recent developments in mining methods and layouts. In pit crushing & amp; conveying, continuous surface mining.
Extraction and dumping. Extraction of seams developed/extracted by underground methods.
Placer mining and solution mining – scope of applicability, sequence of development and machinery.

Suggested Reading:

1	Surface Mine Planning by R.T Deshmukh
2	Das, S.K., Surface Mining Technology, Lovely Prakashan, Dhanbad, 1994
3	Das, S.K., Modern Coal Mining Technology, Lovely Prakashan, Dhanbad, 1994
4	Kennedy, B.A., Surface Mining – 2nd Edition, SME, New York, 1990 6. Hustrulid, W. and Kuchta, M., (eds).,
5	Cummings, A.B. and Given, I.V., SME Mining Engg. Hand book Vol.I and II, New York,1994
6	Proceedings of National Seminar on Surface Mining, IME Publications/ Calcutta, 1995
7	Fundamentals of Open Pit Mine Planning & Design, Elsevier, 1995.

MN 102	ROCK MECHANICS AND GROUND CONTROL					
	(CORE –II)					
Pre-requisites	Strength of Materials		**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To study about application of Rock Mechanics, Physico-Mechanical properties of rocks, non-destructive testing methods, time dependent properties of rocks.
2	Design of different types of underground supports, etc.
3	To study the theories of failure and approaches used for open pit and underground designs.

Course Outcomes:	
On completion of this course, the student will be able to do:	
CO-1	Understand rock properties, time-dependent behavior, and their role in structural design
CO-2	Understand stress analysis in 2D and 3D, equipping for stress distribution in structures
CO-3	Learn in-situ stress measurement and application of rock failure theories for design
CO-4	Gain skills in designing openings, managing subsidence, addressing rock burst, and ensuring slope stability
CO-5	Comprehend mine support design, including diverse methods, for safe and stable mining

Unit - I

PROPERTIES OF ROCKS

Physio-mechanical properties of rocks including tri-axial strengths and in-situ strengths, rock indices viz. drillability index, caving index, etc. Time dependent properties of rocks and their application in structural design, static and dynamic elastic constants of rocks, rock mass classification methods.

Unit - II

STRESS ANALYSIS

Stress analysis in 2D and 3D, equations of equilibrium, Mohr's Circles, plane stress and plane strain condition, stress distribution in simple structures, Flexure of beams and rectangular plates.

Unit - III
IN-SITU STRESSES AND THEORIES OF FAILURE In-situ stresses and instrumentation, measurement of stresses, strains, deformations, in-situ stress determination, Different theories of rock failure and their applications in design of mining structures.

Unit - IV
DESIGN OF UNDERGROUND OPENINGS, SUBSIDENCE, ROCK BURST AND SLOPE STABILITY Design of single and multiple underground openings, pillars including shaft pillar, scaling factors, mining subsidence, rock burst, design of slopes and spoil banks, slope stability in rock & soil.

Unit - V
DESIGN OF MINE SUPPORTS Supports in bord and pillar and longwall workings, rock load assessment, design of different types of supports like conventional and non-conventional supports like shotcrete, fibre reinforced shotcrete, strata grouting, rock bolting, supports in tunnels and shafts.

Suggested Reading:

TEXT BOOKS:	
1.	Obert, L. and Duvall, W.I., Rock Mechanics and Design of Structure in Rock John Wiley and Sons Inc., New York, 1967.
2.	Vutukuri, V.S., and Lama, R.D., Handbook on Mechanical Properties of Rocks, Vol. I, II, III and IV, Transtech Publication, Berlin, 1974/78.
3.	Peng, S.S., Ground Control, Wiley Interscience, New York, 1987.

REFERENCES:

1	Brady, B.H.G. and Brown, S.T., Rock Mechanics, Wiley Interscience, 1985.
2	Hoek, E., and Brown, S.T., Underground Excavations in Rocks, Institute of Mining Metallurgy, London, 1980.
3	Jumkis, A.R. Rock Mechanics, Transtech Publications, Berlin, 1983.
4	Stacey, T.R. and Page, C.H., Practical Handbook for Underground Rock Mechanics, Transtech Publications, Berlin, 1986.
5	Whittaker, B.N. and Reddish, D.J., Subsidence – Occurrence, Prediction and Control – Elsevier Science Publishers, the Netherlands, 1989.

MN 103	NUMERICAL MODELLING IN MINING					
(CORE- III)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To study the finite element methods and finite difference methods
2	To understand the practical applications of numerical methods in mining field

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand elastic and plastic models, apply numerical methods for stress analysis, slope stability, and pillar design in mining
CO-2	Understand finite difference concepts and their use in mining with commercial software
CO-3	Proficiency in explicit finite difference methods, their applications, and use of numerical modeling packages in mining
CO-4	Comprehend finite element methods, element stiffness assembly, and boundary conditions for structural analysis in mining
CO-5	Apply finite element methods to solve geomechanical challenges in mining, using commercial software for linear and non-linear analysis

Unit - I

INTRODUCTION TO ELASTIC AND PLASTIC MODELS PRACTICAL APPLICATIONS IN MINING

Fundamentals, elastic, plastic, homogeneous and isotropic, non-linear elastic and elastoplastic models. Need for numerical modelling in design of excavations in mines; Domain and boundary conditions; Discretisation of domain and boundary; Methods of numerical simulation for excavations in mining. Practical Applications in stress analysis, slope and dump stability, pillar design.

Unit - II

INTRODUCTION TO FINITE DIFFERENCE METHODS

Concept, formation of mesh element, finite difference patterns, solutions, application to mining. Commercial Softwares for application in mining.

Unit - III

APPLICATION OF FINITE DIFFERENCE METHODS

Explicit finite difference method; Finite difference equation; Mechanical damping, mechanical time-step determination, solution stability, advantages and their limitations. Non-linear solution methods Introduction to Numerical Modelling Packages: Strand – 7 and FLAC.

Unit - IV
INTRODUCTION TO FINITE ELEMENT METHODS Concept, discretisation, element configuration, element stiffness, Assembling elements to form a structural stiffness matrix; Imposing boundary conditions and solving structural equations Elements on assumed displacements, constant strain triangle, isoperimetric formulation

Unit - V
APPLICATION OF FINITE ELEMENT METHODS Advantages and their limitations, two and three dimensional solutions, linear and non-linear analysis, applications in geomechanics; simulation of joints in strata. Commercial Software for application in mining.

Suggested Reading:

1	Desai, C.S. and Abel, J.F., Introduction to the finite Element Method, Van Nostrand Riehokl Co., New York, 1983.
2	Zienkiewicz, O.C., The Finite Element Method in Engineering Science, Tata McGraw Hill 1972.
3	Segerlind, L.J., Applied Finite Element Analysis, John Wiley and Sons, New York, 1987.
4	Mukhopadyay, M., Matrix Finite Element – Computer and Structural Analysis, Oxford and IBH Publishing co., 1984
5	Brown, E.T., (Ed) Analytical and Computational Methods in Engineering and Rock Mechanics, Allen and Unwin, London, 1987.

MN111	INSTRUMENTATION IN MINING					
	(PROGRAM ELECTIVE – I)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To know about the various pressure instruments
2	To know about the various humidity instruments
3	To know about the various excavation instruments
4	To know about the various strata monitoring instruments

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Upon Completion of this subject, the students can able to explain different types instruments used in various mining activities
CO-2	Knowledge in various pressure instruments
CO-3	Knowledge in various humidity instruments
CO-4	Knowledge in various excavation instruments
CO-5	Knowledge in various strata monitoring instruments

Unit – I

ELECTRICAL INSTRUMENTS

Basic Concepts: Sensitivity, range, reproducibility and accuracy, drift, absolute and relative measurements, error, environmental factors and planning for instrumentation. Accuracy, precision, resolution, sensitivity, linearity, span and range-Dynamic characteristics. Ammeters (MI & MC), Volt meters, Watt meters (Dynami), Energy Meters, Megger, Earth resistance measurement and thermocouples, Inclinometers

Unit – II

PRESSURE AND FLOW MEASUREMENTS

Unit of Pressure – Manometers- Different types, - Elastic type pressure gauges and sensors– Bourdon tube – Bellows – Diaphragm – Elastic elements with LVDT and strain gauge, deformation gauge – Capacitive type pressure gauge – Measurement of vacuum – McLeod gauge – Thermal conductivity gauge – Ionisation gauge. Piezometer, Flow meters – Variable head type flow meter – Orifice plate – Venture tube – Positive displacement flow meter: Nutating disc, Reciprocating piston, oval gear and helix type flow meter – Rotameter.

Unit – III

VIBRATION, HUMIDITY, VELOCITY AND LEVEL MEASUREMENTS

Mechanical type vibration measuring instruments – Seismic instruments as an accelerometer – Vibrometers – Geo-phones. Humidity – Hot wire electro type hygrometer – Dew cell – Electrolysis type hygrometer. Anemometer, Velometer, Pitot static tube, Sound level meter, microphone, Lux meter; Level measurements: – Float gauges - Displacer type – D/P methods -Bubbler system-Load cell – Electrical types – Conductivity sensors – Capacitive sensors. Differential pressure method and Hydrastep method -Solid level measurement.

Unit – IV
INSTRUMENTATION IN EXCAVATION Introduction to various instruments in excavation, electronic and manual data generation Bore hole logging system, acoustic/ultrasonic instruments, ground penetrating radars Stress and strain, deformation, Instrumentation for performance monitoring. Field investigations for selection and design of mechanical excavators and drilling systems. Data loggers, Automated data acquisition, analysis and interpretation.

Unit – V
INSTRUMENTATION IN ROCK MECHANICS Different types of Load cells, stress capsules, Flatjack, tape extensor meters, convergence indicators and recorders, borehole deformation gauges of different types, depth indicators. Seismic measurements, Application of instrumentation in rock mechanicsin Mining**,** rock slope instrumentation.

Suggested Reading:

TEXT BOOKS:	
1.	De, N.K. and Sen, P.K. 'Electric Drives' Prentice Hall of India Private Ltd, 2002.
2.	Subramaniam, V. 'Electric Drives' Tata McGraw Hill , New Delhi,2007
3.	Dubey, G.K. 'Fundamentals of Electrical Drives' Narosa, Second Edition.
4.	Morrris, A.S. Principles of Measurement and Instrumentation, Print ice-Hall of India Pvt., Ltd. New Delhi, 1999.
5.	Doeblin, E.O. Measurement Systems Application & Design, Tata McGraw Hill Publishing Co., New. Delhi, 1999.
6.	Whittaker, B. N. and Frith, R. C. (1990): Tunneling: Design, Stability and Construction, London: Institution of Mining and Metallurgy
7.	Hoek, E and Brown, E.T. (1980):Underground Excavation in Rock, The Institution of Mining and Metallurgy, London
8.	Bieniawski, Z. T. (1984): Rock Mechanics Design in Mining and Tunneling, Balkema.
9.	John Dunnicliff Geotechnical Instrumentation for Monitoring Field Performance Lexington, Massachusetts

REFERENCES:

1	Bhattacharya, S.K., Singh, B. 'Control of Electrical Machines', New Age International Publishers,2002.
2	Bird, J. 'Electrical Circuit theory and technology' Elsevier, First Indian Edition, 2006.
3	Murthy, D.V.S. Transducers and Instrument and Instrumentation, Prentice Hall of India Pvt. Ltd. New Delhi.
4	Patranabir, D. Principle of Industrial Instrumentation, Tata McGraw Hill Publishing Co., New Delhi 1999.
5	Jain, R.K. Mechanical and Industrial Measurements, Khanna Publishing, New Delhi, 1999.
6	Liptak, B.G. Instrumentation Engineers Hand Book (Measurement), Chilton Book Co., 1994.

MN 112	ADVANCED EXPLORATION TECHNIQUES					
	(PROGRAM ELECTIVE – I)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To know the mineral resources and prospecting techniques
2	To study the physical properties of earth and application of physics in geology, to understand subsurface features and structures for better understanding of subsurface geology.
3	To study the prefeasibility and feasibility reports and its evaluation methods

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	The student will be having thorough knowledge on various geophysical and geochemical prospecting techniques.
CO-2	The students will be able to choose the proper techniques of exploration and estimation of the reserves.
CO-3	They will have knowledge of different mineral processing techniques.
CO-4	They will know about the methods of preparation of feasibility reports and its evaluation techniques.
CO-4	They will have knowledge of mineral reserve estimation and orebody modelling.

Unit – I

INTRODUCTION TO MINERAL AND MINING INDUSTRY

Introduction to mineral exploration, mineral resources in India and worldwide. National Mineral Policy, Economic Mineral Deposits, Sampling. Geological Prospecting: field survey and mapping techniques, field equipment, methods of mapping, pits and trenches. Mineral Prospecting: Exploration by Diamond Drilling. Exploration Geology, Regional Planning and Organization, Topographic Survey, Geological Mapping, Stratigraphy Correlation, Exploration Geochemistry, Field Procedure, Analytical Methods, Mineral Exploration - Triangulation, Establishment of Local Base from National Grid Base- - Exploration Strategy, Groups and their role, Strategy and structure of the exploration group, government policies Exploration investment decision, exploration targets.

Unit – II

GEO-PHYSICAL PROSPECTING

Electrical Methods: Scope of exploration geophysics – physical properties of the earth – Electrical methods – SP, IP, EM and Resistivity - methods of electrode arrangement – field methods resistivity, self-potential methods- interpretation -application in mineral prospecting – groundwater targeting, electrical logging methods in oil exploration,

Geophysical Well Logging — Fundamentals of radioactivity, principle of radioactivity, methods – types of counters – field methods and interpretation – Well logging - Self potential – resistivity – 32 radioactivity logging methods – caliper and other miscellaneous logging methods – field procedure and interpretation of data, Radioactivity Methods and Geophysical Well Logging.

Magnetic and Gravity Methods — types of magnetometer-field survey – anomaly - interpretation and prospecting. Magnetic methods – principle - field procedure – magnetometers – interpretation of magnetic data – size and shape of bodies – correction of magnetic data - applications - airborne geophysical surveys,

Gravity Methods: Principle – field methods – gravimeters – corrections – interpretation of gravity data – determination of shape and depth of ore bodies — corrections & applications – GRACE mission - gravity methods- gravimeter-identification of size and shape of bodies-correction of the data application in mineral exploration.

Seismic Methods: Seismic waves – travel velocity in various geological formations – principles – field operation – refraction and reflection survey – correction of seismic data – methods of interpretation – determination of altitude and depth of formations – various types of shooting. interpretation of seismic data- application identification of geological structures-oil fields location.

Unit – III

GEO-CHEMICAL PROSPECTING

Geochemistry of Minerals, Rocks and Waters: Mineral stability, compositional changes in minerals. River water, Seawater, Seafloor hydrothermal systems; Groundwater and Lakes. Characteristics of Magma, Melting of rocks, Water in Magmas, eutectic and melting. Distribution of trace components between rocks and melts.

Principles of Geochemistry: Introduction, Geochemistry of the Earth; Formation of the solar system and geochemical history of the earth, geochemical cycle- Distribution of elements in rocks and soils. **Geochemical Prospecting**: anomaly- background values- mobility of ions-associated elements-path finder elements-surface indicators - geobotanical methods.

Exploration Geochemistry — Introduction – Primary dispersion pattern, Secondary dispersion pattern – background values. Geochemical anomaly – geochemical sampling. Principles and techniques used in the design and implementation of an exploration geochemical survey. aquatic environment – Marine, fluvial, lacustral, aerosols. Perturbations caused by human activity.

Isotope Geochemistry: Radioactive Decay, Determining Isotope Decay time, Potassium-Argon Systematic, Uranium, Thorium - Lead Systematics. Types of Isotope Fractionation, isotope Exchange between minerals and water, Carbon, Oxygen and Sulphur isotopes, First-order decay and growth equations.

Unit – IV

GEO-STATISTICAL METHODS

Practice of semi-variogram modelling; practice of kriging - steps and procedure. Ordinary Kriging: definition, point/block estimation procedures, techniques of semi-variogram model fitting; Geo-statistical evaluation scheme; Effect of Nugget variance on kriged weights. Brief capsule on Non-linear and Non-parametric Geo-statistics: Lognormal, Disjunctive and Multi Gaussian, Indicator and Probability Kriging. Concepts of Geo-statistics; Semi-variogram: definition, derivation and characteristics and properties. Derivation and solving kriging system of equations for point and block. Geostatistical conditional simulation – Theory and approach, techniques and applications with special reference to Simulated Annealing Simulation. Relation with Co-variogram characteristics; Calculation of Experimental Semi-variograms in One, Two and Three- Dimensions calculation procedures. Computation of semi-variograms; mathematical models of semi-variogram associated difficulties (Models with Sill and without Sill, Nested Models and Trend Models.) viz. anisotropy, no stationarities, regularization, presence of nugget effect and presence of trend.; Techniques of semi-variogram model fit.

Unit – V
ORE-BODY MODELLING, ORE RESERVE ESTIMATIONAND PREPARATION OF PROJECT REPORTS **Mineral Reserve Estimation:** Reserves and Resource, classification of mineral deposits – Geological / Techno economic Considerations in Reserve Classification - Reserve Estimation Methods – Surface and Underground Deposits. **Orebody Modelling:** Integrating Surface/ Underground mapping Drilling Sampling to evolve a 3D Model - Fold/Fault Interpretation from Maps and Bore hole Data - GIS Applications in mining and Mineral Projects. **Preparation and Evaluation of Project Reports**: Evaluation of exploration and development projects, study of typical pre-feasibility and feasibility reports.

Suggested Reading:

Exploration and prospecting

1	Butterworth-Heinemann, Aspects of Ore Treatment and Mineral Recovery, , 8th Edition, 2015
2	Chaussier, J.B., and Mores, J Mineral Prospecting manual, North Oxford Academic press,1987.
3	Haldar, S. K., Mineral Exploration Principles and Applications, Elsevier,First Edition, 2013.
4	Kuzvart, M. and Bohmer, M., Prospecting and Exploration of Mineral Deposits, Elsevier Science Publishers, 1993.
5	Lahee, Field geology, CBS pub, New Delhi, 1987.
6	Moon C J., Whateley M K.G. & Evans A M., Introduction to Mineral Exploration, Blackwell Publishing, Second Edition, 2012

Geo-physics

1) Arnaud Gerkens, J. C. d'. Foundation of exploration geophysics. New York, NY, U.S.A, 1989.
2) Bhattacharjee, S., Frontiers in Exploration Geophysics Oxford and IBH Publishing Company, 1992. Burger, H.R., Exploration Geophysics of the Shallow Subsurface, Prentice Hall, 1992.
3) Butler, B.C.M and Bell, J.D, interpretation of geological maps, Longman Scientific & technical Publ.,1st ED., New Delhi, 1988.
4) Dobrin, Geophysical prospecting, McGraw hill, New Delhi ,1981.
5) Dobrin, M.B An introduction to geophysical prospecting, McGraw Hill, New Delhi,1984
6) Rama Rao, B.S and Murthy I.B.R Gravity and magnetic methods of prospecting. Arnold Heinmann Pub. New Delhi, 1978.
7) Ramachandra Rao, M.B. Outline of geophysical prospecting. Wesley press, Mysore, 1975

Geo-Chemistry

1) Arthur Brownlow, Geochemistry (Second edition), Pearson Education, INC., Australia, 1996.
2) Faure, G., Principles and applications of Geochemistry, Pearson Education, INC, Australia, 1998.
3) John V. Walther, Essentials of Geochemistry, Jones and Bartlett Publishers, 2005, Boston.
4) Mason, B., Introduction to geochemistry, John Wiley, USA, 1982.

MN 121	MINERAL ECONOMICS AND INVESTMENT					
(PROGRAM ELECTIVE – II)						
Pre-requisites	-		**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Study of estimation and valuation of mineral deposits
2	Study of project appraisal
3	Study of finance and accounting

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand minerals' economic importance, legal aspects, and their role in the Indian economy
CO-2	Understand dynamic reserve-resource concepts, learn classification systems, and acquire skills in mine sampling
CO-3	Acquire principles of mineral valuation, project evaluation, financial analysis, and cost accounting
CO-4	Gain insight into mining investment, taxation, international markets, and pricing of minerals
CO-5	Understand national mineral policies, environmental concerns, sustainability strategies, and the economic aspects of mine closure and reclamation

Unit - I

MINERALS AND THE ECONOMY

Scope and definition, Major Mineral Resource Issues, Economics of Depletable Resources, Indian Economy and the mineral Industry

MINERALS AVAILABILITY – GLOBAL VIEW

Land Resource, Mineral Resources and the Law of Sea, Secondary Supply of Minerals, Conservation of Mineral Resource

Unit - II

RESERVE-RESOURCE DYNAMICS

Definition, Dynamic Conceptual Framework for Reserves and Resource, JORC Classification System, United Nations Framework Classification, Uneconomic Occurrence, Mineral Occurrence, Concept of Marginal Reserve, Reserve Estimation Techniques.

MINE SAMPLING

Theory of Sampling, Common Methods of Sampling Selection of Sampling procedure, Size, and Spacing of Samples, Sample Preparation, Errors in Sampling

Unit - III

VALUATION OF MINERAL PROPERTIES AND PROJECT EVALUATION

Principles and Methods of Valuation, Concepts of Cash flow and Time Value of Money, Nominal and Effective Interest Rates, Inflation, Project Techniques, Discounted Cash-Flow Methods, Feasibility Study, Due Diligence.

MINE FINANCE AND ACCOUNTING

Different Source of Finance, Equity and Dept Capital, Preference Shares, Term Loans, Cost of Capital, Costing and Cost Accounting, Cost-Volume-Profit analysis, Depreciation, Amortization, Budget and Budgetary Control, Wages and Incentives.

Unit - IV

MINE INVESTMENT

Expected Investments in Indian Mining Sector, Indian Investment Policies and Incentives.

MINE TAXATION

Meaning of Taxation, Objectives of Taxation, Principles of Mines Taxation, Mining Taxation Structure, Mineral Sector Taxation Methods, Rationale for Mining Specific Taxation, Mineral Taxation in India and Abroad

MINERAL MARKETS AND TRADE

Market Structure, Market Analysis, International Mineral Study Groups, Association and Cartels, Pricing of Minerals

Unit - V

NATIONAL MINERAL POLICY

Objectives of National Mineral Policy, Elements of National Mineral Policy, Mineral Export-Import Policy of India, Mineral Policies of a few Countries, Implementation of Mineral Policy

MINERAL INDUSTRY AND THE ENVIRONMENT

Sustainability Issues, Appropriate Environment Strategies, National Conservation Strategies, Policy Statement for Abatement of Pollution, National Forest Policy, National Environmental Policy, Regulatory Reforms, Legislative Measures, Economics of Mine Closure and Reclamation

Suggested Reading:

1	Deshmukh, R.T., Mineral and Mine Economics, Mira Publications, Nagpur, 1986.
2	Gentry, D.W. and O'Neil, T.J. Mine Investment Analysis, Society for Mining, Metallurgy and Exploration, Inc., Littleton, Colorado. USA.
3	Sloan, D.A., Mine Management, Chapman and Hall, London, 1983.
4	Hartman, H.L. (Ed.). SME Mining Engineering Handbook, Vol. I, Society for Mining, Metallurgy and Exploration, Inc., Littleton, Colorado.
5	Sharma, N.L. and Sinha, R.K. Mineral Economics, Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
6	Rudawsky, O. Minerals Economics – Development and Management of Natural Resources, Vol 20, Elsevier Publications,
7	Chatterjee, K.K., Mineral Economics, Wiley Eastern, 1992.
8	Indian Minerals Year Book 2017 – MMRD Act and Mineral Concession Rules.
9	Ray, S.C. and Sinha, I.N., Mine and Mineral Economics, Kindle Edition, PHI publications.

PE 113	ADVANCED METAL MINING AND MECHANIZATION					
	(PROGRAM ELECTIVE – I)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To introduce the recent advancement of metal mine development
2	To understand the various advanced methods of metal mining

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand recent advancements in mine development techniques, including raising, winzing, and tunneling, along with techno-economic considerations
CO-2	Understand recent developments in metal mining, focusing on advanced stoping practices, deep mining, and back-filling methods
CO-3	Acquire knowledge about mechanization in metal mines, including LHD declines, hydraulic transport, modern support systems, and recent winding and transport advancements
CO-4	Explore specialized mining methods like marine mining, solution mining, and ore leaching techniques
CO-5	Understand challenges of deep mining, including rock pressure, heat, noise, and pollution, and explore solutions for efficient ore extraction

UNIT – I

ADVANCED MINE DEVELOPMENT

Recent advances in raising, winzing, development of drives, tunnels, cross- cuts, drifts, stope preparations, opening up of mineral deposit, enlargement of drives and raises, recent trends in shaft sinking. Techno economic aspects.

UNIT – II

ADVANCED METAL MINING AND STOPING PRACTICES

Recent advances in stoping practices, VCR mining, deep mining, stoping practices in rock burst prone mines, back-filling, recent developments in metal mining in India.

UNIT – III

MECHANISATION, SUPPORT SYSTEMS IN METAL MINES

Mechanisation in metal mines – LHD declines, hydraulic transport, trackless mining, modern support system used in metal mines, recent developments in winding and transport

UNIT – IV
SPECIAL MINING TECHNIQUES Marine mining methods – sea water, marine beaches, continental shelves, sea-bed sediments and polymetallic nodules, solution mining, ore leaching, in situ leaching techniques.

UNIT – V
SPECIAL PROBLEMS OF ORE MINING Special problems of deep mines – rock pressure, heat, humidity, rock burst, noise and dust pollution, deep winding and transport, etc.

Suggested Reading:

1	Cummings, A.B. and Given, I.V., SME Mining Engg. Vol.I and II,Society of Mining Engineers of American Institute of Mining, Metallurgical Petroleum Engineers, Inc., New York, 1994.
2	Hartman, H.L., Mine Ventilation and Air Conditioning, Wiley Inter Science Publication, New York, 1986
3	Peng, S.S, Ground Control, Wiley Interscience, New York, 1985
4	Underground Mining Methods Handbook, AMIE Publication, 1992
5	Karmakar, H., Mine Working, Vol. I and II, Lovely Prakashan, Dhanbad, 1995
6	Underground Mining Methods and Technology, Elsevier Science Publishers, 1990

MN 122	GEO-ENVIRONMENTAL ENGINEERING					
(PROGRAM ELECTIVE – II)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To understand the necessity and scope of safe waste disposal systems
2	To gain comprehensive understanding about the planning and design of waste disposal systems
3	To learn the analysis and design of applications of Geosynthetics in Geo-environmental applications.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Gain an understanding of waste sources, production, and classification, along with soil pollution processes and waste characterization
CO-2	Learn about waste disposal facilities like landfills, impoundments, and barrier systems, focusing on planning, design, stability, and contaminant transport
CO-3	Acquire skills in monitoring surface contamination, waste stabilization, modification, and reuse, including knowledge of contaminated site remediation
CO-4	Understand causes and factors contributing to soil erosion, and explore erosion control methods, including their applications in different contexts
CO-5	Develop insights into geosynthetics, their functions, and applications in geo-environmental engineering, focusing on capping, lining, and design requirements

Unit – I
Wastes: source, production and classification of wastes, soil pollution processes, waste characterization.

Unit - II
Waste disposal facilities such as landfills and impoundments, slurry walls, landfill planning and design. **Barrier systems** – basic concepts, design and construction, stability, compatibility and performance contaminant transformation and transport in subsurface.

Unit – III
Monitoring surface contamination, stabilization, and modification of wastes. **Reuse of waste materials**, contaminated site remediation. Case studies in waste handling.

Unit – IV
Soil erosion and conservations – causes of soil erosions, factors contributing to erosion – climatic factors, topographical factors, vegetation factors. Erosion control – cropping systems, gullies, check dams, contouring, wind striping, ridging, bank protection.

Unit – V
Application of Geosynthetics: Introduction – Classification & Functions of Geosythetics – Over view of Geotextiles, Geogrids, Geonets, Geomembranes and Geocomposites. **Geosynthetics in Geo-environmental Engineering**: Capping & Lining – Design requirements – Case studies

Suggested Reading:

1	Daniel, D. E. Geotechnical practice for waste disposal, Chapman and Hall, London 1993
2	Rowe, R. K., Quigley, R. M. and Booker, Clay barrier systems for waste disposal facilities, J.R., E & FN Spon, London, 1995
3	Reddi, L. N., and Inyang, H. F. Geo-environmental Engineering – principles and applications, Marcel Dekker, 2000.
4	Bagchi, A. Design, construction and monitoring of landfills, John Wiley & Sons, New York 1994
5	Sharma, H. D. and Lewis, S. P., Waste containment systems, Waste stabilization and landfills: Design and evaluation John Wiley & Sons, New York 1994
6	Koener, R.M. (2012), "*Designing with Geosynthetics, Vol.1 & 2,* Xlibriss Corporation LLC.

MN 123	HYDRAULICS AND HYDRAULIC EQUIPMENT IN MINING					
	(PROGRAM ELECTIVE – II)					
Pre-requisites	-		L	T	P	C
			3	-	-	3
Evaluation	SEE	60 Marks	CIE		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To provide student with knowledge on the application of hydraulic power in process, in mining and construction Industries.
2	To provide students with an understanding of the hydraulics and components utilized in modern industrial hydraulic power system.
3	To develop a measurable degree of competence in the design, construction and operation of hydraulic power circuits.
4	To impart students on the science, use and application of hydraulics in Industry. Also to impart knowledge on the methodology of basic and advanced design of hydraulics systems.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand fluid power's advantages, applications, properties, and principles, including Pascal's Law, Bernoulli's theorem, and fluid types
CO-2	Understand pumping theory, pump types, rotary actuators, and hydrostatic drives. Learn about hydraulic power packs
CO-3	Acquire knowledge about hydraulic actuators, control components, and system accessories like valves and accumulators
CO-4	Learn industrial hydraulic circuits, planning, design methodology, and the use of microprocessors in circuit design. Understand safety considerations and power pack circuits
CO-5	Develop skills in installation, maintenance, and troubleshooting of hydraulic systems. Design hydraulic circuits for various applications and understand fault finding and remedies

Unit - I

FLUID POWER PRINICIPLES

Introduction to Fluid power – Advantages and Applications – Fluid power systems – Types of fluids - Properties of fluids and selection Different types of fluids used hydraulic systems, Water base Viz. Oil in water, Water in Oil, Water Glycol; Synthetic fluids like Phosphate easter, their properties, merits demerits and suitability.– Basics of Hydraulics – Pascal's Law – Principles of flow - Friction loss – Work, Power and Torque Problems, Sources of Hydraulic power. Fluid Power ANSI Symbols, Bernoulli's theorem and its applications, Laminar and turbulent flows and their applications.

Unit - II
POWER GENERATING ELEMENTS Pumping Theory – Pump Classification – Construction, Working, Design, Advantages, Disadvantages, Properties, Characteristics and Performance, specifications, Selection criteria of Linear and Rotary – Fixed and Variable displacement pumps – Problems. Rotary Actuators – selection, specification and characteristics, Hydrostatic drives, types, selection. Hydraulic power packs.

Unit - III
CYLINDERS, COMPONENTS AND ACCESSORIES Hydraulic Actuators: Cylinders – Types and construction, Application, Hydraulic cushioning – Hydraulic motors - Control Components : Direction Control, Flow control and pressure control valves – Types, Construction and Operation – Servo and Proportional valves – Applications – Accessories : Reservoirs, Pressure Switches – Applications — Accumulators, Intensifiers, Problems.

Unit – IV
HYDRAULIC CIRCUITS AND SYSTEMS Industrial hydraulic circuits – Regenerative, Pump Unloading, Double Pump, Pressure Intensifier, Air-over oil, Sequence, Reciprocation, Fail-Safe, Speed Control, Hydrostatic transmission, Electro hydraulic circuits. Reciprocation, quick return, sequencing, synchronizing circuits - accumulator circuits – industrial circuits - planning, copying, - Power pack circuits, Drilling machines, powered supports, shearer, continuous miner, road headers, drilling machine, forklift, earth mover (shovels, rippers, graders, etc.) circuits design methodology- design and selection of components - safety and emergency mandrels – Cascade method. Use of relays, counters, timers, ladder diagrams, use of microprocessor in circuit design.

Unit - V
TROUBLE SHOOTING AND APPLICATIONS: Installation, Selection, Maintenance, Trouble Shooting and Remedies in Hydraulic Design of hydraulic circuits for Drilling machines, powered supports, shearer, continuous miner, road headers, drilling machine, forklift, earth mover (shovels, rippers, graders, etc.) applications. Fault finding– application -fault finding - hydro circuits.

Suggested Reading:

TEXT BOOKS:	
1.	Anthony Esposito, “Fluid Power with Applications”, Prentice Hall, 2009.
2.	James A. Sullivan, “Fluid Power Theory and Applications”, Fourth Edition, Prentice Hall, 1997.

REFERENCES:

1	Majumdar, S.R., “Oil Hydraulics Systems – Principles and Maintenance”, Tata McGRaw Hill, 2001.
2	Dudley, A. Pease and John J Pippenger, “Basic Fluid Power”, Prentice Hall, 1987
3	Jagadeesha T, “Pneumatics Concepts, Design and Applications “, Universities Press, 2015.
4	Bolton. W., “Pneumatic and Hydraulic Systems “, Butterworth –Heinemann, 1997.

PE 131	ADVANCED COAL MINING AND MECHANIZATION					
	(PROGRAM ELECTIVE – III)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To introduce the recent trends of level of mechanisation for coal face
2	To understand the various advanced methods of coal mining

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand recent trends and case studies in mechanized bord and pillar mining, enabling effective coal extraction
CO-2	Explore methods and experiences in mining thick, contiguous, and steep coal seams, considering challenges and Indian practices
CO-3	Gain insight into hydraulic mining applicability, equipment, layouts. Understand computer applications in remote control and environmental monitoring
CO-4	Acquire knowledge about powered supports, their types, designs, and selection. Learn about remotely operated powered supports, longwall face salvaging.
CO-5	Understand coal gasification methods, plant design, and environmental monitoring, along with computer applications. Explore coal bed methane extraction techniques

Unit – I
COAL FACE MECHANISATION Recent Trends, mechanised bord and pillar mining, case studies.

Unit - II
MINING OF THICK SEAMS Problems, past experiences in India, current methods, mining of thick, contiguous, and steep seams

Unit – III
HYDRAULIC MINING Applicability, operating parameters, equipment, layouts, Indian experience. Computer applications such as remote control and environmental monitoring in hydraulic mining.

Unit – IV
LONGWALL MINING Powered supports, development of powered supports, their types and designs, selection for different conditions, last drivages for longwall panelling, remotely operated powered support and longwall faces, Indian experiments, salvaging in longwall.

Unit – V
UNDERGROUND COAL GASSIFICATION Scope, application, methods of gasification, design of gasification plants, coal bed methane. Environmental monitoring techniques and computer applications in coal gasification techniques.

Suggested Reading:

1	Das S.K., Modern Coal Mining Technology, Lovely Prakashan, Dhanbad, 1994
2	Singh, T.N., and Dhar, B.B. Thick Seam Mining, Problems and Issues, Oxford & IBH Publishers, 1992
3	Mathur, S.P., Mining Planning for Coal, M G Consultants, Bilaspur, 1993
4	Peng S.S. and Chiang, H.S., Longwall Mining, John Willey and Sons, New York, 1992
5	T.N. Singh, Underground Winning of Coal, Oxford IBH Publishers, 1999
6	R.D. Singh, Principles and Practices of Modern Coal Mining, New Age International, 1997 .

MN 132	APPLIED GEOLOGY FOR MINING ENGINEERING					
(PROGRAM ELECTIVE – II)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Introducing application-oriented concepts of geology to mining engineers.
2	Offering an understanding of the geology-related aspects of the mining industry to mining engineers.
3	Developing expertise in dealing the mineral exploration and extraction-related issues
4	Imparting technical knowledge to mining engineer's to communicate with the mining geologist effectively.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	to appreciate the need for geological exploration to initiate the mining operations
CO-2	to have insight into the various methods of mineral exploration
CO-3	to gain knowledge of hydrogeological aspects influencing the mining operations
CO-4	to understand the impact of mining operations on the environment and society
CO-5	to gain expertise to maximize the mining output while ensuring safety

Unit – I

1. Basics of Mineral Exploration

Mineral Exploration: Definition and objectives of mineral exploration; Prospecting and exploration – concepts and methods; surface and subsurface surveys; Detailed to regional-scale geological mapping; exploration strategy and design; stages of exploration;

Data Management: Data accumulation and analysis; Generation of Maps; Mineral system analysis and ore body modeling; Mineral resource and reserve classification;

Unit - II

2. Mineral Exploration Methods

Geochemical Prospecting for metallic minerals: Abundance of elements in earth materials**;** Distribution and migration of elements-Dispersion, mobility, weathering; Geochemical anomalies; Pathfinder elements; Secondary Cycle; Geochemical field sampling layout &techniques; Geochemical analytical methods

Geophysical Methods: Geophysical applications to regional/geologic mapping; Geophysical applications by (metal) deposit type; Introduction to magnetic, seismic, gravimetric, electrical, and radiometric methods; Recent geophysical developments

Unit – III

3. Mining Hydrogeology

Hydrogeology: Hydrologic cycle, water table, aquifers, the occurrence of groundwater in various lithological formations, groundwater movement, springs, groundwater exploration, and groundwater provinces of India

Groundwater seepage: Analysis of Impact; Mine dewatering; Contamination of soil and water; Indian case studies

Unit – IV

4. Environmental Geology

Impact of Mining Operations: Mining and environmental problem; Deforestation and loss of biodiversity, Overburden, Soil Pollution, Water Pollution, Air Pollution, Acid Mine Drainage; Social impacts; Public health and safety;

Environmental Impact Assessment: Environmental regulations for mining activities in India; States of EIA: (i) Identification,(ii) Screening, (iii) Scoping and consideration of alternatives, (iv)Impact prediction, (v) Mitigation, (vi) Reporting to decision making, (vii) Public hearing, (viii) Review; Environmental management and monitoring plans

Mine Closure & Reclamation: Closure of mine and rehabilitation; Guidelines for the preparation of Mine Closure Plan in India

Unit – V

5. Geo-hazards

Seismic Hazards: Mine-induced seismicity; Impact of earthquakes on mining operations

Mine Flooding: Flooding due to groundwater seepage; flooding due to surface runoff; Impact of flooding on mine operations; flood forecast system

Land Slides and Subsidence: Landslide vulnerability of mines; slope failure in mines and quarries; strata failure in underground mines; Mine subsidence

Suggested Reading:

ESSENTIAL READING

1	Haldar, S. K. (2018). Mineral exploration: principles and applications. Elsevier.
2	Arogyaswamy, R. N. P. Courses in mining geology. Oxford and IBH, 1980.
3	Deb, Pradipta Kumar. An Introduction to mine hydrogeology. Springer International Publishing, 2014.
4	Knödel, Klaus, Gerhard Lange, and Hans-Jürgen Voigt. Environmental geology: handbook of field methods and case studies. Springer Science & Business Media, 2007.
5	Molinda, Gregory M. Geologic hazards and roof stability in coal mines. No. 9466. US Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, Pittsburgh Research Laboratory, 2003.

SUPPLEMENTARY READING

1. Marjoribanks, Roger. Geological methods in mineral exploration and mining. Springer Science & Business Media, 2010.
2. Bobrowsky, Peter T., and Brian Marker, eds. Encyclopedia of engineering geology. Berlin: Springer, 2018.
3. Jain, Ravi. Environmental impact of mining and mineral processing: management, monitoring, and auditing strategies. Butterworth-Heinemann, 2015.
4. Wolkersdorfer, Christian. Water management at abandoned flooded underground mines: fundamentals, tracer tests, modelling, water treatment. Springer Science & Business Media, 2008.
5. Glazer, S. N. Mine seismology: seismic warning concept. SPRINGER INTERNATIONAL PU, 2018.
6. Sengupta, Mritunjoy. Environmental impacts of mining: Monitoring, restoration and control. CRC Press, 2021.

CE 215	**MODELS OF AIR AND WATER QUALITY**					
(PROGRAM SPECIFIC ELECTIVE – III)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Description of the concepts of water and air pollution
2	Exposure to the principles of modeling and their application to water bodies
3	An overview regarding reservoir sedimentation

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand water pollutants, their sources, and stream self-purification
CO-2	Acquire concepts of BOD measurement, Streeter-Phelps equation, and DO Sag curve analysis
CO-3	Understand water quality models, including mass balance, phosphorus, and sedimentation control
CO-4	Comprehend air pollutants, their effects, dispersion, and atmospheric stability
CO-5	Explore Gaussian plume modeling, ground-level concentrations, and plume rise estimation

Unit – I
Introduction: Water pollutants and their sources Stream sampling – hydrological factors affecting the stream self – purification. Steady state conservative system, steady state with non-conservative pollutants.

Unit – II
Stream pollution modeling concepts: Measurement of BOD – Streeter Phelp's equation – Effect of temperature on BOD, Kinetic reaction rate – Stream re-aeration. Analysis of DO Sag curve by Streeter – Phelps equation method, statistical method.

Unit – III
Water Quality of Lakes and Reservoirs: Mass balance model, Phosphorus model, Thermal stratification, Eutrophication of lakes. Reservoir sedimentation: Determination of sediment yield, measurement of suspended load, Bed load estimation by empirical methods, control of sedimentation.

Unit – IV
Air Pollution: Sources and effects, scales of concentration, classification and properties of air pollutants effects of air pollution and air pollution standards, dispersion of air pollutants. Meteorological aspects of air pollution and atmospheric stability

Unit – V
Plume behavior, modeling of air pollution: Gaussian plume model – determination of maximum ground level concentration due to elevated source pollutants. Limitations of Gaussian model, effective stack height concept and estimation of plume rise**.**

Suggested Reading:

1	Keily Gerard (1998), 'Environmental Engineering' McGraw-Hill International Publishers, London.
2	Fischer, H.B., E. John List, Robert C.Y. Koh, JorgImberger, and Norman H. Brooks(1979), 'Mixing in Inland and Coastal Waters' Academic Press Inc., New York.
3	Nelson Leonard Nemerow (1974), 'Scientific Stream Pollution Analysis' McGraw-Hill Publishers.
4	Wurbs, R. A. and James, W.P.(2002), 'Water Resources Engineering', Prentice-Hall of India, New Delhi.
5	Graf, W.H. (1971), 'Hydraulics of Sediment Transport', McGraw-Hill Book company, New York.
6	Yalin, M.S. (1997), 'Mechanics of Sediment Transport', Pergaman Press, Oxford.

MN 151	Applied Geology Lab for Mining Engineering					
Lab–I						
Pre-requisites	-		L	T	P	C
			-	-	2	1
Evaluation	SEE	-	CIE	25		

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Identification and familiarizing properties of minerals, rocks, and ores
2	Interpreting and solving geological maps and structural geology problems
3	Understanding of distribution of various mineral resources and their quantification

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	to identify various metallic and non-metallic rock and ore-forming minerals, and major rocks
CO-2	to gain knowledge to interpret various geological maps pertaining to the mining industry requirements
CO-3	to have the expertise for maximizing the mine output
CO-4	to calculate the carbon footprint of mining operations
CO-5	to plan for environmental monitoring of various mining operations

Experiment - I

Study of minerals and rocks in hand specimens:

1. Major metallic and non-metallic minerals of India and their distribution
2. Igneous, metamorphic and sedimentary rocks and associated minerals

Experiment - II

Study of primary and secondary structures

3. Effects of structural discontinuities on strata/orebodies and their importance in mining operations

Experiment - III

Study the maps

1. Geological map of AP-TS
2. Hydrogeological map of AP-TS
3. Mineral province of AP-TS

Experiment - IV

Quantitative mapping

1. Assessment of the carbon footprint of mining operations

Experiment - V

Geo-Environmental (instrumentation)

Analysis of water pH, EC-TDS

1. Monitoring of air pollution-introduction
2. Soil sampling

Field-based study

3. Geophysical methods for bedrock investigations, delineation of geological structures, and mineral investigations
4. Visit to open and underground mine

Suggested Reading :

1	Bradley Deline, Randa Harris, and Karen Tefend, Laboratory Manual for Introductory Geology, University of North Georgia Press 2015
2	N. Chenna Kesavulu Engineering Geology Lab Record / Manual, Trinity Press, 2016

MN 161	SEMINAR					
Pre-requisites	-		**L**	**T**	**P**	**C**
			-	-	2	1
Evaluation	**SEE**	-	**CIE**	50 Marks		

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Identify appropriate topic of relevance.
2	Update literature on technical articles of selected topic and develop comprehension.
3	Prepare a technical report.
4	Deliver presentation on specified technical topic.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Review literature on technical articles and develop comprehension.
CO-2	Recognize appropriate topic of relevance
CO-3	Prepare review repot of literature studied
CO-4	Write a technical report.
CO-5	Give presentation on specified technical topic

At least two faculty members will be associated with the seminar presentation to evaluate and award marks.

SEMESTER – II

MN 201	MINE WASTE MANAGEMENT					
	(CORE-IV)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	The course underlines the Philosophy of mine waste disposal, land form design & rehabilitation.
2	It gives an overview of Indian & international regulations pertaining to mine waste disposal.
3	Can learn Physical & chemical nature of mine wastes; disposal of mine wastes; geomechanics of mine waste disposal & rehabilitation; rehabilitation of mine wastes; risk assessment & remedial measures.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand mine waste properties and their environmental risks
CO-2	Learn about slurry, paste disposal methods, and pump selection
CO-3	Explore tailings filtration, stacking, and value-added products
CO-4	Acquire insights into tailing pond design and failure analysis
CO-5	Study tailing dam failures, deficiencies in waste disposal, and regulatory aspects

UNIT I
Physical, chemical, and biological characteristics of mine wastes including waste rock, mineral processing wastes (tailings) and wastewater. Environmental hazards of waste generated in mining and mineral processing industries.

UNIT II
Mine waste disposal and rehabilitation approaches, Waste disposal in slurry form into tailing ponds. Principles of Slurry Rheology. Selection of pumps and type of pumps used for slurry transportation to tailing ponds. Paste thickening of tailings and disposal in the form of paste. Paste Characteristics & Rheology. Thickeners & pumps used for paste pumping.

UNIT III
Tailings filtration and disposal in solid form. Filtration processes and equipment. Characteristics of filtered tailings. Transportation and stacking issues of filtered tailings. Alternate use of mining waste by generating value added products.

UNIT IV
Current practices in mining waste utilization – Waste to Wealth concepts. Geomechanics principles in the disposal of mining and mineral processing waste (tailings). Tailing pond design & failure analysis.

UNIT V
Case study: Tailing dam failures: Causes, impact on environment, society and businesses at large. Deficiencies of conventional mine waste disposal and rehabilitation approaches. National and International regulatory regimes pertaining to waste disposal in mining and mineral processing industries.

Suggested Reading:

1	Mine Wastes, Characterization, Treatment and Environmental Impacts, Bernd Lottermoser, 2010.
2	Mine Waste Management – California Mining Association, CRC Press; 1st edition (21 February 1992).
3	Mine Waste Management in China: Recent Development, Author - Di Wu, 2020
4	Mine Waste Utilization By Ram Chandar Karra, Gayana B C, Shubhananda Rao P, Published July 4, 2022 by CRC Press Copyright Year 2022.

MN 202	ROCK EXCAVATION ENGINEERING					
	(CORE-V)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To understand the rock mechanics, rock cutting technology, rock cutting tools and rock excavating machine.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand concepts, historical developments, factors affecting rock fragmentation, and relevant rock properties for excavation
CO-2	Understand rock properties' impact on machining, including strengths, index tests, and elasticity, in the context of rock fragmentation
CO-3	Learn about drilling mechanisms, rock machining mechanics, and evaluation methods for rock drillability and cuttability
CO-4	Acquire knowledge about rock cutting tools, their materials, wear, operational parameters, and interactions in excavation machinery
CO-5	Explore principles, operation, and technical aspects of various excavating machines, along with recent developments in rock excavation machinery

Unit – I

INTRODUCTION

Concepts, historical developments in rock excavation, systems, factors affecting the rock fragmentation, mechanism of rock breakage and fracture; their application to rock fragmentation methods for rock fragmentation – explosive action, cutting, ripping and impacts. Physico-mechanical and geotechnical properties of rocks useful for rock excavation. Rock breaking processes: Primary, Secondary and Tertiary, Energy consumption computations.

Unit – II

ROCK MECHANICS

Rock properties related to machining process; application of compressive, tensile and multiaxial strengths, index tests and abrasivity, anisotropy, elasticity, porosity, laminations, bedding and jointing in rock fragmentation process.

Unit – III
ROCK CUTTING TECHNOLOGY Mechanism of drilling – rotary, percussive, rotary, rotary percussive, mechanics of rock machining, theory of single tool rock cutting, crack initiation and propagation, rock excavation by cutting action – picks, discs, roller cutters water jet cutting, methods of evaluation of drillability and cuttability of rocks. Evaluation of drill performance; mechanism of bit wear; bit selection; economics of drilling.

Unit – IV
ROCK CUTTING TOOLS Rock cutting tool materials, different types, relative applications and their choice, tool shape and size, specific energy consumption, tool wear, effect of operational parameters on tool performance, maintenance and replacement of cutting tools of excavating machines. Theories of rock tool interaction for surface excavation machinery rippers, dozers, scrapers, BWE, continuous surface miners, auger drills; theories of ploughs, shearers.

Unit –V
ROCK EXCAVATING MACHINES Excavating machines, principles, operation, applicability and technical indices of road headers, TBM'S coalface machines and bucket wheel excavators. Recent Developments in rock excavation machinery.

Suggested Reading:

1	Cummings, A.B. and Given, I.V., SME Mining Engg. Vol. I and II, Society of Mining Engineers, America, 1992.
2	Hartman, H.L., Introductory Mining Engineering, John Wiley and Sons, New York, 1987.
3	Chugh, C.P., Diamond Drilling, Oxford-IBH, 1984.
4	Clark, G.B., Principles of Rock Fragmentation, John Wiley and Sons, New York, 1987
5	Douglas Thorby "Structural Dynamics and Vibration in Practice", 1st edition 2008 Butterworth-Heinemann is an imprint of Elsevier

MN 203	ROCK SLOPE ENGINEERING					
(CORE-VI)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To introduce the basic mechanics of rock slope failures
2	To learn the types of rock failure and its influencing parameters

Course Outcomes :	
On completion of this course, the student will be able to do :	
CO-1	Understand rock slope stability, factors causing failure, rock fall analysis, and groundwater influence
CO-2	Understand geological parameters' impact on slope stability, including discontinuities, shear strength determination, and data analysis
CO-3	Learn site investigation, data collection, preliminary and detailed slope design, considering groundwater and geological factors
CO-4	Explore conditions, analysis, and groundwater's role in plane, wedge, circular, and toppling failure scenarios
CO-5	Acquire knowledge of monitoring methods, regulations, and stabilization techniques, including reinforcement, rock removal, and fall control

Unit - I

Basic Mechanics of Rock Slope Failure: Rock Slope Geometry, slope stability, factor of safety of slopes. Causes of rock falls. Analysis of Rock fall hazard, Slope height Vs Slope angle; design of slope economics. Ground water flow in rock masses; field measurement of permeability; measurement of water pressure.

Unit - II

Geological and Rock Strength Properties: Geological parameters & Physico-mechanical properties affecting slope stability, types of discontinuity, graphical representation of geological data; plotting and analysis of field measurements; determination of shear strength of rock and rock discontinuities.

Unit - III
Geological survey and Slope design: Site investigation and geological data collection, Reconnaissance, geological survey data sheet, Route selection/preliminary pit slope design, Various parameters for slope design. Detailed investigations, investigation for rock slope design : geology, rock strength and ground water, geologic mapping, detailed slope stability studies, role of ground water in slope engineering, slope dewatering, ground water in rock slopes, the hydrologic cycle, hydraulic conductivity and flow nets.

Unit - IV
Plane Failure and Wedge Failure: Conditions for Plane Failure and Wedge failure. Plane failure & wedge failure analysis. Influence of ground water & tension crack on stability; Numerical problems on Plane & Wedge failure. **Circular and Toppling Failure:** Conditions for Circular & Toppling failure; Circular failure & Toppling failure analysis. Influence of ground water & tension crack on stability; Numerical problems on Circular & Toppling failure.

Unit - V
Rock Slope Monitoring and Slope Stabilization: Strata monitoring in opencast mines. Surface and Sub-surface monitoring methods in opencast mines including instrumentation and techniques. Regulations & guidelines for slope monitoring. Rock slope stabilization programs – stabilization by rock reinforcement & rock removal; Protection of slopes; control of rock falls.

Suggested Reading:

1	Duncan C.Wylie and Chris Mah, Rock Slope Engineering, 4th Edition, 4th Edition, CRC Press,456p, 2004.
2	John Read and Peter Stacey, Guidelines for Open Pit Slope Design, 1st Edition, CRC Press,510p, 2009.
3	William A. Hustrulid (Ed), Michael K. McCarter (Ed) and Dirk J. A. Van Zyl (Ed), Slope stability in Surface Mining, Society for Mining, Metallurgy, and Exploration, 442p, 2001.
4	John Jaeger, N. G. Cook and Robert Zimmerman, Fundamentals of Rock Mechanics, 4th Edition, Wiley-Blackwell; 4th edition, 488p, 2007.

MN 241	**GEO-STATISTICS**					
(PROGRAM ELECTIVE – IV)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To study various Geo-statistics techniques and their applications to mineral industry
2	To study various Variogram Analysis
3	To study about Estimation by Ordinary Kriging

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand probability, measures of central tendency, dispersion, correlations, and exploratory data analysis
CO-2	Understand geostatistics concepts, theory, schools of thought, and applications in mineral industry
CO-3	Learn variogram characteristics, modeling, cross-validation, and applications in irregular data
CO-4	Acquire knowledge of Kriging methods, ordinary Kriging, block estimation, and resource categorization
CO-5	Apply geostatistics in drilling, grade control, resource modeling, and showcase 3D modeling using software

Unit – I

Basic Statistics

Probability, Random Variables, Measures of Central Tendency, Measures of Dispersion, Histograms, Correlations, Regressions and Exploratory Data Analysis, Moments, Matrices.

Unit – II

Introduction to Geostatistics

Origin of Geostatistics, Pre requisites, Concepts of Geostatistics and theory of Regionalized Variable, Geostatistical Schools of Thought, viz. American, South African and French; Condition of Stationarity. Overview of Deterministic and Probabilistic models of Estimation; what, when and why of geo-statistics. Difference between Classical statistics and Geostatistics, Applications of Geostatistics in Mineral Industry, Work flow of Geostatistics.

Unit – III

Structural Analysis (Variogram Analysis)

Concepts of Semi-variogram: Definition and Characteristics. Experimental Variogram Parameters. Calculation of Experimental Semi-variograms in One, Two and Three-Dimensions. Variograms in regular and irregular data. Calculation of Variogram Cloud.

Concept of Regularization of borehole data, Omni directional variogram.
Concepts of Variogram Modelling: Need of variogram modelling, modelling Parameters nugget, range and sill. Techniques of semi-variogram model fit. Computation of Variogram Models. Variogram Modelling aspects viz., Nested Models, Anisotropy, Presence of Nugget Effect and Presence of Trend. Cross Validation of Variogram Model.

Unit – IV

Estimation by Ordinary Kriging

Comparison of Conventional Estimation and Geostatistical Estimation Methods – An Over view; Concepts of Kriging, Ordinary Kriging: Definition, Steps and Procedure, Point Kriging, Block Kriging Estimation Procedures, Screen Effect.
Block Discretisation, Block Variance, Extension Variance, Estimation Variance and Dispersion Variance; Kriging Variance and Kriging Efficiency. Neighbourhood Analysis.

Evaluation of Resources and Reserves of a mineral deposit, Local and Global Reserves. Categorization of Mineral Resources.

Brief capsule on Non-linear and Non-parametric Geo-statistics and Conditional Simulation

Unit – V

GEO-STATISTICAL APPLICATIONS:

Optimisation of exploration drilling, Grade-Tonnage Relations, Geo-statistical grade control plan.
Practical applications of Geo-statistics in resource modelling of a mineral deposit. Geo-statistical Case Studies of selected mineral deposits. Demonstration of a Case Study showing 3D Geological / Orebody Modelling and Resource Estimation using Surpac mine planning software.

Suggested Reading:

1	Isobel Clarke. Practical Geostatistics, 2001
2	Sarma, D.D. Geostatistics with Applications in Earth Sciences, Springer Publications, 2009.
3	Journel, A.G. and Huijbregts, Ch. J., Mining Geostatistics, Academic Press, 1981.
4	Andereson, F. Geostatictics by Example Approach using R.

MN 242	MINE SYSTEMS ENGINEERING					
(PROGRAM ELECTIVE – IV)						
Pre-requisites	-		**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To know basic of system engineering concept and analysis
2	To study the various techniques of operations research, simulation and network analysis

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand systems analysis concepts, models, and tools
CO-2	Learn linear programming basics and its application in the mineral industry
CO-3	Master Monte Carlo sampling, deterministic simulation, and their application in mining subsystems
CO-4	Grasp CPM and PERT for project monitoring and control in mining
CO-5	Gain insight into mineral resource inventory, optimization models, statistical decision theory, and their applications

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	3	-	1	1	-	-

Unit – I
INTRODUCTION Introduction to systems engineering, systems concept and analysis, models in systems analysis, tools and methodology of system analysis.

Unit – II
OPERATIONS RESEARCH Introduction to operations research, introduction to linear programming, application to mineral industry.

Unit – III
SIMULATION TECHNIQUES Introduction to Monto-carlo sampling and deterministic simulation of different mining subsystems and total system, simulation application for equipment selection and production scheduling.

Unit – IV
NETWORK ANALYSIS Network analysis, monitoring and control of developmental activities in mining project by CPM and PERT.

Unit –V
MISCELLANEOUS Inventory of mineral resources, basic models and optimisation, introduction to statistical decision theory and its application in mineral industry.

Suggested Reading:

1	Syal, I.C., and Gupta, B.P., Computer Programming and Engineering Analysis, A.B., Wheeler and Company, Madras 1986.
2	Anon., Management by Network Analysis, The Institution of Engineers (India), 1976.
3	Rao, S.S., Finite Element Methods in Engineering, Pergamon Press, 1982.
4	Cummings, A.B., and Given I.V. SME Mining Engg., Handbook Vol I and II, SME-41 ME, Inc, New York, 1973.

MN 243	MODERN SURVEYING TECHNIQUES					
(PROGRAM ELECTIVE – IV)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to	
1	To understand the working of Total Station equipment and solve the surveying problems.
2	To introduce the concepts of Space Borne, Air Borne and Terrestrial LASER
3	Scanners for Topographic Mapping

Course Outcomes : (5)	
On completion of this course, the student will be able to :	
CO-1	Understand total station principles, electromagnetic waves, and their applications in land surveying and mine surveying
CO-2	Learn about GPS and satellite systems, methods, accuracy, and applications in surveying
CO-3	Grasp mine surveying techniques, equipment, cadastral survey principles, and mapping software use
CO-4	Understand airborne laser scanner components, ranging principles, and applications in topographic surveying
CO-5	Explore the merits of airborne laser scanners compared to other surveying methods and technologies

Unit – I

FUNDAMENTALS OF TOTAL STATION AND ELECTROMAGNETIC WAVES

Types and working principles of Machines, Methods of Measuring Distance, Basic Principles of Total Station, Historical Development, Classifications, applications and comparison with conventional surveying. Classification - applications of Electromagnetic waves, Propagation properties, wave propagation at lower and higher frequencies- Refractive index (RI) - factors affecting RI. Care and Maintenance of total stations.

Electro-optical system: working principle, Sources of Error, Infrared and Laser Total Station instruments. COGO functions, offsets and stake out-land survey applications.

Unit - II

SATELLITE, GPS SYSTEM and data processing

Basic concepts of GPS, GNSS, IRNSS and GAGAN - Different segments - space, control and user segments - satellite configuration – GPS signal structure, Anti Spoofing and Selective Availability - GPS receivers. Concepts of rapid, static methods with GPS - semi Kinematic and pure Kinematic methods -satellite geometry & accuracy measures - applications.

Unit - III
MINE AND CADASTRAL SURVEYING Reconnaissance – Route surveys for highways, railways and tunnels –Mine surveying Equipment – Weisbach triangle – Tunnel alignment and setting out – Transfer of azimuth – Gyro Theodolite – Shafts and audits - Cadastral survey- Legal – Real – Tax cadastre – Land record system – Settlement procedure – deformation studies. Mine plan preparation - mapping process - use of mapping softwares, VAVIks mapping. Route surveys of water ways, Hydrographic survey Tides – MSL – Sounding methods – Three point problem – River surveys – Measurement of current and discharge.

Unit - IV
AIRBORNE LASER SCANNERS Airborne Topographic Laser Scanner – Ranging Principle – Pulse Laser and Continuous Wave Laser – First Return and Last Return – Ellipsoidal and Geoidal Height - Typical parameters of a Airborne Laser Scanner (ALS) – Specifications of Commercial ALS –- Components of ALS - GPS, IMU, LASER Scanner, Imaging Device, Hardware and Software. Merits of ALS in comparison to Levelling, echo sounding, GPS levelling, Photogrammetry and Interferometry.

Unit - V
AIRBORNE LASER SCANNERS Airborne Topographic Laser Scanner – Ranging Principle – Pulse Laser and Continuous Wave Laser – First Return and Last Return – Ellipsoidal and Geoidal Height - Typical parameters of a Airborne Laser Scanner (ALS) – Specifications of Commercial ALS –- Components of ALS - GPS, IMU, LASER Scanner, Imaging Device, Hardware and Software. Merits of ALS in comparison to Levelling, echo sounding, GPS levelling, Photogrammetry and Interferometry

Suggested Reading:

TEXTBOOKS:
1) Satheesh Gopi, Rasathishkumar, N.Madhu, – Advanced Surveying, Total Station GPS and Remote Sensing – Pearson education, 2007 ISBN: 978-81317 00679 52.
2) Alfred Leick, GPS satellite surveying, John Wiley & Sons Inc., 3rd Edition, 2004.
3) Jie Shan and Charles K. Toth, Topographic Laser Ranging and Scanning – Principles and Processing, CRC Press, Taylor & Francis Group, 2009.

1	Rueger, J.M. Electronic Distance Measurement, Springer-Verlag, Berlin, 1996.
2	Michael Renslow, Manual of Airborne Topographic LiDAR, The American Society for Photogrammetry and Remote Sensing, 2013.
3	R.Subramanian, Surveying and Levelling, Oxford University Press, Second Edition, 2012.

MN 244	SURFACE MINE ENVIRONMENTAL ENGINEERING					
(PROGRAM ELECTIVE – IV)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To study the physics of mechanical ventilators and the parameters governing their performance.
2	To study various methods of ventilation data collection.
3	To study about mine illumination, pollution and ecological systems

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand the goals and strategies of environmental management in mining
CO-2	Identify and assess various pollutants in mining, including air, water, noise, and dust
CO-3	Recognize land pollution issues in mining, analyze soil properties, and understand health impacts
CO-4	Apply EIA processes, establish environmental objectives, and implement EMS based on ISO 14000
CO-5	Interpret and apply environmental laws and regulations relevant to mining activities

Unit – I

INTRODUCTION

Goals, strategies and tools for environmental management – systems approach to environmental management – environmental guideline – National Policies on environment with respects to mining activities – Global and Local environmental issues – resource degradation – desertification – Industrialization, Objectives of Sustainable Development. Structure of the atmosphere – ozone layer depletion – Acid rain – Green house gases and global warming Ambient Air quality and emission standards, Air quality Sampling and monitoring, Dispersion of air pollutants.

Unit - II

ENVIRONMENTAL POLLUTION - I

Environmental Pollutants due to surface – Air, Water, Noise, Sources and Classification of pollutants including dust and their effect on human health, Sources, hazards, sampling and analysis, standards, instrumentation and measurement of pollutants including dust, Air born dust modeling, Control and preventive measures for air pollution including for dust, , Water pollution standards, Noise standards – Measurement – Noise Impact Index assessment, Control and preventive measures for water, noise pollution. Pollution due to blast and equipment vibrations their monitoring, prevention and control.

Unit – III
ENVIRONMENTAL POLLUTION - II Land pollution, land for alternation dealing with mind out land , re-vegetation, tailing management, tailing dams, method and construction, land use plan, Mine closure planning. Textural classification and properties of soil. Impact of pollution on human health, miner's diseases and their social impact.

Unit – IV
ENVIRONMENTAL MANAGEMENT Environmental quality objectives, Emission and ambient standards – Minimum National standards – International environmental standards – ISO 14000 – EIA Notification – Sitting of Industries – Environmental management plans, Environmental impact assessment, Environmental management system audits, Environmental economics – Principles of cost benefit analysis – Valuing the Environment – Environmental Accounting, Environmental administration- training awareness and competence, Mine subsidence, its prediction and control.

Unit – V
ENVIRONMENTAL LEGISLATIONS Environmental laws, the Environmental (Protective) Act, 2004, The Water Act (1974), The Air act (1981), The Forest Act 1927, The forest conservation act 1980, Power and responsibilities of regularity agencies and occupation consent to establish and operate wild life protection act and rules , Environmental clearance procedure for a mining Project.

Suggested Reading:

TEXT BOOKS:
1. Manahan S.E. Environmental Science and Technology.
2. Mackenthun, K.M. Basic Concepts in Environmental Management, Lewis Publications, London, 1998.

REFERENCES

1	Noel de Nevers, Air Pollution Control Engg., McGraw Hill, New York, 1995
2	Anjaneyulu,Y. Air Pollution & Control Technologies, Allied Publishers (P) Ltd, India, 2002.
3	Nick Hanley, Jaison F. Shogren and Ben White. Environmental Economics – In Theory and Practice, Macmillan India Ltd, New Delhi, 1999.
4	Roger Perman, Yue Ma and James McGilvray. Natural Resources and Environmental Economics, Second edition, Addision Wesley Longman Ltd, Singapore, 1997.
5	Christopher Sheldon and Mark Yoxon, Installing Environmental Management System – a step by step guide, Earthsecan Publications Ltd, London, 1999.
6	Lee Kuhre, ISO 14001 Certification –Environmental Management Systems, Prentice Hall, USA, 1995.
7	Shyam Divan and Armin Rosencranz, Environmental Law and Policy in India, Oxford University Press, New Delhi. (2001)
8	Gregor I. Mcgregor. Environmental Law and Enforcement, Lewis Publishers, London, 1994.

CE 305	GROUND IMPROVEMENT TECHNIQUES					
(PROGRAM ELECTIVE – V)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To understand the objectives, necessity and scope of ground improvement techniques
2	To learn different methods of in-situ densification of cohesive, cohesionless soils
3	To learn the classification, functions and applications of Geo-synthetics in ground improvement
4	To learn the process of identification of necessity for ground improvement, finding alternative methods and recommendation of the ideal technique through case studies

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Ability to understand the necessity of ground improvement and evaluation of potential of a ground for improvement
CO-2	comprehensive understanding about the improvement of in-situ Cohesion less soils
CO-3	Competence to plan, design the in-situ densification of cohesive soils
CO-4	Knowledge of Grouting, soil stabilization methods, application of Geosynthetics and competence to apply them for ground improvement
CO-5	Competence to analyse an in-situ ground, identification of ground improvement techniques feasible, selection of the ideal method, its implementation and evaluation of improvement level

CO-PO MAPPING

Course outcome	**Program outcome**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	0.2	0.1	0.2		0.1	0.4
CO2	0.3		0.3	0.1		0.3
CO3	0.3		0.3	0.1		0.3
CO4	0.3		0.3	0.1		0.3
CO5			0.3	0.1	0.1	0.5

Unit – I
General : Formation of rock, soils and soil profiles, soil distribution in India and other countries - marine, black cotton soils (expansive)., lateritic, alluvial, desert soils peat etc., factors affecting the alteration of ground after formation – natural and man-made – reclaimed soils – methods of geotechnical processes.

Unit – II
Compaction methods: moisture density relations – compactive efforts – field methods – surface compaction, deep compactions- vigor compaction methods, vibro-probes, stone columns, sand compaction, stone column piles, selection of methods – quality control – specifications for compaction process for solving field problems.

Unit – III
Drainage methods: seepage, ground water seepage control – filter requirements methods of dewatering – well point methods of discharge computations – design of steps for dewatering – design of well screens – selection of pumps and accessories – deep bored wells. Pre-compression methods: compressibility and consolidation properties of soils estimation of rate of consolidation settlements – accelerating methods – monitoring compressions – design of vertical drains – consolidation by electro osmosis and vacuum compression methods.

Unit – IV
Grouting and injection methods: principles, design methods, selection of methods and requirements. Aspects of grouts, types of grouts and chemical applications, seepage control, solidification and stabilization – equipment and accessories used – quality control – specifications for achieving satisfactory results.

Unit – V
Stabilization methods: mechanical, cement, lime, chemical methods of stabilization of soils – use of admixtures – polymers – geosynthesis – reinforcements thermal slurry trenches, void filling – prewetting – improving rock stability methods – exercise quality control to achieve desired results.

Suggested Reading:
1. H.R. Hausmann, (2013), *Principles of Ground Modification,* Mc-Graw Hill Publications.
2. P.Nicholson, (2015), *Soil Improvement and Ground Modification Methods,* Butterworth-Heinemann Ltd.
3. Purushotham Raj, (2016), *Ground Improvement Techniques*, Laxmi Publications.
4. R.M.Koerner, (2012), *Designing with Geosynthetics Vol-1&2*, Prentice Hall Inc.
5. Indrarathna, Chu, Cholachat, (2015), *Ground Improvement Case Histories*, Butterworth-Heinemann Publications.

MN 251	RELIABILITY ENGINEERING					
(PROGRAM ELECTIVE – V)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To provide students with a comprehensive understanding of reliability and maintenance concepts, enabling them to analyze and manage the reliability of systems, apply statistical distributions, and make informed decisions for ensuring efficient and dependable operation

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand the concepts of discrete and continuous random variables
CO-2	Calculate MTBF and MTTR for maintainability assessment
CO-3	Analyze Markov models for single unit, two-unit, load shared, and standby systems
CO-4	Apply chi-square distribution, confidence limits, and maximum likelihood estimates for distribution fitting. Determine goodness of fit using statistical tests
CO-5	Define outage terms and model generating plants with identical and un-identical units. Calculate LOLE and LOLP for assessing power system reliability

Unit – I
Discrete and Continuous Random Variables - Binomial, Poisson, Normal, Lognormal, Exponential and Weibull distributions - Causes of failure - Failure rate and Failure density - Reliability and MTTF.

Unit – II
Maintainability and Availability - MTBF and MTTR - Reliability block diagram - Series and parallel systems -Redundancy - Standby system with and without imperfect switching device - r out of n configuration

Unit – III
Morkov models - Reliability models of single unit, two unit, Load shared and Standby systems - Reliability and availability models of the above systems with repair. Frequency of failures - State transition matrices and solutions - Accelerated life testing

Unit – IV
Chi-square distribution - Confidence limits for Exponential and Normal distributions - Applications of Weibull distribution and ML estimates - Goodness of fit test - Preventive maintenance - Reliability and MTTF - Imperfect maintenance - Age replacement policy.

Unit – V
Power system reliability – Outage definitions - Morkov model of a generating plant with identical units and un-identical units - Capacity outage probability table – Cumulative frequency -LOLP and LOLE.

Suggested Reading:

1	Charles E. Ebeling, An Introduction to Reliability and Maintainability Engineering, McGraw Hill International Edition, 1997.
2	Endrenyi, Reliability Modelling in Electrical Power Systems - John Wiley & Sons, 1980.
3	Roy Billington and Ronald N.Allan, Reliability Evaluation of Engineering Systems Plenum Press, NewYork,1992.
4	Roy Billington and Ronald N.Allan, Reliability Evaluation of Power Systems, Plenum Press, NewYork, 1996.

MN 252	FINITE ELEMENT ANALYSIS					
(PROGRAM ELECTIVE – V)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To introduce the concepts of Mathematical Modelling of Engineering Problems.
2	To appreciate the use of FEM to a range of Engineering Problems.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand the fundamental steps of FEM analysis and its significance in engineering
CO-2	Develop proficiency in applying FEM to one-dimensional problems like axial loads and trusses
CO-3	Apply FEM to two-dimensional problems, particularly those involving heat transfer
CO-4	Learn to derive stiffness matrices using coordinate transformations and iso parametric formulation
CO-5	Apply FEM concepts to practical engineering problems like slope stability and excavations

Unit – I

INTRODUCTION

Background - General description of the method - Analysis Procedure. Node numbering – Mesh generation - Linear constitutive equations - Plane stress, Plane strain and axisymmetric cases of elasticity - Energy principles - Variational methods – Raleigh-Ritz method – Galerkin Method.

Unit – II

ONE DIMENSIONAL PROBLEMS

Finite element modelling – Coordinates and shape functions – Linear and quadratic elements - Applications to axial loadings of rods – Extension to plane trusses – Bending of beams Element, Finite element formulation of stiffness matrix and load vectors – Assembly for global equations – Boundary conditions.

Unit – III
TWO DIMENSIONAL PROBLEMS Convergence requirements - Constant Strain Triangular (CST) Element – Rectangular Element -Finite element modelling - Element equations, Load vectors and boundary conditions – Assembly - shape functions from Lagrange and serendipity family— Application to heat transfer.

Unit – IV
ISOPARAMETRIC FORMULATION Introduction – Coordinate Transformation –Basic theorem of Isoparametric concept – Uniqueness of mapping – Isoparametric, Subparametric and Superparametric elements – Assembling Stiffness matrix – Numerical Examples.

Unit – V
APPLICATIONS Application of displacement finite elements to the analysis of simple problems (one and two dimensional cases) in the area of structural mechanics. Computer Programs: Development of computer programs for an axial and beam bending elements – Programming and use of computer packages for design of underground excavations, mining structures, slope and dump stability, design of supports, etc..

Suggested Reading:

TEXT BOOK:
1. J.N.Reddy, "An Introduction to the Finite Element Method", 3rd Edition, Tata McGrawHill, 2005.

REFERENCES	
1)	Krishnamoorthy, C.S, Finite Element Analysis Theory & Programming, McGraw-Hill, 1995.
2)	Desai C.S and Abel,, J.F., Introduction to Finite Element Method, Affiliated East West Press Pvt. Ltd., New Delhi, 2000
3)	Chandrupatla T.R., and Belegundu A.D., "Introduction to Finite Elements in Engineering", Pearson Education, 2011, 4th Edition.
4)	Bhavikkatti, S.S. Introduction to Finite Element Analysis –Newage International (P) Limited Publishers, New Delhi, 2011.
5)	Seshu, P., Textbook of Finite Element Analysis. New Delhi: Prentice-Hall of India, 2006.
6)	Bathe. K.J., "Finite Element Procedure", Prentice Hall of India, New Delhi, 2006.
7)	Logan, D.L., "A First course in Finite Element Method", Thomson Asia Pvt. Ltd., 2002
8)	Robert D. Cook, David S. Malkus, Michael E. Plesha, Robert J. Witt, "Concepts and Applications of Finite Element Analysis", 4th Edition, Wiley Student Edition, 2002.
9)	Rao, S.S., "The Finite Element Method in Engineering", 3rd Edition, Butter worth Heinemann, 2004
10)	Chandrupatla, R &Belagundu, A.D. "Introduction to Finite Elements in Engineering", 3rd Edition, Prentice Hall College Div., 1990.
11)	Cook R.D., "Concepts and Applications of Finite Element Analysis", John Wiley and Sons Inc., New York, 1989.
12)	Zienkiewicz, O.C., Taylor, R.L. and Zhu, J.Z. "The Finite Element Method: Its Basics and Fundamentals", Seventh Edition, Volumes 1 &2, Elesevier Publications, 2013.

OPEN ELECTIVE

OE941CE	Green Building Technology
OE942CE	Cost Management of Engineering Projects
OE941ME	Operations Research
OE942ME	Composite Materials
OE943ME	Industrial Safety
OE941CS	Business Analytics
OE941LA	Intellectual Property Rights
OE941BM	Medical Assistive Devices
OE942BM	Medical Imaging Techniques
OE941EE	Waste to Energy
OE942EE	Power point control and instruments
OE941EC	Elements of Embedded System and Controls

OE 941CE	GREEN BUILDING TECHNOLOGY					
	(OPEN ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Exposure to the green building technologies and their significance.
2	Understand the judicial use of energy and its management.
3	Educate about the Sun-earth relationship and its effect on climate.
4	Enhance awareness of end-use energy requirements in the society.
5	Develop suitable technologies for energy management

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand the fundamentals of energy use and energy processes in building.
CO-2	Identify the energy requirement and its management.
CO-3	Know the Sun-earth relationship vis-a-vis its effect on climate.
CO-4	Be acquainted with the end-use energy requirements.
CO-5	Be familiar with the audit procedures of energy

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	3	3	3	2	1	2
CO-2	3	2	3	2	1	1
CO-3	3	2	3	2	1	2
CO-4	3	2	3	2	1	2
CO-5	3	2	3	2	1	1

Unit – I

Overview of the significance of energy use and energy processes in building - Indoor activities and environmental control - Internal and external factors on energy use and the attributes of the factors - Characteristics of energy use and its management - Macro aspect of energy use in dwellings and its implications.

Unit – II
Indoor environmental requirement and management - Thermal comfort - Ventilation and air quality – Air-conditioning requirement - Visual perception - Illumination requirement - Auditory requirement.

Unit – III
Climate, solar radiation and their influences - Sun-earth relationship and the energy balance on the earth's surface - Climate, wind, solar radiation, and temperature - Sun shading and solar radiation on surfaces - Energy impact on the shape and orientation of buildings.

Unit – IV
End-use, energy utilization and requirements - Lighting and day lighting - End-use energy requirements - Status of energy use in buildings Estimation of energy use in a building. Heat gain and thermal performance of building envelope - Steady and non-steady heat transfer through the glazed window and the wall - Standards for thermal performance of building envelope - Evaluation of the overall thermal transfer.

Unit – V
Energy management options - Energy audit and energy targeting - Technological options for energy management.

Suggested Reading:

1	Bryant Edwards (2005): Natural Hazards, Cambridge University Press, U.K.
2	Carter, W. Nick, (1991): Disaster Management, Asian Development Bank, Manila.
3	Sahni, Pardeep et.al. (eds.) (2002), Disaster Mitigation Experiences and Reflections, Prentice Hall of India, New Delhi.
4	Bryant Edwards (2005): Natural Hazards, Cambridge University Press, U.K.

OE 942 CE	**COST MANAGEMENT OF ENGINEERING PROJECTS**					
	(OPEN ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Introduce the concepts of cost management
2	Fundamentals of cost overruns
3	Introduce the concepts of Quantitative techniques for cost management Linear Programming, PERT/CPM.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understanding of strategic cost management process, control of cost and decision making based on the cost of the project.
CO-2	Ability to appreciative detailed engineering activities of the project and execution of projects
CO-3	Preparation of project report and network diagram
CO-4	Able to plan Cost Behavior, Profit Planning , Enterprise Resource Planning, Total Quality Management.
CO-5	Applications of various quantitative techniques for cost management

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1						
CO-2						
CO-3						
CO-4						
CO-5						

Unit – I
Introduction and Overview of the Strategic Cost Management Process-Cost concepts in decision-making; relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System- Inventory valuation- Creation of a Database for operational control; Provision of data for Decision-Making.

Unit – II
Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning- Project execution as conglomeration of technical and non- technical activities- Detailed Engineering activities.

Unit – III
Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process

Unit – IV
Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems- Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector- Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints- Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets- Performance budgets- Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

Unit – V
Quantitative techniques for cost management, Linear Programming, PERT/CPM,- Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

Suggested Reading:

1	Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
2	Charles T. Horngren and George Foster, Advanced Management Accounting
3	Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
4	Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher
5	N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

OE 941 ME	OPERATION RESEARCH					
	(OPEN ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To understand the dynamic programming to solve problems of discrete and continuous variables
2	To apply the concept of non-linear programming and carry out sensitivity analysis
3	To understand deterministic and probabilistic inventory control models.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	To understand the basics of OR, including mathematical modeling, feasible solutions and optimization.
CO-2	Able to carry out sensitivity analysis.
CO-3	Apply PERT/CPM in project management.
CO-4	Select appropriate inventory control model.
CO-5	Able to apply dynamic programming and understand the concept of non-linear programming.

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	1	1	3	2	1	2
CO-2	3	1	2	3	2	-
CO-3	1	3	3	1	2	2
CO-4	3	2	1	3	1	1
CO-5	2	1	3	2	2	2

Unit – I
Development, Different Phases, Characteristics, Operations Research models and applications. Linear Programming Problem: Introduction, Basic Assumptions, Formulation, graphical method, simplex method: Big M and Two Phase method.

Unit – II
DUALITY: Duality theory, primal-dual relationships, Economic interpretation, Dual simplex method, Post optimal or sensitivity analysis.

Unit – III
Project Management: Introduction to PERT and CPM, critical Path calculation, float calculation and its importance. Cost reduction by Crashing of activity. **Inventory models** – Economic order quantity models – Quantity discount models – Stochastic inventory models – Multi product models – Inventory control models in practice.

Unit – IV
Sequencing Models: Introduction, General assumptions, processing n jobs through 2 machines, processing 'n' jobs through m machines. **Game Theory**: Introduction, Characteristics of Game Theory, Dominance theory, Mixed strategies (2 x 2, m x 2), Algebraic and graphical methods. Nonlinear programming problem: - Kuhn-Tucker conditions.

Unit – V
Queuing models - Queuing systems and structures – Notation parameter – Single server and multi server models – Poisson arrivals – Exponential service times – with finite population – Infinite population. Dynamic Programming: Characteristics, principle of optimality, deterministic problems.

Suggested Reading:

1	H.A. Taha, Operations Research, An Introduction, PHI, 2008
2	H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3	J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008.
4	Frederick S. Hillier, Gerald J. Lieberman, Operations Research, 10thEdition, McGraw Hill Pub. 2017.
5	Pannerselvam, Operations Research: Prentice Hall of India 2010.
6	Ronald L. Rardin, Optimization in Operations Research, First Indian Reprint, Pearson Education Asia. 2002,

OE 942 ME	COMPOSITE MATERIALS					
	(OPEN ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Study the concepts of composite construction.
2	Learn analysis and designs of composite beams, floors, columns and trusses as per the recommendations of IS codes of practice.
3	Apply the concepts for design of multi-storey composite buildings.
4	Scope of analysis is restricted to skeletal structures subjected to prescribed dynamic loads.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand the fundamentals of composite construction, and analysis and designs of composite beams.
CO-2	Analyse and design the composite floors
CO-3	Select suitable materials for composite columns,
CO-4	Analyse composite trusses and understand connection details.
CO-5	Analyse and design the multi-storey composite buildings

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

Unit – I

Introduction of composite constructions: Benefits of composite construction - Introduction to IS - BS and Euro codal provisions.

Composite beams: Elastic behaviour of composite beams - No and full interaction cases - Shear connectors - Ultimate load behaviour - Serviceability limits - Effective breadth of flange - Interaction between shear and moment - Basic design consideration and design of composite beams.

Unit – II

Composite floors: Structural elements - Profiled sheet decking - Bending resistance - Shear resistance - Serviceability criterion - Analysis for internal forces and moments - Design of composite floors.

Unit – III
Composite columns: Materials - Concrete filled circular tubular sections - Non-dimensional slenderness - Local buckling of steel sections - Effective elastic flexural stiffness - Resistance of members to axial compressions - Composite column design - Fire resistance.

Unit – IV
Composite trusses: Design of truss - Configuration - Truss members - Analysis and design of composite trusses and connection details.

Unit – V
Design of multi-storey composite buildings: Design basis - Load calculations - Design of composite slabs with profile decks - Composite beam design - Design for compression members - Vertical cross bracings - Design of foundation.

Suggested Reading:

1	R.P. Johnson, "Composite Structures of Steel and Concrete - Beams, Slabs, Columns and Frames in Buildings", Blackwell Publishing, Malden, USA, 2004.
2	"INSDAG Teaching Resources for Structural Steel Design", Vol-2, Institute for Steel Development and Growth Publishers, Calcutta, India.
3	"INSDAG Handbook on Composite Construction – Multi-Storey Buildings", Institute for Steel Development and Growth Publishers, Calcutta, India.
4	"INSDAG Design of Composite Truss for Building", Institute for Steel Development and Growth Publishers, Calcutta, India.
5	"INSDAG Handbook on Composite Construction – Bridges and Flyovers", Institute for Steel Development and Growth Publishers, Calcutta, India.
6	IS: 11384-1985, "Code of Practice for Composite Construction in Structural Steel and Concrete", Bureau of Indian Standards, New Delhi, 1985.

OE943ME	**INDUSTRIAL SAFETY**					
(OPEN ELECTIVE)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Causes for industrial accidents and preventive steps to be taken.
2	Fundamental concepts of Maintenance Engineering.
3	About wear and corrosion along with preventive steps to be taken
4	The basic concepts and importance of fault tracing.
5	The steps involved in carrying out periodic and preventive maintenance of various equipments used in industry

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Identify the causes for industrial accidents and suggest preventive measures.
CO-2	Identify the basic tools and requirements of different maintenance procedures.
CO-3	Apply different techniques to reduce and prevent Wear and corrosion in Industry.
CO-4	Identify different types of faults present in various equipments like machine tools, IC Engines, boilers etc.
CO-5	Apply periodic and preventive maintenance techniques as required for industrial equipments like motors, pumps and air compressors and machine tools etc

Unit – I
Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes, Fire prevention and firefighting, equipment and methods.

Unit – II
Fundamentals of Maintenance Engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

Unit – III
Wear and Corrosion and their Prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications of Screw down grease cup, Pressure grease gun, Splash lubrication, Gravity lubrication, Wick feed lubrication, Side feed lubrication, Ring lubrication, Definition of corrosion, principle and factors affecting the corrosion, Types of corrosion, corrosion prevention methods.

Unit – IV
Fault Tracing: Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, any one machine tool, Pump, Air compressor, Internal combustion engine, Boiler, Electrical motors, Types of faults in machine tools and their general causes.

Unit – V
Periodic and Preventive Maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of Machine tools, Pumps, Air compressors, Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance.

Suggested Reading:

1	H. P. Garg, "Maintenance Engineering", S. Chand and Company
2	Audels, "Pump-hydraulic Compressors", Mcgraw Hill Publication
3	Higgins & Morrow, "Maintenance Engineering Handbook", Da Information Services.
4	Winterkorn, Hans, "Foundation Engineering Handbook", Chapman & Hall London

OE941CS	**BUSINESS ANALYTICS**					
(OPEN ELECTIVE)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Understanding the basic concepts of business analytics and applications
2	Study various business analytics methods including predictive, prescriptive and prescriptive analytics
3	Prepare the students to model business data using various data mining, decision making methods

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	To understand the basic concepts of business analytics
CO-2	Identify the application of business analytics and use tools to analyze business data
CO-3	Become familiar with various metrics, measures used in business analytics
CO-4	Illustrate various descriptive, predictive and prescriptive methods and techniques
CO-5	Model the business data using various business analytical methods and techniques

Unit – I

Introduction to Business Analytics: Introduction to Business Analytics, need and science of data driven (DD) decision making, Descriptive, predictive, prescriptive analytics and techniques, Big data analytics, Web and Social media analytics, Machine Learning algorithms, framework for decision making, challenges in DD decision making and future.

Unit – II

Descriptive Analytics: Introduction, data types and scales, types of measurement scales, population and samples, measures of central tendency, percentile, decile and quadrille, measures of variation, measures of shape-skewness, data visualization.

Unit – III
Forecasting Techniques: Introduction, time-series data and components, forecasting accuracy, moving average method, single exponential smoothing, Holt's method, Holt-Winter model, Croston's forecasting method, regression model for forecasting, Auto regression models, auto-regressive moving process, ARIMA, Theil's coefficient

Unit – IV
Decision Trees: CHAID, Classification and Regression tree, splitting criteria, Ensemble and method and random forest. **Clustering**: Distance and similarity measures used in clustering, Clustering algorithms, K-Means and Hierarchical algorithms, **Prescriptive Analytics**- Linear Programming(LP) and LP model building.

Unit – V
Six Sigma: Introduction, introduction, origin, 3-Sigma Vs Six-Sigma process, cost of poor quality, sigma score, industry applications, six sigma measures, DPMO, yield, sigma score, DMAIC methodology, Six Sigma toolbox.

Suggested Reading:

1	U Dinesh Kumar, "Data Analytics", Wiley Publications, 1st Edition, 2017
2	Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, "Business analytics Principles, Concepts, and Applications with SAS", Associate Publishers, 2015
3	S. Christian Albright, Wayne L. Winston, "Business Analytics - Data Analysis and Decision Making", 5th Edition, Cengage, 2015

Web Resources:

1	https://onlinecourses.nptel.ac.in/noc18-mg11/preview
2	https://nptel.ac.in/courses/110105089/

OE941LA	**INTELLECTUAL PROPERTY RIGHTS**					
(OPEN ELECTIVE)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Acquaint the students with basics of intellectual property rights with special reference to Indian Laws and its practices.
2	Compare and contrast the different forms of intellectual property protection in terms of their key differences and similarities.
3	Provide an overview of the statutory, procedural, and case law underlining these processes and their interplay with litigation.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand the concept of intellectual property rights.
CO-2	Develop proficiency in trademarks and acquisition of trade mark rights.
CO-3	Understand the skill of acquiring the copy rights, ownership rights and transfer.
CO-4	Able to protect trade secrets, liability for misappropriations of trade secrets.
CO-5	Apply the patents and demonstration of case studies.

Unit – I
Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

Unit – II
Trade Marks: Purpose and function of trademarks, acquisition of trade mark rights, protectable matter, selecting, and evaluating trade mark, trade mark registration processes.

Unit – III
Law of copy rights: Fundamental of copy right law, originality of material, rights of reproduction, rights to perform the work publicly, copy right ownership issues, copy right registration, notice of copy right, international copy right law. Law of patents: Foundation of patent law, patent searching process, ownership rights and transfer**.**

Unit – IV
Trade Secrets: Trade secrete law, determination of trade secrete status, liability for misappropriations of trade secrets, protection for submission, trade secrete litigation. Unfair competition: Misappropriation right of publicity, false advertising.

Unit – V
New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

Suggested Reading:

1	Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd, 2007.
2	“Mayall, “Industrial Design”, McGraw Hill,1992
3	“Niebel, “Product Design”, McGraw Hill,1974.
4	“Asimov, “Introduction to Design”, Prentice Hall,1962.
5	“Robert P. Merges, Peter S. Menell, Mark A. Lemley, “Intellectual Property in New Technological Age”,2016.
6	T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand,2008

OE 941 BM	**MEDICAL ASSISTIVE DEVICES**					
(OPEN ELECTIVE)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To extend knowledge of the amputee, of lost and remaining functions affecting locomotion, and to collect information on the best possible medical treatment.
2	To improve fitting techniques and practices, including training, so that existing devices might be used with greater comfort and function.
3	To develop improved lower-extremity devices

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Apply fundamental knowledge of engineering in rehabilitation
CO-2	Apply analytical skills to assess and evaluate the need of the end-user
CO-3	Develop self-learning initiatives and integrate learned knowledge for problem solving
CO-4	Understand the basics of robotics and apply their principles in developing prosthetics
CO-5	Apply the knowledge of computers in solving rehabilitation problems

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

Unit – I
Introduction to Rehabilitation Engineering, Measurement and analysis of human movement, Disability associated with aging in the workplace and their solutions, clinical practice of rehabilitation engineering.

Unit – II
Assistive Technology, Seating Biomechanics and systems. Wheeled Mobility: Categories of Wheelchairs. Wheelchair Structure and Component Design. Ergonomics of Wheel chair propulsion. Power Wheelchair Electrical Systems. Control. Personal Transportation. Auxiliary devices and systems.

Unit – III
Sensory augmentation and substitution: Visual system: Visual augmentation. Tactual vision substitution, Auditory vision substitution; Auditory system: Auditory augmentation. Cochlear implantation, Visual auditory substitution, Tactual auditory substitution, Tactual system: Tactual augmentation. Tactual substitution. Measurement tools and processes: fundamental principles, structure, function; performance and behavior. Subjective and objective measurement methods.

Unit – IV
Rehabilitation Robotics, Major Limb Prosthetic Devices, Orthotic Devices, Types of orthotics and prosthetics, Intelligent prosthetic Knee, Prosthetic Hand, Controlled orthotics and prosthetics FES system, Restoration of Hand function, Restoration of standing and walking, Myo-electric Hand.

Unit – V
Augmentative and Alternative communication technology, Computer applications in Rehabilitation Engineering, telecommunications, and Web Accessibility.

Suggested Reading:

1	Robinson C.J., *Rehabilitation Engineering*, CRC Press, 1995.
2	Ballabio E., et al., *Rehabilitation Technology*, IOS Press, 1993.
3	Rory A Cooper, Hisaichi Ohnabe, Douglas A. Hobson, *Series in medical physis and biomedical engineering: An introduction to rehabilitation engineering*, Taylor and Francis Group, London, 2007.
4	Joseph D. Bronzino *The biomedical engineering handbook -biomedical engineering fundamentals*, 3rdEd., CRC Press, Taylor & Francis Group, London, 2006.

OE 942 BM	MEDICAL IMAGING TECHNIQUES					
	(OPEN ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To familiarize the students with various medical imaging modalities.
2	To make learners understand the principles, detectors and operating procedures of X-ray, CT, MRI, ultrasound, PET and SPECT.
3	To make the students learn the advantages, disadvantages and hazards of various medical imaging equipment.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Interpret the working principle and operating procedure and applications of X-ray equipment.
CO-2	Understand the image reconstruction techniques and applications of CT.
CO-3	Summarize the image acquisition and reconstruction techniques in MRI.
CO-4	Comprehend the working principle, modes and medical applications of ultrasound imaging.
CO-5	Examine the operation and applications of PET, SPECT and radio nuclide instrumentation.

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

Unit – I

X ray Imaging: Electromagnetic spectrum, Production of X-rays, X-ray tubes- Stationary and Rotating Anode types, Block diagram of an X-Ray Machine, Collimators and Grids, Timing and Exposure controls. X-Ray Image visualization-Films, Fluorescent screens, Image Intensifiers.

Dental X-Ray machines, Portable and mobile X-Ray units, Mammographic X-Ray equipment,

Digital Radiography and flat panel detectors.

Radiation safety, ALARA principle, Dose units and dose limits, Radiation dosimeters and detectors.

Unit – II
Computed Tomography: Basic principles, CT number scale, CT Generations. Major sub systems- Scanning system, processing unit, viewing unit, storage unit. Need and Principle of sectional imaging, 2D image reconstruction techniques - Iteration and Fourier methods. Applications of CT - Angio, Osteo, Dental, Perfusion (Body & Neuro), Virtual Endoscopy, Coronary Angiography.

Unit – III
Magnetic Resonance Imaging: Principles of NMR imaging systems, Image reconstruction techniques-Relaxation processes, imaging/ pulse sequences. Sub systems of an NMR imaging system, NMR detection system, types of coils, biological effects and advantages of NMR imaging. Functional MRI - The BOLD effect, intra and extra vascular field offsets, source of T2* effects, Creating BOLD contrast sequence optimization sources and dependences of physiological noise in fMRI.

Unit – IV
Ultrasound Imaging: - Principles of image formation -Imaging principles and instrumentation of A-mode, B-Mode, Gating Mode, Transmission mode and M-mode. Basics of multi-element linear array scanners, Digital scan conversion. Doppler Ultrasound and Colour Doppler imaging, Image artifacts, Biological effects, Ultrasound applications in diagnosis, therapy and surgery.

Unit – V
Nuclear Medicine–Radioisotopes in medical diagnosis, Basic instrumentation- Radiation detectors, Pulse height analyzer, Rectilinear scanner, Gamma camera. Emission Computed Tomography (ECT), Principle and instrumentation of Single Photon Emission Computed Tomography(SPECT) and Positron Emission Tomography (PET). Comparison of SPECT, PET and combined PET/ X-ray CT.

Suggested Reading:

1	Khandpur R.S., *Handbook of Biomedical Instrumentation*, Tata McGraw Hill, 2016.
2	S Webb, "*The Physics of Medical Imaging*", Adam Highler, Bristol Published by CRC Press, 1988.
3	A C Kak, "*Principle of Computed Tomography*", IEEE Press New York, 1988.
4	Hykes, Heorick, Starchman, *Ultrasound physics and Instrumentation* MOSBY year book, 2nd Ed. 1992.
5	Stewart C. Bushong, *Magnetic Resonance Imaging- physical and biological principles*, MOSBY, 2nd Ed., 1995.

OE941EE	**WASTE TO ENERGY**					
(OPEN ELECTIVE)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To know the various forms of waste
2	To understand the processes of Biomass Pyrolysis.
3	To learn the technique of Biomass Combustion.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand the concept of conservation of waste
CO-2	Identify the different forms of wastage.
CO-3	Chose the best way for conservation to produce energy from waste.
CO-4	Explore the ways and means of combustion of biomass.
CO-5	Develop a healthy environment for the mankind.

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	3	-	3	2	3	1
CO-2	3	-	3	2	3	1
CO-3	3	-	3	2	3	1
CO-4	3	-	3	2	3	1
CO-5	3	-	3	2	3	1

Unit – I
Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

Unit – II
Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

Unit – III
Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

Unit – IV
Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

Unit – V
Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

Suggested Reading:

1	Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2	Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3	Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4	Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.

OE 942 EE	POWER PLANT CONTROL AND INSTRUMENTATION					
	(OPEN ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	The operation of different types of power plants.
2	The basic working principle of instruments for measurement of electrical and non-electrical quantities like Temperature Pressure flow level measurements.
3	The instrumentation and protection systems applied in thermal power plant.
4	The control techniques employed for the operation of modern power generation plant

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Explain the different methods of power generation. Along with Piping and Instrumentation diagram of boiler.
CO-2	Select various measurements involved in power generation for measuring electrical and non-electrical parameters.
CO-3	Identify the different types of analyzers used for scrutinizing boiler steam and water.
CO-4	Model different types of controls and control loops in boilers.
CO-5	Illustrate the methods of monitoring and control of different parameters like speed, vibration of turbines

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	3	1	-	-	-	2
CO-2	3	1	-	-	-	2
CO-3	3	1	-	-	-	2
CO-4	3	1	-	-	-	2
CO-5	3	1	-	-	-	2

Unit – I
Brief survey of methods of power generation, hydro, thermal, nuclear, solar and wind power, importance of instrumentation in power generation, thermal power plants, block diagram, details of boiler processes, Piping and Instrumentation diagram of boiler, cogeneration.

Unit – II
Electrical measurements, current, voltage, power, frequency, power factor etc, non-electrical parameters, flow of feed water, fuel, air and steam with correction factor for temperature, steam pressure and steam temperature, drum level measurement, radiation detector, smoke density measurement, dust monitor.

Unit – III
Flue gas oxygen analyzer: Analysis of impurities in feed water and steam, dissolved oxygen analyzer. Chromatography, pH meter, fuel analyzer, pollution monitoring instruments.

Unit – IV
Combustion control, air / fuel ratio control, furnace draft control, drum level control, main steam and reheat steam temperature control, super heater control, air temperature, distributed control system in power plants, interlocks in boiler operation.

Unit – V
Speed, vibration, shell temperature monitoring and control, steam pressure control, lubricant oil temperature control, cooling system.

Suggested Reading:

1	Sam G. Dukelow, The Control of Boilers, Instrument Society of America, 2nd Edition, 2010.
2	P.K. Nag, „Power Plant Engineering“, Tata McGraw-Hill, 1st Edition, 2001.
3	S.M. Elonka and A.L. Kohal, “Standard Boiler Operations”, Tata McGraw-Hill, 1st Edition, 1994.
4	R K Jain, “Mechanical and Industrial Measurements”, Khanna Publishers, 1st Edition, 1995.
5	E Al Wakil, “Power Plant Engineering”, Tata McGraw-Hill, 1st Edition, 1984.

OE 941 EC	ELEMENTS OF EMBEDDED SYSTEMS					
	(OPEN ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Understanding various Embedded Design strategies
2	Designing Micro controller based Embedded Systems
3	Designing FPGA Based Embedded Systems

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand Embedded Design Strategies and architecture of Arduino Board
CO-2	Program using various onboard components of Arduino
CO-3	Design real time interfacing with Arduino
CO-4	Understand Design Flow of FPGA, programming FPGA using Verilog HDL
CO-5	Implement combinational and sequential circuits using verilog HDL

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

Unit – I
Embedded Systems Design Strategies: Micro Controller, DSP, FPGA, Introduction to Arduino (Micro controller Board), Components of Arduino, Architecture and Pin Configuration of ATMega328, Ports of ATMega328.

Unit – II
Interfacing: Interfacing Switches, LEDs, Analog to Digital Converter, Digital to Analog Converter, Interfacing and Programming I2C, SPI

Unit – III
Real Time Programming: Interfacing Key Pad, 7-segment display, LCD, Interfacing Sensors, Interfacing Stepper Motor**,** USB programming

Unit – IV
FPGA Based Embedded Design: FPGA Design flow, Introduction to Verilog HDL**,** Basic building blocks, Data types of Verolog HDL, Behavioral Modelling, Data Flow Modelling, Structural Modelling, Hierarchal Structural Modelling, Case Studies on Verilog HDL descriptions of Basic Circuits

Unit – V
Modelling of Circuits: Verilog HDL Implementation of Combinational MSI Circuits, Verilog HDL Implementation of Sequential MSI Circuits, Finite Sate Machine Design, Tasks and Functions, Introduction to Test Benches

Suggested Reading:

1	Ming-Bo Lin, Digital System Designs and Practices Using Verilog HDL and FPGAs, Wiley India, 2008
2	Samir Palnitkar, Verilog HDL: A Guide to Digital Design and Synthesis, Pearson Education, 2005
3	Simon Monk, Programming Arduino: Getting Started with sketches, Mc.Hill, 2016

Web Resources:

1	www.arduino.cc
2	www.learn.sparkfun.com/tutorials/arduino

MN 162	MINI PROJECT					
Pre-requisites	-		**L**	**T**	**P**	**C**
			-	-	4	2
Evaluation	**SEE**	-	**CIE**	50 Marks		

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	*To review available literature and formulate structural engineering problems*
2	*To learn the technique of writing reports and prepare presentation*

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	*Identify structural engineering problems reviewing available literature*
CO-2	*Study different techniques used to analyse complex structural systems.*
CO-3	*Able to work on the solutions given problem*
CO-4	*Present solution by using his/her technique applying engineering principles.*
CO-5	*Prepare technical report and presentation*

Syllabus Contents:

Mini Project will have mid semester presentation and end semester presentation. Mid semester Presentation will include identification of the problem based on the literature review on the topic referring to latest literature available.

End semester presentation should be done along with the report on identification of topic for the work and the methodology adopted involving scientific research, collection and analysis of data, determining solutions highlighting individuals' contribution. Continuous assessment of Mini Project at Mid Sem and End Sem will be monitored by the departmental committee

MN 152	COMPUTER APPLICATIONS IN MINING LABORATORY					
	Lab II					
Pre-requisites	Concrete Technology Lab		**L**	**T**	**P**	**C**
			-	-	2	1
Evaluation	**SEE**	-	**CIE**		50 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To study the computer programming for mining problems, mine ventilation network analysis, modelling of surface and underground workings using various software.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Know the computer programming for mining problems, mine ventilation network analysis, modelling of surface and underground workings using different softwares.

LIST OF EXPERIMENTS (Students need to learn any three software/ analysis during the semester)

1. Computer programming for mining problems like design of pillars / blast design / subsidence prediction.
2. Mine ventilation network analysis.
3. Ore body modelling.
4. Digital Terrain modelling and Wire-frame modelling
5. Mine modelling
6. Slope stability analysis
7. Modelling of airflow through underground workings using finite element method.
8. Solving problems on excavation in rock and support
9. Modelling of typical open stope in metal mine and stability analysis of walls and pillars
10. Modelling of mechanical behaviour of pillars under different geo-mining conditions
11. Modelling of caving behaviour in strata
12. Modelling of slope
13. Modelling of supports in mines

CE351	GEO-TECHNICAL ENGINEERING LABORATORY					
	Lab III					
Pre-requisites	Concrete Technology Lab		**L**	**T**	**P**	**C**
			-	-	2	1
Evaluation	**SEE**	-	**CIE**		50 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Expose the students to different types of soils and learn to classify them
2	Hands on experience of the laboratory test procedures to determine compaction, strength and permeability characteristics.
3	Knowledge of Rock Mass Classification and procedure to find uniaxial compressive strength of Rock Specimen

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Competence in performing the laboratory experiments for determination of Index properties and for classification of soils
CO-2	Ability to determine the compaction / shear strength / permeability characteristics in the laboratory
CO-3	Hands on experience in Rock mass classification and determination of its UCS
CO-4	Understanding about the application of Geotechnical Engineering properties of soils and rocks in Mining Engineering theory and practice

I. TESTS ON SOILS
1. **Particle Size Analysis using**
a. Dry Sieve analysis b. Wet Sieve Analysis
2. **Consistency of Clays**
a. Determination of Liquid Limitb. Determination of Plastic Limit
3. **Classification of soils** using IS:1498-1970
4. **Compaction Characteristics using**
a. IS Light Compaction Test b. IS Heavy Compaction Test
5. Compaction Quality Control Tests
a. Sand Replacement Method b. Core Cutter Method
c. Rapid Moisture determination using Calcium Carbide method
6. Shear Strength Characteristics using
a. Direct Shear Test b. Unconfined compressive Strength Test
c. Demonstration of Tri-axial Compression Test
d. Demonstration of Vane Shear Test
7. Permeability Characteristics using
a. Constant Head Permeability test b. Variable Head Permeability test
II. TESTS ON ROCK
1. Determination of Core Recovery Ratio (CRR) and Rock Quality Designation (RQD)
2. Determination of Rock Mass Rating (RMR)
3. Rock specimen preparation- Core drilling, cutting and grinding
4. Determination of density, porosity and water absorption
5. Determination of Uni-axial Compressive Strength

Suggested Reading:
1. IS: 2720 – Relevant Parts.
2. Lambe, T.W., "*Soil Testing for Engineers*", Wiley Eastern Ltd., New Delhi, 1969 (Reprint in 2012).
3. Jaeger, J.C. and Cook, N.G.W., *Fundamentals of Rock Mechanics*", Chapman and Hall, 1976
4. Goodman, R.E. *Introduction to Rock Mechanics*, John Wiley and Sons, 1989

SEMESTER –III

MN 301	ENGINEERING RESEARCH METHODOLOGY					
(AUDIT COURSE - I)						
Pre-requisites			L	T	P	C
			2	-		0
Evaluation	SEE	60 Marks	CIE		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Learn the research types, methodology and formulation.
2	Know the sources of literature, survey, review and quality journals.
3	Understand the research design for collection of research data.
4	Understand the research data analysis, writing of research report and grant proposal.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Differentiate the research types and methodology.
CO-2	Able to do literature survey using quality journals.
CO-3	Able to collect research data.
CO-4	Process research data to write research report for grant proposal.

Unit – I

Scientific Research: Definition, Characteristics, Types, Need of research. Research methods vs Methodology. Types of research – Descriptive vs. Analytical, Applied vs. Fundamental, Quantitative vs. Qualitative, Conceptual vs. Empirical.

Defining and formulating the research problem-Meaning of a research problem, Sources of research problems, Criteria of a good research problem, Importance of literature review in defining a problem, Errors in selecting a research problem, Scope and objectives of the research problem. Approaches of investigation of solutions for the research problem

Unit – II

Literature review-Source of literature, Critical literature review – Identifying gap areas from literature review - Development of working hypothesis.

Research design – Basic Principles, Need of research design, Features of good design, Important concepts relating to research design.

Developing a research plan - Exploration, Description, Diagnosis, Experimentation. Determining experimental and sample designs.

Unit – III
Execution of the research - Necessary instrumentations, Various data collection methods in Civil Engineering. Data processing and data interpretation. Data presentation and illustration. Types of the reports–Technical reports and thesis; Different steps in the preparation – Layout, structure and language of technical writing; Writing research papers; Developing a Research Proposal, Common formats of the research proposals; Oral presentation–Planning, Preparation, Practice, Making a presentation, Importance of effective communication

Unit – IV
Ethical issues - Research ethics, Plagiarism, Citation and acknowledgement Patenting and development: technological research, innovation, patenting, and development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT Patent Rights. Problems encountered by researchers in India.

Unit – V
Basics of statistics. Sampling and its types. Determination of sampling size. Sampling and non-sampling errors in statistics. Data: handling of data-significant figures & rounding. quality of data- precision & accuracy. Types of data. Descriptive statistics: Summarization of Data- Measure of central tendency, Measure of central dispersion, Measure of symmetry. Inferential statistics: Hypothesis of testing, Parametric (t-test & Analysis of variance) and Non-Parametric Tests. Univariate and Bivariate analysis; Correlational analysis. Introduction to linear regression model and multi-linear regression models. mathematical basis and introduction to SPSS.

Suggested Reading:

1	C.R Kothari, "Research Methodology, Methods & Technique", New Age International Publishers, New Delhi, 2004.
2	R. Ganesan, "Research Methodology for Engineers", MJP Publishers, Chennai, 2011.
3	RatanKhananabis and SuvasisSaha, "Research Methodology", Universities Press, Hyderabad, 2015.
4	Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & Engineering students"
5	Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners"
6	Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
7	T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008
8	Y.P. Agarwal, "Statistical Methods: Concepts, Application and Computation", Sterling Publishing Pvt. Ltd., New Delhi, 2004.
9	Vijay Upagade and AravindShende, "Research Methodology", S. Chand & Company Ltd., New Delhi, 2009.
10	G. Nageswara Rao, "Research Methodology and Quantitative methods", BS Publications, Hyderabad, 2012

AC 031	ENGLISH FOR RESEARCH PAPER WRITING					
	(AUDIT COURSE - I)					
Pre-requisites			**L**	**T**	**P**	**C**
			2	-		0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Understand that how to improve your writing skills and level of readability
2	Learn about what to write in each section
3	Understand the skills needed when writing a Title
4	Ensure the good quality of paper at very first-time submission

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Write with high skills, readability skills and good quality paper writing skills

Unit – I
Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness.

Unit – II
Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, useful phrases.

Unit – III
Sections of a Paper, Abstracts. Introduction Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.

Unit – IV
key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, skills are needed when writing the Methods.

Unit – V
skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions. How to ensure paper is as good as it could possibly be the first- time submission

Suggested Reading:

1	Goldbort R (2006) Writing for Science, Yale University Press (available on
2	Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3	Google Books) Model Curriculum of Engineering & Technology PG Courses [Volume-I] [41]
4	Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM.
5	Adrian Wallwork, English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

AC 032	DISASTER MITIGATION AND MANAGEMENT					
	(AUDIT COURSE - II)					
Pre-requisites			**L**	**T**	**P**	**C**
			2	-		0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	*Introduction of various types of disasters and its effect on structures.*
2	*Learning of quality assurance and damage assessment of structures*
3	*Educate different types of repair, strengthening, rehabilitation and retrofitting techniques.*
4	*Awareness about flood characteristics and flood forecasting systems*
5	*Description of Flood mitigation, adjustment, and regulation*

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	*Understand the fundamentals of disaster and seismic performance of buildings*
CO-2	*Able to assess various damages in structures and give assurance of quality of concrete*
CO-3	*Decide the appropriate repair, strengthening, rehabilitation and technique required for a case study of building.*
CO-4	*Applications of flood routing, flood forecasting and space time characteristics of rainfall.*
CO-5	*Advanced understanding of flood plain adjustments and employment of appropriate technologies for flood mitigation.*

Unit – I
Disaster: Classifications - Causes - Impacts including social, economical, political, environmental, health, psychosocial, etc.
Seismic performance of buildings: case studies of major earthquakes in the country, damage to buildings, damage patterns, performance of non-engineered buildings- Introduction to repair and rehabilitation of structures.

Unit – II
Quality assurance for concrete – Strength, Durability and Thermal properties of concrete.

Damage Assessment**:** - Condition assessment and distress, Purpose of assessment, Rapid assessment - diagnostic techniques, Investigation of damage, , Evaluation of surface and structural cracks, Damage assessment procedure, destructive, non-destructive and semi destructive testing systems, Procedure for evaluating damaged of structure.

Unit – III

Repair, Rehabilitation And Retrofitting Techniques : Repair materials, Common types of repairs – Repair in concrete structures – Repairs in under water structures – Guniting – Shot create –Underpinning, Strengthening of Structural elements, Repair of structures distressed due to corrosion, fire, Leakage, earthquake, Retrofitting techniques

Unit – IV

Introduction to Disasters: Hazard, Vulnerability, Resilience, Risks.-Disaster- Different types of cold wave-heat wave- droughts- floods-Effect of climate change on Processes.

Flood characteristics and forecasting: Measureable features of a flood (Elevation, discharge, volume, and duration), flood forecasting (unit hydrograph method, meteorological and snow data, and snow field air temperatures), operation of flood forecasting systems.

Space-time characteristics of rainfall: Policy criteria for design flood of a major and minor reservoir, spillways, diversion dams and barrages, design flood criteria for dams and other hydraulic structures (CWC recommendations).

Unit – V

Flood Routing: Mathematics of flood routing, various methods of flood routing, Hydrologic and Hydraulic routing.

Flood mitigation: flood ways, channel improvement, evacuation and flood proofing, land management, flood plain management, estimating benefits of flood mitigation.

Flood plain adjustments and regulations: Results of controlling floods, alternatives to controlling floods, range of possible adjustments, practical range of choice, critical characteristics of flood hazards.

Suggested Reading:

1. A.R. Santakumar, “Concrete Technology”, Oxford University Press, New Delhi, 2006.
2. Pankaj Agarwal and Manish Shrihkande (2006). “Earthquake Resistance Design of Structures.” Prentice Hall of India
3. Ravishankar. K., Krishnamoorthy. T.S, "Structural Health Monitoring, Repair and Rehabilitation of Concrete Structures", Allied Publishers, 2004.
4. CPWD and Indian Buildings Congress, Hand book on Seismic Retrofit of Buildings, Narosa Publishers, 2008.
5. Ven Te Chow (1964), ‘Hand Book of Applied Hydrology’, McGraw-Hill Publishers, New York.
6. Linsley, R. K. and Franzini A. W. (1992), ‘Water Resource Engineering’, McGraw-Hill Publishers, New York.
7. Daniel H. Hoggan (1989), ‘Computer Assisted Flood Plain Hydrology and

Hydraulics', McGraw-Hill Publishers, New York.

AC 033	**SANSKRIT FOR TECHNICAL KNOWLEDGE**					
(AUDIT COURSE - I)						
Pre-requisites			**L**	**T**	**P**	**C**
			2	-		0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	*To get a working knowledge in illustrious Sanskrit, the scientific language in the world*
2	*To make the novice Learn the Sanskrit to develop the logic in mathematics, science & other subjects*
3	*To explore the huge knowledge from ancient Indian literature*

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	*Develop passion towards Sanskrit language*
CO-2	*Decipher the latent engineering principles from Sanskrit literature*
CO-3	*Correlates the technological concepts with the ancient Sanskrit history.*
CO-4	*Develop knowledge for the technological progress*
CO-5	*Explore the avenue for research in engineering with aid of Sanskrit*

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

Unit – I
Introduction to Sanskrit Language: Sanskrit Alphabets-vowels-consonants- significance of Amarakosa-parts of Speech-Morphology-creation of new words-significance of synonyms-sandhi-samasa-sutras-active and passive Voice-Past/Present/Future Tense-Syntax-Simple Sentences (elementary treatment only)

Unit – II

Role of Sanskrit in Basic Sciences: Brahmagupthas lemmas (second degree indeterminate equations), sum of squares of n-terms of AP- sulba, sutram or baudhayana theorem (origination of Pythagoras theorem)-value of pie-Madhava's sine and cosine theory (origination of Taylor's series). The measurement system-time-mass-length-temp, Matter elasticity-optics-speed of light (origination of Michaelson and Morley theory).

Unit – III

Role of Sanskrit in Engineering-I (Civil, Mechanical, Electrical and Electronics Engineering):

Building construction-soil testing-mortar-town planning-Machine definition-crucible-furnace-air blower- Generation of electricity in a cell-magnetism-Solar system-Sun: The source of energy, the earth-Pingala chandasutram (origination of digital logic system)

Unit – IV

*Role of Sanskrit in Engineering-II (Computer Science Engineering & Information Technology):*Computer languages and the Sanskrit languages-computer command words and the vediccommand words-analogy of pramana in memamsa with operators in computer language-sanskrit analogy of physical sequence and logical sequence, programming.

Unit – V

*Role of Sanskrit in Engineering-III (Bio-technology and Chemical Engineering):*Classification of plants- plants, the living-plants have senses-classification of living creatures, Chemical laboratory location and layout- equipment-distillation vessel-kosthiyanthram

Suggested Reading:

1	M Krishnamachariar, "*History of Classical Sanskrit Literature",* TTD Press, 1937.
2	M.R. Kale, "*A Higher Sanskrit Grammar: For the Use of School and College Students*", Motilal Banarsidass Publishers, 2015.
3	Kapail Kapoor, "*Language, Linguistics and Literature: The Indian Perspective",* ISBN- 10: 8171880649, 1994.
4	"*Pride of India*", Samskrita Bharati Publisher, ISBN: 81-87276 27-4, 2007.
5	Shri Rama Verma, "*Vedas the source of ultimate science",* Nag publishers, 2005.

AC103	VALUE EDUCATION					
AUDIT COURSE-II						
Pre-requisites			**L**	**T**	**P**	**C**
			2	-	-	0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Objectives:

1.	Understand the need and importance of Values for self-development and for National development.
2.	Imbibe good human values and Morals
3.	Cultivate individual and National character.

Outcomes: At the end of this course, students will be able to**:**

1.	Gain necessary Knowledge for self-development
2.	Learn the importance of Human values and their application in day to day professional life.
3.	Appreciate the need and importance of interpersonal skills for successful career and social life
4.	Emphasize the role of personal and social responsibility of an individual for all-round growth.
5.	Develop a perspective based on spiritual outlook and respect women, other religious practices, equality, non-violence and universal brotherhood.

Program Articulation Matrix

Course outcome	Program outcome					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1						
CO2						
CO3						
CO4						
CO5						

Row wise cumulative percentage weightage should be equal to 1.0.

UNIT – I

Human Values, Ethics and Morals: Concept of Values, Indian concept of humanism, human values; Values for self-development, Social values, individual attitudes; Work ethics, moral and non- moral behaviour, standards and principles based on religion, culture and tradition.

UNIT – II
Value Cultivation, and Self-management: Need and Importance of cultivation of values such as Sense-of Duty, Devotion to work, Self-reliance, Confidence, Concentration, Integrity & discipline, and Truthfulness.
UNIT – III
Spiritual outlook and social values: Personality and Behavior, Scientific attitude and Spiritual (soul) outlook; Cultivation of Social Values Such as Positive Thinking, Punctuality, Love & Kindness, avoiding fault finding in others, Reduction of anger, forgiveness, Dignity of labour, True friendship, Universal brotherhood and religious tolerance.
UNIT – IV
Values in Holy Books: Self-management and Good health; internal & external cleanliness, Holy books versus Blind faith, Character and Competence, Equality, Nonviolence, Humility, Role of Women.

UNIT – V
*Dharma, Karma and Guna:*Concept of soul; Science of Reincarnation, Character and Conduct, Concept of Dharma; Cause and Effect based Karma Theory; The qualities of Devine and Devilish; Satwic, Rajasic and Tamasic gunas.

References:

1	Chakroborty, S.K., *"Values & Ethics for organizations Theory and practice*", Oxford University Press, New Delhi, 1998.
2	2. Jaya Dayal Goyandaka, "*Srimad Bhagavad Gita with Sanskrit Text*", Word Meaning and Prose Meaning‖, Gita Press, Gorakhpur, 2017.

AC 035	STRESS MANAGEMENT BY YOGA					
	(AUDIT COURSE - II)					
Pre-requisites			**L**	**T**	**P**	**C**
			2	-		0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Creating awareness about different types of stress and the role of yoga in the management of stress.
2	Promotion of positive health and overall wellbeing (Physical, mental, emotional, social and spiritual).
3	Prevention of stress related health problems by yoga practice.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	To understand yoga and its benefits.
CO-2	Enhance Physical strength and flexibility.
CO-3	Learn to relax and focus.
CO-4	Relieve physical and mental tension through Asanas
CO-5	Improve work performance and efficiency.

Unit – I
Meaning and definition of Yoga - Historical perspective of Yoga - Principles of Astanga Yoga by Patanjali.

Unit – II
Meaning and definition of Stress - Types of stress - Eustress and Distress. Anticipatory Anxiety and Intense Anxiety and depression. Meaning of Management- Stress Management.

Unit – III
Concept of Stress according to Yoga - Stress assessment methods - Role of Asana, Pranayama and Meditation in the management of stress.

Unit – IV
Asanas- (5 Asanas in each posture) - Warm up - Standing Asanas - Sitting Asanas - Prone Asanas - Supine asanas - Surya Namaskar.

Unit – V
Pranayama- Anulom and Vilom Pranayama - Nadishudhi Pranayama – Kapalabhati-Pranayama - Bhramari Pranayama - Nadanusandhana Pranayama.
Meditation techniques: Om Meditation - Cyclic meditation : Instant Relaxation technique (QRT), Quick Relaxation Technique (QRT), Deep Relaxation Technique (DRT).

Suggested Reading:

1	"Yogic Asanas for Group Training - Part-I": Janardhan Swami Yogabhyasi Mandal, Nagpur
2	"Rajayoga or Conquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata
3	Nagendra H.R nad Nagaratna R, "Yoga Perspective in Stress Management", Bangalore, Swami Vivekananda Yoga Prakashan

Web resource:

1	https://onlinecourses.nptel.ac.in/noc16_ge04/preview
2	https://freevideolectures.com/course/3539/indian-philosophy/11

AC 036	PERSONALITY DEVELOPMENT THROUGH LIFE ENHANCEMENT SKILLS					
(AUDIT COURSE - II)						
Pre-requisites			**L**	**T**	**P**	**C**
			2	-		0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To learn to achieve the highest goal happily
2	To become a person with stable mind, pleasing personality and determination
3	To awaken wisdom in students

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Develop their personality and achieve their highest goal of life.
CO-2	Lead the nation and mankind to peace and prosperity.
CO-3	To practice emotional self regulation.
CO-4	Develop a positive approach to work and duties.
CO-5	Develop a versatile personality.

Unit – I
Neetisatakam – Holistic development of personality - Verses 19, 20, 21, 22 (Wisdom) - Verses 29, 31, 32 (Pride and Heroism) - Verses 26,28,63,65 (Virtue)

Unit – II
Neetisatakam – Holistic development of personality (cont'd) - Verses 52, 53, 59 (dont's) - Verses 71,73,75 & 78 (do's) - Approach to day to day works and duties.

Unit – III
Introduction to Bhagavad Geetha for Personality Development - Shrimad Bhagawad Geeta: Unit 2 – Verses 41, 47, 48 - Unit 3 – Verses 13,21,27,35 - Unit 6 – Verses 5,13,17,23,35 - Unit 18 – Verses 45, 46, 48 Unit – 6: Verses 5, 13, 17, 23, 35; Unit – 18: Verses 45, 46, 48.

Unit – IV
Statements of basic knowledge - Shrimad Bhagawad Geeta: Unit 2- Verses 56, 62,68 - Unit 12 – Verses 13, 14, 15, 16, 17, 18 - Personality of Role model from Shrimad Bhagawat Geeta.

Unit – V
Role of Bahgavadgeeta in the present scenario - Unit 2 – Verses 17 – Unit 3 – Verses 36, 37, 42 - Unit 4 – Verses 18, 38, 39 - Unit 18 – Verses 37, 38, 63.

Suggested Reading:

1	"Srimad Bhagavad Gita" by Swami SwarupanandaAdvaita Ashram (Publication Department), Kolkata.
2	Bhartrihari's Three Satakam (Niti-sringar-vairagya) by P.Gopinath, Rashtriya Sanskrit, Sansthanam, New Delhi.
3	Rashtriya Sanskrit Sansthanam, New Delhi.

Web resource:

1	NTPEL:http://nptel.ac.in/downloads/109104115

AC 037	CONSTITUTION OF INDIA					
(AUDIT COURSE - II)						
Pre-requisites			**L**	**T**	**P**	**C**
			2	-		0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	The history of Indian Constitution and its role in the Indian democracy.
2	Address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.
3	Have knowledge of the various Organs of Governance and Local Administration.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand the making of the Indian Constitution and its features.
CO-2	Understand the Rights of equality, the Right of freedom and the Right to constitutional remedies.
CO-3	Have an insight into various Organs of Governance - composition and functions
CO-4	Understand powers and functions of Municipalities, Panchayats and Co-operative Societies.
CO-5	Understand Electoral Process, special provisions.

Unit – I
History of making of the Indian constitutions: History, Drafting Committee (Composition & Working). **Philosophy of the Indian Constitution**: Preamble, Salient Features.

Unit – II

Contours of Constitutional Rights and Duties Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties

Unit – III
Organs of Governance": Parliament: Composition, Qualifications, Powers and Functions, Union executives : President, Governor, Council of Ministers, Judiciary, appointment and transfer of judges, qualifications, powers and functions.

Unit – IV
Local Administration - District's Administration head: Role and importance. Municipalities: Introduction, ayor and role of Elected Representative, CEO of Municipal Corporation. Panchayati Raj: Introduction, PRI: Zilla Panchayat, Elected Officials and their roles, CEO Zilla Panchayat: positions and role. Block level: Organizational Hierarchy (Different departments) Village level: role of elected and appointed officials. Importance of grass root democracy.

Unit – V
Election commission: Election Commission: Role and functioning, Chief Election Commissioner and Election Commissioners, State Election Commission :Role and functioning. Institute and Bodies for the welfare of SC/ST/OBC and women**.**

Suggested Reading:

1	The Constitution of India", 1950 (Bare Act), Government Publication
2	Dr. S. N. Busi, Dr. B. R. Ambedkar, "Framing of Indian Constitution", 1st Edition, 2015.
3	M. P. Jain, "Indian Constitution Law", 7th Edn., Lexis Nexis, 2014
4	D.D. Basu, "Introduction to the Constitution of India", Lexis Nexis, 2015.

Web resource:

1	http://www.nptel.ac.in/courses/103107084/Script.pdf

AC 038	PEDAGOGY STUDIES					
	(AUDIT COURSE - II)					
Pre-requisites			**L**	**T**	**P**	**C**
			2	-		0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To present the basic concepts of design and policies of pedagogy studies.
2	To provide understanding of the abilities and dispositions with regard to teaching techniques, curriculum design and assessment practices and familiarize various theories of learning and their connection to teaching practice.
3	To create awareness about the practices followed by DFID, other agencies and other researchers and provide understanding of critical evidence gaps that guides the professional development

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Illustrate the pedagogical practices followed by teachers in developing countries both in formal and informal classrooms.
CO-2	Examine the effectiveness of pedagogical practices.
CO-3	Understand the concept, characteristics and types of educational research and perspectives of research.
CO-4	Describe the role of classroom practices, curriculum and barriers to learning.
CO-5	Understand Research gaps and learn the future directions.

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	1	1	3	2	1	2
CO-2	3	1	2	3	2	-
CO-3	1	3	3	1	2	2
CO-4	3	2	1	3	1	1
CO-5	2	1	3	2	2	2

Unit – I
Introduction and Methodology: Aims and rationale, Policy background, Conceptual framework and terminology - Theories of learning, Curriculum, Teacher education - Conceptual framework, Research questions, Overview of methodology and Searching.

Unit – II
Thematic Overview: Pedagogical practices followed by teachers in formal and informal classrooms in developing countries - Curriculum, Teacher education.

Unit – III
*Evidence on the Effectiveness of Pedagogical Practices***:** Methodology for the in depth stage: quality assessment of included studies - How can teacher education (curriculum and Practicum) and the school curriculum and guidance material best support effective pedagogy? - Theory of change - Strength and nature of the body of evidence for effective pedagogical practices - Pedagogic theory and pedagogical approaches – Teachers attitudes and beliefs and pedagogic strategies.

Unit – IV
Professional Development: alignment with classroom practices and follow up support - Support from the head teacher and the community – Curriculum and assessment - Barriers to learning: Limited resources and large class sizes.

Unit – V
Research Gaps and Future Directions: Research design – Contexts – Pedagogy - Teacher education - Curriculum and assessment – Dissemination and research impact.

Suggested Reading:

1	Ackers J, Hardman F, *"Classroom Interaction in Kenyan Primary Schools, Compare*", 31 (2): 245 – 261, 2001.
2	Agarwal M, *"Curricular Reform in Schools: The importance of evaluation*", Journal of Curriculum Studies, 36 (3): 361 – 379, 2004.
3	Akyeampong K, "*Teacher Training in Ghana – does it count? Multisite teacher education research project (MUSTER)",* Country Report 1. London: DFID, 2003.
4	Akyeampong K, Lussier K, Pryor J, Westbrook J, *"Improving teaching and learning of Basic Maths and Reading in Africa: Does teacher Preparation count?"*International Journal Educational Development, 33 (3): 272- 282, 2013.
5	Alexander R J, *"Culture and Pedagogy: International Comparisons in Primary Education",* Oxford and Boston: Blackwell, 2001.
6	Chavan M, Read India: *"A mass scale, rapid, learning to read campaign",* 2003

MN 181	DISSERTATION PHASE -I					
Pre-requisites	-		**L**	**T**	**P**	**C**
			-	-	20	10
Evaluation	**SEE**	-	**CIE**	100 Marks		

Course Objectives :	
1	Identification of the research problem
2	Discussion of literature survey.

Course Outcomes :	
CO-1	Identification of the objectives of the Research Problem.
CO-2	Ability to update the latest literature in chosen area of research & establishment of the scope of work.
CO-3	Development of the methodology for the chosen research problem and perform basic theoretical /experiment studies.
CO-4	Identification of the objectives of the Research Problem.
CO-5	Ability to update the latest literature in chosen area of research & establishment of the scope of work.

Contents:

Each student will be attached to a faculty member/guide for project. The student will carry out the project which may be development of Software / Hardware / Simulation studies / Design analysis / Experimental related to his/her specialization. The work will be monitored regularly by the guide.

At the end of the semester student will write the report on the work done and submit to the guide. Student has to present his/her work before two faculty members (one guide and other to be appointed by chairman BOS) on a fixed day during last week of the semester in which project is offered. The sessional marks will be awarded jointly by these examiners based on the report, presentation and viva voice

SEMESTER - IV

ME 182	**DISSERTATION PHASE -II**					
Pre-requisites	-		**L**	**T**	**P**	**C**
			-	-	32	16
Evaluation	**SEE**	100	**CIE**	100 Marks		

Course Objectives :	
1	Identification of the research problem
2	Discussion of literature survey.

Course Outcomes :	
CO-1	Expand the defined Research Problem for the dissertation work.
CO-2	Conduct of Laboratory/analytical/ software studies
CO-3	Analysis of Data, development of models, offer solutions to the research problem and provide conclusions of the work.

Contents:

The student will carry out the project under allotted supervisor, which may be development of Software / Hardware / Simulation studies / Design analysis / Experimental related to his/her specialization. The work will be monitored regularly by the guide. After 6th week one review will be conducted and awarded marks by committee. At the end of the semester student will write the report on the work done and submit to the guide. Student has to present his/her work before two faculty members (one guide and other to be appointed by chairman BOS) on a fixed day during last week of the semester in which project is offered. The final marks will be allotted based on the report, presentation and viva voce conducted by the external examiner whose name is suggested by Chairman BOS