INDIAN INSTITUTE OF ENGINEERING SCIENCE AND TECHNOLOGY(IIEST), SHIBPUR

Department of Earth Sciences

Syllabus of M. Sc. In Applied Geology

(Revised as per NEP,2020 and Approved by the BOAC, Department of Earth Sciences, IIEST, Shibpur)

2025

COURSE STRUCTURE FOR M. Sc. IN Applied Geology

First Semester

Sl. No.	Type	Course Name	Course code	Class Load/Week L	T	P	Credit	Class load/ week	Marks
1	PC	Igneous Petrology & Phase Equilibria	ES5101N	4	0	0	4	4	100
2	PC	Mineralogy & Geochemistry	ES5102N	4	0	0	4	4	100
3	PC	Structural Geology & Tectonics	ES5103N	4	0	0	4	4	100
4	PSE	1. Mathematical Geology 2. Marine Geology	ES5121N, ES5122N	3	0	0	3	3	100
5	OE	Introduction to Earth materials/ Earth Surface Processes and Structures	ES5161N, ES5162N	3	0	0	3	3	100
		Theory Sub-total		**18**	**0**	**0**	**18**	**18**	**500**
6	PC	Structural Geology Practical	ES5171N	0	0	3	2	3	50
7	PC	Mineralogy and Igneous Petrology practical	ES5172N	0	0	3	2	3	50
		Practical Sub-total		**0**	**0**	**6**	**4**	**6**	**100**
		First Semester Total		**18**	**0**	**6**	**22**	**24**	**600**

Second Semester

Sl. No.	Type	Course Name	Course code	Class Load/Week L	T	P	Credit	Class load/ week	Marks
1	PC	Sedimentology & Basin Analysis	ES5201N	4	0	0	4	4	100
2	PC	Metamorphic Petrology & Thermodynamics	ES5202N	4	0	0	4	4	100
3	PC	Principles of Stratigraphy & Indian Stratigraphy	ES5203N	4	0	0	4	4	100
4	PSE	1. Geodynamics 2. Geomorphology	ES5221N, ES5222N	3	0	0	3	3	100
5	OE	Life through Ages/ Natural Resources and Energy	ES5261N, ES5262N	3	0	0	3	3	100
		Theory Sub-total		**18**	**0**	**0**	**18**	**18**	**500**
6	PC	Metamorphic Petrology and Sedimentology Practical	ES5271N	0	0	3	2	3	50
7	PC	Fieldwork	ES5272N	0	0	0	2	0	50
		Practical Sub-total		**0**	**0**	**3**	**4**	**3**	**100**
8	P	Term-paper	ES5291N	0	0	4	2	4	50
9	O	Term PaperViva Voce	ES5292N	0	0	0	2	0	50
		Term Paper Sub-total		**0**	**0**	**4**	**4**	**4**	**100**
		Second Semester Total		**18**	**0**	**7**	**26**	**25**	**700**

Third Semester									
Sl. No.	**Type**	**Course Name**	**Course code**	**Class Load/Week**			**Credit**	**Class load/ week**	**Marks**
				L	**T**	**P**			
1	PC	Palaeontology & Mass Extinction	ES6101N	4	0	0	4	4	100
2	PC	Ore Geology & Fuel Geology	ES6102N	4	0	0	4	4	100
3	PC	Introduction to extraction of Critical Minerals	ES6103N	4	0	0	4	4	100
		Theory Sub-total		**12**	**0**	**0**	**12**	**12**	**300**
4	PC	Ore Geology + Palaeontology practical	**ES6171N**	0	0	3	2	3	50
		Practical Sub-total		**0**	**0**	**3**	**2**	**3**	**50**
6	P	M. Sc. Thesis Part-I (Progress report)	ES6191N	0	0	18	6	12	100
7	O	Thesis progress report Seminar and Viva voce	**ES6192N**	0	0	0	2	0	100
		M. Sc. Thesis Sub-total		**0**	**0**	**18**	**8**	**12**	**200**
8	I	Internship	**ES6193N**				2		50
		Third Semester Total		**12**	**0**	**21**	**24**	**27**	**600**

Fourth Semester									
Sl. No.	**Type**	**Course Name**	**Course code**	**Class Load/Week**			**Credit**	**Class load/ week**	**Marks**
				L	**T**	**P**			
	VAC						**3**		**100**
1	PC	GIS & Remote Sensing and Applictaion of AI-ML in Geosciences	ES6201N	4	0	0	4	4	100
2	PC	Hydrogeology & Exploration Geophysics	ES6202N	4	0	0	4	4	100
		Theory Sub-total		**6**	**1**	**0**	**11**	**8**	**300**
3	P	M.Sc Thesis Part-II	ES6291N	0	0	16	8	16	200
4	O	Thesis Seminar and Viva-voce	**ES6292N**	0	0	0	4	0	100
		M. Sc. Thesis Sub-total		**0**	**0**	**16**	**12**	**16**	**300**
		Fourth Semester Total		**6**	**1**	**16**	**23**	**24**	**600**

Total course	**95**		**2500**

Type of Course

Basic Science Course (BSC)
Engineering Science Course (ESC)
Humanities and Social Sciences Course (HSC)
Program Core Courses (PC)
Program Specific Elective Course (PSE)
Open Electives (OE)
Value Added Course (VAC)
Project (P)
Internship (I)

Other (O) such as seminar, viva voce, etc.

Detailed Course Content

FIRST SEMESTER

Course Code	ES5101N	Course Name	Igneous Petrology and Phase Equilibria	Course Category	PC	L	T	P
						4	0	0

Pre-requisite Courses	BSc with Geology/ Earth Sciences as Major in three-year UG Course	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department		Earth Sciences		Data Book / Codes/Standards	Nil

Course Objective	The objective focuses on ideas about various aspects of igneous rocks which are controlled by chemical and physical properties of magmas and their surroundings. This course will help in the understanding of melt generation and crystallization mechanisms, diverse rock types and their relation with the tectonic settings.

Module	Syllabus	Duration (class-hour)	Module outcome
1	Differentiation of the Earth, major structural units of the Earth, magmatism in relation to plate setting. Composition of the upper mantle, energy and mantle heat engine, gravity, pressure and geobaric gradient, viscosity of melts chemical diffusion, heat diffusion, nucleation and crystal growth, vesiculation and fragmentation of magma, igneous rock series.	8	Students will analyze the compositional stratification of Earth's layers and relate magmatic activity to tectonic settings (e.g., mid-ocean ridges, subduction zones). They will evaluate mantle melting processes using heat flow, pressure gradients, and viscosity to interpret magma generation mechanisms.
2	Classification of magmatic rocks - based on fabric, field relations, mineralogical and modal, and whole rock compositions, IUGS classification of plutonic, hypabyssal and volcanic rocks.	4	Learners will classify igneous rocks based on IUGS criteria (mineralogical, modal, and geochemical compositions) and correlate rock types (e.g., basalt, granite) with their tectonic environments. They will distinguish plutonic, hypabyssal, and volcanic textures.
3	Gibbs Phase Rule and Cryoscopic Equation: application to magmatic crystallization. Magmatic phase equilibria: binary, ternary and quaternary systems involving	8	Students will apply Gibbs Phase Rule to binary/ternary systems, modeling equilibrium vs. fractional crystallization. They will interpret phase diagrams

	congruent and incongruent melting, continuous and discontinuous solid solutions, polymorphism, liquid immiscibility, equilibrium crystallization and fractional crystallization, equilibrium partial melting and fractional partial melting.		(e.g., Bowen's Reaction Series) to predict mineral assemblages and reaction textures (e.g., peritectic melting).
4	Cooling behaviour, convection, crystal settling and floating, diffusion, Soret effect, flow and diapirism. Simple numerical problems. Trace element fractionation in magmas: equilibrium crystallization and Rayleigh fractionation, REE patterns of common basalts.	4	Learners will quantify cooling rates using diffusion models and convection dynamics. They will calculate trace element distributions (e.g., REE patterns) to assess magma differentiation processes (e.g., Rayleigh fractionation).
5	Low-pressure fractional crystallization of basaltic magmas: thermal barrier between tholeiitic and alkaline trends, generation of common crustal-level igneous rocks. Melt composition, mantle material, partial melting of the peridotite mantle and magma generation, alkaline magma generation, magma generation in continental crust, differentiation (open and closed systems) and assimilation, hybrid magmas, magma storage, ascent and emplacement, field relations of intrusions.	8	Students will model tholeiitic vs. alkaline magma differentiation trends and evaluate crustal assimilation effects. They will reconstruct mantle partial melting scenarios using geochemical datasets and experimental petrology.
6	Layered mafic complexes: Structural, petrographic and chemical characters, origin of cumulates and layering.	4	Learners will interpret cumulate textures and layering in intrusions (e.g., Bushveld Complex) to deduce crystallization histories and magma chamber dynamics.
7	Magmatic evolution in different plate tectonic settings: Mid-oceanic ridge basalts, ocean floor basalts, ophiolites, intra-plate oceanic island basalts, andesites and calc-alkaline volcanic rocks in plate convergences, continental flood basalts.	4	Students will correlate magma compositions (MORBs, arc andesites, kimberlites) with plate boundary processes. They will critique geodynamic models for flood basalts and oceanic island volcanism.
8	Granites and granitic rocks: Review of the structural-tectonic and petrographic –chemical varieties. Primary magmatic, anatectic and metasomatic processes in different settings. Isotopic-geochemical and geochronological signatures of granites. Simple numerical problems.	4	Learners will discriminate primary magmatic, anatectic, and metasomatic granites using isotopic/geochemical signatures. They will assess carbonatite/kimberlite genesis in rift and hotspot settings.

	Alkaline rocks, carbonatites and kimberlites: brief review of the mode of occurrence, petrography, chemistry and genetic processes		
9	Precambrian magmatism: petrology of komatiites and massif-type anorthosites—brief introduction to problems of heat flow, plate movements and place-time constrains in the Precambrian	4	Students will evaluate komatiite petrogenesis in Archean thermal regimes and contrast them with modern analogs. They will analyze massif-type anorthosites as probes of early crustal processes.
10	Ultramafic rocks: Structure, petrography and chemistry in relation to tectonic settings. Upper mantle petrology and phase equilibria: geophysical and geochemical constraints partial melting, origin of primary basaltic magmas	4	Learners will relate ultramafic xenoliths to mantle rheology and metasomatism. They will apply geo-thermo-barometry to estimate mantle melting conditions using experimental phase equilibria.
Total		**52**	

Course Outcome	Upon completion, students will demonstrate proficiency in analyzing physicochemical processes governing magma generation, differentiation, and crystallization using phase diagrams and thermodynamic principles. They will classify igneous rocks through mineralogical, geochemical, and textural criteria, linking them to tectonic environments. Learners will evaluate magmatic processes (e.g., partial melting, fractional crystallization) via petrogenetic models and experimental datasets, apply geo-thermo-barometry to interpret crystallization histories, and critically assess research to infer crust-mantle dynamics. This prepares them for advanced research in igneous systems and geodynamic reconstructions.

Learning Resources	1. Igneous Petrology by Anthony Hall. . 2. Introduction to Igneous and Metamorphic Petrology by John D. Winter. 3. Igneous and Metamorphic Petrology by Myron G. Best. 4. Principles of Igneous and Metamorphic Petrology by Anthony R. Philpotts and Ague 5. Using Geochemical Data: Evaluation, Presentation, Interpretation, Hugh Rollinson. 6. Igneous and Metamorphic Rocks under the Microscope: Classification, textures, microstructures and mineral preferred orientation by D. Shelley.

Course Code	ES5102N	**Course Name**	Mineralogy and Geochemistry	**Course Category**	PC	L	T	P
						4	0	0

Pre-requisite Courses	BSc with Geology/ Earth Sciences as Major in three-year UG Course	**Co-requisite Courses**	Nil	**Progressive Courses**	Nil
Course Offering Department		**Earth Sciences**		**Data Book / Codes/Standards**	Nil

Course Objective	The course aims to provide knowledge on the characteristics of major rock forming mineral groups, their crystal symmetry, crystallography and atomic structure. A detailed study on their formation environments and associations of rock-forming minerals will be provided along with techniques of mineral characterization. The course will further give an insight on how chemical principles are used to explain the mechanisms that control the large geological systems such as the Earth´s mantle, crust, ocean and atmosphere and the formation of the solar system.

Module	Syllabus	Duration (class-hour)	Module outcome
1	**Mineralogy:** Rock Forming Minerals: their distribution; importance; some important crystals. Chemical features in silicate minerals, coordination, substitution, omission Solid Solution, order-disorder etc.	4	Students will classify major rock-forming minerals by crystal chemistry, structural features, and substitution mechanisms, and explain mineral stability in geologic environments.
2	Crystal Field Theory: its application in distribution of transition elements in minerals and rocks; bonding in minerals.	2	Learners will apply crystal field theory to explain coloration, magnetic behavior, and trace element incorporation in minerals.
3	Calculation of atomic ratios from analysis	2	Students will compute atomic proportions from mineral analyses and interpret compositional trends in silicate systems.
4	Alkali feldspar: classification; optic relation; perthite solvus; structure of feldspar; aluminium silicon ratio; order in feldspar; ordering paths; estimate of the degree of order. Polymorphism of $NaAlSi_3O_8$, structural states of plagioclase	4	Learners will analyze feldspar polymorphism, order-disorder phenomena, and interpret phase transitions using optical and structural data.
5	Structure of Nepheline, constitution of Nepheline and its significance	2	Students will evaluate the constitution of nepheline and

			its implications in silica-undersaturated igneous systems
6	Pyroxene group: classification: atomic structure; optical properties; pyroxene inversion; experimental observations; exsolution; Fe-Mg order	2	Learners will classify pyroxenes based on optical and crystallographic properties and interpret inversion and exsolution phenomena
7	Olivine group: classification; structure; optical properties; paragenesis; Olivine-Spinel transition and its significance	2	Students will assess olivine structures, Fe-Mg ordering, and paragenesis, including olivine-spinel transitions under mantle conditions.
8	Amphibole group: classification; structure; comparison with pyroxene	2	Learners will compare amphiboles and pyroxenes structurally and interpret amphibole stability in metamorphic and igneous rocks
9	X-ray crystallography: Bragg's law; single crystal and powder methods; principle and application in determination of crystal structure. Defects in minerals, phase relations in major groups of minerals.	4	Students will apply Bragg's Law and x-ray methods to characterize mineral structures, assess defects, and interpret phase relations.
10	Ore mineralogy: mineralogy of important ores of the following elements; iron, manganese, titanium, chromium, tin, tungsten, copper, lead, zinc, nickel, uranium, thorium. Texture of the ore minerals and their interpretations	4	Learners will describe ore minerals of economic elements and interpret textures to infer ore genesis processes
11	Concept of symmetry, point group, lattice and space group, principles of crystal chemistry, principles of optical and x-ray mineralogy	2	Students will utilize symmetry and crystallographic concepts to classify minerals and predict atomic arrangements
12	**Geochemistry:** Origin and abundance of elements in the solar system and Earth; Chemical composition and properties of atmosphere, hydrosphere and lithosphere; Geochemical cycles; Atomic structures and properties of elements in the periodic table with special reference to major, minor and trace elements (transition, LILE, HFSE) including rare earth elements; Geochemical classification of elements	4	Learners will explain elemental behavior using periodic properties and assess chemical composition of Earth systems.
13	Laws of Thermodynamics; Concepts of Free Energy, Activity, Fugacity and Equilibrium Constant, Thermodynamics of Ideal, Non-Ideal and Dilute Solutions.	6	Students will apply thermodynamic principles (Gibbs Free Energy, Activity,

	Element Partitioning In Minerals/Rock Formation and Concept of Distribution of Coefficients.		Fugacity) to model mineral stability and equilibria
14	Radioactive Isotope: Radioactive decay schemes. Growth of Daughter Isotopes and Radiometric Dating. Geochronology—Methods	4	Learners will evaluate radioactive decay schemes and apply isotope systematics to date geologic materials.
15	Stable isotopes: Nature, Abundance, Fractionation, Evolution and Fluid interactions.	4	Students will interpret stable isotope data to assess fluid interactions, weathering, metamorphism, and environmental conditions
16	Concepts of P-T-X, Eh-Ph Diagrams and Mineral Stability; Geochemical processes involved in rock weathering and soil formation; Metamorphism as a geochemical phenomenon. Mineral/Mineral Assemblages as 'Sensors' Of Ambient Environments.	4	Students will interpret stable isotope data to assess fluid interactions, weathering, metamorphism, and environmental conditions
Total		**52**	

Course Outcome	Upon completion, students will be able to identify and classify major rock-forming minerals based on crystallographic symmetry, atomic structure, and physicochemical properties. They will analyze mineral formation environments, associations, and their role in geological processes using advanced characterization techniques (e.g., XRD, SEM-EDS). Learners will apply geochemical principles to interpret elemental distribution, isotopic systems, and chemical processes governing Earth's mantle, crust, oceans, atmosphere, and solar system evolution. This equips them to integrate mineralogical and geochemical data for research in petrogenesis, environmental systems, and planetary science.

Learning Resources	1. Rock-Forming minerals, Deer, W.A., Howie, R.A. & Zusaman. 2. Introduction to Mineralogy by William D. Nesse. 3. Manual of Mineralogy by James D. Dana, Cornelius S. Hurlbut, and Cornelis Klein. 4. Using Geochemical Data: Evaluation, Presentation and Interpretation by Hugh Rollinson. **5.** Principles of Geochemistry, 4^{th} edition by B Mason & C. B Moore. **6.** Geochemistry: An Introduction by Albrecht W. Hofmann and Francis Albarède. **7.** Principles and Applications of Geochemistry by Gunter Faure.

Course Code	ES5103N	Course Name	Structural Geology and Tectonics	Course Category	PC	L	T	P
						4	0	0

Pre-requisite Courses	BSc with Geology/ Earth Sciences as Major in three-year UG Course	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department		Earth Sciences		Data Book / Codes/Standards	Nil

Course Objective	Tectonic activity of the Earth's surface is the external manifestation of internal dynamism of the Earth. Enormous tectonic forces are developed due to this tectonic activity. These trigger deformation of rocks which subsequently lead to the development of different complex structures. The present course will help the students to understand the deformation-mechanisms of rocks through geometric, kinematic, dynamic analysis of rock structures and their relation to different tectonic environments

Module	Syllabus	Duration (class-hour)	Module outcome
1	**Structural Geology:** Stress: Definition, Stress at a point, component of stress matrix, principal axes of stress, stress ellipsoid, stress on planes inclined to principal axes of stress, Mohr circle diagram of tress.	3	Students will learn stress components using matrices, construct Mohr circles, and determine principal stresses on inclined planes to analyze rock deformation conditions
2	Strain: Types and measurement of strain, strain ellipse and ellipsoid, principal axes of strain, rotational and irrotational deformation, flattening, constriction and plane strain, pure shear and simple shear, concept of zones of shortening and extension in pure and simple shear.	4	Learners will differentiate between rotational/irrotational deformation, quantify strain using ellipsoids, and model shortening/extension zones in pure and simple shear regimes
3	Progressive Deformation: Concept of infinitesimal and finite strain, co-axial and non-coaxial deformation, particle paths for pure and simple shear and combined pure and simple shears. Rotation of rigid spherical and ellipsoid inclusion	3	Students will distinguish finite vs. infinitesimal strain, trace particle paths in combined shear systems, and predict rigid inclusion rotation during deformation.
4	Behavior of Rocks under Stress: Brittle, ductile and plastic deformation with stress-strain relation, creep deformation. Rheology. Classification of Rheology. How extrinsic parameters (Pressure,	4	Learners will classify brittle/ductile/plastic deformation, correlate stress-strain curves with creep mechanisms, and evaluate

	Temperature etc.) influence Rheology. Rheology in Earth Science, Constitutive equation of Rheology, Rheological models, complex rheology		pressure/temperature impacts on rock rheology.
5	Superposed Folds: Fold interference in a single deformation, types of superposed fold, Ramsay's classification of fold interference [pattern, superposed folding depending on the mechanism of late fold and early and late folds, methods of geometrical analysis of superposed folds in mesoscopic and macroscopic scales.	5	Students will identify various fold interference patterns, analyze superposed folding mechanisms, and reconstruct deformation histories at multiple scales.
6	Lineation: Types of lineation, use of lineation in structural geology, reorientation of early lineation in superposed deformation	3	Learners will categorize lineation types, utilize them as structural indicators, and model reorientation in polyphase deformation settings.
7	Cleavage: Nomenclature, geometrical relation with folds, use of axial plane cleavage in geometrical/structural analysis, origin of axial plane cleavage, problem concerning the origin of cleavage	3	Students will relate cleavage geometry to folds, learn structural analysis, and evaluate genetic models for cleavage formation.
8	Boudinage: Significance of boudin shapes, geometrical relation with fold, origin of boudinage	3	Learners will interpret boudin shapes as strain markers, correlate boudinage with regional structures.
9	Shear zone: Brittle and ductile shear zones, structures in ductile shear zone, Mylonites-classification and textural features, shear sense indicator	4	Students will classify shear zones, identify shear textures, and use kinematic indicators to determine shear sense.
10	Mechanism of faulting: Anderson's theory of faulting, Halfner's analysis of faulting. Rejuvenation of earlier fault/weak zone by imposed later stress	4	Learners will apply various theory to fault genesis, and predict reactivation of pre-existing weaknesses under new stress fields.
11	**Tectonics:** Mobile Belts and Craton	4	Students will learn tectonic evolution of mobile belts vs. cratons and evaluate their roles in continental assembly.
12	Concept of vertical and horizontal tectonics and its limitations	2	Learners will critique limitations of vertical/horizontal tectonic models using geophysical and structural evidence.
13	Concepts of plates, plate boundaries, pole of rotation, Euler's theorem, plate tectonics on sphere, plate tectonics and mountain building processes, plate tectonics at subduction zones, transform and divergent boundaries, evolution of plateau and rift	10	Students will apply Euler's theorem to plate motions, correlate boundary types (convergent/divergent/transform) with mountain building/rift formation, and reconstruct

	valleys, study of plate tectonics and interior of the earth through seismology, Driving forces of plate tectonics, origin of mantle plumes/hot spot and its role on plate tectonics of the Indian plate, Drifting of the Indian sub-continent through time		India's drift history using hotspot/seismic data.
Total		**52**	

Course Outcome	Upon completion, students will analyze deformation mechanisms in rocks through geometric, kinematic, and dynamic approaches, interpreting structures like folds, faults, and shear zones. They will apply stress-strain models to assess rock behavior under tectonic forces and correlate structural patterns with plate boundary settings (e.g., convergent, divergent). Learners will utilize field techniques, cross-section balancing, and stereo-net analysis to reconstruct deformation histories. This equips them to evaluate tectonic processes shaping Earth's crust and contribute to applications in resource exploration, seismic hazard assessment, and geodynamic modeling.

Learning Resources	1. Structural Geology—Fundamentals and Modern developments by S.K. Ghosh. 2. Folding and Fracturing of Rocks by J.G. Ramsay. 3. Structural Geology by H Fossen 4. An outline of Structural Geology by B.E. Hobbs, W.D. Means and P.F. Williams. 5. Structural analysis of Metamorphic tectonites by J.G. Turner and L. E. Weiss. 6. Use of stereographic projection in Structural Geology by F. C. Phillips. 7. Elasticity, Fracture and flow by J.C. Jaeger. 8. Structural Geology by Twiss and Moores 9. Rheology of the Earth by G. Ranalli, Allen and Unwin 10. Plate tectonics and crustal evolution, 3rd ed. Ed by K.C. Condie. 11. The Dynamic Earth by P.J. Willie

Course Code	ES5121N	Course Name	Mathematical Geology	Course Category	PSE	L	T	P
						3	0	0

Pre-requisite Courses	BSc with Geology/ Earth Sciences as Major in three-year UG Course	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department		Earth Sciences		Data Book / Codes/Standards	Nil

Course Objective	Geology is an applied science and in different branches of geology mathematics is used as a tool. Mathematical tools are required Mathematics has a wide application in Geology to understand geological processes too. Knowledge of mathematics is essential to conduct analog and numerical experiments in geology in order to match field observations. The course claims to help students to understand and develop an idea on the nature of geological and deformational processes precisely

Module	Syllabus	Duration (class-hour)	Module outcome
1	Solving equations graphically and analytically	7	Students will solve geological equations using graphical plots and algebraic methods, enabling quantitative modeling of Earth processes
2	Numerical differentiation and integration	7	Learners will compute derivatives/integrals of geological functions to analyze rates of change (e.g., sedimentation, cooling) and volumetric properties.
3	The concept of probability	3	Students will apply probability distributions to assess uncertainties in resource estimation and geospatial data.
4	Normal statistics, Universe, population, sample, random variable, Normal distribution, mean, mode, median, skewness, kurtosis, log-normal distribution, Multivariate distribution, 't'test, 'F'test, fiducian levels correlation, covariance, regression, linear and non-linear relationship	7	Learners will perform t-tests, F-tests, and regression to identify correlations in geochemical/petrological datasets and validate geological hypotheses.
5	Fundamentals of geostatistics, spatial and numerical variability of samples, variogram, estimation variance, geostatistical modeling, krigging	10	Students will model spatial variability of ore grades/reservoir properties using variograms and optimize resource estimation via kriging.

6	Some geosciences applications of trigonometry	5	
Total		**39**	

Course Outcome	Upon completion, students will apply mathematical tools to model geological processes such as deformation, fluid flow, and sedimentation. Learners will interpret spatial and temporal datasets. The course equips them to quantify uncertainties in geological models, integrate mathematical frameworks with geological principles, and solve complex problems in resource exploration, hazard assessment, and tectonic reconstructions.

Learning Resources	1. Statistics and data analysis in Geology by J.C. Davis. 2. Statistical methods in geology by R.F. Cheeney. 3. Essential maths for Geoscientists: An Introduction by Paul I. Palmer. 4. Principles of mathematical geology by Andreĭ Borisovich Vistelius 5. Handbook of Mathematical Geosciences edited by Daya Sagar, B.S., Cheng, Qiuming, Agterberg

Course Code	ES5122N	Course Name	Marine Geology	Course Category	PSE	L	T	P
						3	0	0

Pre-requisite Courses	BSc with Geology/ Earth Sciences as Major in three-year UG Course	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department		Earth Sciences		Data Book / Codes/Standards	Nil

Course Objective	The study of Marine Geology is interdisciplinary. It is concerned with all aspects of the oceans and seas, including their physical and chemical properties, origin, geology and life forms. The objective is to study all aspects of the ocean. It covers a wide range of topics, from marine life and ecosystems, to currents and waves, to the movement of sediments, to seafloor geology.

Module	Syllabus	Duration (class-hour)	Module outcome
1	Morphologic and tectonic domains of the ocean floor. Structure, composition and mechanism of the formation of oceanic crust. Hydrothermal vents.	5	Learners gain an understanding of the morphological and tectonic features of the ocean floor, the processes behind oceanic crust formation, and the significance of hydrothermal systems.
2	Ocean margins and their significance. Ocean Circulation, Coriolis effect and Ekman spiral, convergence, divergence and upwelling, El Nino. Indian Ocean Dipole Thermohaline circulation and oceanic conveyor belt. Formation of Bottom waters; major water masses of the world’s oceans	5	Provides a comprehensive insight into physical oceanographic processes and their role in global climate regulation and water mass formation.
3	Oceanic sediments: Factors controlling the deposition and distribution of oceanic sediments; geochronology of oceanic sediments, diagenetic changes in oxic and anoxic environments	6	Enables interpretation of marine sedimentary records through an understanding of depositional controls, dating techniques, and diagenetic alterations in varied redox conditions.
4	Tectonic evolution of the ocean basins	4	Facilitates the reconstruction of ocean basin development and the geodynamic mechanisms underlying their structural evolution.
5	Mineral resources	5	Enhances the ability to assess marine mineral deposits with emphasis on genesis, distribution,

			and exploration strategies in oceanic settings.
6	Paleoceanography– Approaches to paleo-oceanographic reconstructions; various proxy indicators for palaeoceanographic interpretation.	6	Introduces methods and proxy systems used in paleoceanographic reconstructions to infer past marine and climatic conditions.
7	Reconstruction of monsoon variability by using marine proxy records	4	Develops the skill to utilize marine proxies in reconstructing past monsoon dynamics and evaluating long-term climatic variability.
8	Opening and closing of ocean gateways and their effect on circulation and climate during the Cenozoic. Sea level processes and Sea level changes	4	Encourages critical analysis of oceanic gateway dynamics and sea-level fluctuations, and their influence on global circulation and climate throughout the Cenozoic.
Total		**39**	

Course Outcome	Upon completion, students will assess seafloor geology, sediment transport, and marine ecosystems using geophysical tools (e.g., bathymetric mapping, core sampling) and geochemical data. They will interpret tectonic, oceanographic, and climatic processes shaping marine environments through seismic stratigraphy and palaeoceanographic proxies. Learners will integrate geological, biological, and chemical datasets to evaluate coastal dynamics, hydrocarbon reservoirs, and climate interactions. This prepares them for interdisciplinary research and roles in environmental management, resource exploration, and marine conservation.

Learning Resources	1. Marine Geology by J Kennett 2. The Sea floor Spreading- An introduction to Marine Geology by Seibold, Eugen Berger and Wolfgang 3. An Introduction to Marine Geology by M. J. Keen. 4. Essentials of oceanography by Harold V. Thurman 5. Descriptive Physical Oceanography: An Introduction by George L Pickard

Course Code	ES5161N	Course Name	Introduction to Earth Materials	Course Category	OE	L	T	P
						3	0	0

Pre-requisite Courses	BSc with Geology/ Earth Sciences as Major in three-year UG Course	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department		Earth Sciences		Data Book / Codes/Standards	Nil

Course Objective	The course is designed to give a brief idea of the material by which our mother Earth is made up of. The main objective is to familiarize earth material within the students of different departments. The main aim is to build a base knowledge of minerals and rocks. Fundamentals of minerals and rock properties and their use will be an important part of the course other than identification

Module	Syllabus	Duration (class-hour)	Module outcome
1	Definition of Earth materials.	1	Understand Earth based on origin, and physical properties.
2	Earth as a planet in solar system. Gross features of the Earth. Brief idea about core, mantle, crust, hydrosphere, atmosphere, biosphere and elemental abundance in each constituent	2	Understand core, mantle, and crust, as well as the hydrosphere, atmosphere, and biosphere.
3	Layered structure of the Earth	2	Based on geophysical and geochemical evidence, and relate it to geological processes and Earth dynamics.
4	Earth's materials, minerals and rocks. Broad groups of minerals, oxides, sulphides, carbonates, sulphates and phosphates, silicates. Rocks as mineral assemblages, fabric, texture. Igneous rocks, acid, intermediate, mafic and ultramafic rocks. Sedimentary rocks, clastic and nonclastic. Metamorphic rocks, foliated, nonfoliated	14	Identify and classify Earth's materials Differentiate between major mineral groups Describe the concept of rocks as mineral assemblages, Classify igneous, metamorphic and sedimentary rock
5	Ore Mineralogy: Mineralogy of Important Ores of the Following Elements—Iron, Manganese, Titanium, Chromium, Tin, Tungsten, Copper, Lead, Zinc, Nickel, Uranium, Thorium. Texture	7	Identify and describe the mineralogy of important ore minerals Classify ore minerals Apply mineralogical characteristics and textures

	of the Ore Minerals and their Interpretations		
6	Study of rock forming minerals in hand specimen: identifications of common rock forming minerals and rocks	5	Identify common rock-forming minerals. Interpret basic geological characteristics of rocks and minerals. Develop observational and analytical skills essential for field and laboratory-based geological investigations
7	Physical Properties of minerals and rocks and their uses	8	Describe the physical properties of minerals and rock Evaluate the suitability of rocks and minerals for specific economic and engineering applications.
Total		**39**	

Course Outcome	Upon completion, students will identify and classify minerals and rocks based on their physical, chemical, and structural properties. They will analyze formation processes, geological environments, and diagnostic features of common Earth materials. Learners will apply analytical techniques (e.g., hand lens, microscopy) to distinguish rock types and interpret their geological significance. The course equips them to correlate material characteristics with Earth's dynamic processes and human applications (e.g., construction, resource extraction), fostering interdisciplinary understanding of planetary composition and material science.

Learning Resources	1. An introduction to the rock forming minerals by W. A. Deer, R. A. Howie and J. Zussman, 2. Optical mineralogy by P. K. Verma. 3. A Textbook of Geology by P. K. Mukherjee. 4. Fundamentals of Geology by Borges, Gwalani and Veena Rao. 5. Understanding Earth, 3rd edition, by Frank Press and Raymond Siever

Course Code	ES5162N	Course Name	Earth Surface Processes and Structures	Course Category	OE	L	T	P
						3	0	0

Pre-requisite Courses	BSc with Geology/ Earth Sciences as Major in three-year UG Course	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department		Earth Sciences		Data Book / Codes/Standards	Nil

Course Objective	The course provides an overview of surfacial processes responsible on for the formation of different primary and secondary landforms, land forming processes, landscape evolution and how these depend on climate and tectonic regimes.

Module	Syllabus	Duration (class-hour)	Module outcome
1	Earth's energy balance, hydrological cycle, carbon cycle, heat transfer, topography and bathymetry	2	Interpret and relate Earth's energy and material cycles to environmental and geological processes.
2	Landforms in relation to climate, rock type, structure and tectonics	2	Identify and classify major landforms
3	Processes – weathering, pedogenesis, mass movement, erosion, transportation and deposition	5	Explain the processes of physical, chemical, and biological weathering and their role in landscape evolution. Analyze erosion processes caused by water, wind, ice, and gravity, and their effects on the Earth's surface. Interpret the interplay among exogenic processes in shaping terrestrial and marine landforms.
4	Geomorphic processes and landforms – fluvial, glacial, Aeolian, coastal and karst. River forms and processes – stream flow, stage discharge relationship; hydrographs and flood frequency analysis. Submarine relief	5	Students will be able to explain geomorphic processes and associated landforms. They will also understand and interpret the features of submarine relief.
5	Geomorphology and topographic analysis including DEM, Environmental change– causes, effects on processes and landforms. Extra-terrestrial geomorphology	5	Students will be able to analyze Earth's surface using topographic and DEM data, assess the impact of environmental changes on geomorphic processes and landforms, and compare geomorphological features on Earth with those on other planetary bodies.

6	Types of rocks and the environment in which they occur	1	Students will be able to identify different rock types and their environmental settings, explain the rock cycle
7	Rock cycle	2	
8	Introduction to rock deformation, causes for deformation, Ductile and Brittle behaviors of rock	4	Understand the causes and mechanisms of rock deformation, including ductile and brittle behaviors.
9	Structures of rock: Primary and Secondary structures	1	Students will be able to identify and interpret primary and secondary rock structures, distinguish between penetrative and non-penetrative features, and analyze structural elements
10	Penetrative and Non-penetrative structures, fold, fault, lineation, foliation, shear zone	4	
11	Mechanical properties of rocks and their controlling factors	3	Students will be able to understand the mechanical properties of rocks and their controlling factors, and apply graphical and stereographic methods, including π and β diagrams, to analyze and solve structural geology problems.
12	Structural data analysis: Solution of structural problem using graphical method Stereographic method, and π and β diagrams	5	
Total		**39**	

Course Outcome	Upon completion, students will analyze surficial processes (e.g., erosion, weathering, sediment transport) shaping primary and secondary landforms and evaluate their role in landscape evolution. They will interpret geomorphic features using field, remote sensing, and geochronological tools to deduce climatic and tectonic influences. Learners will model interactions between surface processes, lithology, and environmental drivers to predict landscape responses. This equips them to address challenges in geohazard mitigation, land-use planning, and paleoenvironmental reconstruction through interdisciplinary applications in geomorphology and Earth system science.

Learning Resources	1. Earth Surface Processes and Landforms and Sediment Deposit by John Bridge and Robert Demicco. 2. Earth Surface Processes by P. A. Allen 3. Geomorphology: A Systematic Analysis of Late Cenozoic Landforms, Pearson Education by A.L. Bloom. 4. Global Geomorphology by M.A. Summerfield. 5. Structural Geology—Fundamentals and Modern developments by S.K. Ghosh. 6. Folding and Fracturing of Rocks by J.G. Ramsay. 7. An outline of Structural Geology by B.E. Hobbs, W.D. Means and P. F. Williams. 8. Engineering and general geology by Prabin Singh.

Course Code	ES5171N	Course Name	Structural Geology Practical	Course Category	PC	L	T	P
						0	0	3

Pre-requisite Courses	BSc with Geology/ Earth Sciences as Major in three-year UG Course	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department		Earth Sciences		Data Book / Codes/Standards	Nil

Course Objective	Objective of the present study is to introduce various problems of structural geology and equip students to enable identification of various structures in field, processing structural data and making an integrated structural map

Module	Syllabus	Duration (class-hour)	Module outcome
1	Solution of structural problems of stereographic projection (in combination with other graphical methods when necessary) in the laboratory	25	Students will determine orientations of folds/faults using stereonets, resolving complex deformational histories from field data.
2	Structural interpretation of geological maps of superposed fold and complex structure related to fault and fold in the laboratory	14	Learners will reconstruct multi-phase deformation sequences by analyzing interference patterns and fault-fold relationships in geological maps
Total		**39**	

Course Outcome	Upon completion, students will demonstrate proficiency in identifying and analyzing geological structures (e.g., folds, faults, foliations) through field observations, stereonet projections, and structural datasets. They will apply techniques for processing and interpreting orientation data, constructing geological cross-sections, and integrating field measurements into structural maps. Learners will synthesize spatial relationships, kinematic indicators, and deformation histories to infer tectonic regimes. This equips them with practical skills for fieldwork, resource exploration, and geohazard assessment, preparing them to address complex structural challenges in academic and industry settings.

Learning Resources	1. Barnes, J.W. and Lisle, R.J., 2013. Basic geological mapping. John Wiley & Sons. 2. Lisle, R.J., Brabham, P. and Barnes, J.W., 2011. Basic geological mapping. John Wiley 3. Compton, R.R. and Compton, R.R., 1985. Geology in the Field (p. 416). New York: 4. Ghosh, S.K., 2013. Structural geology: Fundamentals and modern developments. 5. Gokhale, N.W., 1991. a Manual of Problems in Structural Geology. CBS Pub.. 6. Billi, A. and Fagereng, A., 2019. Problems and solutions in structural geology and tectonics (Vol. 5). Elsevier.

Course Code	ES5172N	Course Name	Mineralogy Practical and Igneous Petrology and	Course Category	PC	L	T	P
						0	0	3

Pre-requisite Courses	BSc with Geology/ Earth Sciences as Major in three-year UG Course	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department		Earth Sciences		Data Book / Codes/Standards	Nil

Course Objective	Identification of minerals and igneous rocks is one of the main objectives of this course. With a revision of each common specimens of minerals and rocks this course is designed to give and teach students advanced techniques of deduction of paragenesis of mineral evolution or crystallization. Thorough textural, compositional (presence of zoning) study of rocks and minerals under microscope will be taught with an aim to decipher the palaeo-tectonic model of magma generation and the formation of that particular mineral/ rock

Module	Syllabus	Duration (class-hour)	
2	**Mineralogy** ➢ Study of common rock forming minerals in light of their optical properties under microscope. Training in preparation of microscopic thin sections of rocks, etching and staining of rock samples.	20	Students will systematically identify and classify common rock-forming minerals thin sections using optical and textural relationships under petrological microscopes
1	**Igneous Petrology** ➢ Studies of petrography of common igneous rocks under microscope. ➢ Study of rock texture under microscope and their interpretation. ➢ Calculation of CIPW norms and preparation of variation diagrams.	19	Identifying igneous rock minerals students will further identify textural relationships interpreting crystallization histories and cooling conditions. They will calculate CIPW norms from bulk-rock geochemical data, correlating normative mineralogy with rock classification (IUGS) and tectonic settings
Total		**39**	

Course Outcome	Upon completion, students will proficiently identify and classify igneous rocks and minerals using macroscopic and microscopic techniques, analyzing textures (e.g., zoning, reaction rims) and compositional variations. They will deduce crystallization sequences, magmatic evolution, and paragenetic relationships through petrographic analysis. Learners will interpret mineral assemblages and geochemical data to reconstruct paleotectonic settings and magma generation processes. The course equips them to apply geothermobarometry and phase equilibria principles for modeling magmatic conditions, preparing them for advanced research and industry roles in petrogenesis, mineral exploration, and tectonic reconstructions.

Learning Resources	1. Deer, W.A., 1978. Rock-forming minerals. Geological Society of London. 2. Perkins, D., 1998. Mineralogy. Begin, 17, pp.17-38. 3. Dyar, M.D., Gunter, M.E. and Tasa, D., 2008. Mineralogy and optical mineralogy (p. 708). Chantilly, VA: Mineralogical Society of America. 4. Dana, J.D., 2022. Manual of mineralogy. BoD–Books on Demand. 5. RAITH, M.M. and RAASE, P., THIN SECTION MICROSCOPY. 6. Shelley, D., 1985. Optical mineralogy. 7. Nesse, W.D., 1987. Introduction to optical mineralogy. Applied Optics, 26(18), p.3739. 8. Gunter, M.E. and Light, I., 1992. Optical mineralogy. Encyclopedia of earth system science, 3, p.467.

Second Semester

Course Code	ES5201N	Course Name	Sedimentology and Basin Analysis	Course Category	PC	L	T	P
						4	0	0

Pre-requisite Courses	BSc with Geology/ Earth Sciences as Major in three-year UG Course	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department		Earth Sciences		Data Book / Codes/Standards	Nil

Course Objective	Sedimentology is the study of sediments, particularly focusing on how it is produced, transported, and deposited. Sedimentary rocks illuminate many of the details of the Earth's history-- effects of sea level change, global climate, tectonic processes, and geochemical cycles. This course will cover basics of fluid flow and sediment transport, sedimentary textures and structures. It will provide an overview of facies analyses, modern and ancient depositional sedimentary environments, and the relationship of tectonics and sedimentation

Module	Syllabus	Duration (class-hour)	
1	Physical Sedimentology: sedimentary rocks & their types; clastic, volcaniclastic and chemical. Transportation and flow mechanisms. Dynamics of sediment transportation and deposition. Different types of flows, flow regimes. Sedimentary textures and structures and their genetic relation to the different parameters controlling the transportation and deposition	10	Learners develop a fundamental understanding of sediments, sedimentary rock types and their formation processes, along with the mechanics of sediment transport, flow regimes, genesis of sedimentary textures and structures.
2	➢ Sedimentary Environments: Application of Walther's law, concept of facies, facies associations, facies sequence and transgression and regression Fluvial Systems: Alluvial Fan, Braided fluvial system and Meandering fluvial system, Architectural Elements Aeolian Environment: Aeolian facies attributes and associations--evaporites, ephemeral facies, draas, erg and their migration	20	Enables interpretation of depositional systems through the application of facies ananlysis, learning various facies of ancient sedimentary environments, Walther's Law, with emphasis on paleo-environmental reconstruction across diverse sedimentary settings from continental to deep marine.

	Shallow-marine (Coastal Environments—Tidal flats, Deltas, Lagoons, Barrier Bars) Deep-Marine (Slope facies, Olitostromes, Turbidites and Contourites		
3	Carbonate Sedimentary Environments	5	Enhances the ability to identify and interpret carbonate depositional systems, their facies characteristics, and the controls influencing carbonate sedimentation. It also ignites the curious minds to relook into the paleo-ocean environment
4	Paleoenvironment analysis: Application of radioactive and stable isotopes in reconstruction of paleoenvironments	5	Introduces isotope geochemistry as a tool to reconstruct ancient environments and infer climatic and oceanographic changes through time.
5	Sedimentation and Tectonics: a) Cratonic Sedimentation. b) Plate tectonics and sedimentary basins. c) Tectonics and sandstone petrology d) Depositional styles of sandstones, mudstones, carbonates, evaporites and iron-rich rocks through the vast span of geological time.	8	Encourages critical analysis of the tectono-sedimentary interplay across geological time, highlighting how tectonic settings influence depositional patterns and sediment characteristics.
6	Basin Analysis: Sedimentary basins and their evolution	4	Provides knowledge to classify, interpret, and reconstruct sedimentary basin types, their tectonic evolution, and implications for resource potential.
Total		**52**	

Course Outcome	Upon completion, students will analyze sedimentary processes (e.g., sediment transport, fluid dynamics) and interpret depositional environments using facies analysis, sedimentary textures, and structures. They will evaluate sedimentary records to reconstruct tectonic activity, sea-level fluctuations, and paleoclimate shifts. Learners will apply stratigraphic logging, sequence stratigraphy, and basin modeling to correlate sedimentation patterns with tectonic regimes and geochemical cycles. This equips them to assess hydrocarbon reservoirs, paleoenvironmental changes, and geohazards, preparing for roles in energy exploration, environmental consulting, and academic research in Earth system dynamics.

Learning Resources	1. Sedimentary Environments: Processes, Facies and Stratigraphy H. G. Reading. 2. Sedimentary Petrology by M. E. Tucker. 3. Approaches to Interpretation of Sedimentary Environments by Douglas J. Cant and F. J. Hein. 4. Applied Sedimentology by Richard C. Selley. 5. Principles of Sedimentology and Stratigraphy by Sam Boggs Jr. 6. The Evolution Of Clastic Sedimentology by Hakuyu Okada and Alec Kenyon-Smith 7. Basin Analysis: Principles and Applications by P.A. Allen and J. R. Allen. 8. Principles of sedimentary basin analysis by A.D. Miall.

Course Code	ES5202N	Course Name	Metamorphic Petrology and Thermodynamics	Course Category	PC	L	T	P
						4	0	0

Pre-requisite Courses	BSc with Geology/ Earth Sciences as Major in three-year UG Course	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department		Earth Sciences		Data Book / Codes/Standards	Nil

Course Objective	The objective of the course will enable students to critically identify the geodynamic processes and orogenic event which the rock suffered, through mathematical, textural and theoretical study. Identification of mineral assemblage and their interpretation of the process involved in the evolution will be aimed. Quantitative and qualitative plots of each assemblage and the reaction texture will be aimed to interpret the evolutionary history

Module	Syllabus	Duration (class-hour)	Module outcome
1	Introduction: Factors controlling transformations (T, P and fluids, Heat flow), minerals as pure and impure phases. Types of metamorphism: Regional, contact, dynamic, hydrothermal, impact, retrograde and ocean floor metamorphism; Protolith types and characteristic metamorphic minerals; metamorphic textures. Textures of contact and regional metamorphism, Tectonic context of metamorphic transformations Metamorphism: controls and types. Factors controlling metamorphism	8	Students will distinguish different types of metamorphism (e.g., regional, contact) and assess the roles of pressure, temperature, and fluids in driving metamorphic processes.
2	Metamorphic phase equilibria: nature of metamorphic transformations; textural and mineralogical evidence of equilibrium in metamorphic rocks; fluid-free, dehydration and decarbonation type metamorphic reactions; calculation of metamorphic reaction curves using standard state thermodynamic parameters (Gibbs free energy, enthalpy, entropy and volume) of mineral end members and fluid phase fugacities; activity-composition relations and solution models for important metamorphic minerals, variance of metamorphic assemblages, metamorphic geothermometry and geobarometry, solution of numerical problems	12	Learners will apply thermodynamic parameters (G, H, S, V) to model metamorphic reactions, construct reaction curves, and interpret equilibrium assemblages
3	Metamorphic grade and metamorphic facies: historical review; geological set-ups of low- and	10	Students will classify rocks by metamorphic

	high-grade regional, thermal and burial type metamorphism; prograde and retrograde metamorphism. Concept of Geothermobarometry and calculations		grade/facies and use thermobarometric data to reconstruct P-T paths and interpret tectonothermal evolution.
4	Graphical analysis of metamorphic rocks: construction and use of ACF, AKF and AFM diagrams; Schreinemakers analysis of metamorphic equilibria	10	Learners will construct and interpret compositional diagrams and Schreinemakers bundles to analyze metamorphic assemblage stability and reaction sequences
5	Progressive regional metamorphism- of pelitic, quartzo-feldspathic, basic and calcareous rocks: brief outlines of the classic type-areas; progressive metamorphism in relation to progressive deformation: pre-, syn- and post-deformation metamorphic textures.	6	Students will evaluate mineral assemblage evolution in pelitic, mafic, calcareous, and quartzo-feldspathic rocks through progressive metamorphism, integrating deformation phases
6	Metamorphism and global tectonics: regional metamorphism in relation to plate movements, orogeny and plutonism; origin of granulites and regional high-grade belts; pressure-temperature-time paths of metamorphism	6	Learners will synthesize tectonic models with metamorphic data to interpret orogenic evolution, origin of granulites, and retrograde paths using pressure-temperature-time trajectories.
Total		**52**	

Course Outcome	Upon completion, students will interpret geodynamic processes and orogenic events by analyzing mineral assemblages, reaction textures, and thermodynamic principles. They will construct phase diagrams and P-T-t paths to deduce metamorphic conditions and evolutionary histories of rocks. Learners will apply quantitative methods (e.g., geothermobarometry) to assess reaction equilibria and interpret chemical zoning in minerals. The course equips them to correlate metamorphic facies with tectonic settings, reconstruct orogenic cycles, and evaluate crustal dynamics, preparing them for advanced research in petrogenesis, subduction systems, and planetary metamorphism.

Learning Resources	1. Shelly, D., 1993. Igneous and metamorphic rocks under microscope Chapman and Hall. 2. Fry, N., 2013. The field description of metamorphic rocks. John Wiley & Sons. 3. Miyashiro, A., 1994. Metamorphic petrology. Crc Press. 4. Winter, J.D., 2014. Principles of igneous and metamorphic petrology (Vol. 2). Harlow, UK: Pearson education. 5. Vernon, R.H. and Clarke, G.L., 2008. Principles of metamorphic petrology. Cambridge University Press. 6. Philpotts, A.R. and Ague, J.J., 2009. Principles of igneous and metamorphic petrology. Cambridge University Press. 7. Frost, B.R. and Frost, C.D., 2019. Essentials of igneous and metamorphic petrology. Cambridge University Press. 8. Best, M.G., 2002. Igneous and metamorphic petrology. John Wiley & Sons. 9. Spear, F.S., Pattison, D.R. and Cheney, J.T., 2017. The metamorphosis of metamorphic petrology. 10. Mason, R. and Mason, R., 1990. Petrology of the metamorphic rocks (p. 230). London: Unwin Hyman. 11. Tyrrell, G.W., 2012. The principles of petrology: an introduction to the science of rocks. Springer Science & Business Media. 12. Kornprobst, J., 2002. Metamorphic rocks and their geodynamic significance: a petrological handbook. Springer Science & Business Media.

Course Code	ES5203N	Course Name	Principles of Stratigraphy and Indian Stratigraphy	Course Category	PC	L	T	P
						4	0	0

Pre-requisite Courses	BSc with Geology/ Earth Sciences as Major in three-year UG Course	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department		Earth Sciences		Data Book / Codes/Standards	Nil

Course Objective	The objective of learning Stratigraphy is to acquire knowledge of synthesis of the stratal record, emphasizing the analysis of layered sequences, principally sedimentary, that cover about 3/4th of the Earth's surface. Archaean cratonic nucleii of Peninsular India (Dharwar, Singhbhum, and Aravalli cratons); Proterozoic mobile belts (Central Indian Tectonic Zone, Aravalli-Delhi and Eastern Ghats); Purana sedimentary basins (Cuddapah and Vindhyan); Phanerozoic stratigraphy of India- Spiti, Kashmir, Assam-Arakan, Damodar valley, Kutch, Trichinopoly, Siwaliks and Indo-Gangetic alluvium

Module	Syllabus	Duration (class-hour)	Module outcome
1	**Principles of Stratigraphy** Law of superposition. Stratigraphic nomenclature- lithostratigraphy, biostratigraphy and chronostratigraphy	4	Introduces the foundational principles of stratigraphy and stratigraphic classification systems, enabling learners to understand how stratigraphic units are defined, correlated, and interpreted.
2	Sequence Stratigraphy-- Early Development of Sequence Stratigraphy Era—Eustatic vs. Tectonic Controls on Sedimentation; Sequence Models, Sea-level changes; Definitions of eustasy; relative sea-level and water depth, Accommodation and Shoreline Shifts, Shoreline trajectories--Transgression; Forced Regressions; Normal Regressions, Stratigraphic Surfaces, Concept of system tracts	8	Develops the ability to interpret stratigraphic architecture through sequence stratigraphic principles, emphasizing on the roles of sea-level change, sediment supply, and tectonics in controlling stratigraphic sequences.
3	Event stratigraphy	4	Equips learners with the skills to recognize and analyze time-significant geological events recorded in the stratigraphic

			record and their global correlations.
4	Boundary problems	6	Promotes critical understanding of the complexities in defining and correlating stratigraphic boundaries and their implications in chronostratigraphy and geologic time scales.
5	**Indian Stratigraphy** ➢ Scope of stratigraphy: Broad distinction between Precambrian and Phanerozoic Stratigraphy	2	Provides a broad stratigraphic framework of India, distinguishing between major temporal divisions and their lithological and fossil characteristics.
6	Precambrian stratigraphy ➢ Precambrian and its subdivisions, Archean Provinces, Archean Nucleii, Cratons, Shields, Platforms and Mobile belts. Plate tectonics during the Precambrian ➢ Stratigraphy of Cuddapah and Vindhyan basins; Tectonostratigraphic framework of Dharwar craton, an overview of Bastar, Singhbhum, Bundelkhand and Aravalli cratons, Eastern Ghat mobile belt, Central Indian Tectonic Zone; Proterozoic sedimentary basins of India. Precambrian biota and its stratigraphic significance	16	Enhances comprehension of the tectonic, lithologic, and biotic evolution of India’s Precambrian terrains, with emphasis on key stratigraphic successions and their geodynamic context.
7	Phanerozoic stratigraphy ➢ Major plate movements during Phanerozoic. Subdivisions of Phanerozoic up to Stage level. ➢ Stratigraphic framework of Marine Palaeozoic rocks of Himalaya with special reference to Kashmir, Spiti, Kumaon and their correlatives in Salt Range and peninsular India. ➢ Criteria for recognising major stratigraphic boundaries of Phanerozoic and their GSSPS. ➢ Permian-Triassic boundary sections of India Marine Mesozoic Rocks of the Himalaya	12	Enables learners to analyze the stratigraphic evolution of Indian Phanerozoic basins in the context of global events, including paleogeography, biodiversity trends, boundary events, and basin development from the Paleozoic to the Quaternary.

	➢ Gondwana Supergroup of rocks, its fauna and flora, depositional history, economic importance and climate; Jurassic sedimentary basins of Kachchh and Jaisalmer; Cretaceous stratigraphy of the Cauvery Basin and Narmada Valley; Deccan Volcanic Province ➢ Cretaceous-Palaeogene boundary sections of India. Palaeogene stratigraphy of Kachchh. Stratigraphy of the Himalayan foreland basin (Subathu, Murree/Dagshai-Kasauli, Siwalik) and recent advances. Indus Basin sediments of the Indus Tsangpo Suture Zone. Quaternary deposits of Andaman Islands		
Total		**52**	

Course Outcome	Upon completion, students will analyze stratigraphic records to interpret depositional environments, sea-level fluctuations, and basin evolution using sequence stratigraphy, lithostratigraphy, and chronostratigraphic frameworks. They will correlate Indian stratigraphic units (e.g., Dharwar craton, Vindhyan Basin, Siwaliks) with global tectonic and climatic events. Learners will evaluate field data, fossil assemblages, and sedimentary cycles to reconstruct geological histories of key regions like Assam-Arakan and Kutch. This prepares them to address challenges in hydrocarbon exploration, basin analysis, and paleogeographic reconstructions, leveraging India's stratigraphic diversity for academic and industrial applications.

Learning Resources	1. Principles of Sequence Stratigraphy by Octavian Cateneauau 2. Geology of India and Burma, M.S. Krishnan 3. Manual of Geology of India and Burma, E.H. Pascoe. 4. Fundamentals of Historical Geology and Stratigraphy of India by Ravindra Kumar. 5. Applied Stratigraphy by Eduardo A.M. Koutsoukos. 6. Geology of India, Vol-I, Vol-II, M. Ramakrishnan and R. Vaidyanadhan, Geological Society of India, Bangalore

Course Code	ES5221N	Course Name	Geodynamics	Course Category	PSE	L	T	P
						3	0	0

Pre-requisite Courses	BSc with Geology/ Earth Sciences as Major in three-year UG Course	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department		Earth Sciences		Data Book / Codes/Standards	Nil

Course Objective	The course is formulated to develop so that the students develop an overall idea about the dynamism of the Earth and different factors controlling the dynamism

Module	Syllabus	Duration (class-hour)	Module outcome
1	Concept on dynamism of the Earth: The driving mechanism of Plates, Paleomagnetism and Motion of Plates, Wilson Cycle, Continental Collision, Accreting Plate Boundaries, Subduction, Transform Faults, Hotspots and Mantle Plumes	8	Students will correlate plate motions with paleomagnetic data to reconstruct supercontinent cycles and subduction/collision events.
2	Heat budget and heat transfer: Fourier’s Law of Heat Conduction, Earth’s Surface Heat Flux, Heat Generation, One-dimension Steady Heat Conduction, Continental Geotherm, Subsurface Temperature, Plate Cooling Model of the Lithosphere	8	Learners will model geothermal gradients and lithospheric thinning using Fourier's law, predicting basin subsidence and metamorphic conditions
3	Introduction to fluid mechanics: One-Dimensional Channel Flows, Asthenospheric Counterflow, Pipe Flow, Flow Through Volcanic Pipes, Conservation of Fluid in Two Dimensions, Force Balance, Stream function, Post Glacial rebound, Angle of Subduction, Diapirism, Folding, Stokes law.	8	Students will quantify mantle convection, magma flow, and glacial rebound using Stokes flow equations
4	Fluid flow in porous media: Darcy’s Law, Permeability Models, Flow in Confined and unconfined Aquifers, Equations of Conservation of Mass, Momentum, and Energy for Flow in Porous Media, Flow Model for Magma Migration	8	Learners will simulate magma migration/aquifer dynamics through permeability models and conservation equations.

5	Rheological modeling of crust and mantle: Diffusion and Dislocation Creep, Shear Flows of Fluids, Mantle rheology, Rheological Effects on Mantle Convection, Crustal rheology	7	Students will learn brittle/ductile behaviors of rocks, linking creep mechanisms to seismic anisotropy.
Total		**39**	

Course Outcome	Upon completion, students will analyze Earth's dynamic processes, including mantle convection, plate tectonics, and lithospheric deformation, using geophysical models and observational data. They will evaluate forces driving plate motions, crustal stresses, and mantle-crust interactions through numerical simulations and stress-strain relationships. Learners will interpret seismic, gravity, and heat flow data to infer Earth's thermal evolution and rheological behavior. This equips them to assess geodynamic mechanisms (e.g., subduction, rifting) and their surface expressions, preparing for advanced research in tectonic reconstructions, geohazard prediction, and planetary evolution studies.

Learning Resources	1. **Geodynamics** by D Turcotte and G Schubert. 2. Elasticity, Fracture and flow by J.C. Jaeger 3. Rheology of the Earth by G. Ranalli, Allen and Unwin 4. The Dynamic Earth by P.J. Willie

Course Code	ES5222N	Course Name	Geomorphology	Course Category	PSE	L	T	P
						3	0	0

Pre-requisite Courses	BSc with Geology/ Earth Sciences as Major in three-year UG Course	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department		Earth Sciences		Data Book / Codes/Standards	Nil

Course Objective	A subtle difference exists between Geomorphology and Geology. Geomorphology is the study of the physical features of the Earth's crust as related to its geological features. The course provides an overview of various physical features on the surface of the earth which includes landforms, land forming processes, landscape evolution and how these depend on climate and tectonic regimes.

Module	Syllabus	Duration (class-hour)	Module outcome
1	Concepts in geomorphology. Historical and process Geomorphology.	4	Introduces foundational concepts in geomorphology, emphasizing both the historical evolution of landform studies and the principles governing surface processes.
2	Landforms in relation to climate, rock type, structure and tectonics.	10	Facilitates an understanding of the controls exerted by lithology, structural features, tectonic activity, and climatic regimes on landform development and landscape evolution.
3	Processes– weathering, pedogenesis, mass movement, erosion, transportation and deposition.	10	Develops the ability to explain surface-shaping processes and their interrelationships, with focus on the origin and modification of Earth's surface features.
4	Geomorphic processes and landforms – fluvial, glacial, aeolian, coastal and karst. River forms and processes – stream flow, stage discharge relationship; hydrographs and flood frequency analysis. Submarine relief.	10	Enhances comprehension of geomorphic systems across varied environments, including river behavior, landform types, and submarine topography, through quantitative and conceptual analysis.
5	Geomorphology and topographic analysis including DEM, Environmental change– causes, effects	5	Enables learners to interpret landforms using digital elevation models (DEMs), assess the impact of environmental change on

	on processes and landforms. Extra-terrestrial geomorphology.		geomorphic processes, and explore geomorphic principles beyond Earth.
Total		**39**	

Course Outcome	Upon completion, students will analyze land-forming processes (e.g., fluvial, glacial, aeolian) and interpret landform evolution using field observations, remote sensing, and geochronological tools. They will evaluate climatic and tectonic influences on landscapes through geomorphic indices and digital terrain models. Learners will integrate spatial data and process-based models to predict landscape responses to environmental changes. This prepares them for roles in geohazard assessment, environmental management, and paleoenvironmental reconstruction, applying geomorphological principles to address scientific and societal challenges.

Learning Resources	1. Earth Surface Processes and Landforms and Sediment Deposit by John Bridge and Robert Demicco. 2. Earth Surface Processes by P. A. Allen 3. Geomorphology: A Systematic Analysis of Late Cenozoic Landforms, Pearson Education by A.L. Bloom. 4. Global Geomorphology by M.A. Summerfield.

Course Code	ES5261N	Course Name	Life through ages	Course Category	OE	L	T	P
						3	0	0

Pre-requisite Courses	BSc with Geology/ Earth Sciences as Major in three-year UG Course	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department		Earth Sciences		Data Book / Codes/Standards	Nil

Course Objective	Our planet Earth hosts several forms of life through the ages. The organisms including human beings are the fittest in the recent environments. Similarly, the history of the Earth also preserved the impressions of different environment friendly organisms. In the rock record we get glimpses of these organisms for different time periods. So, knowledge of the appearance, ecology, and evolution of the organisms will help to decipher the geological history of different rock strata

Module	Syllabus	Duration (class-hour)	Module outcome
1	Ideas about origin of life; Geological Time Scale	3	Students will be able to explain scientific ideas about the origin of life and interpret the Geological Time Scale in the context of Earth's biological and geological evolution
2	Evidences of early life in the rock record.	3	Students will be able to interpret geological evidence of early life preserved in the rock record and understand its significance in Earth's evolutionary history.
3	Fossils—Different Types; Taphonomy and Preservation.	8	Students will classify different types of fossils and explain the processes of taphonomy and fossil preservation.
4	Classification of the organic world.	6	Students will be able to explain organic world based on biological taxonomy and evolutionary relationships.
5	Cambrian Explosion	3	Students will be able to describe Cambrian Explosion and its significance in rapid diversification of multicellular life during early Paleozoic era.
6	Appearance of Vertebrates and Invertebrates and their evolutionary diversification	8	Students will be able to explain the origin, appearance, and evolutionary diversification of vertebrates and invertebrates through geological time.
7	Appearance of plants and their evolutionary diversification	6	Students will be able to describe the origin of plants and analyze their evolutionary

			diversification through different geological periods.
8	Law of Faunal Succession	2	Students will be able to explain the Law of Faunal Succession and apply it to interpret the relative ages of rock layers and the fossil record.
Total		**39**	

Course Outcome	Upon completion, students will analyze fossil records to interpret evolutionary trends, ecological adaptations, and biodiversity shifts across geological time scales. They will correlate fossil assemblages with stratigraphic units to reconstruct paleoenvironments and bio-stratigraphic zonation. Learners will evaluate extinction events, speciation patterns, and climate interactions using paleontological data and molecular clocks. The course equips them to apply principles of taphonomy, biostratigraphy, and paleoecology to decipher Earth's biological history, preparing for roles in paleontological research, hydrocarbon exploration, and conservation paleobiology.

Learning Resources	1. Principles of Paleontology by David M. Raup and Steven M. Stanley. 2. Invertebrate Paleontology and Evolution by E.N.K Clarkson. 3. Microfossils, Brasier, M.D. 4. Micropaleontology: Principles and applications by Pratul Kumar Saraswati, M.S. Srinivasan, 5. Vertebrate Paleontology by M Benton 6. Evolution of the Vertebrates: A History of the Backboned Animals Through Time by Edwin H. Colbert

Course Code	ES5262N	**Course Name**	Natural resources and Energy	**Course Category**	OE	L	T	P
						3	0	0

Pre-requisite Courses	BSc with Geology/ Earth Sciences as Major in three-year UG Course	**Co-requisite Courses**	Nil	**Progressive Courses**	Nil
Course Offering Department		**Earth Sciences**		**Data Book / Codes/Standards**	Nil

Course Objective	The course aims to introduce the natural energy systems coupled with unconventional energy resources emphasising particularly on geological contexts. The lectures under this course will explore the present and projected demands; genesis, resources and reserves of conventional energy (fossil fuels and nuclear energy) - their usage, application and related environmental issues. The classes will also cover a series of other alternate, unconventional and renewable energy sources including enhanced coal and shale gas energy, natural and engineered geothermal resources together with solar, biomass (conversions), wind power, and hydro-energies

Module	**Syllabus**	**Duration (class-hour)**	**Module outcome**
1	Introduction; historical developments; classification of energy systems	1	Students will be able to understand the energy systems and classify different types of energy systems based on their sources and characteristics.
2	Conventional Energy: origin and genesis through geological time scale; classifications; global and Indian resources; different methods of exploration and beneficiation; future demand and usage	10	Students will be able to explain the origin and classification of conventional energy resources, assess their global and Indian distribution, describe exploration methods and beneficiation, and future demand and usage trends.
3	Unconventional/Alternative/Renewable Energy: Coal Bed Methane (CBM); occurrence and genesis; natural processes of recovery; Enhanced Coal Bed Methane (ECBM); processes of recovery, concepts of adsorption and desorption; application and recovery; resources and estimates for future usage; environmental risks	10	By the end of this module, students will understand recovery processes, occurrence, and environmental implications of Coal Bed Methane (CBM) and Enhanced Coal Bed Methane (ECBM), including key concepts such as adsorption/desorption and future resource potential.
4	Geothermal Energy; concepts and developments; natural and engineered Geothermal energy resources; hydro-fracking; application and recovery;	3	By the end of this module, students will be able to understand the principles, technologies, and environmental considerations of

	resources and estimates for future usage; environmental risks		geothermal energy, including natural and engineered resources, hydro-fracking methods, applications, and future resource potential.
5	Concepts, developments, usage and estimates of solar, biomass (conversions), wind power, and hydro-energies	3	By the end of this module, students will gain a comprehensive understanding of the concepts, technological developments, conversion methods, applications, and future potential of solar, biomass, wind, and hydro energy sources.
6	Geological CO2 sequestration	3	By the end of this module, students will understand principles, methods involved in CO_2 sequestration for long-term carbon storage and climate change mitigation.
7	Present and future resources	3	students will be able to assess current energy resources and evaluate their sustainability, availability, potential for future use.
8	Resource and energy management	3	By the end of this module, students will understand principles and strategies of resource and energy management for sustainable development and efficient utilization.
9	Energy and mineral resources in India, global scenario and demand	3	By the end of this module, students will be able to analyze the distribution, demand, and management of energy and mineral resources in India within the context of the global scenario.
Total		**39**	

Course Outcome	Upon completion, students will evaluate the genesis, distribution, and sustainability of conventional energy resources (fossil fuels, nuclear) and unconventional systems (shale gas, geothermal, renewables) using geological, geochemical, and geophysical principles. They will assess resource exploration strategies, environmental impacts, and mitigation measures for energy extraction and utilization. Learners will analyze renewable energy potential in geological contexts and integrate economic, technical, and policy frameworks for energy transition. This prepares them for roles in sustainable resource management, energy sector innovation, and climate-resilient policy formulation.

Learning Resources	➢ Introducing Natural Resources by G. Park ➢ Earth's Natural resources by J. V. Walther ➢ Fundamentals and Applications of Renewable Energy by Mehmet Kanoglu, Yunus A. Cengel Dr., John M. Cimbala ➢ Advances in Sustainable Energy by Ahmad Vasel, David S-K. Ting ➢ Solar and Wind Energy by Catherine Waltz ➢ Energy: Perspectives, Problems, and Prospects by Michael B. McElroy ➢ Fossil Fuels by Neil Morris ➢ Energy Resources by Andrew L. Simon ➢ Energy for a Sustainable World: From the Oil Age to a Sun-Powered Future by Vincenzo Balzani and Nicola Armaroli

Course Code	ES5271N	Course Name	Metamorphic Petrology and Sedimentology Practical	Course Category	PC	L	T	P
						0	0	3

Pre-requisite Courses	BSc with Geology/ Earth Sciences as Major in three-year UG Course	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department		Earth Sciences		Data Book / Codes/Standards	Nil

Course Objective	The main objective of the petrological study of metamorphic rock is to familiarize student with different variety of metamorphic rocks in hand specimens for field identification and also under thin section in laboratory work. The textural study will teach them the process to identify the reaction texture, processes involved and finally deduction of the evolutionary history of the rocks. The practical lessons in sedimentology will enable the students to identify sedimentary rocks in hand specimens and thin sections. Detailed study of textures, grain-size analyses, diagenetic structures will be dealt in detail to formulate an idea on the depositional condition and provenance

Module	Syllabus	Duration (class-hour)	Module outcome
1	**Metamorphic Petrology** ➢ Studies of petrography of common metamorphic rocks under microscope. ➢ Microscopic study of metamorphic facies, deformation and recrystallisation history from set of thin sections of metamorphic rocks. ➢ Construction of ACF, AKF, and AFM diagrams. ➢ P-T estimation using important models of geothemobarometry. ➢ Interpretation of reaction textures.	19	Students will develop skills in understanding different textures under microscope in metamorphic rocks and interpret their evolutionary path and identify their protolith
2	**Sedimentology** ➢ Study of sedimentary rocks from hand specimens. ➢ Detailed petrographic studies of various clastics, non-clastics and volcaniclastics--descriptive studies and grain-size analysis Paleocurrent Analysis	20	Learners develop hands-on skills in identifying sedimentary rock types using hand specimens and thin sections, performing grain-size analysis, and interpreting sedimentary processes and paleoenvironments

			through paleocurrent and petrographic data
Total		**39**	

Course Outcome	Upon completion, students will identify and classify metamorphic rocks in hand specimens and thin sections, analyzing reaction textures (e.g., coronas, porphyroblasts) to deduce P-T conditions and evolutionary histories. They will apply petrographic techniques and phase equilibria models to interpret metamorphic processes. In sedimentology, learners will characterize sedimentary rocks via grain-size analysis, diagenetic structures, and textural studies to infer depositional environments and provenance. The course equips them to integrate field and laboratory data for reconstructing geological histories, preparing them for roles in resource exploration, basin analysis, and academic research.

Learning Resources	➢ Shelly, D., 1993. Igneous and metamorphic rocks under microscope Chapman and Hall. ➢ Fry, N., 2013. The field description of metamorphic rocks. John Wiley & Sons. ➢ Miyashiro, A., 1994. Metamorphic petrology. Crc Press. ➢ Winter, J.D., 2014. Principles of igneous and metamorphic petrology (Vol. 2). Harlow, UK: Pearson education. ➢ Vernon, R.H. and Clarke, G.L., 2008. Principles of metamorphic petrology. Cambridge University Press. ➢ Adams, A.E., MacKenzie, W.S. and Guilford, C., 2017. Atlas of sedimentary rocks under the microscope. Routledge. ➢ Boggs Jr, S., 2009. Petrology of sedimentary rocks. Cambridge university press. ➢ Korte, D., Kaukler, D., Fanetti, M., Cabrera, H., Daubront, E. and Franko, M., 2017. Determination of petrophysical properties of sedimentary rocks by optical methods. Sedimentary Geology, 350, pp.72-79. ➢ Tucker, M.E., 2011. Sedimentary rocks in the field: a practical guide. John Wiley & Sons.

Course Code	ES5272N	Course Name	Fieldwork	Course Category	PC	L	T	P
						0	0	0

Pre-requisite Courses	BSc with Geology/ Earth Sciences as Major in three-year UG Course	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department		Earth Sciences		Data Book / Codes/Standards	Nil

Course Objective	This module aims to equip students with advanced field skills to map lithological boundaries, identify structural features (e.g., folds, faults, foliations), and interpret their relationship to regional deformational histories. Through immersive fieldwork, students will learn to integrate field observations with tectonic frameworks, using tools like cross-section balancing, stereonet analysis, and geological mapping. The two-week duration ensures hands-on exposure to diverse litho-units, fostering proficiency in data collection, spatial interpretation, and synthesis of structural evolution for applications in resource exploration, geohazard assessment, and tectonic reconstructions.

Module	Syllabus	Duration (class-hour)	Module outcome
1	Mapping of lithological boundaries, identify rock types in field, identification of structural features and interpretation with respect to the regional deformational history of the different litho-units in the field. **The field duration will be of at least two weeks duration**	Minimum 2 weeks	Hands-on training of the students on rock exposures in hard rock terrain to prepare lithological and structural maps and identify rocks in the field.
Total		**Minimum 2 weeks**	

Course Outcome	Upon completion, students will demonstrate competence in mapping lithological contacts, structural features, and deformational sequences using field techniques (e.g., compass-clinometer measurements, GPS mapping). They will correlate field data with regional tectonic histories through kinematic analysis, cross-section construction, and strain quantification. Learners will synthesize findings into comprehensive geological reports, integrating structural interpretations with regional geodynamic models. This prepares them for roles in mineral exploration, geotechnical engineering, and academic research, emphasizing teamwork, technical communication, and applied problem-solving in geological fieldwork.

Learning Resources	➢ Coe, A.L. ed., 2010. Geological field techniques. John Wiley & Sons. ➢ Barnes, J.W. and Lisle, R.J., 2013. Basic geological mapping. John Wiley & Sons. ➢ Lisle, R.J., Brabham, P. and Barnes, J.W., 2011. Basic geological mapping. John Wiley & Sons. ➢ Compton, R.R. and Compton, R.R., 1985. Geology in the Field (p. 416). New York: Wiley. ➢ Ghosh, S.K., 2013. Structural geology: Fundamentals and modern developments. Elsevier. ➢ Gokhale, N.W., 1991. a Manual of Problems in Structural Geology. CBS Publication ➢ Billi, A. and Fagereng, A., 2019. Problems and solutions in structural geology and tectonics (Vol. 5). Elsevier.

Third Semester

Course Code	ES6101N	Course Name	Paleontology and Mass Extinction	Course Category	PC	L	T	P
						4	0	0

Pre-requisite Courses	BSc with Geology/ Earth Sciences as Major in three-year UG Course	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department		**Earth Sciences**		**Data Book / Codes/Standards**	Nil

Course Objective	The main objective of the Paleontology study is to is to familiarize student with preserves evidences of life either as whole body or, parts or their activities in majority of rock records from Late Archaean to Quaternary. Appearances, persistence and disappearances of different forms of life in the rock record across time confirm the theory of evolution, extinction. Detailed study of microfossils has a significant role in petroleum exploration.

Module	Syllabus	Duration (class-hour)	Module outcome
1	➢ Types of organisms, growth, outline of molluscan coiling, growth rate, population study, species concept, functional morphology, concept of adaptation and exaptation. ➢ Theories on evolution, types, patterns and rate of evolution, paleoecology, Taphonomy, Mass extinction. Concepts of Linnean, Numerical and Cladistic Taxonomy. ➢ Evolutionary patterns in different groups of mega-invertebrate and vertebrates with an outline of study of important morphological aspects.	20	Students will classify organisms using taxonomic principles, analyze evolutionary patterns through fossil records, and evaluate mechanisms of adaptation/extinction to reconstruct paleoecological dynamics.
2	➢ Synoptic overview of development of land plants. ➢ Brief outline of palynology and its uses. ➢ Gondwana flora—Indian and global aspects. ➢ Hominid and Proboscidian evolution. ➢ Trace fossils and Precambrian fossils. ➢ Morphological study of Foraminifers, Radiolaria, Ostracods, Conodonts, Diatoms, nannofossils and their importance in paleo-ecological analysis.	20	Learners will correlate plant/vertebrate evolution with Gondwana stratigraphy, utilize microfossils as paleoenvironmental proxies, and interpret trace fossils to infer Precambrian biotic activity.
3	➢ Definition of Extinction, background extinction, extermition and mass extinction.	12	Students will learn extinction mechanisms, analyze PT/KT

	➢ Major and minor Mass Extinction: with special emphasis on PT and KT boundary.		boundary records to evaluate causal factors (e.g., volcanism, impacts), and assess biodiversity crises in deep-time contexts
Total		**52**	

Course Outcome	Upon completion, students will analyze fossil records to interpret evolutionary trends, extinction mechanisms, and biodiversity shifts using taxonomic, taphonomic, and paleoecological frameworks. They will evaluate mass extinction events (e.g., PT/KT boundaries) through multidisciplinary datasets, correlating biotic crises with environmental drivers. Learners will apply micropaleontological techniques to reconstruct depositional environments and assess fossil fuel reservoirs. This prepares them for roles in hydrocarbon exploration, paleoclimate research, and conservation paleobiology, integrating fossil data with Earth's dynamic history.

Learning Resources	1. Principles of Paleontology by David M. Raup and Steven M. Stanley. 2. Invertebrate Palaeontology and Evolution by E.N.K Clarkson. 3. Microfossils, Brasier, M.D. 4. Micropaleontology: Principles and applications by Pratul Kumar Saraswati, M.S. Srinivasan,

Course Code	ES6102N	Course Name	Ore Geology and Fuel Geology	Course Category	PC	L	T	P
						4	0	0

Pre-requisite Courses	BSc with Geology/ Earth Sciences as Major in three-year UG Course	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department		Earth Sciences		Data Book / Codes/Standards	Nil

Course Objective	The main objective of the course is to familiarize with common ore minerals, their identifying criteria at various scales of study, to understand the genetic controls exerted by physical and chemical processes on ore formation in various geologic settings. Understanding on the origin of different variety of fuels and their process of preservation and thus finally track down natural reserves.

Module	Syllabus	Duration (class-hour)	Module outcome
1	**Ore Geology** ➢ Introduction to ore and ore deposits: Primary differentiation of the earth into shell structure and elemental zonation. Mineralization through ages and geological events. Classification of ore deposits with special emphasis on tectonics, mineralization in mobile belts and in stable areas in relation to plate theory.	6	Students will identify ore body types and morphologies, interpreting their genesis based on structural, stratigraphic, and lithologic controls.
2	➢ Magmatic Ore Deposits: Petrological and geochemical background to ore formation; general characteristics and genesis of magmatic ore deposits: chromite deposits, base-metal Ni-Cu sulfide deposits, PGE sulfide deposits, rare-metal pegmatites and diamond deposits associated with kimberlites and lamproites.	6	Students will assess magmatic segregation processes using textural and mineralogical evidence.
3	➢ Hydrothermal Ore Deposits: Basic concepts related to hydrothermal ore formation - Role of physical and chemical environment on metal complexing, transport and deposition; chemical nature of hydrothermal ore fluid in magmatic, metamorphic and sedimentary basinal environments; fluid. General characteristics and genesis of hydrothermal ore deposits: Porphyry deposits; greisens and related ore	6	Students will assess hydrothermal alteration processes using textural and mineralogical evidence

	deposits; skarn and carbonate-replacement deposits; epithermal deposits; volcanic-hosted massive sulfide deposits; orogenic gold deposits; iron oxide-copper-gold (IOCG) deposits; SEDEX Pb-Zn-Ag deposits.		
4	➢ Ore deposits Formed by Chemical and Clastic Sedimentary Processes: Ore deposits formed by chemical precipitation from surface waters (hydrogene deposits) and clastic sedimentation - Iron ores in ironstones; sedimentary-rock-hosted Mn and P deposits; coastal heavy mineral sand deposits; and fluvial placer (and paleo-placer) deposits. Ore deposits formed by supergene processes. In-situ supergene ores and formation of lateritic bauxite and Ni-Co deposits; overprinting of hypogene ores and formation of supergene gold (in lateritic weathering) and copper (in arid and semi-arid climates) ores.	6	Learners will interpret sedimentary and weathering processes responsible for the formation of ores like banded iron formations, manganese nodules, and laterites
5	➢ Indian Mineral deposits: India's geological frame and Precambrian mineralization and Archean Greenstone belts and Metallogenic pattern. Metallogenic provinces and epoch in Indian subcontinent; distribution of various types of ore deposits and industrial minerals in India. Major ferrous and non-ferrous metal deposits in India and their genesis. Classification of Precious metal deposits with special reference to Platinum Group metals and Gold. Genetic processes and Indian context.	6	Learners will evaluate the geological framework and genesis of key Indian ore deposits, integrating tectonic, metamorphic, and structural data.
6	**Fuel Geology** ➢ Physico-chemical properties of natural hydrocarbon. Its composition and different fractions. Source rock, maturation studies. Origin, nature and migration (primary and secondary) of oil and gas. Transformation of organic matter into kerogen, organic maturation, thermal cracking of kerogen. ➢ Characteristics of Reservoir rocks and traps: structural, stratigraphic and combination), Reservoir geometry, porosity, permeability, overpressure, entrapment: classification of traps. Oilfield fluid: water, oil and gas occurrence. Movement of oil and gas in a pool.	10	Students will assess hydrocarbon generation, migration, and accumulation using basin modeling and reservoir characterization techniques. Learners will examine the geology and tectonic evolution of major Indian petroleum provinces and correlate with global analogues

	➢ Surface indications and direct detention of hydrocarbon: mode of occurrence-surface and subsurface occurrences. ➢ Migration and accumulation of petroleum and its geological framework. Prospecting for oil and gas, drilling and logging procedures. ➢ Oil bearing basins of India and the world. Geology of productive oilfields of India. Position of oil and natural gas in India, future prospects and economic scenario.		
	➢ Definition of Coal, Types of Coal, stages of coal formation ➢ Peatification, ➢ Coalification and its stages Geological features of peatlands and coal seams. Coal petrography: macerals, their origin and microlithotypes. Application of coal petrology. Coal characterization. Beneficiation, utilization and industrial classification. Processing and end-use sector quality control, environmental aspects of coal-based industries. Geological and geographical distribution of coal deposits in India. Detailed geology for some important coalfields of India. Methods of coal prospecting and estimation of coal reserves. Coal production and problems of coal industry in India. Coalbed Methane----mode of occurrence, method/s of extraction. ➢ Minerology, Geochemistry and mode of occurrence of radioactive minerals. Techniques of detection and measurements of radioactivity, Distribution of radioactive minerals in India.	12	Students will describe coal types, maceral composition, and transformation processes through ranks using petrographic and geochemical methods. Learners will map major Indian coalfields, analyze their depositional environments, and interpret their economic significance. Students will evaluate the exploration, extraction, and environmental aspects of unconventional fuels using geological and geochemical datasets
Total		**52**	

Course Outcome	Students will classify ore deposits and hydrocarbon systems using genetic models, mineralogical criteria, and geochemical data. They will evaluate magmatic, hydrothermal, and sedimentary processes governing mineralization and fossil fuel formation. Learners will interpret exploration datasets to assess reserves, apply beneficiation techniques, and analyze coal petrology. This equips them to address challenges in mining, energy resource management, and sustainable extraction, preparing for careers in mineral exploration, petroleum geology, and industrial resource sectors.

Learning Resources	1. Elements of Petroleum Geology by Richard C. Selley. 2. Coal: Classification, Coalification, Mineralogy, Trace-Element Chemistry, and Oil and Gas Potential, Edited by P.C. Lyons B. Alpern. 3. Coal and Lignite Resources of India: An overview, Geological Society of India, Banglore by S.K. Acharyya. 4. Stach E. Mackowsky M.T.H., Teichmuller M., Taylor G.H. Chandra D., Teichmuller R., 1982, Coal petrology, Gebruder Borntraeger, Stuttgart 5. Textbook of Coal (Indian Context) by D. Chandra, R.M. Singh and M.P Singh. 6. Petroleum Geology by F.K North. 7. Principles of Nuclear Geology by U. Aswathanarayana. 8. Radioactivity in Geology. Principles and applications by Ellis Hoorwool Durrance E.M

Course Code	ES6103N	Course Name	Introduction to extraction of Critical Minerals	Course Category	PC	L	T	P
						4	0	0

Pre-requisite Courses	BSc with Geology/ Earth Sciences as Major in three-year UG Course	**Co-requisite Courses**	Nil	**Progressive Courses**	Nil
Course Offering Department		**Earth Sciences**		**Data Book / Codes/Standards**	Nil

Course Objective	The main objective of the course is to familiarize with critical minerals, REE and their identifying criteria. To understand physical and chemical processes on Critical mineral formation in various geologic settings. Understanding the origin of different variety of Critical Minerals thus finally track down natural reserves and their process of extraction.

Module	Syllabus	Duration (class-hour)	Module outcome
1	**Introduction to Critical Minerals:** -Definition of Critical Elements, Critical Minerals, Strategic Elements, Energy Critical Elements. An Introduction to Physical properties of Minerals containing 30 Critical Elements: Antimony, Beryllium, Bismuth, Cobalt, Copper, Gallium, Germanium, Graphite, Hafnium, Indium, Lithium, Molybdenum, Niobium, Nickel, PGE, Phosphorous, Potash, REE, Rhenium, Silicon, Strontium, Tantalum, Tellurium, Tin, Titanium, Tungsten, Vanadium, Zirconium, Selenium and Cadmium.	**4**	Students will define critical minerals based on economic, strategic, and supply chain criteria. They will assess current global trends in critical mineral demand and understand their roles in renewable energy, electronics, and national security
2	**Sources of Critical Minerals:** **Primary sources–** Magmatic, Sedimentary and Metamorphic–Metasomatic rocks, hydrothermal activity, syn-/dia-/epi-genetic affects, remobilization–recrystallization, weathering, transportation (in placers), **Secondary sources-** Waste Materials mainly e-waste	**4**	Learners will identify key geological environments (e.g., pegmatites, carbonatites, laterites, hydrothermal veins) associated with critical minerals like REEs, lithium, and cobalt, and explain mineralization processes using petrogenetic models.
3	**Genesis of Critical Minerals:** **Magmatic mineral systems-** (1) Komatiite-hosted Ni-Cu systems; (2) Layered intrusion-	**4**	Students will classify critical minerals using compositional and structural

	hosted Cr-PGE systems; and (3) Mafic to Ultramafic Ni-Cu±PGE systems, (4) Carbonatite-hosted rare-metal (LREE±Nb±Th) systems, (5) Pegmatite-hosted Li systems **Magmatic-hydrothermal mineral systems-** Carlin-type Au systems, VMS Cu-Pb-Zn-Au systems, porphyry-skarn Cu-Au-Mo systems, Kiruna-type Fe-P systems, Iron-oxide Cu-Au-U-LREE (IOCG) systems, Intrusion-related Au (IRGD) systems		properties, interpret trace element and isotopic signatures, and use geochemical data to guide exploration and beneficiation planning**.**
4	**Hydrothermal mineral systems**-Epithermal Au-Ag systems **Sedimentary Mineral systems-** Evaporite Li brine systems, Placer Au systems, Paleo-placer Au-U systems, Titanium-REE beach sand placer **Basinal Hydrothermal Mineral systems:** Zambian-type Cu-Co systems, Intrusion-hosted Ni-Cu±PGE, Sedimentary rock-hosted sedimentary-exhalative sulfide (SEDEX) Cu-Zn-Pb systems, Carbonatite REE, Mississippi Valley-type (MVT) Pb-Zn-Ba systems, Broken Hill-Type (BHT) Pb-Zn-Ag systems, BIF-type Fe systems, BIF-type Mn systems, Unconformity-related and Roll front-type U systems	**8**	Learners will apply geochemical and geophysical principles to estimate reserves and interpret drill-core data for subsurface mineral exploration.
5	**Occurrence and Use of Critical Minerals:** Global occurrence of Critical Minerals, Emphasis on Indian context. Uses of Critical Minerals	**2**	Learners will apply geochemical and geophysical principles to estimate reserves and interpret drill-core data for subsurface mineral exploration. Students learn different mining mechanisms their pros and cons for specially used mechanism in Indian context compared to world mining processes

6.	**Minning of Critical Minerals** ➢ Planning and Design ➢ Development of the deposit ➢ Extraction Methods • Cut-and-Fill method • Placer Mining and Dredging • Leaching • Solution Mining Hydraulic Mining	20	
7	**Extractive Metallurgy for Critical Minerals:** Hydrometallurgical Techniques - Solvent extraction, ion exchange. Pyro metallurgical Techniques - Smelting, roasting, refining. Recycling & Urban Mining - Circular economy, e-waste recovery	10	Students will compare and contrast mining methods (e.g., cut-and-fill, placer, leaching) and metallurgical processes (hydrometallurgy, pyrometallurgy) for critical mineral recovery, assessing their efficiency and environmental impacts
Total		**52**	

Course Outcome	Learners will identify critical minerals and their geological settings, analyzing magmatic, hydrothermal, and sedimentary systems. They will assess extraction methods (e.g., leaching, placer mining) and apply geochemical models to evaluate resource potential. Students will integrate sustainability principles in mineral recovery and e-waste recycling. This prepares them for roles in strategic mineral exploration, green technology industries, and policy-making, addressing global demands for energy-critical elements.

Learning Resources	**Text Book:** ➢ Mineral Exploration Principles and Applications (2012) S. K. Haldar ➢ Mineral Resources of India: An Introduction to Economic Geology (2022). Rohini Singh ➢ Rare Earth Metals and Minerals Industries (2024) Y.V Murty, Mary A. Alvin, Jack. P Lifton ➢ Strategic Minerals in India: present status and future challenges. (2019). Randive, K.,

Course Code	ES6171N	Course Name	Paleontology practical + Ore Geology practical	Course Category	PC	L	T	P
						0	0	3

Pre-requisite Courses	BSc with Geology/ Earth Sciences as Major in three-year UG Course	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department		Earth Sciences		Data Book / Codes/Standards	Nil

Course Objective	For detailed idea about different physical, micro structural properties of ore minerals laboratory-demonstration is essential. Observing the fossils in hand specimen and under microscope will help to get the vivid ideas on functional morphology of the ancient faunas. Thorough knowledge in micropaleontology helps to get idea on petroleum exploration. This creates the opportunity to the students to serve the petroleum industry in future.

Module	Syllabus	Duration (class-hour)	Module outcome
1	**Ore Geology practical** ➢ Megascopic study of the common ores---structures, fabric and associations. ➢ Microscopic study of common sulphide, oxide and non-metallic ore minerals. ➢ Study of the ore textures. ➢ Interpretation of drill core data to reconstruct subsurface structures. ➢ Tackling problems related to reserve estimation.	19	Students will proficiently identify common ore minerals in thin sections, analyzing their textures, structures, and associations to infer genetic processes. Using drill-core data, students will reconstruct subsurface geometries of ore bodies, integrating lithological and structural observations to evaluate deposit models. Learners will apply geometric and statistical methods to estimate mineral reserves, addressing uncertainties in resource assessment.
	Paleontology practical ➢ Study of population in bivalves/brachiopods. ➢ Study of assemblage of fossils for paleo-ecological reconstruction. ➢ Functional morphology of bivalves. ➢ Study of sexual dimorphism in ammonites.	**20**	Students will learn reconstruction of environment from functional morphology, they will be able to differentiate sexual dimorphism, various foraminifera and also help to understand the importance of

	➢ Biometric study and simple statistical analysis there from. ➢ Study of larger and smaller foraminifers. ➢ Description of echinoid and gastropods.		evolution of echinoid with Mollusca
Total		**39**	

Course Outcome	Students will demonstrate proficiency in megascopic/microscopic ore mineral identification, texture analysis, and drill-core interpretation. Learners will classify fossils using morphological and biometric analyses, interpreting functional adaptations and population dynamics. They will apply statistical tools to microfossil datasets (e.g., foraminifers) for paleoenvironmental reconstruction and stratigraphic correlation. Proficiency in micropaleontological techniques prepares students for petroleum exploration, biostratigraphy, and academic research, emphasizing fossil-based solutions to energy and environmental challenges.

Learning Resources	**Text Book (Ore Geology):** 1. Pracejus, B., 2015. The ore minerals under the microscope: an optical guide (Vol. 3). Elsevier. 2. Craig, J.R., Vaughan, D.J. and Hagni, R.D., 1994. Ore microscopy and ore petrography (Vol. 406). New York, NY: John Wiley & Sons. 3. Deer, W.A., 1978. Rock-forming minerals. Geological Society of London. 4. Uytenbogaardt, W. and Burke, E.A.J., 1985. Tables for microscopic identification of ore minerals. Courier Corporation. 5. Castroviejo, R., 2023. Introduction to Ore Microscopy. In A Practical Guide to Ore Microscopy—Volume 1: Mineral Identification (pp. 3-25). Cham: Springer International Publishing. Lindsley, D.H. ed., 2018. Oxide minerals: petrologic and magnetic significance (Vol. 25). Walter de Gruyter GmbH & Co KG. **Text Book (Palaeontology):** 1. Donovan, S.K., 2021. Hands-on Palaeontology: a practical manual. Liverpool University Press. 2. Subramani, K., & Manivannan V., Palaeontology Practical Manual. Vishal Publishing Co.

Fourth Semester

Course Code	ES6201N	Course Name	GIS & Remote Sensing and Application of AI-ML in Geosciences	Course Category	PC	L	T	P
						4	0	0

Pre-requisite Courses	BSc with Geology/ Earth Sciences as Major in three-year UG Course	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department		Earth Sciences		Data Book / Codes/Standards	Nil

Course Objective	This course aims to integrate GIS, Remote Sensing, and AI-ML techniques to analyze geospatial data for solving geological challenges. Students will learn to process satellite imagery, apply machine learning algorithms (e.g., neural networks, clustering), and interpret results for mineral exploration, hazard assessment, and environmental monitoring. The course emphasizes hands-on workflows for predictive modeling, spatial pattern recognition, and ethical AI practices in geosciences.

dule	Syllabus	Duration (class-hour)	Module outcome
1	➢ **Fundamentals of GIS & Remote Sensing**: Principles, platforms, sensors, resolutions (spatial, spectral, temporal), geospatial data types.	8	Students will define core principles of GIS and remote sensing, explain electromagnetic spectrum interactions with Earth's surface, and differentiate between active/passive sensors. Learners will apply coordinate systems and map projections to geospatial data, preparing for advanced spatial analysis.
2	➢ **Data Acquisition & Preprocessing**: Noise reduction, normalization, geometric/radiometric correction, spectral analysis.	10	Learners will learn geoprocessing operations (e.g., buffering, overlay, interpolation). They will quantify terrain attributes (slope, aspect, curvature) from DEMs and evaluate spatial autocorrelation to identify patterns in geological/environmental datasets.
3	AI-ML Techniques: Supervised (regression, classification) and unsupervised learning (clustering) for lithology mapping, anomaly detection.	12	Students will implement supervised and unsupervised ML algorithms for land cover classification.
4	**Applications in Geosciences**: Mineral prospectivity	10	Learners will design for high-resolution image segmentation. They will integrate

	mapping, landslide susceptibility modeling, climate change studies using satellite data.		transfer learning with satellite imagery to automate feature extraction and detect anomalies (e.g., landslides, pollution plumes).
5	**Geo-statistics & ML Integration**: Variogram modeling, kriging with Python libraries (e.g., Scikit-learn), uncertainty quantification.	8	Students will process large-scale geospatial datasets. They will deploy scalable AI pipelines for time-series analysis of environmental changes.
6	**Ethics & Challenges: Bias mitigation, data privacy, sustainability in AI-driven geoscience workflows.**	4	Learners will develop end-to-end projects combining GIS, remote sensing, and AI/ML to solve real-world problems. They will validate models with field data and communicate results through interactive geospatial dashboards.
Total		**52**	

Course Outcome	Students will demonstrate proficiency in processing geospatial datasets (GIS/Remote Sensing) and applying AI-ML algorithms for resource exploration, hazard prediction, and environmental analysis. They will design workflows for mineral prospectivity, seismic interpretation, and land-use classification using Python tools. Learners will evaluate model accuracy, integrate geostatistical methods, and address ethical challenges in AI applications, preparing for roles in sustainable resource management and geoscientific research.
Learning Resources	1. Lillesand, T., Kiefer, R.W. and Chipman, J., 2015. Remote sensing and image interpretation. John Wiley & Sons. 2. Longley, P.A. and Cheshire, J.A., 2017. Geographical information systems. In The Routledge Handbook of Mapping and Cartography (pp. 251-258). Routledge. 3. Machine Learning for Geoscientists by Sebastian Hölz. 4. Raschka, S. and Mirjalili, V., 2019. Python machine learning: Machine learning and deep learning with Python, scikit-learn, and TensorFlow 2. Packt publishing ltd. 5. Aurélien, G., 2017. Hands-on machine learning with scikit-learn & tensorflow. Geron Aurelien, 134, pp.145-150. 6. Geospatial Analysis Using AI and ML by S. Shekhar et al.

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">ES6202N</td><td rowspan="2">Course Name</td><td rowspan="2">Hydrogeology & Exploration Geophysics</td><td rowspan="2">Course Category</td><td rowspan="2">PC</td><td>L</td><td>T</td><td>P</td></tr>
<tr><td>4</td><td>0</td><td>0</td></tr>
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<table>
<tr><td>Pre-requisite Courses</td><td>BSc with Geology/ Earth Sciences as Major in three-year UG Course</td><td>Co-requisite Courses</td><td>Nil</td><td>Progressive Courses</td><td>Nil</td></tr>
<tr><td colspan="2">Course Offering Department</td><td colspan="2">Earth Sciences</td><td>Data Book / Codes/Standards</td><td>Nil</td></tr>
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Course Objective	Water crisis is a burning topic globally. The present-day society is affected by a few challenges regarding water crisis, ground water contamination, inferior quality of water, saline water intrusion etc. Students of geology should have therefore the ideas about occurrence, physical and chemical attributes of water along with the exploration of groundwater resources. In the course content main emphasis has been given on these important aspects of groundwater. Exploration geophysics deals several indirect techniques to understand the subsurface geology as well as the subsurface structures which is necessary for any kind of exploration work. Students will be acquainted with geophysical techniques, extensively to be used in exploration sector.

Module	**Syllabus**	**Duration (class-hour)**	
1	**Hydrogeology** ➢ Hydrologic cycle and occurrence of ground water, Porosity and permeability, Aquifer properties, Darcy's Law and groundwater movement, Specific yield, Specific retention, transmissivity, storage co-efficient or storativity, Hydraulic conductivity, Cone of Depression, Hydrologic data interpretation, and flow-net analysis.	**5**	To give the general ideas about the occurrences of different water resources and groundwater. The movement and availability of groundwater in different sub-surface conditions
3	➢ Groundwater provinces of West Bengal and India. ➢ Solution of Problems related to Hydrogeology	**2**	To develop the perception on the present status of groundwater considering problems and prospects in global and Indian scenario.
4	**Exploration Geophysics** ➢ Seismology and the interior of the earth: elementary principles of elastic wave propagation through the earth; travel-time curves and location of earthquakes; earthquake intensity and scales; whole earth seismic velocity-depth models and crust-mantle-outer core-inner core zonation; seismic tomography.	**7**	Students will interpret seismic profiles to identify subsurface structures (e.g., faults, reservoirs) and quantify rock velocities

5	➢ Earth's gravity field and gravitational acceleration; gravity anomalies and isostasy; simple isostatic compensation calculations for the Airy and Pratt models. ➢ Earth's magnetism, basic concepts of magnetic field, field components and intensity, magnetic susceptibility, magnetic anomalies; magnetization and remnant magnetization, paleomagnetism; paleomagnetic poles and polar wandering: tectonic implications; earth's magnetic field reversals, reversal time scale. ➢ Plates and plate configuration of the earth; plate motion: geometry, time scales and forces, physical basis of plate tectonics. ➢ Heat and thermal structure of the earth; oceanic and continental heat flow; the geotherm and the adiabat: implications for melting in the mantle and primary magma generation.	**20**	Learners will analyze anomalies to map basement topography, igneous intrusions, and ore bodies. will assess groundwater/salinity zones and mineral deposits using resistivity tomography. And they will learn to detect conductive ore bodies/aquifers through EM induction profiling
Total		**52**	

Course Outcome	Students will assess groundwater resources using Darcy's law, well hydraulics, and geophysical methods (e.g., seismic, electrical surveys). They will evaluate aquifer properties, contamination risks, and artificial recharge strategies. Learners will interpret geophysical data to model subsurface structures and tectonic processes. This equips them to address water security, resource exploration, and environmental management, integrating hydrogeological and geophysical principles for sustainable development.

Learning Resources	1. Ingebritsen, S.E., Sanford, W.E. and Neuzil, C.E., 2006. Groundwater in geologic processes. Cambridge University Press. 2. Moore, J.E., 2016. Field hydrogeology: a guide for site investigations and report preparation. CRC Press. 3. Todd, D.K. and Mays, L.W., 2004. Groundwater hydrology. John Wiley & Sons. 4. De Wiest, R.J., 1986. Diagnostic Hydrology a. Groundwater, 24(3), pp.332-341. 5. Groundwater Hydrology by David Keith Todd and Larry W. Mays 6. Fowler, C.M.R., 1990. The solid earth: an introduction to global geophysics. Cambridge University Press. 7. Skinner, B.J. and Porter, S.C., 1995. The blue planet: an introduction to earth system science. New York: John Wiley. 8. Van der Pluijm, B.A. and Marshak, S., 2004. Earth structure: an introduction to structural geology and tectonics. (No Title). 9. Robinson, E.S., 1988. Basic exploration geophysics.