दिल्ली विश्वविद्यालय
University of Delhi

परिषद शाखा - II, कमरा नं: 211, नया प्रशासनिक खंड, दिल्ली विश्वविद्यालय, दिल्ली-110007, दूरभाष: 011-27001156/54
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CNC-II/093/1/AC-1027/26/7
Dated: 27.07.2026

NOTIFICATION

Sub: Amendment to Ordinance V

(AC dated 24.07.2026)

Following addition be made to Annexure-II-A to the Ordinance V (2-A) of the Ordinances of the University;

Add the following:

The following syllabi of the Department of Geology under the Faculty of Science based on Postgraduate Curriculum Framework 2024 are notified herewith for the information of all concerned:

Department	Syllabi	Annexure
Geology	Two-Year M.Sc. Geology (Semester III/IV) and One-Year M.Sc. Geology (Semester I/II).	1

REGISTRAR

Annexure-1

Department of Geology

University of Delhi

2-year PG Geology curricular framework based on NEP 2020

(III^{rd} and IV^{th} Semester Courses)

Curricular structure of 2^{nd}-year (3^{rd} and 4^{th} Semester) of PG of 2-year M.Sc Geology (NEP) course (3+2)

Structure 1 (Level 6.5): PG curricular structure with only course work

Semester- III				
Core courses	Credit in each core course			
Courses	Theory	Practical	Tutorial	Credits
DSC 7 Economic Geology	3	1	-	4
DSC 8 Hydrogeology	3	1	-	4
Total Credit in Core course	6	2	-	8
Elective courses	Credit in each Elective course			
Discipline Specific Electives (DSE) A student has to choose 3 DSE or 2 DSE from the following options. Those who will take 2 DSE, also has to take one GE from other Department	Theory	Practical	Tutorial	Credits
DSE				
5. Advanced River Science	3	1	-	4
6. Paleoclimate	3	1	-	4
7. Environmental Geology	3	1	-	4
8. Glacial Geology	3	-	1	4
9. Quaternary Geology	3	-	1	4
10. Applied Geophysics	3	-	1	4
Generic Elective (GE) GE-III Geo-heritage and Geopark *(To be offered to MSc students of other departments)*	3	-	1	4
Total credit from Electives	9	3		12
Skill-based course				
Skill-based course SBC (SBC-III) Thin-section preparation for Geological studies (Hands on training)	1	1	-	2
Total Credit in Semester	22			

Semester- IV				
Core courses	Credit in each core course			
Courses	Theory	Practical	Tutorial	Credits
DSC 10 Engineering Geology	3	1	-	4
DSC 11 Sequence stratigraphy and Basin Analysis	3	1	-	4
Total Credit in Core course	6	2	-	8
Elective courses	Credit in each Elective course			
Discipline Specific Electives (DSE) A student has to choose 3 DSE or 2 DSE from the following options. Those who will take 2 DSE, also has to take one GE from other Department	Theory	Practical	Tutorial	Credits
11. Petroleum and Coal Geology	3	1	-	4
12. Earthquakes: A Geological perspective	3	1	-	4
13. Climate Change and Sustainability	3	1	-	4
14. Applied Hydrogeology	3	-	1	4
15. Geo-archeology	3	-	1	4
Generic Elective (GE) **GE-IV** Natural hazard and Disaster Management *(To be offered to MSc students of other departments)*	3	-	1	4
Total credit from Electives	9	3		12
Skill-based course				
(SBC-IV) Advanced Geological Mapping	1	1	-	2
Total Credit in Semester	22			

Structure 2 (Level 6.5): PG curricular structure with course work + Research

Semester- III				
Core courses	Credit in each core course			
Courses	Theory	Practical	Tutorial	Credits
DSC 7 Economic Geology	3	1	-	4
DSC 8 Hydrogeology	3	1	-	4
Total Credit in Core course	6	2	-	8
Elective courses	Credit in each Elective course			
Discipline Specific Electives (DSE) A student has to choose 2 DSE or 1 DSE from the following options. Those who will take 1 DSE, also has to take one GE from other Department	Theory	Practical	Tutorial	Credits
DSE				
5. Advanced River Science	3	1	-	4
6. Paleoclimate	3	1	-	
7. Environmental Geology	3	1	-	4
8. Glacial Geology	3	-	1	4
9. Quaternary Geology	3	-	1	4
10. Applied Geophysics	3	-	1	4
Generic Elective (GE) GE-III Geo-heritage and Geopark *(To be offered to MSc students of other departments)*	3	-	1	4
Total credit from Electives	6	2		8
Dissertation/ Academic Project/ entrepreneurship	6			
Total Credit in Semester	22			

Semester- IV				
Core courses	Credit in each core course			
Courses	Theory	Practical	Tutorial	Credits
DSC 10 Engineering Geology	3	1	-	4
DSC 11 Sequence stratigraphy and Basin Analysis	3	1	-	4
Total Credit in Core course	6	2	-	8
Elective courses	Credit in each Elective course			
Discipline Specific Electives (DSE) A student has to choose 2 DSE or 1 DSE from the following options. Those who will take 1 DSE, also has to take one GE from other Department	Theory	Practical	Tutorial	Credits
DSE				
11. Petroleum and Coal Geology	3	1	-	4
12. Earthquakes: A Geological perspective	3	1	-	4
13. Climate Change and Sustainability	3	1	-	4
14. Applied Hydrogeology	3	-	1	4
15. Geo-archeology	3	-	1	4
Generic Elective (GE) **GE-IV** Natural hazard and Disaster Management *(To be offered to MSc students of other departments)*	3	-	1	4
Total credit from Electives	9	3		12
Dissertation/ Academic Project/ Entrepreneurship	6			
Total Credit in Semester	22			

Structure 3 (Level 6.5) PG Curricular Structure (Research)

Semester- III				
Core courses	Credit in each core course			
Courses	Theory	Practical	Tutorial	Credits
DSC 9 Current trends in Geoscience Research	3	1	-	4
Total Credit in Core course	- 4			
Elective courses	Credit in each Elective course			
Discipline Specific Electives (DSE)	Theory	Practical*	Tutorial*	Credits
DSE 5. Advanced River Science 6. paleoclimate 7. Environmental Geology 8. Glacial & Periglacial Geology 9. Quaternary Geology 10. Applied Geophysics *According to the elective chosen, the credit system (Practical/Tutorial) may vary	3	1/0	0/1	4
Total credit from Electives	4			
Research Methods/ Tools/Writing				
(a) Advanced Research Methodology	1	-	1	2
b) Tools for Research	1	1	-	2
Total Credit from Research Methods/ Tools/Writing	4			
Dissertation/ Academic Project/ entrepreneurship	10			
Total Credit in Semester	22			

Semester- IV				
	Credit in each core course			
Courses	Theory	Practical	Tutorial	Credits
Elective courses	Credit in each Elective course			
Discipline Specific Electives (DSE)	Theory	Practical*	Tutorial*	Credits

DSE 11. Petroleum and Coal Geology 12. Earthquakes: A Geological perspective 13. Climate change and sustainability 14. Applied Hydrogeology 15. Geo-archaeology ****According to the elective chosen, the credit system (Practical/Tutorial) may vary***	3	1/0	0/1	4
Total credit from Electives	4			
Research Methods/ Tools/Writing				
Techniques of Research Writing	1	-	1	2
Total Credit from Research Methods/ Tools/Writing	2			
Dissertation/ Academic Project/ entrepreneurship	16			
Total Credit in Semester	22			

Semester -III

DSC 7: Economic Geology Duration: 45 Hours (Lecture) + 30 Hours (Practical)

Course Title and Code	Total Credit	Credit distribution in course		
Economic Geology	4	Lecture	Tutorial	Practical
		03	0	01

LEARNING OBJECTIVES:

- To introduce the understanding of ore deposits and how they form
- Ores in the context within the framework of tectonics and metallogeny.
- The student will be introduced to several ore deposit styles.
- A suite of important ore minerals (oxides and sulphides) will be examined in reflected light.

LEARNING OUTCOMES:

- Students will be able to identify a number of important ore minerals in reflected light, thereby aiding in the exploration and characterization of ore deposits
- Students will recognize the key factors controlling several ore deposits so that deposits may be characterized and linked to existing ore deposit models
- Students will have knowledge on metallogenic provinces and their evolution in time domain
- Students will also be able to apply their knowledge to link these ore deposits within a metallogenic framework and thereby enhance exploration strategies

CONTENTS **3 Credit (45 Hrs)**

Unit-I: Concept of metallogeny and metallogenic provinces **(12 Hours)**

Introduction and objectives; Metallogeny principles and practice; Metallogenic terms and definitions; Metallogenic classification of ore and mineral deposits; The concept of metallogenic provinces and epochs

Unit-II: Tectonics and Metallogeny **(14 Hours)**

Global Tectonics and Supercontinent Cycles, Introduction to crustal evolution and metallogeny ; Metallogeny in relation to geodynamics and deep time, and the significance of non-uniformitarian models in understanding ancient geodynamic regimes. Metallogeny and plate tectonics: within-plate settings, incipient rift environments, divergent plate boundaries, and convergent plate boundaries

Unit-III: Controls on ore mineralization **(11 Hours)**

Hydrothermal alteration Ore deposits within the context of their characterization, tectonic setting, structural control, alteration, and ore mineralogy: Porphyry Cu and Mo; Carlin gold; Epithermal; SEDEX and VMS; MVT; Sedimentary Ore deposits: Iron and Manganese; Magmatic – Bushveld Igneous Complex

Unit-IV: Metallogeny models **(8 Hours)**

Metallogenic models: source of elements, supercritical hydrous melts and fluids, architecture and timing of flow path activation, controls on sites and physico-chemical conditions; Features of Metallogenic Provinces: Regional tectonic types of ore-bearing provinces, Evolution of ore-bearing provinces in time, composition of ores characterizing the ore-bearing provinces, form of ore deposits, and the ore-bearing provinces.

PRACTICAL **1 credit (30 Hours)**

1. Learning diagnostic physical properties and identification of metallic and non-metallic ore minerals in hand specimens.
2. Training on the microscopic identification of sulphide, oxide and carbonate ore minerals
3. Learning approaches to understand the textural relationships and mineral paragenesis in the assemblage of gangue and ore minerals.

SUGGESTED READINGS:

1. Richard, H. Sillitoe (2024). Metallogeny and Mineral Exploration – Some Personal Reminiscences. Geochemical Perspectives.
2. Moon, C.J., Whateley, M.K.G. and Evans, A.M. (2006). Introduction to mineral exploration.
3. Robb, L.J. (2005). Introduction to ore-forming processes
4. Ridley, J. (2013) Ore Deposit Geology
5. Sawkins, F. J. (1984). Metal Deposits in Relation to Plate Tectonics (Minerals and Rocks Series, Vol. 17). Springer-Verlag, Berlin, Heidelberg, New York, Tokyo. xiv + 325 pp. ISBN: 3-540-12752-6

DSC 8: Hydrogeology **Duration: 45 Hours (Lecture) + 30 Hours (Practical)**

Course Title and Code	**Total Credit**	**Credit distribution in course**	
Hydrogeology	**4**	**Lecture**	**Practical**
		03	**01**

Learning Objectives:

- The course is aimed at imparting advanced-level conceptual clarity and understanding of hydrogeology.
- It will share knowledge about the occurrence and movement of groundwater, water-bearing properties of formations, aquifer types, aquifer parameters, drilling methods, well construction, and completion.
- It also enables students to acquire knowledge about the physical and chemical attributes and the exploration of the groundwater resources

Learning Outcomes:

- The students will learn about occurrence of groundwater, water bearing properties of formations, aquifer types and aquifer parameters.
- The course imparts knowledge about construction, design and development of water wells, aquifer parameter estimation and the science of groundwater flow under different conditions.
- Develop a concise understanding of groundwater quality, its analytical representation, contamination and variability in India
- The students will learn about the concepts of groundwater exploration and the different methods of groundwater exploration.

CONTENTS

Unit I: General concepts: **(14 hours)**

Water on earth. Types of water: meteoric, juvenile, magmatic and sea waters. Hydrologic cycle. Vertical distribution of subsurface water: zone of aeration and zone of saturation. Concept of depth to water level and water table contour maps. Concepts of drainage basin and groundwater basin. Classification of rocks and formations according to their water-bearing properties. Aquifers and their types. Water table and piezometric surface. Water bearing properties of rocks and aquifer parameters: porosity, permeability, specific yield, specific retention, hydraulic conductivity, transmissivity, intrinsic permeability, storage coefficient, storativity, specific storage. Fluctuations of water table and piezometric surface; Barometric and tidal efficiencies. Geologic and geomorphic controls on groundwater. Hydrostratigraphic units. Springs. Introduction to hydrogeology of India and the groundwater provinces of India.

Unit II: Water wells and well hydraulics: **(13 hours)**

Types of wells, drilling methods, construction, design, development, maintenance and revitalization of wells. Specific capacity and its determination. Darcy's Law and its applications. Theory of groundwater flow, numerical solutions for steady state linear groundwater flow in confined and unconfined aquifers and Dupuit's assumption for unconfined flow. Numerical solutions for steady state radial flow to a well in confined (Thiem's equation) and unconfined aquifers (Dupuit's equation). Numerical solutions for unsteady state groundwater water flow condition. Methods of permeability estimation in laboratory and field. Evaluation of aquifer parameters of confined aquifer using Theis and Jacob methods.

Unit III: Groundwater chemistry: **(10 hours)**

Groundwater quality – physical and chemical properties of water, quality criteria for different uses. Groundwater contamination and pollution from natural (geogenic) and anthropogenic sources. Graphical presentation of water quality data. Saline water intrusion in aquifers and its prevention. Groundwater quality in different provinces of India

Unit IV: Groundwater exploration: **(8 hours)**

Geological, lithological, structural and hydrogeomorphic mapping, fracture trace analysis, lineament mapping in context of groundwater exploration. Remote sensing as a tool in groundwater exploration. Surface-based geophysical methods – seismic, gravity, electrical resistivity and magnetic. Subsurface geophysical methods.

Practical (1 Credit) **(30 Hours)**

1. Depth to water level and water table contour map-based exercise.
2. Numerical problems related to steady state radial flow to wells in confined and unconfined aquifer.
3. Numerical problems related to estimation of permeability in laboratory and field.
4. Practical exercise based on Theis and Jacob's equation and methods of aquifer parameter estimation.
5. Practical exercises based on Hydrochemical facies and Trilinear (Hill-Piper) diagram.
6. Numerical problems related to sea water intrusion in the coastal aquifers.

ESSENTIAL READINGS:

1. Todd, D. and Mays, L. 2005 *Groundwater Hydrology*. (3rd ed.), John Wiley and Sons, Inc., Hoboken, N.J.
2. Fetter, C.W., and D. Kreamer. 2022. *Applied Hydrogeology*, 5th ed. Long Grove, IL: Waveland Press
3. Fitts, C.R., 2023. *Groundwater Science* (3rd ed.), Academic Press.
4. Freeze, R.A. and Cherry, J.A., 1979. *Groundwater*, Englewood Cliffs, New Jersey: Prentice-Hall.
5. Karanth K.R., 1987. *Groundwater: Assessment, Development and Management*, Tata McGraw-Hill Pub. Co. Ltd.

SUGGESTED READINGS:

1. Davies, S.N. and De-West, R.J.N., 1966. *Hydrogeology*, John Wiley & Sons, New York.
2. Driscoll, F.G., 1988. *Ground Water and Wells*, UOP, Johnson, Div. St. Paul. Min. USA.
3. Raghunath, H.M., 1987. *Ground Water*, Wiley Eastern Ltd., Calcutta.
4. Schwartz, F. W., & Zhang, H. 2024. *Fundamentals of groundwater* (2nd ed.). Wiley.
5. EPG Pathsala lecture modules at web link: http://epgp.inflibnet.ac.in/ahl.php?csrno=448
6. Uliana, M. M. 2025. *Basic hydrogeology: An introduction to the fundamentals of groundwater science*. The Groundwater Project. https://doi.org/10.62592/CBIQ7579.
7. Younger, P. L., 2009. *Groundwater in the environment: an introduction*. John Wiley

DSC 9: Current trends in Geoscience Research

Course Title and Code	**Total Credit**	**Credit distribution in course**		
Current trends in Geosciences Research	**4**	**Lecture**	**Tutorial**	**Practical**
		03	**0**	**01**

Course Objectives:

The sustainable development of our society depends on balanced utilization of natural resources including economic minerals, ground water and hydrocarbon resources. Also, we require continuous improvement of our infrastructure including roads, bridges and dams etc. Keeping this mind, the course is designed to expose students to state-of-the art techniques in the fields of economic Geology, Groundwater, Engineering geology and Sequence stratigraphy. The course will also attempt exposing to the students the recent ideas in these fields of research.

Course Learning Outcomes:

Students will be come to know about

1. Different ore generation processes and how the processes related to global tectonics

2. Nuances of groundwater science

3. Role of engineering geology in different infrastructural development projects

4. How applied stratigraphy help in identification of stratigraphic traps of oil and gas

Unit-I: Metallogeny, Geodynamics and Ore Deposit Systems (11 Hours)

Metallogenic classification of ore and mineral deposits; The concept of metallogenic provinces and epochs. Metallogeny in relation to geodynamics and deep time, and the significance of non-uniformitarian models in understanding ancient geodynamic regimes. Metallogeny and plate tectonics: within-plate settings, incipient rift environments, divergent plate boundaries and convergent plate boundaries. Ore deposits within the context of their characterization, tectonic setting, structural control, alteration, and ore mineralogy.

UNIT II: Groundwater science (12 Hours)

Classification of rocks and formations according to their water-bearing properties. Water table and piezometric surface. Water bearing properties of rocks and aquifer parameters: porosity, permeability, specific yield, specific retention, hydraulic conductivity, transmissivity, intrinsic permeability, storage coefficient, storativity, specific storage. Types of wells, drilling methods, construction, design, development, maintenance and revitalization of wells. Specific capacity and its determination. Darcy's Law and its applications. Theory of groundwater flow, numerical solutions for steady state linear groundwater flow in confined and unconfined aquifers and Dupuit's assumption for unconfined flow. Numerical solutions for steady state radial flow to a well in confined (Thiem's equation) and unconfined aquifers (Dupuit's equation). Numerical solutions for unsteady state groundwater water flow condition. Methods of permeability estimation in laboratory and field. Evaluation of aquifer parameters of confined aquifer using Theis and Jacob methods.

Unit- III: Engineering Geology for societal benefits (10 Hours)

Engineering properties of rocks and soil. Engineering bedrock and their characteristics. Laboratory index and strength tests for rocks and soil. Rock slope failure mechanism. Mass wasting and their types. Rock slope stabilization techniques; factor of safety. Application of rock mechanics for underground openings, rock slope engineering, and foundation engineering. Landslide hazard zonation mapping.

Unit- IV: Sequence stratigraphy: An integrated applied stratigraphy for basin analysis hydrocarbon exploration (12 Hours)

Definitions and key concepts. Base level (stratigraphic and geomorphic) changes, Eustatic and Relative Sea level, Transgressions and regressions, T-R cycles. Regional and global stratigraphic cycles. Unconformity, Flooding surface ...... Stratal geometry, terminations, sequence stratigraphic surfaces. Unconformity and correlative conformity, Basal surface of

Marine regression, Ravinement surface, Initial and maximum flooding surface. Concept of stratigraphic trap.

Practical:

1. Exercises on effects of Tectonics and Eustacy in basin accommodation
2. Exercise of stratal geometry in different Systems Tracts
3. Practical exercise based on Theis and Jacob's equation and methods of aquifer parameter estimation.

Essential Readings:

1. Principles of Sequence Stratigraphy: Octavian Catuneanu (2006) Elsevier
2. Sequence Stratigraphy: D. Emery, and K. Mayers (1996) Blackwell Publishers
3. Todd, D. and Mays, L. 2005 Groundwater Hydrology. (3rd ed.), John Wiley and Sons, Inc., Hoboken, N.J.
4. Fetter, C.W., and D. Kreamer. 2022. Applied Hydrogeology, 5th ed. Long Grove, IL: Waveland Press
5. Robb, L. (2020). Introduction to Ore-Forming Processes (2nd ed.). Wiley-Blackwell.
6. Sawkins, F. J. (1984). Metal Deposits in Relation to Plate Tectonics (Minerals and Rocks Series, Vol. 17). Springer-Verlag, Berlin, Heidelberg, New York, Tokyo. xiv + 325 pp. ISBN: 3-540-12752-6

Suggested Readings

EPG Pathsala lecture modules at web link: http://epgp.inflibnet.ac.in/ahl.php?csrno=448

DSE 5: Advanced River Science Duration: 45 Hours (Lecture) + 30 Hours (Practical)

Course Title and Code	**Total Credit**	**Credit distribution in course**	
Advanced River Science	4	**Lecture**	**Practical**
		03	01

Learning Objectives

- To provide an in-depth understanding of river system dynamics through interdisciplinary perspectives combining geomorphology, hydrology, sedimentology, and ecology.
- To train students to analyse fluvial processes using modern quantitative tools, field data, and remote sensing–GIS techniques to interpret river behaviour, assess changes, and design sustainable river management strategies.

Learning outcomes

Upon completion of the course, students should be able to:

- Understand and appreciate river basins as systems with internal and external dynamics
- Explain river morphology, discharge behaviour, including hydrographs and flood, and sediment transport processes
- Employ theoretical and quantitative techniques to study bedrock rivers and landscape evolution.
- Assess human impacts on rivers and explore approaches for sustainable management and restoration
- Apply advanced technologies, including AI and GIS, for river monitoring and analysis.

CONTENTS

Unit I: Fundamentals of River System Dynamics (10 Hours)

Catchment hydrology, runoff, hillslope processes, channel initiation; River as a system: system approaches in fluvial geomorphology, Driving and resisting forces in river systems; Key concepts in river geomorphology: spatial and temporal scale, disturbance events, river sensitivity, resilience, threshold, (dis)connectivity, hierarchy and complexity

Unit II: Fluvial forms, processes and evolution (14 Hours)

River diversity: Channel pattern, Channel geometry, Channel morphology, Floodplains, instream features; River flow, discharge, and discharge measurement; Sediment load, entrainment, transport, deposition and measurement; Weathering and river chemistry: geochemical proxies and tracers to study fluvial dynamics; Hydrographs, hydrograph separation, baseflow; Groundwater-river interaction; Hyporheic zone; Flood hydrology, Flood frequency analysis; River evolution – River response to climate, tectonics and human disturbance; Impact of increased cryospheric dynamism on rivers

Unit III: Bedrock rivers (8 Hours)

Bedrock channel processes, Longitudinal profile analysis, Stream power incision model, Geomorphometrics, Evolution of fluvial landscapes.

Unit IV: Rivers in the Anthropocene, River Management and Emerging Themes (13 Hours)

Anthropogenic impacts on rivers: dams, diversions, river sand mining, land-use change, and pollution, Emerging contaminants in rivers; River management and River future: Riverine Ecology and Habitat, River Health, e-flow, Application of the River Styles Framework in River Management, River rehabilitation and repair; River rights and governance; Transboundary rivers; Modern methods and tools of data acquisition and data analysis for river science; Applications of Artificial Intelligence and Cloud based GIS in river science.

Practical 1 credit (30 Hrs)

1. Exercises on Hydrographs
2. Exercises on Flood frequency analysis
3. Extraction and analysis of geomorphometrics using MATLAB Topotoolbox
4. Fluvial morphological mapping and analysis using cloud and desktop GIS
5. Analysis of sediment load data

SUGGESTED READINGS

1. Fryirs, K. A., & Brierley, G. J. (2013). *Geomorphic analysis of river systems*. Wiley-Blackwell.
2. Wohl, E. (2010). *Mountain rivers revisited*. American Geophysical Union.
3. Bierman, P., & Montgomery, D. (2014). *Key concepts in geomorphology* (2nd ed.). W. H. Freeman.
4. Kondolf, G. M., & Piégay, H. (2003). *Tools in fluvial geomorphology*. Wiley.
5. Charlton, R. (2008). *Fundamentals of fluvial geomorphology* (2nd ed.). Routledge.
6. Kelly, J. M., Scarpino, P. V., Berry, H., Syvitski, J., & Meybeck, M. (Eds.). (2018). *Rivers of the Anthropocene*. Springer.
7. Robert, A. (2011). *River processes: An introduction to fluvial dynamics* (2nd ed.). Routledge.
8. Brierley, G. J., & Fryirs, K. A. (Eds.). (2008). *River futures: An integrative scientific approach to river repair*. Island Press.

DSE 6: PALEOCLIMATE

Duration: 45 Hours (Lecture) + 30 Hours (Practical)

Course Title and Code	Total Credit	Credit Distribution in Course		
Paleoclimate	4	Lecture	Tutorial	Practical
		3	0	1

LEARNING OBJECTIVES:

- Understand Earth's climate system, energy balance, and feedback mechanisms.
- Apply sampling, dating, and analytical techniques to paleoclimate archives.
- Reconstruct past climates using multiproxy data and Earth system processes.
- Evaluate anthropogenic impacts and mitigation strategies in a changing climate.

LEARNING OUTCOMES

- Explain climate system dynamics, energy balance, and radiative forcing.
- Apply sampling, dating, and proxy analysis for paleoclimate reconstruction.
- Reconstruct past climates and relate them to orbital, oceanic, and tectonic controls.
- Evaluate anthropogenic impacts, risks, and mitigation/adaptation strategies.

LECTURE **3 Credit (45 Hrs)**

Unit I: Introduction to Weather and Climate **(12 Hours)**

Concepts of **weather** and **climate** and their classification systems, **Greenhouse gases**: sources, changing concentrations, and their role in climate change, Components of the **climate system** and their interactions, **Climate forcing**, system responses, response rates, and feedback mechanisms, **Incoming solar radiation**: short-term and long-term variability (insolation), Receipt, storage, and transformation of heat; **Earth's heat budget**, Radiative forcing, albedo, and anthropogenic influences on energy balance

Unit II: Sampling Earth Materials to Understand Climate Change (14 Hours)

Sampling methods for retrieving **climate and oceanographic archives** (deep-sea cores, ice cores, lake sediments, speleothems), **Dating techniques**: radiometric, radiocarbon, and others; advantages, limitations, and uncertainties, **Elemental and isotopic analysis** for paleoclimate reconstruction, Instruments used in paleoclimate studies: mass spectrometers, gas chromatographs, stable isotope analysers, Climate modelling approaches and **IPCC climate change projections**; multiproxy integration for climate reconstructions

Unit III: Paleoclimate Reconstruction (11 Hours)

Reconstruction from **deep-sea cores, ice cores, pollen and spores, biogeochemical proxies, corals, and speleothems,** Astronomical controls: **Milankovitch cycles** and solar variability, Glacial–interglacial cycles; **Last Glacial Maximum (LGM)** and **Younger Dryas,** Monsoon variability over geological timescales and the role of the **Intertropical Convergence Zone (ITCZ),** Atmospheric layering, circulation, and **heat transfer in the atmosphere and oceans, Global Ocean Conveyor Belt** and its control on climate, Plate tectonics and long-term climate regulation, Teleconnections, ocean–atmosphere feedbacks, and paleoclimate modelling

Unit IV: Anthropogenic Effects, Climate Impacts, and Mitigation (8 Hours)

Natural vs **anthropogenic drivers** of climate change, **Regional climate records**, with emphasis on the Indian subcontinent, Biosphere responses to climate variability, Human impacts on climate and consequences for society, ecosystems, and economy, Climate change hazards, disasters, and risk assessment, Mitigation strategies, adaptation measures, and policy frameworks

PRACTICAL 1 credit (30 Hours)

1. Interpreting Paleoclimatic data
   (a) Quantitative Faunal data
   (b) Distribution of Fossils on Paleogeographic Maps
   (c) Interpreting Stable Isotope Data obtained from Archives
2. Exercises on Ocean Circulation and resultant Climate Change
3. Exercises on Closing and Opening of Ocean gateways and resultant Continental Glaciations
4. Interpreting Past sea level curves and their climatic Causes.

ESSENTIAL READINGS:

1. Ruddiman, W.F., 2001. Earth's climate: past and future. Edition 2, Freeman Publisher.
2. Rohli, R.V., and Vega, A.J., 2007. Climatology. Jones and Barlatt
3. Lutgens, F., Tarbuck, E., and Tasa, D., 2009. The Atmosphere: An Introduction to Meteorology. Pearson Publisher.
4. Aguado, E., and Burt, J., 2009. Understanding weather and climate. Prentice Hall.
5. Bradley, R.S., *Paleoclimatology: Reconstructing Climates of the Quaternary*, Academic

Press.
6. Braiser, M.D., 1980. *Microfossils*, George Allen, and Unwin.

SUGGESTED READINGS:

1. Cronin, T.M., 1999.*Principles of Paleoclimatology*, Columbia University Press.
2. Fischer, G. and Wefer, G., 1999.*Use of Proxies in Paleoceanography: Examples from the South Atlantic*, Springer.
3. Kennett, J.P., 1982.*Marine Geology*, Prentice-Hall Inc.
4. North, G.R. and Crowley, T.J., 1995. *Paleoclimatology*, Oxford University Press

DSE 7: Environmental Geology Duration: 45 Hours (Lecture) + 30 Hours (Practical)

Course Title and Code	Total Credit	Credit distribution in course	
Environmental Geology	4	**Lecture**	**Practical**
		03	01

Learning Objectives:

- To understand the interaction of humans with the geological environment.
- To familiarise students of challenges of environmental geology in the urban Environment.
- To teach practical contribution that geologists can make in managing human interaction with the physical environment.

Learning Outcomes:

- Student will understand the concepts of environmental geology.
- They will learn about concepts of managing geological resources.
- Learn appropriate use of the geological environment for waste disposal.
- Students will learn about the natural hazards and mitigation of their human impacts.

Contents:

Unit I: INTRODUCTION AND GEOLOGICAL RESOURCES (13 Hours)

Definition; History of Environmental Geology; Environmental Geology and Commercial reality; The Tools of the Environmental geologist; Critical thinking about the environment Economic mineral resources; Construction resources; Water resources; Aesthetic and Scientific geological resources (aesthetic, cultural and scientific importance of Geology).

Unit II: **ENVIRONMENTAL HAZARDS (16 Hours)**

Exogenic hazards; Endogenic hazards; Engineering geology in extreme events.

Unit III: **WASTE AND POLLUTION MANAGEMENT (8 Hours)**

Waste management and geological environment; Waste and Pollution; Waste and Society; Wastes in open dumps; Landfilling wastes; Effluent treatment and disposal; Waste gases and the atmosphere; Radioactive wastes and management;

Unit IV: **ENVIRONMENTAL GEOLOGY: AN URBAN CONCEPT (8 Hours)**

Urban Environments; Urban planning and geology

Practicals 1 Credit (30 Hours)

1. Environmental geological mapping
2. Landslide susceptibility mapping
3. River health assessment
4. Groundwater vulnerability assessment
5. Change detection using Google Earth
6. Environmental risk matrix preparation

SUGGESTED READINGS:

1) Environmental Geology: Geology and the Human Environment by Bennett and Doyle by Wiley Publications

2) Environmental Geology by Jim Reichard by McGraw Hill

3) Environmental Science by Botkin and Keller by Wiley Publications

DSE 8: Glacial and Periglacial Geology

Course Title and Code	Total Credit	Credit distribution in course	
Glacial and Periglacial Geology	4	**Lecture**	**Practical**
		03	01

Learning Objectives

The main aim of this course is

- to provide students with a comprehensive understanding of the glacial system and processes.
- to provide a thorough knowledge of the dynamics of different glacial and periglacial processes and landform formation.
- to discuss the linkages between climate and glaciations/deglaciations, and their impacts.

Learning outcomes

After completing this course, students will be able to:

- explain how different processes operate in the glacial and periglacial environment
- Identify glacial and periglacial landforms and sediments on the map and in the field

- Conduct a study to understand the long-term glacial history of an area using a range of field and laboratory techniques.

Unit I **(10 Hours)**

Glacial Geology and the Cryosphere: Concept and scope of Glacial Geology; components of the cryosphere, including ice sheets, ice caps, valley glaciers, sea ice and snow cover; formation of Glaciers; physical and mechanical characteristics of Glacial ice; relationship between climate and Glaciers; significance and applications of Glacial geology; techniques and methods used in glacial studies.

Unit II **(10 Hours)**

Glacial Processes, Dynamics and Landforms: Glacial erosion and depositional processes; erosional and depositional landforms produced by Glaciers; ice flow mechanisms and glacier dynamics; sediment entrainment, transportation and deposition; Glacial mass balance and Equilibrium Line Altitude (ELA); Glacial hydrology; Glacial lakes and Glacial Lake Outburst Floods (GLOFs).

Unit III **(10 Hours)**

Periglacial Environment and Glacial Sediments: Concept and characteristics of periglacial environments; periglacial climate, weathering, ground freezing and thawing processes; permafrost; slope movement and hillslope evolution; characteristics of glacial sediments (Tills) including shape, form, roundness, texture, size and macro fabrics; methods of sediment sampling and analysis; glaciofluvial, glaciolacustrine and glaciomarine sediments.

Unit IV **(10 Hours)**

Past Glaciations and Climate Change: Climate change and glaciation; major glaciations during Earth's history; Quaternary glaciations and climatic fluctuations; Last Glacial Maximum (LGM); Little Ice Age (LIA); significance of past glaciations in palaeoclimate reconstruction and understanding present-day climate change.

Practical **(15 Hours)**

i. Glacial and periglacial landform mapping
ii. Glacial mass balance exercise
iii. Identification and reconstruction of Equilibrium Line Altitude (ELA).
iv. Glacial sediments: shape, form and texture analysis.

Suggested Readings:

Bennett, Matthew R., and Neil F. Glasser. 2009. Glacial Geology: Ice Sheets and Landforms. 2nd ed. Oxford, U.K.: Wiley-Blackwell.

Ballantyne, Colin K. 2018. Periglacial Geomorphology. 2nd ed. Oxford, U.K.: Wiley-Blackwell.

Summerfield, Michael A. 2014. Global Geomorphology. London: Routledge

Evans, David J. A., and Douglas I. Benn, eds. 2014. A Practical Guide to the Study of Glacial Sediments. London: Routledge.

Ruddiman, William F. 2014. Earth's Climate: Past and Future. 3rd ed. New York: W. H. Freeman and Company.

DSE 9: Quaternary Geology

Course Title and Code	**Total Credit**	**Credit distribution in the course**	
Quaternary Geology	**4**	**Lecture**	**Tutorial**
		03	**01**

Learning Objective

- To introduce the Quaternary period as a time of significant climatic, environmental, and geomorphic change.
- This course also introduces the stratigraphy, dating methods, sedimentary records, and biotic responses, with emphasis on understanding landscape evolution and human–environment interactions during the Quaternary.

Learning Outcomes

By the end of the course, students will be able to:

- Explain the significance and characteristics of the Quaternary period
- Interpret Quaternary stratigraphic records using multiple proxies
- Apply geochronological methods to Quaternary sediments and landforms
- Analyse geomorphic and tectonic processes active during the Quaternary
- Reconstruct past environments using biological and sedimentological evidence
- Evaluate the relationship between climate change, biotic evolution, and human development

Unit I: Introduction to the Quaternary (11 Hours)

Definition, duration, and subdivision of Quaternary; Characteristics of the Quaternary: climatic fluctuations and environmental instability; Development of Quaternary studies; Glacial–interglacial cycles and their global significance; Principles of Quaternary stratigraphy; Introduction to Oxygen isotope stratigraphy (marine isotope stages), biostratigraphy; magnetostratigraphy, and Palynology.

Unit II: Quaternary Geochronology (4 Hours)

Principles of dating: relative vs absolute methods; Radiocarbon dating; Uranium-series dating; Luminescence dating; Amino acid dating; Applications and limitations of dating techniques

Unit III: Quaternary Geology of India: Geomorphic, Sedimentary and Tectonic Systems (22 Hours)

Major Quaternary stratigraphic sequences of India; Fluvial systems (Indus–Ganga–Brahmaputra plains); Glacial records (Himalaya); Aeolian systems (Thar Desert); Coastal and marine records; Regional correlations and paleoenvironmental reconstruction; Response of geomorphic systems to Quaternary climate change; Neotectonics and active tectonics; Role of tectonics in landscape evolution

Unit IV: Environment and Life in the Quaternary (8 Hours)

Natural hazards in the Quaternary context; Evolution of plant and animal life during glacial–interglacial cycles; Human evolution and Stone Age cultures in the Quaternary

Practical 1 Credit (30 Hours)

- Interpretation of stratigraphic logs and sedimentary sequences
- Grain size analysis and depositional environment interpretation
- Identification of paleosols and sedimentary facies
- Interpretation of oxygen isotope curves
- Basic exposure to dating techniques (demonstration/data interpretation)
- Map-based analysis of Quaternary landforms

Essential Readings

1. Pant, R. K., & Rajaguru, S. N. (1999). Quaternary Climate and Environment of India. Geological Society of India, Bangalore.
2. Williams, M., Dunkerley, D., De Deckker, P., Kershaw, P., and Chappell (1993). Quaternary Environments. Arnold, Hodder Headline Group, London.

Suggested Readings

1. Encyclopedia of Quaternary Science (3rd Edition) (2024) Editor: Scott A. Elias; Elsevier.
2. Ruddiman, W. F. (2014). *Earth's Climate: Past and Future* (3rd ed.). W.H. Freeman, New York.
3. Bradley, Paleoclimatology Reconstructing Climates of The Quaternary.
4. Quaternary environments and geoarchaeology of India: essays in honour of Professor SN Rajaguru (1995).

DSE 10: Applied Geophysics Duration: 45 Hours (Lecture) + 30 Hours (Practical)

Course Title and Code	Total Credit	Credit distribution in the course	
Applied Geophysics	4	Lecture	Tutorial

		03	**01**

LEARNING OBJECTIVES

- This course introduces students to Earth's physical properties and the fundamentals of geophysical investigation.
- It covers essential exploration techniques such as gravity, magnetic, electrical, and seismic methods used to study Earth's resources.
- Students will develop a vital understanding of how geology and geophysics are interconnected, aiding in comprehending Earth's geodynamic behaviour and interior.
- The course emphasises core concepts, exploration methods, and the analysis of geophysical anomalies to deepen insights into Earth's dynamics and resource distribution.

LEARNING OUTCOMES

After completing the course, students will be able to:

- Develop a fundamental understanding of geophysical methods and how they are used to explore and study the Earth's interior.
- Students will explore gravity, magnetism, palaeomagnetism, electrical, and seismic techniques.
- They will gain essential skills in identifying geophysical anomalies and understanding their links to geological processes.
- Students will be introduced to data collection methods in geophysics, along with the correction and reduction techniques.

Lecture **3 Credit (45 Hrs)**

Unit- I: Introduction **(7 Hrs)**

Introduction to Geophysical Prospecting. Branches of geophysics: solid earth geophysics and exploration geophysics. Overview of geophysical methods, measured parameters, and their associated physical properties. Signal and noise. Data acquisition and processing. Concept of geophysical modelling: forward and inverse modelling. Importance of geophysical methods in mineral exploration.

Unit- II: Gravity and Magnetic **(15 Hrs)**

Gravity fields of the Earth: Gravity potential, Earth's figure, International Reference Ellipsoid, Normal-gravity, Geoid, and gravity anomalies. Principles of gravimeters, stable and unstable types. Gravity corrections and reduction: Free-air, Bouguer, and terrain. Gravity anomalies and the concept of isostatic compensation. Interpretation of anomalies for simple geometric bodies, e.g. sphere, horizontal cylinder, dyke and fault. Origin of Earth's magnetic field and changes in the geomagnetic field. Magnetic properties of rocks and minerals. Measurement and reduction of magnetic data. Magnetometer and magnetic anomalies. Application of gravity and magnetic surveys in mineral exploration. Palaeomagnetism, Paleopole, Apparent Polar wandering curves and Continental drift.

Unit- III: Electrical and Electromagnetic **(10 Hrs)**

Electrical resistivity of rocks and minerals. Apparent resistivity and special electrode configurations. Vertical Electrical Sounding (VES) and Profiling techniques. Application of resistivity data for groundwater and mineral exploration. Induced Polarisation and Self-potential methods. Theory of electromagnetic induction, skin depth. Transient electro-magnetic methods (TEM), Very low frequency methods (VLF), Magnetotelluric (MT) methods, Ground Penetrating radar (GPR) methods.

Unit- IV: Seismic and Well Logging **(13 Hrs)**

Nature and types of seismic waves (P, S, and surface waves). Seismic ray paths and principles of reflection and refraction. Subcritical and supercritical reflections and critical refraction. Seismic refraction in 2- and 3-layered Earth models. Seismic reflection survey and normal moveout (NMO). Elements of earthquake seismology, focal mechanism and fault plane solutions. Concept of well logging and the borehole environment. Differences among geological, geophysical, and petrophysical logs. Well-logging techniques: Resistivity log, induction log, spontaneous potential log, calliper log, gamma ray log, and density log.

Tutorial (30 Hrs)

- Problems on free air and Bouguer anomalies.
- Numerical problems on isostasy and density contrasts.
- Calculating paleolatitude and paleopole,
- Resistivity curve plotting and interpretation
- Problems on seismic survey.

Essential readings:

1. Lowrie, W. (2007). Fundamentals of geophysics. Cambridge University Press.
2. Kearey, P., Brooks, M. and Hill, I., (2002). An Introduction to Geophysical Exploration. Third Edition. Blackwell Publishing.
3. Lillie, Robert J. (1999). Whole Earth Geophysics: An Introductory textbook for Geologists and Geophysicists.
4. Fowler, C.M.R. (2005). The Solid Earth: An Introduction to Global Geophysics. Cambridge University Press.

Suggested readings:

1. Mussett, A.E. and Khan, M.A. (2000). Looking into the Earth: An Introduction to Geological Geophysics. Cambridge University Press.

2. Telford, W.M., Geldart, L.P., and Sheriff, R.E. (1990). Applied Geophysics. Cambridge University Press.
3. Serra, O., P. Westaway, and H. Abbott. "Fundamentals of well-log interpretation. I: The acquisition of logging data." Developments in Petroleum Science 15 (1984).

GE 3: Geo-heritage and Geopark Duration: 45 Hours (Lecture) + 30 Hours (Practical)

Course Title	Total Credit	Credit Distribution in Course	
Geo-heritage and Geopark	4	Lecture	Practical
		3	1

Learning Objectives

This course aims to consider strategies to sample, understand, and address geoconservation and geopark issues. It should lead to the development of the skills and knowledge to conduct and curate (geo)heritage inventories, assess prospective sites for use as geopark purposes, propose new geotouristic opportunities and develop materials for geoconservation and geotourism consumers and operators. The course is designed as an applied course where student learns optimization of tourism potential of spectacular geological features.

Learning outcomes

On completion of the course, the student will be able to learn, distinguish, and identify potential geological sites of tourist interest. Spectacular (e.g. geomorphic landforms, structures) as well as intrinsic sites (major time boundaries, fossil sites, LIP's, transgressions regressions etc), Economic aspects and linking geospots with other tourist destinations in a theme

UNIT – I **(10 Hrs)**

Geodiversity, Geoheritage, Geoconservation and their relationship to geotourism. Concept of geoheritage in relation to other historical heritages, Tourism and its different forms and their interrelations, Geotourism: definition, characteristics and international/national perspectives, Eco-tourism and Geo-tourism, Defining the geoheritage sites and the concept of Geoheritage parks (UNESCO guidelines). Geographical context and contemporary geoheritage challenges, Geoheritage inventory of India and its curation context, legal framework of geoheritage, Relevance of geoheritage to Sustainable Development Goals (SDG).

UNIT – II **(10 hours)**

Education as a key tenet of geotourism and Earth Science Education & Geotourism. Geoheritage and public geoliteracy: opportunities for effective geoscience education within geosites Earth Science Museums and their role in promotion of Geotourism. Examples of Geotourist sites from India – e.g. Glacier features, Ox-bow lakes, Deltas etc.

UNIT – III **(10 Hours)**

Geotourism, Society and Sustainability: Public–private partnership framework for sustainable geopark development. Geotourism—a focus on the urban environment including historical Geotourism. Geotourism and cultural heritage. Potential of Geotourism in Economic development of any region.

Role of Tourism sector in terms of world economy/ Indian economy. Role of Geotourism in Tourism industry with special reference to Indian scenario Entrepreneurship and start-up.

UNIT – IV **(15 Hours)**

Geotourism and geoparks: UNESCO Global Geoparks and Geoconservation. Geo site developed by Geological Survey of India. The application of geographical information systems in geotourism. Geotourism potential of the Indian geoheritage sites-societal and economic context including case studies

Basic concepts of geology in relation to Geoheritage: Study of Geological Map of India

Plotting the established geosites, geoparks and geo monuments of India on map. Plotting geosites, geoparks and geo monuments on map of World. Detailed study of geosites of India-Locality, Approach, Geological importance and foot fall. Five Case studies from India where geosites can be developed.

Tutorial **(30 hours)**

Students in different batches or groups will be given exercises to prepare shorts reports about the life evolution and extinction through different geological times on Earth.

Essential readings

T.A. Hose (Ed.) (2016). Appreciating Physical Landscapes: Three Hundred Years of Geotourism, Geological Society Special Publication No. 417, London.

Thomas A. Hose (Ed.)(2016).Geoheritage and Geotourism- a European Perspective, Boydell Press Woodbridge, UK

Ross Dowling & David Newsome (Eds) (2018). Handbook on Geotourism, Edward Elgar Publishing.

A monograph on National Geoheritage Monuments of India. Indian National Trust for Art

and Cultural Heritage(INTACH) Natural Heritage Division, New Delhi (2016).

National Geological Monuments. Geological Survey of India, Kolkata, Special Publication No.6 1(2001)

Kale, V.S. (ed.) (2014). Landscapes and Landforms of India, Springer, Dordrecht.

C. V. Burek and C.D. Prosser (Eds.) (2008) History of Geoconservation Special Publication 300, Geological Society of London

Suggestive readings

Young C.Y. Ng. &Yunting Lu (2015). The Principles of Geotourism, Anze Chen, (Springer).

Dowling, R. & Newsome, D. (Eds) (2018). Handbook on Geotourism, Edward Elgar Publishing.

National Geological Monuments. (2001) Geological Survey of India, Kolkata, Special Publication No.61

Burek, C.V. & Prosser, C.D. (Eds.) (2008). History of Geoconservation Special Publication 300, Geological Society of London.

Santangelo, N. and Valente, E. (Eds.) (2020). Geoheritage and Geotourism Resources, MdpiAG

Skill –Based Course

SBC 3: Thin-section preparation Techniques for Geological studies

Duration: 15 Hours (Lecture) + 30 Hours (Practical)

Course Title and Code	Total Credit	Credit distribution in the course		
Thin section preparation techniques for Geological studies	2	Lecture	Tutorial	Practical
		01	0	01

LEARNING OBJECTIVES:

- This course aims to train students in the preparation of thin and polished rock sections
- Students will develop proficiency in using both optical and reflected light microscopes.
- They will learn to identify and interpret minerals and textures observed under the microscope. Additionally, the course will cover laboratory safety, maintenance, and quality control in petrographic work.

LEARNING OUTCOMES:

- Students will learn the process of preparing standard-quality thin and polished sections.
- Students will identify minerals under plane-polarized and cross-polarized light.
- The will get to know the use petrographic and ore microscopes effectively for mineral and textural analysis.
- They will be able to appreciate maintenance of laboratory instruments and follow standard safety procedures. Also, they will be able to document and report petrographic observations systematically.

LECTURE **1 Credit (15 hours)**

Unit- I: Introduction to Microscopy and Laboratory Tools **(10 Hours)**

Importance of microscopy in geology. Parts and functioning of a petrographic microscope. Principles of transmitted and reflected light microscopy. Preparation tools and materials: saws, grinders, polishing wheels, resins, and adhesives.
Optical Properties and Mineral Identification: Optical principles: isotropic and anisotropic minerals, Relief, colour, pleochroism, interference colours, Extinction, twinning, cleavage, and refractive index, Identification of common rock-forming minerals (silicate and ore minerals) in thin section, Diagnostic features of major rock types.

Unit- II: Preparation of Thin and Polished Sections **(5 Hours)**

Selection and orientation of rock samples. Cutting, mounting, grinding, and thinning procedures. Standard thin section thickness (≈30 µm). Polishing techniques for opaque

PRACTICAL **1 credit (30 Hrs)**

1. Demonstration of rock cutting, mounting, and grinding.
2. Preparation of thin and polished sections.
3. Identification of minerals in thin sections under PPL and XPL.
4. Study of textures and microstructures in igneous, sedimentary, and metamorphic rocks.
5. Observation of opaque minerals under reflected light.
6. Maintenance of the microscope.

ESSENTIAL READINGS:

1. Barker, A. J., 2014. A Key for Identification of Rock-Forming Minerals in Thin Section-CRC Press
2. MacKenzie, W.S. & Guilford, C. 1980. Atlas of Rock-Forming Minerals in Thin Section. Longman.
3. Nesse, W.D. (2012). Introduction to Optical Mineralogy. Oxford University Press.

Research Methods/ Tools/ Writing

ADVANCE RESEARCH METHODOLOGY

Duration: 15 Hours (Lecture) + 30 Hours (Tutorial)

Course Title and Code	Total Credit	Credit distribution in course		
		Lecture	Tutorial	Practical
Advance Research Methodology	2	01	01	0

LEARNING OBJECTIVES:

- Develop an advanced understanding of research design, scientific investigation, and identification of research problems with the formulation of hypotheses.
- Improve the ability to review and evaluate scientific literature, identify research gaps, and select suitable methods for data collection.
- Provide knowledge of statistical tools and analytical techniques for analyzing, interpreting, and presenting research results effectively.
- Create awareness about research ethics and plagiarism, and develop skills in scientific writing and research communication.

LEARNING OUTCOMES:

- Design appropriate research strategies for scientific studies.
- Choose suitable methods for data collection, sampling, analyze and interpret data with proper techniques.
- Present findings through tables, graphs, and scholarly discussion.
- Write research papers, theses, and scientific reports following ethical standards and proper citation practices.

Lecture **(15 hours)**

Unit I: Fundamentals of Research and Research Design **(07 Hours)**

Meaning, objectives, and significance of research. Types of research. Steps in the research process. Identification and formulation of research problems. Development of research questions and hypotheses. Review of literature: sources, techniques, and critical evaluation. Research design: exploratory, descriptive, and experimental designs. Sampling techniques and methods of data collection in Earth Science.

Unit II: Data Analysis, Research Ethics and Scientific Communication **(08 Hours)**

Advanced statistical techniques in research, Multivariate data analysis and modelling, Data visualization and scientific interpretation, Big data, machine learning and computational approaches in Earth Science, Scientific data management and reproducibility, Research ethics, patent; intellectual property rights (IPR), and plagiarism, Writing high-impact research papers and review articles, Process of submitting article and scientific publishing, Preparation of research proposals, project reports, and grant applications, Oral and poster presentation of research findings.

TUTORIAL **(15 Hrs)**

1. **Field tutorials:** Stratigraphic logging and collection of rock and mineral samples.
2. **Laboratory practical:** Identification of minerals and description of rock textures. Chemical data of geological samples.
3. **Data analysis exercises:** Graphical representation of geochemical data, and use of computer tools such as spreadsheets.
4. **Research writing workshops:** Preparation of research proposals, writing of scientific reports and research papers, proper citation practices, and oral/poster presentation of research findings.

ESSENTIAL READINGS:

1. Kumar, R., 2018. Research Methodology: A step-by-step guide for beginners. SAGE Publications.
2. Creswell, J.W. and Creswell, J.D., 2017. Research design: Qualitative, quantitative, and mixed methods approaches. SAGE Publications.
3. Sarma, D.D., 2009. Geostatistics with applications in earth sciences. Dordrecht: Springer Netherlands.
4. Davis, J.C. and Sampson, R.J., 1986. Statistics and data analysis in geology (Vol. 646). New York: Wiley.
5. Ferguson, J., 1988. Mathematics in geology. London: Allen & Unwin.

Tools for research

Duration: 15 Hours (Lecture) + 30 Hours (Practical)

Course Title and Code	Total Credit	Credit distribution in the course		
Tools for research	2	Lecture	Tutorial	Practical
		01	0	01

LEARNING OBJECTIVES

- To introduce tools used in academic research.
- To train students in searching research literature effectively.
- To develop skills in reference management, plagiarism checking, and document preparation.
- To familiarize students with research writing using software tools.

LEARNING OUTCOMES

- Identify and apply effective techniques for searching academic information using tools like Google Scholar, Scopus, and Web of Science.
- Use reference management tools such as Zotero and Mendeley to manage citations and generate bibliographies in standard formats (APA, MLA).
- Utilize AI-based research and writing tools including Paperguide, ChatPDF, Notebook LM, QuillBot, Grammarly, and Paperpal for research assistance and document improvement.

LECTURE **1 Credit (15 Hours)**

Unit I: Research Information Search and Reference Management (7.5 Hours)

Methods to search required information effectively, Keyword searching and advanced search strategies, Use of academic databases such as Google Scholar, Scopus, and Web of Science, Pre-writing considerations in research, Identifying research problems and basics of literature review, Importance of proper citation and referencing, reference management using Zotero and Mendeley, Generating bibliography and citations (APA, IEEE, MLA styles), Core AI Research Tools like Paperguide, Chat PDF etc, Practical AI Application Tools (Writing, Editing, & Data) like NotebookLM , Quillbot, Grammarly, Paperpal etc.

Unit II: Research Document Preparation, Presentation and Ethics (7.5 Hours)

Software for paper formatting and document preparation, Introduction to Microsoft Office, Writing research papers, theses, and reports using Microsoft Office, Bibliography creation using Microsoft Office tools, Creating presentations using PowerPoint presentation, Concepts of plagiarism and research ethics, Plagiarism detection tools such as Turnitin and iThenticate

PRACTICAL **1 credit (30 Hrs)**

- Searching research papers using Google Scholar
- Downloading and organizing research articles,
- Importing research papers into Zotero/Mendeley,
- Creating bibliography and citations automatically.
- Formatting reports using MS Office, Checking plagiarism reports using Turnitin/iThenticate.
- Interpreting similarity index

ESSENTIAL READINGS:

1. Ranjit Kumar, "Research Methodology: A Step by Step Guide for Beginners", 2nd Edition, SAGE Publications Ltd.

2. G.C. Ramamurthy, "Research Methodology", Dream Tech Press, New Delhi

Semester-IV

DSC 10: Engineering Geology Duration: 45 Hours (Lectures) + 30 Hours (Practical)

Course Title and Code	Total Credit	Credit distribution in course		
Engineering Geology	4	Lecture	Tutorial	Practical
		03	0	01

LEARNING OBJECTIVES:

- This course aims to provide an in-depth understanding of rock mechanics and engineering geology principles
- The course will emphasize the mechanical behaviour of rocks, rock mass characterization, and slope stability analysis.
- It will focus on the geological and geotechnical investigations required for designing and evaluating engineering structures such as tunnels, dams, and foundations.

LEARNING OUTCOMES:

- Students will be able to explain the fundamental concepts of rock mechanics, stress-strain behaviour in rock, and rock mass classification systems.
- Students will be able to analyze slope stability problems and propose suitable stabilization and foundation treatment techniques.
- They will be able to apply geological and geotechnical principles, along with relevant software tools
- Students will be able to assess and design engineering structures in varied geological settings.

LECTURE **3 Credit (45 Hrs)**

Unit- I **(11 Hours)**

Development of rock mechanics and rock engineering. Rock strength; stress-strain relationships, *in-situ* stress measurements and their geological significance. Hoek's Brown criterion of rock failure. Structural discontinuities and their types; their effect on Rock Mass Strength.

Unit- II **(10 Hours)**

Engineering properties of rocks and soil. Engineering bedrock and their characteristics. Laboratory index and strength tests for rocks and soil.

Unit- III **(10 Hours)**

Rock slope failure mechanism. Mass wasting and their types. Rock slope stabilization techniques; factor of safety. Application of rock mechanics for underground openings, rock slope engineering, and foundation engineering. Landslide hazard zonation mapping.

Unit- IV **(14 Hours)**

Reservoir Induced Seismicity: their cause, effects and mitigation measures. Geological and geotechnical investigation for site selection and foundation treatment of dams, reservoirs, and tunnels. Case histories on rock engineering design and the geological, geophysical, and geotechnical aspects of megastructures, including major Indian examples such as the Tehri Dam, Chenab Bridge, and Rohtang Tunnel, along with other significant global engineering projects and their documented failures.

Comparative analysis of failure and successes of mega projects and their environmental impacts.

PRACTICAL **1 Credit (30 Hours)**

Rock Mass Classification: Rock Structure Rating; Rock Mass Rating; Q-System; Rock Quality Designation.

1) Geological mapping of engineering sites and assessment of site selection
2) Application of engineering software such as Stereonet, Rockworks, Rock-Slide etc.

ESSENTIAL READINGS:

1. Krynin, D.P. and Judd, W.R. (1957). Principles of Engineering Geology and Geotechnique, McGraw Hill (CBS Publ).
2. Gangopadhyay, S. (2013). Engineering geology. Oxford University Press.
3. Goodman, R.E. (1993). Engineering Geology: Rock in engineering constructions. Wiley& Sons, N.Y.
4. Waltham, T. (2009). Foundations of Engineering Geology (3rd Edn.) Taylor & Francis.
5. Bell, F.G. (2007). Engineering Geology, Butterworth-Heinema.

SUGGESTED READINGS:

1. Anbalagan, R. Singh, B, Chakraborthy, D. and Kohli, A. (2007) "A filed Manual for Landslide investigations". DST, Government of India, New Delhi.
2. Duncan C. Wyllie and Christopher W. Mah. (2004). Rock Slope Engineering. CRC Press. London.
3. David George Price (2009). Engineering Geology: Principles and Practice. Springer-Verlag Berlin Heidelberg.
4. Hoek, E., and Brown, E.T. (2019). The Hoek–Brown Failure Criterion – 2018 Edition. Rockscience.

DSC 11: Sequence stratigraphy and Basin analysis Duration: 45 Hours (Lectures) + 30 Hours (Practical)

Course Title and Code	Total Credit	Credit distribution in course		
		Lecture	Tutorial	Practical
Sequence stratigraphy and Basin analysis	4	03	0	01

Objectives:

To make the student understand

- A combination of forcings viz. tectonics and subsidence, Eustacy and Sediment supply shape filling and evolutionary history of any sedimentary basin.
- Sequence stratigraphy and Basin Analysis deals with subdivision of sedimentary basins fills into genetic packages bounded by unconformities and their correlative conformitites.
- to unravel before the student various nuances of this fascinating art of deconvolution of basin evolution history.

Learning Outcomes:

- To understand key concepts of Base level, Basin Accommodation Space, Eustatic and Relative Sea level change, Transgression/Regression and stratigraphic cyclicity
- To describe geometries of stratal surfaces, their terminations and key role in defining facies packaging
- To understand concepts of Systems Tracts, patterns of facies packaging within Systems Tracts and their bounding surfaces
- To comprehend Sequence development models in basins of different tectonic setting
- To understand methodologies of basin analysis, importance of Isopach and paleocurrent
- To comprehend parameters of basin analysis

Contents:

Unit I: Sequence stratigraphy: An integrated approach towards Applied stratigraphy

Historical developments. Definitions and key concepts. Base level (stratigraphic and geomorphic) changes, Eustatic and Relative Sea level, Transgressions and regressions, T-R cycles. Regional and global stratigraphic cycles.

Unit II: Stratigraphic surfaces, Systems Tracts and Sequence Models: Unconformity, Flooding surface ...... Stratal geometry, terminations, sequence stratigraphic surfaces. Unconformity and correlative conformity, Basal surface of Marine regression, Ravinement surface, Initial and maximum flooding surface

Unit III: Systems Tracts: Falling Stage (FSST), Lowstand (LST), Transgressive (TST), Highstand (HST), Falling stage. Sequence Models: Depositional sequence (Type I, II, III), Genetic stratigraphic sequence, Transgressive-Regressive sequence. Hierarchy of sequences and bounding surfaces.

Unit IV: Sedimentary basins in tectonic backdrop

a) Tectonic classification of sedimentary basins. Classification of sedimentary basins in India. Tectonics and sedimentation; Evolution of sedimentary basins in different tectonic settings

b) Geohistory analysis: Thermal history, Porosity and Burial depth. Subsidence and Thermal history of divergent margin basins, convergent margin basins, transform and transcurrent fault basins, basins developed during continental collision and suturing and cratonic basins. Review of Indian basins.

Practical:

1. Exercises related to gradient of relative sea level curve and facies belt migration

2. Exercises related to Eustacy and Tectonics

3. Exercises related to Systems Tracts and their bounding surfaces

4. Exercises related to facies stacking pattern, lateral correlation and demarcation of Systems Tracts

Suggested Readings:

1. Principles of sedimentary basin analysis: A.D.Miall (1999), Springer

2. Sequence Stratigraphy: D. Emery, and K. Mayers (1996) Blackwell Publishers

3. Principles of Sequence Stratigraphy: Octavian Catuneanu (2006) Elsevier

4. Basin Analysis: Principles and Applications: P.A. Allen and J.R.Allen (1990) Blackwell

Publishing

5. The geology of stratigraphic sequences: A.D. Miall (1997) Springer

6. Tectonics of Sedimentary basins. Buby, C. and Azor, A. (2012) Wiley Blackwel

E-pathsala module: https://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/s000448go/p000594/m022675/et/1505974094e- extsedimentarybasinsandtheirclassification.

DSE 11: Petroleum and Coal Geology

Duration: 45 Hours (Lecture)+ 30 Hours (Practical)

Course Title and Code	Total Credit	Credit distribution in course		
Petroleum and Coal Geology	4	Lecture	Tutorial	Practical
		03	0	01

LEARNING OBJECTIVES:

- Understand the different types of natural fuels, their origin, and the mechanisms involved in the generation, accumulation, and migration of hydrocarbons.
- Learn the major hypotheses related to the formation of hydrocarbons and coal, and examine coal as a significant reservoir of plant-derived carbon and organic matter.
- Develop knowledge of coal-forming environments, coalification processes, coal microscopy, petrography, classification, analytical techniques, and industrial applications of coal.
- Explore coal as an unconventional energy resource, including Coal Bed Methane (CBM) and synthetic crude oil, along with their environmental implications.

LEARNING OUTCOMES:

- Understand the mechanisms of hydrocarbon generation from organic matter and the influence of temperature, pressure, and other physical parameters on hydrocarbon distribution.

- Examine different sedimentary environments through geological records and evaluate their role in controlling hydrocarbon generation potential.
- Develop knowledge of coal fundamentals, coal-forming sedimentary environments, the influence of tectonics and sea-level changes on coal formation and quality, and the principles of coal classification.
- Learn analytical techniques in coal studies, including macerals and their microscopic properties, and explore applications such as coal utilization, underground coal gasification, clean coal technology, carbonization, CBM, coal liquefaction, and their environmental implications in India.

Lecture **3 Credit (45 Hrs)**

Unit I: Petroleum Geology and Petroleum System **(12 Hrs)**

Introduction to petroleum geology, physical and chemical properties of petroleum, and theories of petroleum origin. Formation of source rocks, kerogen evolution, organic maturation, and thermal cracking. Reservoir rocks: types, classification, porosity, permeability, and capillary properties. Hydrocarbon migration: primary and secondary migration, controlling factors, migration pathways, and relative permeability.

Unit II: Hydrocarbon Traps and Petroleum Basins **(10 Hrs)**

Hydrocarbon traps: definition, classification, and timing of trap formation and hydrocarbon accumulation. Cap rocks and their properties. Plate tectonics and global hydrocarbon distribution. Methods of petroleum prospecting and geological modeling. Major oil belts of the world and petroleum geology of important Indian basins including Assam-Arakan, Cambay, Cauvery, Krishna-Godavari, and Bombay Offshore basins.

Unit III: Coal Geology and Classification **(12 Hrs)**

Origin, formation, and classification of coal. Coal-forming environments, effects of sea-level change and tectonics, coalification processes, peat bogs, swamps, cyclothems, and coal seam structures. Classification of coal based on type, grade, rank, coking and non-coking characteristics, and international standards.

Unit IV: Coal Petrography and Industrial Applications **(11 Hrs)**

Coal composition, lithotypes, microlithotypes, and analytical techniques, including proximate and ultimate analysis. Macerals: classification, properties, microscopy, reflectance, and fluorescence studies. Applications of coal petrography in seam correlation, paleoclimate, and palaeogeography. Industrial applications of coal, CBM, underground coal gasification, coal liquefaction, carbonisation, clean coal technology, and distribution of coal and lignite in India in relation to Gondwanaland and plate tectonics.

Practical **1 Credit (30 Hrs)**

- Macroscopic characterization and classification of banded coals based on lithological and physical properties, including identification of coal lithotypes and their depositional significance.
- Completion and interpretation of coal outcrop maps, correlation of coal seams, construction of geological cross-sections, and estimation of coal reserves using standard methods.
- Preparation of polished particulate mounts of coal samples for petrographic analysis under reflected light microscopy.
- Microscopic identification and classification of coal macerals and microlithotypes, and interpretation of coal rank, maturity, and depositional environment.
- Study and interpretation of geological maps and cross-sections of major oilfields of India, including structural and stratigraphic features related to petroleum accumulation.
- Calculation and estimation of petroleum reserves using standard volumetric methods and reservoir parameters.

Suggested Readings:

1. Barker, C. (1996): Thermal Modeling of Petroleum Generation, Elsevier Science.
2. Jahn, F., Cook, M. and Graham, M. (1998):Hydrocarbon Exploration and Production, Eslevier Science.
3. Makhous, M. (2000): The Formation of Hydrocarbon Deposits in North African Basins, Geological and Geochemical Conditions, Springer-Verlag.
4. North, F.K. (1985): Petroleum Geology, Allen Unwin. Selley, R.C. (1998): Elements of petroleum geology, Academic Press.
5. Tissot, B.P. and Welte, D.H. (1984): Petroleum formation and occurrence, Springer–Verlag.
6. Chandra, D., Singh, R.M., Singh M.P., (2000): Text book of coal (Indian context), Tara Book Agency, Varanasi.
7. Scott, A.C., (1987): Coal and coal bearing strata: Recent Advances, Blackwell Scientifics Publications.
8. Stach, E., Mackowsky, M-Th., Tylor, G.H., Chandra, D., Teichumullelr, L . and Teichumuller, R. (1982): Text book on coal petrology, Gebruder Borntreager Stuttgart.
9. Taylor, G.H., Teichmuller, M., Davis, A., Diessel, C.F.K., Littke, R and Robert, P. (1998): Organic Petrology. Gebruder Borntreager Stuttgart.
10. Thomas Larry (2002): Coal Geology. John Wiley and Sons. Ltd. England.
11. Van Krevelen, D.W. (1993): Coal: Typology-Physics-Chemistry-Constitution. Elsevier Scienc, Netherlands.

DSE 11: Earthquakes: A geological perspective

Course Title and Code	**Total Credit**	**Credit distribution in course**		
Earthquake Geology and Seismotectonics	**4**	**Lecture**	**Tutorial**	**Practical**
		03	**0**	**01**

Course Objectives:

- The use of geological methods, in their broadest sense, is crucial for understanding and investigating seismic events for effective seismic hazard assessment.
- The paper aims to introduce the concepts of structural geology, seismology, and risk assessment to better understand the earthquake mechanism and associated risks.

Course Learning Outcomes:

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

- Demonstrate an understanding of rock deformation, stress–strain relationships, and fault mechanics associated with earthquake processes.
- Understand earthquake cycle models and analyse the geomorphic expressions of active tectonics.
- Apply geodetic techniques for analysing crustal deformation and seismic source characteristics.
- Understand the properties of seismic waves, their measurement and applications.
- Evaluate seismic hazards based on the geological and seismic data.

Unit I **(10 Hours)**

Rock deformation and structure: Stress and strain, Mohr Failure Envelope, shear-fracture criteria, Griffith crack theory, friction, and the effect of pore fluid. Change in rock strength at depth – abrasive versus adhesive wear.

Earthquake Cycle: Earthquake Models; Asperities and barriers along a fault, Fault length and displacement variation, Fault segment linkage, Geomorphic expression of faults. Characteristic earthquake. Scaling ratios of faults. Slow, quiet and silent earthquakes; microearthquakes, small, moderate, large and mega earthquakes.

Unit II **(10 Hours)**

Geodetic measurements of crustal deformation: Conventional geodetic methods: triangulation, trilateration and levelling; Space-based geodesy: Very Long Baseline Interferometry, Satellite Laser Ranging, Global Navigation Satellite Systems, Synthetic Aperture Radar.

Geology of the Seismic Source Region: Depth distribution of earthquakes, slip patterns along a fault plane. Deep focus intra-plate earthquakes within the ductile regime.

Unit III: **(15 Hours)**

Seismology: Seismic waves – types and physical characteristics; Velocity structure of the Earth and different seismic phases; measurement of earthquakes; locating earthquakes. Earthquake magnitude; Intensity measurement– Intensity scales; Energy of an earthquake. Gutenberg-Richter relationships, b value. Seismic inversion, Seismic tomography. Earthquake source mechanism: double-couple mechanism and fault-plane solutions.

Unit IV **(10 Hours)**

Seismic sources and hazard assessment: Subduction zone earthquakes; Intraplate seismicity – Stable Continental Region (SCR) earthquakes; Geomorphic and stratigraphic evidence of past earthquakes. Intraplate seismicity–Stable Continental Region (SCR) earthquakes. Triggered and induced earthquakes. Secondary effects of earthquakes: Tsunami, liquefaction, landslides etc.

Seismic risk and hazard; Hazard assessment– probabilistic and deterministic approaches

Practical **(15 Hours)**

(i) Interpretation of the remote-sensing data for active faulting.
(ii) Phase identification in the seismic waveforms.
(iii) Determination of earthquake epicentre from the seismic waveforms.
(iv) Construction of the fault plane solution of earthquakes,
(v) Earthquake catalogue, b-value calculation, and magnitude calculation.
(vi) Trench logging and event interpretations.

Suggested Readings:

l. Scholz, C.H., 1990. The Mechanics of Earthquakes and Faulting Cambridge University Press.

2. Yeats, R.S., Sieh, K. and AlIen, C.R., 1997. The Geology of Earthquakes. Oxford University Press.

3. Burbank, D.W. and Anderson, R.S., 2012. Tectonic Geomorphology, Wiley-Blackwell Publishers.

4. McCalpin, James P., ed. Paleoseismology. 2nd ed. Amsterdam: Elsevier/Academic Press, 2009.

DSE 13: Climate Change and Sustainability Duration: 45 Hours (Lecture)+ 30 Hours (Practical)

Course Title and Code	Total Credit	Credit distribution in the course		
		Lecture	Tutorial	Practical
Climate Change and Sustainability	4	03	0	01

LEARNING OBJECTIVES:

- To understand the fundamental concepts and scientific basis of climate change.
- To examine the environmental, social and economic impacts of climate change.
- To develop awareness about sustainability and sustainable development practices.
- To analyse the relationship between natural resources, ecosystems and human activities.
- To understand climate change mitigation, adaptation and environmental governance strategies.
- To encourage critical thinking and responsible actions towards environmental sustainability.

LEARNING OUTCOMES:

- Students will be able to explain the causes and evidence of climate change.
- Students will be able to assess the impacts of climate change on ecosystems and society.
- Students will be able to interpret concepts of sustainability and sustainable development.
- Students will be able to evaluate environmental challenges and possible sustainable solutions.
- Students will be able to understand international climate policies and adaptation strategies.
- Students will be able to apply sustainability principles in academic, professional and daily life contexts.

Lecture: **3 Credit (45 Hrs)**

UNIT I: Fundamentals of Climate Change **(14 hrs)**

Weather, climate and climate system, Components of Earth's climate system, Greenhouse effect and greenhouse gases, Carbon cycle and energy balance, Natural vs anthropogenic climate change, Evidence of climate change, Global warming trends and temperature records, Role of oceans, atmosphere and cryosphere, Climate modelling and future projections, IPCC and climate assessment reports

Unit-II: Impacts of Climate Change **(12 hrs)**

Climate change and hydrological cycle, sea level rise and coastal vulnerability, extreme weather events: floods, droughts, cyclones and heat waves, impacts on biodiversity and ecosystems, agriculture and food security, water resources and human health, climate change and Himalayan glaciers, urban climate challenges, climate migration and socio-economic impacts, climate justice and vulnerable communities.

UNIT III: Sustainability and Sustainable Development **(11 hrs)**

Concept and principles of sustainability, sustainable development: history and evolution, United Nations Sustainable Development Goals (SDGs), ecological footprint and carrying capacity, sustainable consumption and production, renewable and non-renewable resources, circular economy and waste management, sustainable agriculture and water conservation, green buildings and sustainable cities, environmental ethics and traditional ecological knowledge.

UNIT IV: Climate Action, Policy and Future Pathways **(8 hrs)**

Climate change mitigation and adaptation, renewable energy technologies, carbon neutrality and net-zero concepts, carbon sequestration and nature-based solutions, international climate agreements: UNFCCC, Kyoto Protocol and Paris Agreement, climate finance and carbon markets, disaster risk reduction and resilience planning, community participation and environmental governance, role of education, innovation and technology, lifestyle changes for sustainability

Practical **1 Credit (30 Hrs)**

1. Study and interpretation of temperature, rainfall and carbon dioxide datasets to understand climate trends.
2. Analysis of paleoclimatic data to understand long term climate change. Study of Sea Level Change curves in recent and geological past.

3. Preparation of a case study on floods, droughts, glacier retreat, coastal erosion or extreme weather events.
4. Evaluation of selected SDGs and their implementation at local, national or global levels.

Essential Readings

1. Climate Change 2021: The Physical Science Basis, edited by Valérie Masson-Delmotte et al., Cambridge University Press, 2021.
2. Introduction to Climate Change, by David D. Kemp, Cambridge University Press, 2012.
3. Sustainability Principles and Practice, by Margaret Robertson, Routledge, 2017.
4. Bradley, R. S., Quaternary Paleoclimatology: Methods of Paleoclimatic Reconstruction, Academic Press, 3rd Edition, 2015.
5. Earth's Climate: Past and Future, by William F. Ruddiman, W. H. Freeman and Company, 3rd Edition, 2014

DSE 14: Applied Hydrogeology

Course Title and Code	Total Credit	Credit distribution in course		
Applied Hydrogeology	4	Lecture	Tutorial	Practical
		03	0	01

LEARNING OBJECTIVES:

- The course content aims to enrich the knowledge of the students in the field of applied hydrogeology.
- The teaching and learning process focuses on conceptual clarity of the applied aspects of the subject.
- Students will apply the knowledge they have gained in solving real-world problems as part of the learning process.

LEARNING OUTCOMES:

- The students will learn about the surface- groundwater dynamics; basics of River hydrology; River hydrographs and the flow nets.
- The course imparts knowledge about the advanced and applied aspects of well hydraulics where students will learn in detail about the pumping test data analysis of unconfined and semi-confined aquifers. The learning process will make students familiar with groundwater modelling
- The students will learn the basic concepts related to the use of isotopes in hydrogeological studies.
- The students will learn about the utility of hydrogeology in infrastructure projects; groundwater resources estimation; groundwater management and governance.

LECTURE **3 Credit (45 Hrs)**

Unit I: General concepts: **(4 hrs.)**

Surface water and groundwater interaction. Stream discharge parameters and their measurement. Stage-discharge relationship and rating curves, River Hydrographs. Flow nets.

Unit II: Well Hydraulics and Groundwater Modelling: (22 hrs.)

Pumping tests - methods, data analysis and diagnostic plots. Well design and well Performance Tests. Evaluation of the aquifer parameters from pumping test data of the unconfined and semi-confined aquifers (Walton's method). Evaluation of the aquifer parameters from the recovery data of the pumping tests. Basic concepts of groundwater modelling and the governing equations. Model conceptualisation; design and execution; sensitivity analysis; calibration; validation; assessment and prediction based on the model.

Unit III: Isotope hydrogeology: (4 hrs)

Basic concepts. Stable isotopes in the hydrogeological study. Radio isotopes in the hydrogeological study.

Unit IV: Groundwater management: (15 hrs)

Groundwater problems related to foundation work, mining, canals, dams, reservoirs and tunnels. Water balance and groundwater resources estimation. Problems of overexploitation and groundwater mining. Groundwater management: supply side and demand side management. Rainwater harvesting and managed aquifer recharge. Conjunctive use of surface and groundwater. Groundwater management in urban and rural areas, arid and semi-arid areas. Possible climate change impact on the groundwater resources and the mitigation measures. Concept of sustainable development of groundwater resources. Groundwater legislation. Hydrogeology of arid zones of India and the management issues. Hydrogeology of the wetlands and the management issues.

PRACTICAL (30 Hours)

1. Hands-on exercises using real-time groundwater level data (DWLR, etc)
2. Estimation of stream discharge, rating curves
3. River hydrographs related exercises
4. Flow net related exercises
5. Evaluation of Well Performance Tests data
6. Diagnostic plots-based aquifer assessment
7. Evaluation of the aquifer parameters from the pumping test data of unconfined aquifers
8. Evaluation of the aquifer parameters from the pumping test data of semi-confined aquifers (Walton's method)
9. Pumping test data analysis from the recovery data
10. Hands-on exercises on groundwater flow model, conceptualization, design, execution, calibration, validation and prediction
11. Interpretation of environmental isotope data of water samples

ESSENTIAL READING:

1. Fetter, C.W., and D. Kreamer. 2022. *Applied Hydrogeology*, 5th ed. Waveland Press.
2. Fitts, C.R., 2023. *Groundwater Science* (3rd ed.), Academic Press.
3. Karanth K.R., 1987. *Groundwater: Assessment, Development and Management*, Tata McGraw-Hill Pub. Co. Ltd.

4. Todd, D. and Mays, L. 2005 *Groundwater Hydrology*. (3rd ed.), John Wiley and Sons, Inc.
5. Kruesman, G.P and De Ridder N.A., 1990. *Analysis and Evaluation of Pumping Test Data,* International Institute for Land Reclamation and Improvement.
6. Clark, I.D., 2015. *Groundwater Geochemistry and Isotopes*, CRC Press.

SUGGESTED READING:

1. Anderson, M., Woessner, W., Hunt, R., 2015. *Applied Groundwater Modelling*, Elsevier.
2. Thangarajan, M., Singh V.P., 2016. *Groundwater Assessment, Modelling and Management*, CRC Press.
3. Thangarajan, M., 2007. *Groundwater: Resource Evaluation, Augmentation, Contamination, Restoration, Modelling and Management*, Springer.
4. Schwartz, F.W. and Zhang, H., 2024. *Fundamentals of groundwater* (2nd Edition). John Wiley & Sons.
5. Hiscock, K.M. and Bense, V.F., 2021. *Hydrogeology: principles and practice* (3rd Edition). John Wiley & Sons.

DSE 15: Geo-Archaeology

Course Title and Code	**Total Credit**	**Credit distribution in course**		
Geo-Archeology	**4**	**Lecture**	**Tutorial**	**Practical**
		03	**0**	**01**

Learning Objective

- To introduce geoarchaeology from an Earth surface systems perspective.
- To introduce the concept of Anthropocene and debates around it.
- To introduce how geomorphic, sedimentary, and geochemical processes shape the archaeological record and human–environment interactions from the Quaternary to the Anthropocene.

Learning Outcomes

By the end of the course, students will be able to:

- Explain the relationship between Quaternary environmental change and human evolution
- Interpret archaeological sites using geomorphological and stratigraphic principles
- Apply basic geochronological and geochemical methods in geoarchaeological contexts
- Analyse site formation processes using sedimentological and biogeochemical evidence
- Evaluate human impacts on Earth systems from early agriculture to the Anthropocene

Unit I: Quaternary Framework and Human Evolution

Quaternary timescale: glacial–interglacial cycles and environmental variability; Human evolution in environmental context; Dispersal of humans: Africa to Asia and India; Out of India hypothesis; Megafaunal extinctions: climatic vs anthropogenic drivers; Archaeological signatures: stone tools and early fire in geomorphic context

Unit II: Dating Methods in Geoarchaeology

Principles of geochronology: relative vs absolute dating; Radiometric methods: Radiocarbon (AMS), U-series, Argon dating; Luminescence dating: OSL/IRSL and applications in sediments; Surface and exposure dating; Dendrochronology; Applications and limitations in archaeological contexts

Unit III: Geoarchaeological Methods, Site Formation Processes and Preservation

Stratigraphy and microstratigraphy in site interpretation; Sedimentology and depositional environments; Organic geochemistry and biomolecular evidence; Stable isotope analysis in archaeology; Provenance analysis: ceramics, lithics, and sediments; Applications: paleoclimate, paleoenvironment, fire history, and diet; Site formation processes: natural vs anthropogenic; Role of geomorphic processes (fluvial, aeolian, slope) in site preservation; Settlement patterns in relation to landforms and resources; Catchment analysis and landscape use; Case studies from Indian subcontinent (river valleys, plateaus, coasts)

Unit IV: Human–Environment Interactions and the Anthropocene

Origins of agriculture and landscape transformation; Domestication and environmental change; Early anthropogenic impacts (CO_2, CH_4, Early Anthropogenic Hypothesis); Land use change: agriculture, mining, and urbanisation; Sustainability and the Anthropocene

Practical

1. Stratigraphic logging and section interpretation
2. Grain size analysis (sieve + pipette)
3. Soil micromorphology (introductory)
4. Fluvial geomorphology: river terrace mapping and site context
5. Experimental sedimentation (flume/tray)
6. Charcoal identification and basic anthracology
7. Luminescence (OSL) sampling demonstration
8. GIS-based terrain analysis and site catchment modelling

Essential Readings:

1. Cordova, C., 2018. Geoarchaeology: the human-environmental approach. Bloomsbury Publishing.

2. Rapp, G.R., Hill, C.L. and Rapp, M.R., 2006. Geoarchaeology: the earth-science approach to archaeological interpretation. Yale University Press.

Suggested Readings:

1. Goldberg, Paul, and Richard I. Macphail. 2006. Practical and Theoretical Geoarchaeology. Blackwell Science, Malden, Massachusetts

2. Walker, M., 2005. Quaternary dating methods. John Wiley & Sons.

3. Ruddiman, W.F., 2017. Plows, plagues, and petroleum: how humans took control of climate. Princeton University Press.

4. Suggested Papers from Quaternary Science Reviews, Journal of Quaternary Science, Earth Science Reviews, Quaternary International, etc.

GE 3: Natural Hazard and Disaster Management Duration: 45 Hours (Lectures) + 30 Hours (Practical)

Course Title and Code	Total Credit	Credit distribution in course		
Natural Hazards and Disaster Mitigation	4	**Lecture**	**Tutorial**	**Practical**
		03	0	01

LEARNING OBJECTIVES:

- Understand the causes and types of major natural hazards and their impacts.
- Explain the relationship between Earth processes and environmental hazards.
- Learn basic principles of disaster risk reduction and mitigation strategies.
- Develop awareness of disaster preparedness, response, and management practices.

LEARNING OUTCOMES:

After completion of the course, the students will learn:

- What is the Earth's composition and what are the various processes that make it a dynamic planet?
- How do the earth's natural processes turn into hazards and disasters?
- How do the different factors interact to create disaster risk?
- What are the existing approaches and frameworks to minimise the risk?

LECTURE **3 Credit (45 Hrs)**

Unit I: Introduction to the Earth system and natural hazards (10 hours)

Earth's composition: minerals and rocks, internal and atmospheric structure of Earth, Earth's energy sources. Dynamic Earth: Endogenic and exogenic processes in Earth, Balance in mass and energy flow in the Earth system, Equilibrium and perturbations in the natural equilibrium. **Disaster terminology:** Hazard, physical and social vulnerability, exposure, risk, susceptibility, coping capacity and disaster. Introduction to major natural hazards and Human-induced hazards: Geological hazards, Hydrometeorological hazards, Pandemics, and wars.

Unit II: Understanding geological hazards (15 hours)

Geological hazards and their causes, types, impacts, and mitigation measures: landslides, earthquakes, floods, coastal hazards, and volcanoes. Secondary impacts of natural hazards/disasters.

Unit III: Understanding hydrometeorological and other hazards (10 hours)

Hydrometeorological hazards, their causes and impacts: cyclones, drought, heat and cold waves. Pandemics, their causes and impacts; Human-induced hazards: wars and technology failure; climate change and its impact; Urban heat islands. Cascading and compound disaster.

Unit IV: Disaster Risk Reduction approaches (10 hours)

Disaster management cycle: Disaster preparedness, Hazard mitigation-structural and non-structural measures, Rescue, Relief and Rehabilitation, Response; cost-benefit analysis, Institutional and policy framework for disaster risk reduction. Sustainable development. Risk communication and technology in disaster risk reduction.

PRACTICAL (30 Hrs)

- Introduction to rocks and minerals;
- Introduction to maps;
- Vulnerability assessment;
- Hazard maps and hazard matrix;
- Mitigation strategies
- Seismic data and epicentre location.

Suggested Readings:

1. Allen, P. A. (1997). *Earth surface processes*. Wiley-Blackwell.
2. Highland, L. M., & Bobrowsky, P. (2008). *The landslide handbook—A guide to understanding landslides* (U.S. Geological Survey Circular 1325). U.S. Geological Survey. https://doi.org/10.3133/cir1325
3. U.S. Geological Survey. "Earthquake Magnitude, Energy Release, and Shaking Intensity." Accessed October 19, 2025. https://www.usgs.gov/programs/earthquake-hazards/earthquake-magnitude-energy-release-and-shaking-intensity.
4. Hyndman, D., & Hyndman, D. (2016). *Natural hazards and disasters* (5th ed.). Cengage Learning.
5. Keller, E. A., & Blodgett, R. H. (2021). *Natural hazards: Earth's processes as hazards, disasters, and catastrophes* (6th ed.). Pearson Education.

6. PG Diploma in Disaster Management (Textbooks). Indira Gandhi National Open University, New Delhi.
7. PreventionWeb. "Understanding Disaster Risk: Key Concepts." Accessed October 19, 2025. https://www.preventionweb.net/understanding-disaster-risk#key-concepts.

SBC 4 Thematic Geological Mapping Duration: 15 Hours (Lecture) + 30 Hours (Practical)

Course Title and Code	Total Credit	Credit distribution in the course		
		Lecture	Tutorial	Practical
Thematic Geological Mapping	2	01	0	01

LEARNING OBJECTIVES

- This course will introduce students to geological mapping, focusing on rock types, their affinities, and patterns of occurrence.
- Students will develop skills in rock identification, structural measurements, and geological interpretation in the field.

LEARNING OUTCOMES:

- Students will develop basic skills to carry out geological fieldwork in different terrains.
- Students will prepare geological maps and cross-sections from field data and interpret them in terms of stratigraphy, structure, and tectonics.
- They will use geological instruments (such as the Brunton compass, GPS).
- Students will also learn to plot data on base maps or toposheets to create lithological and structural maps and prepare a report

LECTURE **(15 hours)**

Unit- I: Introduction to Geological Mapping and rock identification **(6 Hours)**

Importance and scope of geological fieldwork. Topographic sheets: scales, symbols, and interpretation. Use of Brunton compass, GPS, and other field instruments. Base map and field notebook maintenance. Field safety, ethics, and logistics. Beds in deformed and undeformed terrains – rule of V. Identification and description of igneous, sedimentary, and metamorphic rocks in the field. Methods of delineating contacts between lithological units. Textural features of different rocks through field study and microscopy. Sampling techniques and field photography.

Unit- II: Structural Features **(9 Hours)**

Identification of various structural features in the field. Identification and structural measurement of a fold in the field. Geometric classification of a fold based on field data and understanding the outcrop pattern of a fold. Overprinting nature of folds and metamorphic foliations. Distinguishing criteria of a fault in the field. Measurement and plotting of planar and linear structures (strike, dip, joints, faults, folds, foliations, lineations). Use of stereonets and structural symbols on maps. Construction of cross-sections and interpretation of structure from outcrop patterns. Preparation of geological maps. Writing a detailed geological report with an interpretation of geological history.

PRACTICAL **(30 Hrs)**

All the aforementioned techniques for measurement and identification will be demonstrated and practiced in the field. The practical classes of this course will take place through a field visit in a suitable geological terrain.

Essential Readings:

1. Lisle, R.J., Brabham, P., & Barnes, J.W. (2011) Basic Geological Mapping, Wiley-Blackwell.
2. Lisle, R. J. (2004). Geological structures and maps: A practical guide. Elsevier.
3. Park, R. G. (2004) Foundations of Structural Geology. Chapman & Hall.
4. Davis, G. R. (1984) Structural Geology of Rocks and Region. John Wiley.

Research Methods/ Tools/ Writing

TECHNIQUES OF RESEARCH WRITING

Course Title and Code	Total Credit	Credit distribution in the course		
Techniques of Research Writing	2	Lecture	Tutorial	Practical
		01	01	0

LEARNING OBJECTIVES:

- To introduce students to the principles of publication, impact factor, ethics and issues such as plagiarism, authorship, and conflicts of interest in research sponsoring and publishing.
- To develop students' knowledge of citation styles, data presentation techniques, and digital tools used in academic publishing and journal selection.

LEARNING OUTCOMES:

- Understand the purpose and structure of academic research writing.
- Develop skills in formulating research questions and thesis statements.
- Apply proper citation and referencing techniques and follow ethical standards in academic writing and publishing.
- Avoid plagiarism and maintain academic integrity.

LECTURE **1 credit (15 Hours)**

Unit- I: Fundamentals of effective research paper writing; Need and knowledge gap for writing any research paper; Types of research writing (analytical, descriptive, argumentative); Academic Language and Style-Strategies to improve the writing process and exploring disciplinary requirements: Vocabulary-Effective use of words and expansion of vocabulary, Crafting better sentences and paragraphs, Effective and varied use of punctuation marks in complex sentences, text structure: clarity, coherence, and conciseness; Organization and streamlining the writing process; Structure of manuscript: Title and abstract, Introduction and problem statement, Methodology, Results and discussion, Conclusion and recommendations; Introduction to publication misconduct: plagiarism, authorship, ghostwriting, reproducible research, conflicts of interest; Citation and Referencing Styles.

Unit-II: Introduction to data presentation, editing and proofreading; Peer Review and introduction to open access publication; Introduction to software tools to identify predatory publications and journal suggestion tools like Elsevier Journal Finder, Springer, Journal Suggestion, etc.; Use of plagiarism detection software.

Tutorial **1 Credit (30 Hours)**

- Topic Selection Exercise: Choose a research topic and justify its relevance;
- Research Question Development: Formulating research questions, objectives and a thesis statement;
- Data collection basics (primary and secondary sources): Conducting literature review;
- Annotated Bibliography: Prepare summaries of at least 5 scholarly sources;
- Paragraph Writing Practice: Write structured paragraphs (introduction, body, conclusion);
- Citation Practice: Format references in APA/MLA style;
- Mini Research Paper: Write a short research paper (1000–1500 words) following proper structure.

Essential Readings:

1) The Craft of Research – Wayne C. Booth, Gregory G. Colomb & Joseph M. Williams
2) Writing Your Dissertation in Fifteen Minutes a Day – Joan Bolker
3) MLA Handbook – Modern Language Association
4) Mason J. (2002) Qualitative Researching. London: SAGE.
5) Weissberg R. & Buker S. (1990) Writing up Research. Englewood Cliffs, NJ: Prentice Hall.
6) Wolcott H.F. (1990) Writing Up Qualitative Research. Newbury Park, CA: SAGE.
7) Holliday A. (2007) Doing and Writing Qualitative Research. London: SAGE.
8) Silverman D. (2012) Doing Qualitative Research: a practical handbook. 4th edition. London: SAGE
9) Hopkins A. & Dudley-Evans T. (1988) A genre-based investigation of discussion sections in articles and dissertations. ESP Journal 7: 113-21.

Department of Geology

University of Delhi

1-year PG Geology course curricula based on NEP 2020

1 -year NEP PG structure

(Structure 1 (Level 6.5) PG Curricular Structure with only course work

Semester	**DSC**	**DSE & GE** (A student has to choose 3 DSE or 2 DSE from the following options. Those who will take 2 DSE, also has to take one GE from other Department)	**2 Credit course** Skill-based course/ workshop/ Specialised laboratory/ Hands on Learning	**Dissertation/ Academic Project/ Entrepreneurship**	**Total Credits**
Semester - I	**1. DSC 7** Economic Geology **2. DSC 8** Hydrogeology **(08 credits)**	1. **DSE 5** Advanced River Science 2. **DSE 6** Paleoclimate 3. **DSE 7** Environmental Geology 4. **DSE 8** Glacial & Periglacial Geology 5. **DSE 9** Quaternary Geology 6. **DSE 10** Applied Geophysics **GE (GE-3)** **Geoheritage and Geopark** *(To be offered to MSc students of other departments)* **(12 credits)**	**SBC (SBC—3)** Thin-section preparation for Geological studies (Hands on training)	Nil	**22**

Semester- II	**3. DSC 10** Engineering Geology **4. DSC 11** Sequence stratigraphy and Basin Analysis **(8 credits)**	**DSE** 7. **DSE 11** Petroleum and Coal Geology 8. **DSE 12** Earthquakes: A Geological perspective 9. **DSE 13** Climate change and sustainability 10. **DSE 14** Applied Hydrogeology 11. **DSE 15** Geo-archaeology **GE (GE-IV)** **Natural hazard and Disaster Management** *(To be offered to MSc students of other departments)* **(12 credits)**	**SBC (SBC—IV)** Advanced Geological Mapping	Nil	**22**

Structure 2 (Level 6.5): PG Curricular Structure with Course work + Research

Semester	DSC	DSE (A student has to choose 2 DSE or 1 DSE from the following options. Those who will take 1 DSE, also has to take one GE from other Department)	2 Credit course	Dissertation/ Academic Project/ Entrepreneurship	Total Credits

Semester - I	**1. DSC 7 Economic Geology** **2. DSC 8 Hydrogeology** **(8 credits)**	1. **DSE 5** Advanced River Science 2. **DSE 6** Paleoclimate 3. **DSE 7** Environmental Geology 4. **DSE 8** Glacial & Periglacial Geology 5. **DSE 9** Quaternary Geology 6. **DSE 10** Applied Geophysics **GE (GE-III)** **Geoheritage and Geopark** *(To be offered to MSc students of other departments)*	Nil	**See detail outcomes (6 credits)**	**22**
Semester - II	**3. DSC 10** Engineering Geology **4. DSC 11** Sequence stratigraphy and Basin Analysis	7. **DSE 11** Petroleum and Coal Geology 8. **DSE 12** Earthquakes : A Geological perspective 9. **DSE 13** Climate change and sustainability 10. **DSE 14** Applied Hydrogeology	Nil	**See detail outcomes (6 credits)**	**22**

	(8 credits)	11. **DSE 15** Geo-archaeology **GE (GE-IV)** **Natural hazard and Disaster Management** *(To be offered to MSc students of other departments)* **(12 credits)**			

<u>Structure 3 (Level 6.5): PG Curricular Structure (Research)</u>

Semester	DSC	DSE (related to identified research field)	Research Methods/ Tools/ Writing (2 courses)	One intensive problem-based research	Total Credits
Semester-I	**DSC 9 Current trends in Geoscience Research** **(4 credits)**	1. **DSE 5** Advanced River Science 2. **DSE 6** Paleoclimate 3. **DSE 7** Environmental Geology 4. **DSE 8** Glacial & Periglacial Geology 5. **DSE 9** Quaternary Geology 6. **DSE 10** Applied Geophysics **According to the elective chosen, the*	(a) **Advanced Research Methodology** of the core discipline + (b) **Tools for Research** **(2x2 = 4 credits)**	**Outcomes are listed (10 credits)**	**22**

		credit system (Practical/Tutorial) may vary **(4 credits)**			
Semester-II	-	1. **DSE 11** Petroleum and Coal Geology 2. **DSE 12** Earthquakes: A Geological perspective 3. **DSE 13** Climate change and sustainability 4. **DSE 14** Applied Hydrogeology 5. **DSE 15** Geo-archaeology ****According to the elective chosen, the credit system (Practical/Tutorial) may vary*** **(4 credits)**	**Techniques of research writing** **(2 credits)**	**Research (16 credits)**	**22**

Semester -I

DSC 7: Economic Geology   Duration: 45 Hours (Lecture) + 30 Hours (Practical)

Course Title and Code	Total Credit	Credit distribution in course		
Economic Geology	4	Lecture	Tutorial	Practical
		03	0	01

LEARNING OBJECTIVES:

- To introduce the understanding of ore deposits and how they form
- Ores in the context within the framework of tectonics and metallogeny.
- The student will be introduced to several ore deposit styles.
- A suite of important ore minerals (oxides and sulphides) will be examined in reflected light.

LEARNING OUTCOMES:

- Students will be able to identify a number of important ore minerals in reflected light, thereby aiding in the exploration and characterization of ore deposits
- Students will recognize the key factors controlling several ore deposits so that deposits may be characterized and linked to existing ore deposit models
- Students will have knowledge on metallogenic provinces and their evolution in time domain
- Students will also be able to apply their knowledge to link these ore deposits within a metallogenic framework and thereby enhance exploration strategies

CONTENTS **3 Credit (45 Hrs)**

Unit-I: Concept of metallogeny and metallogenic provinces **(12 Hours)**

Introduction and objectives; Metallogeny principles and practice; Metallogenic terms and definitions; Metallogenic classification of ore and mineral deposits; The concept of metallogenic provinces and epochs

Unit-II: Tectonics and Metallogeny **(14 Hours)**

Global Tectonics and Supercontinent Cycles, Introduction to crustal evolution and metallogeny ; Metallogeny in relation to geodynamics and deep time, and the significance of non-uniformitarian models in understanding ancient geodynamic regimes. Metallogeny and plate tectonics: within-plate settings, incipient rift environments, divergent plate boundaries, and convergent plate boundaries

Unit-III: Controls on ore mineralization **(11 Hours)**

Hydrothermal alteration Ore deposits within the context of their characterization, tectonic setting, structural control, alteration, and ore mineralogy: Porphyry Cu and Mo; Carlin gold; Epithermal; SEDEX and VMS; MVT; Sedimentary Ore deposits: Iron and Manganese; Magmatic – Bushveld Igneous Complex

Unit-IV: Metallogeny models **(8 Hours)**

Metallogenic models: source of elements, supercritical hydrous melts and fluids, architecture and timing of flow path activation, controls on sites and physico-chemical conditions; Features of Metallogenic Provinces: Regional tectonic types of ore-bearing provinces, Evolution of ore-bearing provinces in time, composition of ores characterizing the ore-bearing provinces, form of ore deposits, and the ore-bearing provinces.

PRACTICAL **1 credit (30 Hours)**

1. Learning diagnostic physical properties and identification of metallic and non-metallic ore minerals in hand specimens.
2. Training on the microscopic identification of sulphide, oxide and carbonate ore minerals
3. Learning approaches to understand the textural relationships and mineral paragenesis in the assemblage of gangue and ore minerals.

SUGGESTED READINGS:

1. Richard, H. Sillitoe (2024). Metallogeny and Mineral Exploration – Some Personal Reminiscences. Geochemical Perspectives.
2. Moon, C.J., Whateley, M.K.G. and Evans, A.M. (2006). Introduction to mineral exploration.
3. Robb, L.J. (2005). Introduction to ore-forming processes
4. Ridley, J. (2013) Ore Deposit Geology
5. Sawkins, F. J. (1984). Metal Deposits in Relation to Plate Tectonics (Minerals and Rocks Series, Vol. 17). Springer-Verlag, Berlin, Heidelberg, New York, Tokyo. xiv + 325 pp. ISBN: 3-540-12752-6

DSC 8: Hydrogeology **Duration: 45 Hours (Lecture) + 30 Hours (Practical)**

Course Title and Code	Total Credit	Credit distribution in course	
Hydrogeology	4	Lecture	Practical
		03	01

Learning Objectives:

- The course is aimed at imparting advanced-level conceptual clarity and understanding of hydrogeology.
- It will share knowledge about the occurrence and movement of groundwater, water-bearing properties of formations, aquifer types, aquifer parameters, drilling methods, well construction, and completion.
- It also enables students to acquire knowledge about the physical and chemical attributes and the exploration of the groundwater resources

Learning Outcomes:

- The students will learn about occurrence of groundwater, water bearing properties of formations, aquifer types and aquifer parameters.
- The course imparts knowledge about construction, design and development of water wells, aquifer parameter estimation and the science of groundwater flow under different conditions.
- Develop a concise understanding of groundwater quality, its analytical representation, contamination and variability in India
- The students will learn about the concepts of groundwater exploration and the different methods of groundwater exploration.

CONTENTS

Unit I: General concepts: (14 hours)

Water on earth. Types of water: meteoric, juvenile, magmatic and sea waters. Hydrologic cycle. Vertical distribution of subsurface water: zone of aeration and zone of saturation. Concept of depth to water level and water table contour maps. Concepts of drainage basin and groundwater basin. Classification of rocks and formations according to their water-bearing properties. Aquifers and their types. Water table and piezometric surface. Water bearing properties of rocks and aquifer parameters: porosity, permeability, specific yield, specific retention, hydraulic conductivity, transmissivity, intrinsic permeability, storage coefficient, storativity, specific storage. Fluctuations of water table and piezometric surface; Barometric and tidal efficiencies. Geologic and geomorphic controls on groundwater. Hydrostratigraphic units. Springs. Introduction to hydrogeology of India and the groundwater provinces of India.

Unit II: Water wells and well hydraulics: (13 hours)

Types of wells, drilling methods, construction, design, development, maintenance and revitalization of wells. Specific capacity and its determination. Darcy's Law and its applications. Theory of groundwater flow, numerical solutions for steady state linear groundwater flow in confined and unconfined aquifers and Dupuit's assumption for unconfined flow. Numerical solutions for steady state radial flow to a well in confined (Thiem's equation) and unconfined aquifers (Dupuit's equation). Numerical solutions for unsteady state groundwater water flow condition. Methods of permeability estimation in laboratory and field. Evaluation of aquifer parameters of confined aquifer using Theis and Jacob methods.

Unit III: Groundwater chemistry: (10 hours)

Groundwater quality – physical and chemical properties of water, quality criteria for different uses. Groundwater contamination and pollution from natural (geogenic) and anthropogenic sources. Graphical presentation of water quality data. Saline water intrusion in aquifers and its prevention. Groundwater quality in different provinces of India

Unit IV: Groundwater exploration: (8 hours)

Geological, lithological, structural and hydrogeomorphic mapping, fracture trace analysis, lineament mapping in context of groundwater exploration. Remote sensing as a tool in groundwater exploration. Surface-based geophysical methods – seismic, gravity, electrical resistivity and magnetic. Subsurface geophysical methods.

Practical (1 Credit) (30 Hours)

1. Depth to water level and water table contour map-based exercise.
2. Numerical problems related to steady state radial flow to wells in confined and unconfined aquifer.
3. Numerical problems related to estimation of permeability in laboratory and field.
4. Practical exercise based on Theis and Jacob's equation and methods of aquifer parameter estimation.
5. Practical exercises based on Hydrochemical facies and Trilinear (Hill-Piper) diagram.
6. Numerical problems related to sea water intrusion in the coastal aquifers.

ESSENTIAL READINGS:

1. Todd, D. and Mays, L. 2005 *Groundwater Hydrology*. (3rd ed.), John Wiley and Sons, Inc., Hoboken, N.J.
2. Fetter, C.W., and D. Kreamer. 2022. *Applied Hydrogeology*, 5th ed. Long Grove, IL: Waveland Press
3. Fitts, C.R., 2023. *Groundwater Science* (3rd ed.), Academic Press.
4. Freeze, R.A. and Cherry, J.A., 1979. *Groundwater*, Englewood Cliffs, New Jersey: Prentice-Hall.
5. Karanth K.R., 1987. *Groundwater: Assessment, Development and Management*, Tata McGraw-Hill Pub. Co. Ltd.

SUGGESTED READINGS:

1. Davies, S.N. and De-West, R.J.N., 1966. *Hydrogeology*, John Wiley & Sons, New York.
2. Driscoll, F.G., 1988. *Ground Water and Wells*, UOP, Johnson, Div. St. Paul. Min. USA.
3. Raghunath, H.M., 1987. *Ground Water*, Wiley Eastern Ltd., Calcutta.
4. Schwartz, F. W., & Zhang, H. 2024. *Fundamentals of groundwater* (2nd ed.). Wiley.
5. EPG Pathsala lecture modules at web link: http://epgp.inflibnet.ac.in/ahl.php?csrno=448
6. Uliana, M. M. 2025. *Basic hydrogeology: An introduction to the fundamentals of groundwater science*. The Groundwater Project. https://doi.org/10.62592/CBIQ7579.
7. Younger, P. L., 2009. *Groundwater in the environment: an introduction*. John Wiley

DSC 9: Current trends in Geoscience Research

Course Title and Code	**Total Credit**	**Credit distribution in course**		
Current trends in Geosciences Research	4	**Lecture**	**Tutorial**	**Practical**
		03	**0**	**01**

Course Objectives:

The sustainable development of our society depends on balanced utilization of natural resources including economic minerals, ground water and hydrocarbon resources. Also, we require continuous improvement of our infrastructure including roads, bridges and dams etc.

Keeping this mind, the course is designed to expose students to state-of-the art techniques in the fields of economic Geology, Groundwater, Engineering geology and Sequence stratigraphy. The course will also attempt exposing to the students the recent ideas in these fields of research.

Course Learning Outcomes:

Students will be come to know about

- Different ore generation processes and how the processes related to global tectonics
- Nuances of groundwater science
- Role of engineering geology in different infrastructural development projects
- How applied stratigraphy help in identification of stratigraphic traps of oil and gas

Unit-I: Metallogeny, Geodynamics and Ore Deposit Systems (11 Hours)

Metallogenic classification of ore and mineral deposits; The concept of metallogenic provinces and epochs. Metallogeny in relation to geodynamics and deep time, and the significance of non-uniformitarian models in understanding ancient geodynamic regimes. Metallogeny and plate tectonics: within-plate settings, incipient rift environments, divergent plate boundaries and convergent plate boundaries. Ore deposits within the context of their characterization, tectonic setting, structural control, alteration, and ore mineralogy.

UNIT II: Groundwater science (12 Hours)

Classification of rocks and formations according to their water-bearing properties. Water table and piezometric surface. Water bearing properties of rocks and aquifer parameters: porosity, permeability, specific yield, specific retention, hydraulic conductivity, transmissivity, intrinsic permeability, storage coefficient, storativity, specific storage. Types of wells, drilling methods, construction, design, development, maintenance and revitalization of wells. Specific capacity and its determination. Darcy's Law and its applications. Theory of groundwater flow, numerical solutions for steady state linear groundwater flow in confined and unconfined aquifers and Dupuit's assumption for unconfined flow. Numerical solutions for steady state radial flow to a well in confined (Thiem's equation) and unconfined aquifers (Dupuit's equation). Numerical solutions for unsteady state groundwater water flow condition. Methods of permeability estimation in laboratory and field. Evaluation of aquifer parameters of confined aquifer using Theis and Jacob methods.

Unit- III: Engineering Geology for societal benefits (10 Hours)

Engineering properties of rocks and soil. Engineering bedrock and their characteristics. Laboratory index and strength tests for rocks and soil. Rock slope failure mechanism. Mass wasting and their types. Rock slope stabilization techniques; factor of safety. Application of rock mechanics for underground openings, rock slope engineering, and foundation engineering. Landslide hazard zonation mapping.

Unit- IV: Sequence stratigraphy: An integrated applied stratigraphy for basin analysis hydrocarbon exploration (12 Hours)

Definitions and key concepts. Base level (stratigraphic and geomorphic) changes, Eustatic and Relative Sea level, Transgressions and regressions, T-R cycles. Regional and global stratigraphic cycles. Unconformity, Flooding surface ...... Stratal geometry, terminations, sequence stratigraphic surfaces. Unconformity and correlative conformity, Basal surface of

Marine regression, Ravinement surface, Initial and maximum flooding surface. Concept of stratigraphic trap.

Practical:

1. Exercises on effects of Tectonics and Eustacy in basin accommodation
2. Exercise of stratal geometry in different Systems Tracts
3. Practical exercise based on Theis and Jacob's equation and methods of aquifer parameter estimation.

Essential Readings:

1. Principles of Sequence Stratigraphy: Octavian Catuneanu (2006) Elsevier
2. Sequence Stratigraphy: D. Emery, and K. Mayers (1996) Blackwell Publishers
3. Todd, D. and Mays, L. 2005 Groundwater Hydrology. (3rd ed.), John Wiley and Sons, Inc., Hoboken, N.J.
4. Fetter, C.W., and D. Kreamer. 2022. Applied Hydrogeology, 5th ed. Long Grove, IL: Waveland Press
5. Robb, L. (2020). Introduction to Ore-Forming Processes (2nd ed.). Wiley-Blackwell.
6. Sawkins, F. J. (1984). Metal Deposits in Relation to Plate Tectonics (Minerals and Rocks Series, Vol. 17). Springer-Verlag, Berlin, Heidelberg, New York, Tokyo. xiv + 325 pp. ISBN: 3-540-12752-6

Suggested Readings

EPG Pathsala lecture modules at web link: http://epgp.inflibnet.ac.in/ahl.php?csrno=448

DSE 5: Advanced River Science Duration: 45 Hours (Lecture) + 30 Hours (Practical)

Course Title and Code	**Total Credit**	**Credit distribution in course**	
Advanced River Science	4	**Lecture**	**Practical**
		03	01

Learning Objectives

- To provide an in-depth understanding of river system dynamics through interdisciplinary perspectives combining geomorphology, hydrology, sedimentology, and ecology.
- To train students to analyse fluvial processes using modern quantitative tools, field data, and remote sensing–GIS techniques to interpret river behaviour, assess changes, and design sustainable river management strategies.

Learning outcomes

Upon completion of the course, students should be able to:

- Understand and appreciate river basins as systems with internal and external dynamics
- Explain river morphology, discharge behaviour, including hydrographs and flood, and sediment transport processes
- Employ theoretical and quantitative techniques to study bedrock rivers and landscape evolution.
- Assess human impacts on rivers and explore approaches for sustainable management and restoration
- Apply advanced technologies, including AI and GIS, for river monitoring and analysis.

CONTENTS

Unit I: Fundamentals of River System Dynamics (10 Hours)

Catchment hydrology, runoff, hillslope processes, channel initiation; River as a system: system approaches in fluvial geomorphology, Driving and resisting forces in river systems; Key concepts in river geomorphology: spatial and temporal scale, disturbance events, river sensitivity, resilience, threshold, (dis)connectivity, hierarchy and complexity

Unit II: Fluvial forms, processes and evolution (14 Hours)

River diversity: Channel pattern, Channel geometry, Channel morphology, Floodplains, instream features; River flow, discharge, and discharge measurement; Sediment load, entrainment, transport, deposition and measurement; Weathering and river chemistry: geochemical proxies and tracers to study fluvial dynamics; Hydrographs, hydrograph separation, baseflow; Groundwater-river interaction; Hyporheic zone; Flood hydrology, Flood frequency analysis; River evolution – River response to climate, tectonics and human disturbance; Impact of increased cryospheric dynamism on rivers

Unit III: Bedrock rivers (8 Hours)

Bedrock channel processes, Longitudinal profile analysis, Stream power incision model, Geomorphometrics, Evolution of fluvial landscapes.

Unit IV: Rivers in the Anthropocene, River Management and Emerging Themes (13 Hours)

Anthropogenic impacts on rivers: dams, diversions, river sand mining, land-use change, and pollution, Emerging contaminants in rivers; River management and River future: Riverine Ecology and Habitat, River Health, e-flow, Application of the River Styles Framework in River Management, River rehabilitation and repair; River rights and governance; Transboundary rivers; Modern methods and tools of data acquisition and data analysis for river science; Applications of Artificial Intelligence and Cloud based GIS in river science.

Practical 1 credit (30 Hrs)

1. Exercises on Hydrographs
2. Exercises on Flood frequency analysis
3. Extraction and analysis of geomorphometrics using MATLAB Topotoolbox
4. Fluvial morphological mapping and analysis using cloud and desktop GIS
5. Analysis of sediment load data

SUGGESTED READINGS

1. Fryirs, K. A., & Brierley, G. J. (2013). *Geomorphic analysis of river systems*. Wiley-Blackwell.
2. Wohl, E. (2010). *Mountain rivers revisited*. American Geophysical Union.
3. Bierman, P., & Montgomery, D. (2014). *Key concepts in geomorphology* (2nd ed.). W. H. Freeman.
4. Kondolf, G. M., & Piégay, H. (2003). *Tools in fluvial geomorphology*. Wiley.
5. Charlton, R. (2008). *Fundamentals of fluvial geomorphology* (2nd ed.). Routledge.
6. Kelly, J. M., Scarpino, P. V., Berry, H., Syvitski, J., & Meybeck, M. (Eds.). (2018). *Rivers of the Anthropocene*. Springer.
7. Robert, A. (2011). *River processes: An introduction to fluvial dynamics* (2nd ed.). Routledge.
8. Brierley, G. J., & Fryirs, K. A. (Eds.). (2008). *River futures: An integrative scientific approach to river repair*. Island Press.

DSE 6: PALEOCLIMATE   Duration: 45 Hours (Lecture) + 30 Hours (Practical)

Course Title and Code	Total Credit	Credit Distribution in Course		
Paleoclimate	4	Lecture	Tutorial	Practical
		3	0	1

LEARNING OBJECTIVES:

- Understand Earth's climate system, energy balance, and feedback mechanisms.
- Apply sampling, dating, and analytical techniques to paleoclimate archives.
- Reconstruct past climates using multiproxy data and Earth system processes.
- Evaluate anthropogenic impacts and mitigation strategies in a changing climate.

LEARNING OUTCOMES

- Explain climate system dynamics, energy balance, and radiative forcing.
- Apply sampling, dating, and proxy analysis for paleoclimate reconstruction.
- Reconstruct past climates and relate them to orbital, oceanic, and tectonic controls.
- Evaluate anthropogenic impacts, risks, and mitigation/adaptation strategies.

LECTURE   3 Credit (45 Hrs)

Unit I: Introduction to Weather and Climate   (12 Hours)

Concepts of **weather** and **climate** and their classification systems, **Greenhouse gases**: sources, changing concentrations, and their role in climate change, Components of the **climate system** and their interactions, **Climate forcing**, system responses, response rates, and feedback mechanisms, **Incoming solar radiation**: short-term and long-term variability (insolation), Receipt, storage, and transformation of heat; **Earth's heat budget**, Radiative forcing, albedo, and anthropogenic influences on energy balance

Unit II: Sampling Earth Materials to Understand Climate Change (14 Hours)

Sampling methods for retrieving **climate and oceanographic archives** (deep-sea cores, ice cores, lake sediments, speleothems), **Dating techniques**: radiometric, radiocarbon, and others; advantages, limitations, and uncertainties, **Elemental and isotopic analysis** for paleoclimate reconstruction, Instruments used in paleoclimate studies: mass spectrometers, gas chromatographs, stable isotope analysers, Climate modelling approaches and **IPCC climate change projections**; multiproxy integration for climate reconstructions

Unit III: Paleoclimate Reconstruction (11 Hours)

Reconstruction from **deep-sea cores, ice cores, pollen and spores, biogeochemical proxies, corals, and speleothems,** Astronomical controls: **Milankovitch cycles** and solar variability, Glacial–interglacial cycles; **Last Glacial Maximum (LGM)** and **Younger Dryas,** Monsoon variability over geological timescales and the role of the **Intertropical Convergence Zone (ITCZ),** Atmospheric layering, circulation, and **heat transfer in the atmosphere and oceans, Global Ocean Conveyor Belt** and its control on climate, Plate tectonics and long-term climate regulation, Teleconnections, ocean–atmosphere feedbacks, and paleoclimate modelling

Unit IV: Anthropogenic Effects, Climate Impacts, and Mitigation (8 Hours)

Natural vs **anthropogenic drivers** of climate change, **Regional climate records**, with emphasis on the Indian subcontinent, Biosphere responses to climate variability, Human impacts on climate and consequences for society, ecosystems, and economy, Climate change hazards, disasters, and risk assessment, Mitigation strategies, adaptation measures, and policy frameworks

PRACTICAL 1 credit (30 Hours)

1. Interpreting Paleoclimatic data
    (a) Quantitative Faunal data
    (b) Distribution of Fossils on Paleogeographic Maps
    (c) Interpreting Stable Isotope Data obtained from Archives
2. Exercises on Ocean Circulation and resultant Climate Change
3. Exercises on Closing and Opening of Ocean gateways and resultant Continental Glaciations
4. Interpreting Past sea level curves and their climatic Causes.

ESSENTIAL READINGS:

1. Ruddiman, W.F., 2001. Earth's climate: past and future. Edition 2, Freeman Publisher.
2. Rohli, R.V., and Vega, A.J., 2007. Climatology. Jones and Barlatt
3. Lutgens, F., Tarbuck, E., and Tasa, D., 2009. The Atmosphere: An Introduction to Meteorology. Pearson Publisher.
4. Aguado, E., and Burt, J., 2009. Understanding weather and climate. Prentice Hall.
5. Bradley, R.S., *Paleoclimatology: Reconstructing Climates of the Quaternary*, Academic Press.

6. Braiser, M.D., 1980. *Microfossils*, George Allen, and Unwin.

SUGGESTED READINGS:

1. Cronin, T.M., 1999.*Principles of Paleoclimatology*, Columbia University Press.
2. Fischer, G. and Wefer, G., 1999.*Use of Proxies in Paleoceanography: Examples from the South Atlantic*, Springer.
3. Kennett, J.P., 1982.*Marine Geology*, Prentice-Hall Inc.
4. North, G.R. and Crowley, T.J., 1995. *Paleoclimatology*, Oxford University Press

DSE 7: Environmental Geology Duration: 45 Hours (Lecture) + 30 Hours (Practical)

Course Title and Code	Total Credit	Credit distribution in course	
Environmental Geology	4	**Lecture**	**Practical**
		03	01

Learning Objectives:

- To understand the interaction of humans with the geological environment.
- To familiarise students of challenges of environmental geology in the urban Environment.
- To teach practical contribution that geologists can make in managing human interaction with the physical environment.

Learning Outcomes:

- Student will understand the concepts of environmental geology.
- They will learn about concepts of managing geological resources.
- Learn appropriate use of the geological environment for waste disposal.
- Students will learn about the natural hazards and mitigation of their human impacts.

Contents:

Unit I: INTRODUCTION AND GEOLOGICAL RESOURCES (13 Hours)

Definition; History of Environmental Geology; Environmental Geology and Commercial reality; The Tools of the Environmental geologist; Critical thinking about the environment Economic mineral resources; Construction resources; Water resources; Aesthetic and Scientific geological resources (aesthetic, cultural and scientific importance of Geology).

Unit II: **ENVIRONMENTAL HAZARDS (16 Hours)**

Exogenic hazards; Endogenic hazards; Engineering geology in extreme events.

Unit III: **WASTE AND POLLUTION MANAGEMENT (8 Hours)**

Waste management and geological environment; Waste and Pollution; Waste and Society; Wastes in open dumps; Landfilling wastes; Effluent treatment and disposal; Waste gases and the atmosphere; Radioactive wastes and management;

Unit IV: **ENVIRONMENTAL GEOLOGY: AN URBAN CONCEPT (8 Hours)**

Urban Environments; Urban planning and geology

Practicals 1 Credit (30 Hours)

1. Environmental geological mapping
2. Landslide susceptibility mapping
3. River health assessment
4. Groundwater vulnerability assessment
5. Change detection using Google Earth
6. Environmental risk matrix preparation

SUGGESTED READINGS:

1) Environmental Geology: Geology and the Human Environment by Bennett and Doyle by Wiley Publications

2) Environmental Geology by Jim Reichard by McGraw Hill

3) Environmental Science by Botkin and Keller by Wiley Publications

DSE 8: Glacial and Periglacial Geology

Course Title and Code	Total Credit	Credit distribution in course	
Glacial and Periglacial Geology	4	**Lecture**	**Practical**
		03	01

Learning Objectives

The main aim of this course is

- to provide students with a comprehensive understanding of the glacial system and processes.
- to provide a thorough knowledge of the dynamics of different glacial and periglacial processes and landform formation.
- to discuss the linkages between climate and glaciations/deglaciations, and their impacts.

Learning outcomes

After completing this course, students will be able to:

- explain how different processes operate in the glacial and periglacial environment
- Identify glacial and periglacial landforms and sediments on the map and in the field

- Conduct a study to understand the long-term glacial history of an area using a range of field and laboratory techniques.

Unit I **(10 Hours)**

Glacial Geology and the Cryosphere: Concept and scope of Glacial Geology; components of the cryosphere, including ice sheets, ice caps, valley glaciers, sea ice and snow cover; formation of Glaciers; physical and mechanical characteristics of Glacial ice; relationship between climate and Glaciers; significance and applications of Glacial geology; techniques and methods used in glacial studies.

Unit II **(10 Hours)**

Glacial Processes, Dynamics and Landforms: Glacial erosion and depositional processes; erosional and depositional landforms produced by Glaciers; ice flow mechanisms and glacier dynamics; sediment entrainment, transportation and deposition; Glacial mass balance and Equilibrium Line Altitude (ELA); Glacial hydrology; Glacial lakes and Glacial Lake Outburst Floods (GLOFs).

Unit III **(10 Hours)**

Periglacial Environment and Glacial Sediments: Concept and characteristics of periglacial environments; periglacial climate, weathering, ground freezing and thawing processes; permafrost; slope movement and hillslope evolution; characteristics of glacial sediments (Tills) including shape, form, roundness, texture, size and macro fabrics; methods of sediment sampling and analysis; glaciofluvial, glaciolacustrine and glaciomarine sediments.

Unit IV **(10 Hours)**

Past Glaciations and Climate Change: Climate change and glaciation; major glaciations during Earth's history; Quaternary glaciations and climatic fluctuations; Last Glacial Maximum (LGM); Little Ice Age (LIA); significance of past glaciations in palaeoclimate reconstruction and understanding present-day climate change.

Practical **(15 Hours)**

i. Glacial and periglacial landform mapping
ii. Glacial mass balance exercise
iii. Identification and reconstruction of Equilibrium Line Altitude (ELA).
iv. Glacial sediments: shape, form and texture analysis.

Suggested Readings:

Bennett, Matthew R., and Neil F. Glasser. 2009. Glacial Geology: Ice Sheets and Landforms. 2nd ed. Oxford, U.K.: Wiley-Blackwell.

Ballantyne, Colin K. 2018. Periglacial Geomorphology. 2nd ed. Oxford, U.K.: Wiley-Blackwell.

Summerfield, Michael A. 2014. Global Geomorphology. London: Routledge

Evans, David J. A., and Douglas I. Benn, eds. 2014. A Practical Guide to the Study of Glacial Sediments. London: Routledge.

Ruddiman, William F. 2014. Earth's Climate: Past and Future. 3rd ed. New York: W. H. Freeman and Company.

DSE 9: Quaternary Geology

Course Title and Code	Total Credit	Credit distribution in the course	
Quaternary Geology	**4**	**Lecture**	**Tutorial**
		03	**01**

Learning Objective

- To introduce the Quaternary period as a time of significant climatic, environmental, and geomorphic change.
- This course also introduces the stratigraphy, dating methods, sedimentary records, and biotic responses, with emphasis on understanding landscape evolution and human–environment interactions during the Quaternary.

Learning Outcomes

By the end of the course, students will be able to:

- Explain the significance and characteristics of the Quaternary period
- Interpret Quaternary stratigraphic records using multiple proxies
- Apply geochronological methods to Quaternary sediments and landforms
- Analyse geomorphic and tectonic processes active during the Quaternary
- Reconstruct past environments using biological and sedimentological evidence
- Evaluate the relationship between climate change, biotic evolution, and human development

Unit I: Introduction to the Quaternary (11 Hours)

Definition, duration, and subdivision of Quaternary; Characteristics of the Quaternary: climatic fluctuations and environmental instability; Development of Quaternary studies; Glacial–interglacial cycles and their global significance; Principles of Quaternary stratigraphy; Introduction to Oxygen isotope stratigraphy (marine isotope stages), biostratigraphy; magnetostratigraphy, and Palynology.

Unit II: Quaternary Geochronology (4 Hours)

Principles of dating: relative vs absolute methods; Radiocarbon dating; Uranium-series dating; Luminescence dating; Amino acid dating; Applications and limitations of dating techniques

Unit III: Quaternary Geology of India: Geomorphic, Sedimentary and Tectonic Systems (22 Hours)

Major Quaternary stratigraphic sequences of India; Fluvial systems (Indus–Ganga–Brahmaputra plains); Glacial records (Himalaya); Aeolian systems (Thar Desert); Coastal and marine records; Regional correlations and paleoenvironmental reconstruction; Response of geomorphic systems to Quaternary climate change; Neotectonics and active tectonics; Role of tectonics in landscape evolution

Unit IV: Environment and Life in the Quaternary (8 Hours)

Natural hazards in the Quaternary context; Evolution of plant and animal life during glacial–interglacial cycles; Human evolution and Stone Age cultures in the Quaternary

Practical 1 Credit (30 Hours)

- Interpretation of stratigraphic logs and sedimentary sequences
- Grain size analysis and depositional environment interpretation
- Identification of paleosols and sedimentary facies
- Interpretation of oxygen isotope curves
- Basic exposure to dating techniques (demonstration/data interpretation)
- Map-based analysis of Quaternary landforms

Essential Readings

1. Pant, R. K., & Rajaguru, S. N. (1999). Quaternary Climate and Environment of India. Geological Society of India, Bangalore.
2. Williams, M., Dunkerley, D., De Deckker, P., Kershaw, P., and Chappell (1993). Quaternary Environments. Arnold, Hodder Headline Group, London.

Suggested Readings

1. Encyclopedia of Quaternary Science (3rd Edition) (2024) Editor: Scott A. Elias; Elsevier.
2. Ruddiman, W. F. (2014). *Earth's Climate: Past and Future* (3rd ed.). W.H. Freeman, New York.
3. Bradley, Paleoclimatology Reconstructing Climates of The Quaternary.
4. Quaternary environments and geoarchaeology of India: essays in honour of Professor SN Rajaguru (1995).

DSE 10: Applied Geophysics Duration: 45 Hours (Lecture) + 30 Hours (Practical)

Course Title and Code	Total Credit	Credit distribution in the course

Applied Geophysics	4	Lecture	Tutorial
		03	01

LEARNING OBJECTIVES

- This course introduces students to Earth's physical properties and the fundamentals of geophysical investigation.
- It covers essential exploration techniques such as gravity, magnetic, electrical, and seismic methods used to study Earth's resources.
- Students will develop a vital understanding of how geology and geophysics are interconnected, aiding in comprehending Earth's geodynamic behaviour and interior.
- The course emphasises core concepts, exploration methods, and the analysis of geophysical anomalies to deepen insights into Earth's dynamics and resource distribution.

LEARNING OUTCOMES

After completing the course, students will be able to:

- Develop a fundamental understanding of geophysical methods and how they are used to explore and study the Earth's interior.
- Students will explore gravity, magnetism, palaeomagnetism, electrical, and seismic techniques.
- They will gain essential skills in identifying geophysical anomalies and understanding their links to geological processes.
- Students will be introduced to data collection methods in geophysics, along with the correction and reduction techniques.

Lecture 3 Credit (45 Hrs)

Unit- I: Introduction (7 Hrs)

Introduction to Geophysical Prospecting. Branches of geophysics: solid earth geophysics and exploration geophysics. Overview of geophysical methods, measured parameters, and their associated physical properties. Signal and noise. Data acquisition and processing. Concept of geophysical modelling: forward and inverse modelling. Importance of geophysical methods in mineral exploration.

Unit- II: Gravity and Magnetic (15 Hrs)

Gravity fields of the Earth: Gravity potential, Earth's figure, International Reference Ellipsoid, Normal-gravity, Geoid, and gravity anomalies. Principles of gravimeters, stable and unstable types. Gravity corrections and reduction: Free-air, Bouguer, and terrain. Gravity anomalies and the concept of isostatic compensation. Interpretation of anomalies for simple geometric bodies, e.g. sphere, horizontal cylinder, dyke and fault. Origin of Earth's magnetic field and changes in the geomagnetic field. Magnetic properties of rocks and minerals. Measurement and reduction of magnetic data. Magnetometer and magnetic anomalies. Application of gravity and magnetic surveys in mineral exploration. Palaeomagnetism, Paleopole, Apparent Polar wandering curves and Continental drift.

Unit- III: Electrical and Electromagnetic (10 Hrs)

Electrical resistivity of rocks and minerals. Apparent resistivity and special electrode configurations. Vertical Electrical Sounding (VES) and Profiling techniques. Application of resistivity data for groundwater and mineral exploration. Induced Polarisation and Self-potential methods. Theory of electromagnetic induction, skin depth. Transient electro-magnetic methods (TEM), Very low frequency methods (VLF), Magnetotelluric (MT) methods, Ground Penetrating radar (GPR) methods.

Unit- IV: Seismic and Well Logging (13 Hrs)

Nature and types of seismic waves (P, S, and surface waves). Seismic ray paths and principles of reflection and refraction. Subcritical and supercritical reflections and critical refraction. Seismic refraction in 2- and 3-layered Earth models. Seismic reflection survey and normal moveout (NMO). Elements of earthquake seismology, focal mechanism and fault plane solutions. Concept of well logging and the borehole environment. Differences among geological, geophysical, and petrophysical logs. Well-logging techniques: Resistivity log, induction log, spontaneous potential log, calliper log, gamma ray log, and density log.

Tutorial (30 Hrs)

- Problems on free air and Bouguer anomalies.
- Numerical problems on isostasy and density contrasts.
- Calculating paleolatitude and paleopole,
- Resistivity curve plotting and interpretation
- Problems on seismic survey.

Essential readings:

1. Lowrie, W. (2007). Fundamentals of geophysics. Cambridge University Press.
2. Kearey, P., Brooks, M. and Hill, I., (2002). An Introduction to Geophysical Exploration. Third Edition. Blackwell Publishing.
3. Lillie, Robert J. (1999). Whole Earth Geophysics: An Introductory textbook for Geologists and Geophysicists.
4. Fowler, C.M.R. (2005). The Solid Earth: An Introduction to Global Geophysics. Cambridge University Press.

Suggested readings:

1. Mussett, A.E. and Khan, M.A. (2000). Looking into the Earth: An Introduction to Geological Geophysics. Cambridge University Press.
2. Telford, W.M., Geldart, L.P., and Sheriff, R.E. (1990). Applied Geophysics. Cambridge University Press.
3. Serra, O., P. Westaway, and H. Abbott. "Fundamentals of well-log interpretation. I: The acquisition of logging data." Developments in Petroleum Science 15 (1984).

GE 3 Geo-heritage and Geopark Duration: 45 Hours (Lecture) + 30 Hours (Practical)

Course Title	Total Credit	Credit Distribution in Course	
Geo-heritage and Geopark	4	Lecture	Practical
		3	1

Learning Objectives

This course aims to consider strategies to sample, understand, and address geoconservation and geopark issues. It should lead to the development of the skills and knowledge to conduct and curate (geo)heritage inventories, assess prospective sites for use as geopark purposes, propose new geotouristic opportunities and develop materials for geoconservation and geotourism consumers and operators. The course is designed as an applied course where student learns optimization of tourism potential of spectacular geological features.

Learning outcomes

On completion of the course,

- the student will be able to learn, distinguish, and identify potential geological sites of tourist interest.
- Will appreciate spectacular (e.g. geomorphic landforms, structures) as well as intrinsic sites (major time boundaries, fossil sites, LIP's, transgressions regressions etc),
- Will be able to comprehend economic aspects and linking geospots with other tourist destinations in a thematic manner

UNIT – I **(10 Hrs)**

Geodiversity, Geoheritage, Geoconservation and their relationship to geotourism. Concept of geoheritage in relation to other historical heritages, Tourism and its different forms and their interrelations, Geotourism: definition, characteristics and international/national perspectives, Eco-tourism and Geo-tourism, Defining the geoheritage sites and the concept of Geoheritage parks (UNESCO guidelines). Geographical context and contemporary geoheritage challenges, Geoheritage inventory of India and its curation context, legal framework of geoheritage, Relevance of geoheritage to Sustainable Development Goals (SDG).

UNIT – II **(10 hours)**

Education as a key tenet of geotourism and Earth Science Education & Geotourism. Geoheritage and public geoliteracy: opportunities for effective geoscience education within geosites Earth Science Museums and their role in promotion of Geotourism. Examples of Geotourist sites from India – e.g. Glacier features, Ox-bow lakes, Deltas etc.

UNIT – III **(10 Hours)**

Geotourism, Society and Sustainability: Public–private partnership framework for sustainable geopark development. Geotourism—a focus on the urban environment including historical Geotourism. Geotourism and cultural heritage. Potential of Geotourism in Economic development of any region. Role of Tourism sector in terms of world economy/ Indian economy. Role of Geotourism in Tourism industry with special reference to Indian scenario Entrepreneurship and start-up.

UNIT – IV **(15 Hours)**

Geotourism and geoparks: UNESCO Global Geoparks and Geoconservation. Geo site developed by Geological Survey of India. The application of geographical information systems in geotourism. Geotourism potential of the Indian geoheritage sites-societal and economic context including case studies

Basic concepts of geology in relation to Geoheritage: Study of Geological Map of India

Plotting the established geosites, geoparks and geo monuments of India on map. Plotting geosites, geoparks and geo monuments on map of World. Detailed study of geosites of India-Locality, Approach, Geological importance and foot fall. Five Case studies from India where geosites can be developed.

Tutorial **(30 hours)**

Students in different batches or groups will be given exercises to prepare shorts reports about the life evolution and extinction through different geological times on Earth.

Essential readings

T.A. Hose (Ed.) (2016). Appreciating Physical Landscapes: Three Hundred Years of Geotourism, Geological Society Special Publication No. 417, London.

Thomas A. Hose (Ed.)(2016).Geoheritage and Geotourism- a European Perspective, Boydell Press Woodbridge, UK

Ross Dowling & David Newsome (Eds) (2018). Handbook on Geotourism, Edward Elgar Publishing.

A monograph on National Geoheritage Monuments of India. Indian National Trust for Art

and Cultural Heritage(INTACH) Natural Heritage Division, New Delhi (2016).

National Geological Monuments. Geological Survey of India, Kolkata, Special Publication No.6 1(2001)

Kale, V.S. (ed.) (2014). Landscapes and Landforms of India, Springer, Dordrecht.

C. V. Burek and C.D. Prosser (Eds.) (2008) History of Geoconservation Special Publication 300, Geological Society of London

Suggestive readings

Young C.Y. Ng. &Yunting Lu (2015). The Principles of Geotourism, Anze Chen, (Springer).

Dowling, R. & Newsome, D. (Eds) (2018). Handbook on Geotourism, Edward Elgar Publishing.

National Geological Monuments. (2001) Geological Survey of India, Kolkata, Special Publication No.61

Burek, C.V. & Prosser, C.D. (Eds.) (2008). History of Geoconservation Special Publication 300, Geological Society of London.

Santangelo, N. and Valente, E. (Eds.) (2020). Geoheritage and Geotourism Resources, MdpiAG

Skill –Based Course

SBC 3: Thin-section preparation Techniques for Geological studies

Duration: 15 Hours (Lecture) + 30 Hours (Practical)

Course Title and Code	Total Credit	Credit distribution in the course		
		Lecture	Tutorial	Practical
Thin section preparation techniques for Geological studies	2	01	0	01

LEARNING OBJECTIVES:

- This course aims to train students in the preparation of thin and polished rock sections
- Students will develop proficiency in using both optical and reflected light microscopes.
- They will learn to identify and interpret minerals and textures observed under the microscope. Additionally, the course will cover laboratory safety, maintenance, and quality control in petrographic work.

LEARNING OUTCOMES:

- Students will learn the process of preparing standard-quality thin and polished sections.
- Students will identify minerals under plane-polarized and cross-polarized light.
- The will get to know the use petrographic and ore microscopes effectively for mineral and textural analysis.
- They will be able to appreciate maintenance of laboratory instruments and follow standard safety procedures. Also, they will be able to document and report petrographic observations systematically.

LECTURE **1 Credit (15 hours)**

Unit- I: Introduction to Microscopy and Laboratory Tools **(10 Hours)**

Importance of microscopy in geology. Parts and functioning of a petrographic microscope. Principles of transmitted and reflected light microscopy. Preparation tools and materials: saws, grinders, polishing wheels, resins, and adhesives.

Optical Properties and Mineral Identification: Optical principles: isotropic and anisotropic minerals, Relief, colour, pleochroism, interference colours, Extinction, twinning, cleavage, and refractive index, Identification of common rock-forming minerals (silicate and ore minerals) in thin section, Diagnostic features of major rock types.

Unit- II: Preparation of Thin and Polished Sections **(5 Hours)**

Selection and orientation of rock samples. Cutting, mounting, grinding, and thinning procedures. Standard thin section thickness (≈30 µm). Polishing techniques for opaque

PRACTICAL **1 credit (30 Hrs)**

1. Demonstration of rock cutting, mounting, and grinding.
2. Preparation of thin and polished sections.
3. Identification of minerals in thin sections under PPL and XPL.
4. Study of textures and microstructures in igneous, sedimentary, and metamorphic rocks.
5. Observation of opaque minerals under reflected light.
6. Maintenance of the microscope.

ESSENTIAL READINGS:

1. Barker, A. J., 2014. A Key for Identification of Rock-Forming Minerals in Thin Section- CRC Press
2. MacKenzie, W.S. & Guilford, C. 1980. Atlas of Rock-Forming Minerals in Thin Section. Longman.
3. Nesse, W.D. (2012). Introduction to Optical Mineralogy. Oxford University Press.

Research Methods/ Tools/ Writing

ADVANCE RESEARCH METHODOLOGY

Duration: 15 Hours (Lecture) + 30 Hours (Tutorial)

Course Title and Code	Total Credit	Credit distribution in course		
		Lecture	Tutorial	Practical
Advance Research Methodology	2	01	01	0

LEARNING OBJECTIVES:

- Develop an advanced understanding of research design, scientific investigation, and identification of research problems with the formulation of hypotheses.
- Improve the ability to review and evaluate scientific literature, identify research gaps, and select suitable methods for data collection.
- Provide knowledge of statistical tools and analytical techniques for analyzing, interpreting, and presenting research results effectively.
- Create awareness about research ethics and plagiarism, and develop skills in scientific writing and research communication.

LEARNING OUTCOMES:

- Design appropriate research strategies for scientific studies.
- Choose suitable methods for data collection, sampling, analyze and interpret data with proper techniques.
- Present findings through tables, graphs, and scholarly discussion.
- Write research papers, theses, and scientific reports following ethical standards and proper citation practices.

Lecture **(15 hours)**

Unit I: Fundamentals of Research and Research Design **(07 Hours)**

Meaning, objectives, and significance of research. Types of research. Steps in the research process. Identification and formulation of research problems. Development of research questions and hypotheses. Review of literature: sources, techniques, and critical evaluation. Research design: exploratory, descriptive, and experimental designs. Sampling techniques and methods of data collection in Earth Science.

Unit II: Data Analysis, Research Ethics and Scientific Communication **(08 Hours)**

Advanced statistical techniques in research, Multivariate data analysis and modelling, Data visualization and scientific interpretation, Big data, machine learning and computational approaches in Earth Science, Scientific data management and reproducibility, Research ethics, patent; intellectual property rights (IPR), and plagiarism, Writing high-impact research papers and review articles, Process of submitting article and scientific publishing, Preparation of research proposals, project reports, and grant applications, Oral and poster presentation of research findings.

TUTORIAL **(15 Hrs)**

1. **Field tutorials:** Stratigraphic logging and collection of rock and mineral samples.
2. **Laboratory practical:** Identification of minerals and description of rock textures. Chemical data of geological samples.
3. **Data analysis exercises:** Graphical representation of geochemical data, and use of computer tools such as spreadsheets.
4. **Research writing workshops:** Preparation of research proposals, writing of scientific reports and research papers, proper citation practices, and oral/poster presentation of research findings.

ESSENTIAL READINGS:

1. Kumar, R., 2018. Research Methodology: A step-by-step guide for beginners. SAGE Publications.
2. Creswell, J.W. and Creswell, J.D., 2017. Research design: Qualitative, quantitative, and mixed methods approaches. SAGE Publications.
3. Sarma, D.D., 2009. Geostatistics with applications in earth sciences. Dordrecht: Springer Netherlands.
4. Davis, J.C. and Sampson, R.J., 1986. Statistics and data analysis in geology (Vol. 646). New York: Wiley.
5. Ferguson, J., 1988. Mathematics in geology. London: Allen & Unwin.

Tools for research

Duration: 15 Hours (Lecture) + 30 Hours (Practical)

Course Title and Code	Total Credit	Credit distribution in the course		
Tools for research	2	Lecture	Tutorial	Practical
		01	0	01

LEARNING OBJECTIVES

- To introduce tools used in academic research.
- To train students in searching research literature effectively.
- To develop skills in reference management, plagiarism checking, and document preparation.
- To familiarize students with research writing using software tools.

LEARNING OUTCOMES

- Identify and apply effective techniques for searching academic information using tools like Google Scholar, Scopus, and Web of Science.
- Use reference management tools such as Zotero and Mendeley to manage citations and generate bibliographies in standard formats (APA, MLA).
- Utilize AI-based research and writing tools including Paperguide, ChatPDF, Notebook LM, QuillBot, Grammarly, and Paperpal for research assistance and document improvement.

LECTURE **1 Credit (15 Hours)**

Unit I: Research Information Search and Reference Management (7.5 Hours)

Methods to search required information effectively, Keyword searching and advanced search strategies, Use of academic databases such as Google Scholar, Scopus, and Web of Science, Pre-writing considerations in research, Identifying research problems and basics of literature review, Importance of proper citation and referencing, reference management using Zotero and Mendeley, Generating bibliography and citations (APA, IEEE, MLA styles), Core AI Research Tools like Paperguide, Chat PDF etc, Practical AI Application Tools (Writing, Editing, & Data) like NotebookLM , Quillbot, Grammarly, Paperpal etc.

Unit II: Research Document Preparation, Presentation and Ethics (7.5 Hours)

Software for paper formatting and document preparation, Introduction to Microsoft Office, Writing research papers, theses, and reports using Microsoft Office, Bibliography creation using Microsoft Office tools, Creating presentations using PowerPoint presentation, Concepts of plagiarism and research ethics, Plagiarism detection tools such as Turnitin and iThenticate

PRACTICAL **1 credit (30 Hrs)**

- Searching research papers using Google Scholar
- Downloading and organizing research articles,
- Importing research papers into Zotero/Mendeley,
- Creating bibliography and citations automatically.
- Formatting reports using MS Office, Checking plagiarism reports using Turnitin/iThenticate.
- Interpreting similarity index

ESSENTIAL READINGS:

1. Ranjit Kumar, “Research Methodology: A Step by Step Guide for Beginners”, 2nd Edition, SAGE Publications Ltd.

2. G.C. Ramamurthy, “Research Methodology”, Dream Tech Press, New Delhi

Semester-II

DSC 10: Engineering Geology Duration: 45 Hours (Lectures) + 30 Hours (Practical)

Course Title and Code	Total Credit	Credit distribution in course		
Engineering Geology	4	Lecture	Tutorial	Practical
		03	0	01

LEARNING OBJECTIVES:

- This course aims to provide an in-depth understanding of rock mechanics and engineering geology principles
- The course will emphasize the mechanical behaviour of rocks, rock mass characterization, and slope stability analysis.
- It will focus on the geological and geotechnical investigations required for designing and evaluating engineering structures such as tunnels, dams, and foundations.

LEARNING OUTCOMES:

- Students will be able to explain the fundamental concepts of rock mechanics, stress-strain behaviour in rock, and rock mass classification systems.
- Students will be able to analyze slope stability problems and propose suitable stabilization and foundation treatment techniques.
- They will be able to apply geological and geotechnical principles, along with relevant software tools
- Students will be able to assess and design engineering structures in varied geological settings.

LECTURE **3 Credit (45 Hrs)**

Unit- I **(11 Hours)**

Development of rock mechanics and rock engineering. Rock strength; stress-strain relationships, *in-situ* stress measurements and their geological significance. Hoek’s Brown criterion of rock failure. Structural discontinuities and their types; their effect on Rock Mass Strength.

Unit- II **(10 Hours)**

Engineering properties of rocks and soil. Engineering bedrock and their characteristics. Laboratory index and strength tests for rocks and soil.

Unit- III **(10 Hours)**

Rock slope failure mechanism. Mass wasting and their types. Rock slope stabilization techniques; factor of safety. Application of rock mechanics for underground openings, rock slope engineering, and foundation engineering. Landslide hazard zonation mapping.

Unit- IV **(14 Hours)**

Reservoir Induced Seismicity: their cause, effects and mitigation measures. Geological and geotechnical investigation for site selection and foundation treatment of dams, reservoirs, and tunnels. Case histories on rock engineering design and the geological, geophysical, and geotechnical aspects of megastructures, including major Indian examples such as the Tehri Dam, Chenab Bridge, and Rohtang Tunnel, along with other significant global engineering projects and their documented failures.

Comparative analysis of failure and successes of mega projects and their environmental impacts.

PRACTICAL **1 Credit (30 Hours)**

Rock Mass Classification: Rock Structure Rating; Rock Mass Rating; Q-System; Rock Quality Designation.

1) Geological mapping of engineering sites and assessment of site selection
2) Application of engineering software such as Stereonet, Rockworks, Rock-Slide etc.

ESSENTIAL READINGS:

1. Krynin, D.P. and Judd, W.R. (1957). Principles of Engineering Geology and Geotechnique, McGraw Hill (CBS Publ).
2. Gangopadhyay, S. (2013). Engineering geology. Oxford University Press.
3. Goodman, R.E. (1993). Engineering Geology: Rock in engineering constructions. Wiley& Sons, N.Y.
4. Waltham, T. (2009). Foundations of Engineering Geology (3rd Edn.) Taylor & Francis.
5. Bell, F.G. (2007). Engineering Geology, Butterworth-Heinema.

SUGGESTED READINGS:

1. Anbalagan, R. Singh, B, Chakraborthy, D. and Kohli, A. (2007) “A filed Manual for Landslide investigations”. DST, Government of India, New Delhi.
2. Duncan C. Wyllie and Christopher W. Mah. (2004). Rock Slope Engineering. CRC Press. London.
3. David George Price (2009). Engineering Geology: Principles and Practice. Springer-Verlag Berlin Heidelberg.
4. Hoek, E., and Brown, E.T. (2019). The Hoek–Brown Failure Criterion – 2018 Edition. Rockscience.

DSC 11: Sequence stratigraphy and Basin analysis Duration: 45 Hours (Lectures) + 30 Hours (Practical)

Course Title and Code	Total Credit	Credit distribution in course		
		Lecture	Tutorial	Practical
Sequence stratigraphy and Basin analysis	4	03	0	01

Objectives:

To make the student understand

- A combination of forcings viz. tectonics and subsidence, Eustacy and Sediment supply shape filling and evolutionary history of any sedimentary basin.
- Sequence stratigraphy and Basin Analysis deals with subdivision of sedimentary basins fills into genetic packages bounded by unconformities and their correlative conformitites.
- to unravel before the student various nuances of this fascinating art of deconvolution of basin evolution history.

Learning Outcomes:

- To understand key concepts of Base level, Basin Accommodation Space, Eustatic and Relative Sea level change, Transgression/Regression and stratigraphic cyclicity
- To describe geometries of stratal surfaces, their terminations and key role in defining facies packaging
- To understand concepts of Systems Tracts, patterns of facies packaging within Systems Tracts and their bounding surfaces
- To comprehend Sequence development models in basins of different tectonic setting
- To understand methodologies of basin analysis, importance of Isopach and paleocurrent
- To comprehend parameters of basin analysis

Contents:

Unit I: Sequence stratigraphy: An integrated approach towards Applied stratigraphy

Historical developments. Definitions and key concepts. Base level (stratigraphic and geomorphic) changes, Eustatic and Relative Sea level, Transgressions and regressions, T-R cycles. Regional and global stratigraphic cycles.

Unit II: Stratigraphic surfaces, Systems Tracts and Sequence Models: Unconformity, Flooding surface ...... Stratal geometry, terminations, sequence stratigraphic surfaces. Unconformity and correlative conformity, Basal surface of Marine regression, Ravinement surface, Initial and maximum flooding surface

Unit III: Systems Tracts: Falling Stage (FSST), Lowstand (LST), Transgressive (TST), Highstand (HST), Falling stage. Sequence Models: Depositional sequence (Type I, II, III), Genetic stratigraphic sequence, Transgressive-Regressive sequence. Hierarchy of sequences and bounding surfaces.

Unit IV: Sedimentary basins in tectonic backdrop

a) Tectonic classification of sedimentary basins. Classification of sedimentary basins in India. Tectonics and sedimentation; Evolution of sedimentary basins in different tectonic settings

b) Geohistory analysis: Thermal history, Porosity and Burial depth. Subsidence and Thermal history of divergent margin basins, convergent margin basins, transform and transcurrent fault basins, basins developed during continental collision and suturing and cratonic basins. Review of Indian basins.

Practical:

1. Exercises related to gradient of relative sea level curve and facies belt migration

2. Exercises related to Eustacy and Tectonics

3. Exercises related to Systems Tracts and their bounding surfaces

4. Exercises related to facies stacking pattern, lateral correlation and demarcation of Systems Tracts

Suggested Readings:

1. Principles of sedimentary basin analysis: A.D.Miall (1999), Springer

2. Sequence Stratigraphy: D. Emery, and K. Mayers (1996) Blackwell Publishers

3. Principles of Sequence Stratigraphy: Octavian Catuneanu (2006) Elsevier

4. Basin Analysis: Principles and Applications: P.A. Allen and J.R.Allen (1990) Blackwell

Publishing

5. The geology of stratigraphic sequences: A.D. Miall (1997) Springer

6. Tectonics of Sedimentary basins. Buby, C. and Azor, A. (2012) Wiley Blackwel

E-pathsala module:
https://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/s000448go/p000594/m022675/et/1505974094e- extsedimentarybasinsandtheirclassification.

DSE 11: Petroleum and Coal Geology

Duration: 45 Hours (Lecture)+ 30 Hours (Practical)

Course Title and Code	Total Credit	Credit distribution in course		
Petroleum and Coal Geology	4	Lecture	Tutorial	Practical
		03	0	01

LEARNING OBJECTIVES:

- Understand the different types of natural fuels, their origin, and the mechanisms involved in the generation, accumulation, and migration of hydrocarbons.
- Learn the major hypotheses related to the formation of hydrocarbons and coal, and examine coal as a significant reservoir of plant-derived carbon and organic matter.
- Develop knowledge of coal-forming environments, coalification processes, coal microscopy, petrography, classification, analytical techniques, and industrial applications of coal.
- Explore coal as an unconventional energy resource, including Coal Bed Methane (CBM) and synthetic crude oil, along with their environmental implications.

LEARNING OUTCOMES:

- Understand the mechanisms of hydrocarbon generation from organic matter and the influence of temperature, pressure, and other physical parameters on hydrocarbon distribution.
- Examine different sedimentary environments through geological records and evaluate their role in controlling hydrocarbon generation potential.

- Develop knowledge of coal fundamentals, coal-forming sedimentary environments, the influence of tectonics and sea-level changes on coal formation and quality, and the principles of coal classification.

- Learn analytical techniques in coal studies, including macerals and their microscopic properties, and explore applications such as coal utilization, underground coal gasification, clean coal technology, carbonization, CBM, coal liquefaction, and their environmental implications in India.

Lecture **3 Credit (45 Hrs)**

Unit I: Petroleum Geology and Petroleum System **(12 Hrs)**

Introduction to petroleum geology, physical and chemical properties of petroleum, and theories of petroleum origin. Formation of source rocks, kerogen evolution, organic maturation, and thermal cracking. Reservoir rocks: types, classification, porosity, permeability, and capillary properties. Hydrocarbon migration: primary and secondary migration, controlling factors, migration pathways, and relative permeability.

Unit II: Hydrocarbon Traps and Petroleum Basins **(10 Hrs)**

Hydrocarbon traps: definition, classification, and timing of trap formation and hydrocarbon accumulation. Cap rocks and their properties. Plate tectonics and global hydrocarbon distribution. Methods of petroleum prospecting and geological modeling. Major oil belts of the world and petroleum geology of important Indian basins including Assam-Arakan, Cambay, Cauvery, Krishna-Godavari, and Bombay Offshore basins.

Unit III: Coal Geology and Classification **(12 Hrs)**

Origin, formation, and classification of coal. Coal-forming environments, effects of sea-level change and tectonics, coalification processes, peat bogs, swamps, cyclothems, and coal seam structures. Classification of coal based on type, grade, rank, coking and non-coking characteristics, and international standards.

Unit IV: Coal Petrography and Industrial Applications **(11 Hrs)**

Coal composition, lithotypes, microlithotypes, and analytical techniques, including proximate and ultimate analysis. Macerals: classification, properties, microscopy, reflectance, and fluorescence studies. Applications of coal petrography in seam correlation, paleoclimate, and palaeogeography. Industrial applications of coal, CBM, underground coal gasification, coal liquefaction, carbonisation, clean coal technology, and distribution of coal and lignite in India in relation to Gondwanaland and plate tectonics.

Practical **1 Credit (30 Hrs)**

- Macroscopic characterization and classification of banded coals based on lithological and physical properties, including identification of coal lithotypes and their depositional significance.

- Completion and interpretation of coal outcrop maps, correlation of coal seams, construction of geological cross-sections, and estimation of coal reserves using standard methods.
- Preparation of polished particulate mounts of coal samples for petrographic analysis under reflected light microscopy.
- Microscopic identification and classification of coal macerals and microlithotypes, and interpretation of coal rank, maturity, and depositional environment.
- Study and interpretation of geological maps and cross-sections of major oilfields of India, including structural and stratigraphic features related to petroleum accumulation.
- Calculation and estimation of petroleum reserves using standard volumetric methods and reservoir parameters.

Suggested Readings:

1. Barker, C. (1996): Thermal Modeling of Petroleum Generation, Elsevier Science.
2. Jahn, F., Cook, M. and Graham, M. (1998):Hydrocarbon Exploration and Production, Eslevier Science.
3. Makhous, M. (2000): The Formation of Hydrocarbon Deposits in North African Basins, Geological and Geochemical Conditions, Springer-Verlag.
4. North, F.K. (1985): Petroleum Geology, Allen Unwin. Selley, R.C. (1998): Elements of petroleum geology, Academic Press.
5. Tissot, B.P. and Welte, D.H. (1984): Petroleum formation and occurrence, Springer–Verlag.
6. Chandra, D., Singh, R.M., Singh M.P., (2000): Text book of coal (Indian context), Tara Book Agency, Varanasi.
7. Scott, A.C., (1987): Coal and coal bearing strata: Recent Advances, Blackwell Scientifics Publications.
8. Stach, E., Mackowsky, M-Th., Tylor, G.H., Chandra, D., Teichumullelr, L . and Teichumuller, R. (1982): Text book on coal petrology, Gebruder Borntreager Stuttgart.
9. Taylor, G.H., Teichmuller, M., Davis, A., Diessel, C.F.K., Littke, R and Robert, P. (1998): Organic Petrology. Gebruder Borntreager Stuttgart.
10. Thomas Larry (2002): Coal Geology. John Wiley and Sons. Ltd. England.
11. Van Krevelen, D.W. (1993): Coal: Typology-Physics-Chemistry-Constitution. Elsevier Scienc, Netherlands.

DSE 12: Earthquakes: A geological perspective

Course Title and Code	**Total Credit**	**Credit distribution in course**		
Earthquake Geology and Seismotectonics	**4**	**Lecture**	**Tutorial**	**Practical**
		03	**0**	**01**

Course Objectives:

- The use of geological methods, in their broadest sense, is crucial for understanding and investigating seismic events for effective seismic hazard assessment.

- The paper aims to introduce the concepts of structural geology, seismology, and risk assessment to better understand the earthquake mechanism and associated risks.

Course Learning Outcomes:

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

- Demonstrate an understanding of rock deformation, stress–strain relationships, and fault mechanics associated with earthquake processes.
- Understand earthquake cycle models and analyse the geomorphic expressions of active tectonics.
- Apply geodetic techniques for analysing crustal deformation and seismic source characteristics.
- Understand the properties of seismic waves, their measurement and applications.
- Evaluate seismic hazards based on the geological and seismic data.

Unit I **(10 Hours)**

Rock deformation and structure: Stress and strain, Mohr Failure Envelope, shear-fracture criteria, Griffith crack theory, friction, and the effect of pore fluid. Change in rock strength at depth – abrasive versus adhesive wear.

Earthquake Cycle: Earthquake Models; Asperities and barriers along a fault, Fault length and displacement variation, Fault segment linkage, Geomorphic expression of faults. Characteristic earthquake. Scaling ratios of faults. Slow, quiet and silent earthquakes; microearthquakes, small, moderate, large and mega earthquakes.

Unit II **(10 Hours)**

Geodetic measurements of crustal deformation: Conventional geodetic methods: triangulation, trilateration and levelling; Space-based geodesy: Very Long Baseline Interferometry, Satellite Laser Ranging, Global Navigation Satellite Systems, Synthetic Aperture Radar.

Geology of the Seismic Source Region: Depth distribution of earthquakes, slip patterns along a fault plane. Deep focus intra-plate earthquakes within the ductile regime.

Unit III: **(15 Hours)**

Seismology: Seismic waves – types and physical characteristics; Velocity structure of the Earth and different seismic phases; measurement of earthquakes; locating earthquakes. Earthquake magnitude; Intensity measurement– Intensity scales; Energy of an earthquake. Gutenberg-Richter relationships, b value. Seismic inversion, Seismic tomography. Earthquake source mechanism: double-couple mechanism and fault-plane solutions.

Unit IV **(10 Hours)**

Seismic sources and hazard assessment: Subduction zone earthquakes; Intraplate seismicity – Stable Continental Region (SCR) earthquakes; Geomorphic and stratigraphic evidence of past earthquakes. Intraplate seismicity–Stable Continental Region (SCR) earthquakes.

Triggered and induced earthquakes. Secondary effects of earthquakes: Tsunami, liquefaction, landslides etc.

Seismic risk and hazard; Hazard assessment– probabilistic and deterministic approaches

Practical **(15 Hours)**

(i) Interpretation of the remote-sensing data for active faulting.
(ii) Phase identification in the seismic waveforms.
(iii) Determination of earthquake epicentre from the seismic waveforms.
(iv) Construction of the fault plane solution of earthquakes,
(v) Earthquake catalogue, b-value calculation, and magnitude calculation.
(vi) Trench logging and event interpretations.

Suggested Readings:

1. Scholz, C.H., 1990. The Mechanics of Earthquakes and Faulting Cambridge University Press.

2. Yeats, R.S., Sieh, K. and AlIen, C.R., 1997. The Geology of Earthquakes. Oxford University Press.

3. Burbank, D.W. and Anderson, R.S., 2012. Tectonic Geomorphology, Wiley-Blackwell Publishers.

4. McCalpin, James P., ed. Paleoseismology. 2nd ed. Amsterdam: Elsevier/Academic Press, 2009.

DSE 13: Climate Change and Sustainability

Duration: 45 Hours (Lecture)+ 30 Hours (Practical)

Course Title and Code	Total Credit	Credit distribution in the course		
		Lecture	Tutorial	Practical
Climate Change and Sustainability GEOL DSE 7 (iii) GEOL DSE 10 (i)	4	03	0	01

LEARNING OBJECTIVES:

- To understand the fundamental concepts and scientific basis of climate change.
- To examine the environmental, social and economic impacts of climate change.
- To develop awareness about sustainability and sustainable development practices.
- To analyse the relationship between natural resources, ecosystems and human activities.
- To understand climate change mitigation, adaptation and environmental governance strategies.
- To encourage critical thinking and responsible actions towards environmental sustainability.

LEARNING OUTCOMES:

- Students will be able to explain the causes and evidence of climate change.

- Students will be able to assess the impacts of climate change on ecosystems and society.
- Students will be able to interpret concepts of sustainability and sustainable development.
- Students will be able to evaluate environmental challenges and possible sustainable solutions.
- Students will be able to understand international climate policies and adaptation strategies.
- Students will be able to apply sustainability principles in academic, professional and daily life contexts.

Lecture: **3 Credit (45 Hrs)**

UNIT I: Fundamentals of Climate Change **(14 hrs)**

Weather, climate and climate system, Components of Earth's climate system, Greenhouse effect and greenhouse gases, Carbon cycle and energy balance, Natural vs anthropogenic climate change, Evidence of climate change, Global warming trends and temperature records, Role of oceans, atmosphere and cryosphere, Climate modelling and future projections, IPCC and climate assessment reports

Unit-II: Impacts of Climate Change **(12 hrs)**

Climate change and hydrological cycle, sea level rise and coastal vulnerability, extreme weather events: floods, droughts, cyclones and heat waves, impacts on biodiversity and ecosystems, agriculture and food security, water resources and human health, climate change and Himalayan glaciers, urban climate challenges, climate migration and socio-economic impacts, climate justice and vulnerable communities.

UNIT III: Sustainability and Sustainable Development **(11 hrs)**

Concept and principles of sustainability, sustainable development: history and evolution, United Nations Sustainable Development Goals (SDGs), ecological footprint and carrying capacity, sustainable consumption and production, renewable and non-renewable resources, circular economy and waste management, sustainable agriculture and water conservation, green buildings and sustainable cities, environmental ethics and traditional ecological knowledge.

UNIT IV: Climate Action, Policy and Future Pathways **(8 hrs)**

Climate change mitigation and adaptation, renewable energy technologies, carbon neutrality and net-zero concepts, carbon sequestration and nature-based solutions, international climate agreements: UNFCCC, Kyoto Protocol and Paris Agreement, climate finance and carbon markets, disaster risk reduction and resilience planning, community participation and environmental governance, role of education, innovation and technology, lifestyle changes for sustainability

Practical **1 Credit (30 Hrs)**

1. Study and interpretation of temperature, rainfall and carbon dioxide datasets to understand climate trends.
2. Analysis of paleoclimatic data to understand long term climate change. Study of Sea Level Change curves in recent and geological past.

3. Preparation of a case study on floods, droughts, glacier retreat, coastal erosion or extreme weather events.
4. Evaluation of selected SDGs and their implementation at local, national or global levels.

Essential Readings

1. Climate Change 2021: The Physical Science Basis, edited by Valérie Masson-Delmotte et al., Cambridge University Press, 2021.
2. Introduction to Climate Change, by David D. Kemp, Cambridge University Press, 2012.
3. Sustainability Principles and Practice, by Margaret Robertson, Routledge, 2017.
4. Bradley, R. S., Quaternary Paleoclimatology: Methods of Paleoclimatic Reconstruction, Academic Press, 3rd Edition, 2015.
5. Earth's Climate: Past and Future, by William F. Ruddiman, W. H. Freeman and Company, 3rd Edition, 2014

DSE 14: Applied Hydrogeology

Course Title and Code	Total Credit	Credit distribution in course		
		Lecture	**Tutorial**	**Practical**
Applied Hydrogeology	**4**	**03**	**0**	**01**

LEARNING OBJECTIVES:

- The course content aims to enrich the knowledge of the students in the field of applied hydrogeology.
- The teaching and learning process focuses on conceptual clarity of the applied aspects of the subject.
- Students will apply the knowledge they have gained in solving real-world problems as part of the learning process.

LEARNING OUTCOMES:

- The students will learn about the surface- groundwater dynamics; basics of River hydrology; River hydrographs and the flow nets.
- The course imparts knowledge about the advanced and applied aspects of well hydraulics where students will learn in detail about the pumping test data analysis of unconfined and semi-confined aquifers. The learning process will make students familiar with groundwater modelling
- The students will learn the basic concepts related to the use of isotopes in hydrogeological studies.
- The students will learn about the utility of hydrogeology in infrastructure projects; groundwater resources estimation; groundwater management and governance.

LECTURE **3 Credit (45 Hrs)**

Unit I: General concepts: **(4 hrs.)**

Surface water and groundwater interaction. Stream discharge parameters and their measurement. Stage-discharge relationship and rating curves, River Hydrographs. Flow nets.

Unit II: Well Hydraulics and Groundwater Modelling: (22 hrs.)

Pumping tests - methods, data analysis and diagnostic plots. Well design and well Performance Tests. Evaluation of the aquifer parameters from pumping test data of the unconfined and semi-confined aquifers (Walton's method). Evaluation of the aquifer parameters from the recovery data of the pumping tests. Basic concepts of groundwater modelling and the governing equations. Model conceptualisation; design and execution; sensitivity analysis; calibration; validation; assessment and prediction based on the model.

Unit III: Isotope hydrogeology: (4 hrs)

Basic concepts. Stable isotopes in the hydrogeological study. Radio isotopes in the hydrogeological study.

Unit IV: Groundwater management: (15 hrs)

Groundwater problems related to foundation work, mining, canals, dams, reservoirs and tunnels. Water balance and groundwater resources estimation. Problems of overexploitation and groundwater mining. Groundwater management: supply side and demand side management. Rainwater harvesting and managed aquifer recharge. Conjunctive use of surface and groundwater. Groundwater management in urban and rural areas, arid and semi-arid areas. Possible climate change impact on the groundwater resources and the mitigation measures. Concept of sustainable development of groundwater resources. Groundwater legislation. Hydrogeology of arid zones of India and the management issues. Hydrogeology of the wetlands and the management issues.

PRACTICAL (30 Hours)

1. Hands-on exercises using real-time groundwater level data (DWLR, etc)
2. Estimation of stream discharge, rating curves
3. River hydrographs related exercises
4. Flow net related exercises
5. Evaluation of Well Performance Tests data
6. Diagnostic plots-based aquifer assessment
7. Evaluation of the aquifer parameters from the pumping test data of unconfined aquifers
8. Evaluation of the aquifer parameters from the pumping test data of semi-confined aquifers (Walton's method)
9. Pumping test data analysis from the recovery data
10. Hands-on exercises on groundwater flow model, conceptualization, design, execution, calibration, validation and prediction
11. Interpretation of environmental isotope data of water samples

ESSENTIAL READING:

1. Fetter, C.W., and D. Kreamer. 2022. *Applied Hydrogeology*, 5th ed. Waveland Press.
2. Fitts, C.R., 2023. *Groundwater Science* (3rd ed.), Academic Press.
3. Karanth K.R., 1987. *Groundwater: Assessment, Development and Management*, Tata McGraw-Hill Pub. Co. Ltd.

4. Todd, D. and Mays, L. 2005 *Groundwater Hydrology*. (3rd ed.), John Wiley and Sons, Inc.
5. Kruesman, G.P and De Ridder N.A., 1990. *Analysis and Evaluation of Pumping Test Data,* International Institute for Land Reclamation and Improvement.
6. Clark, I.D., 2015. *Groundwater Geochemistry and Isotopes*, CRC Press.

SUGGESTED READING:

1. Anderson, M., Woessner, W., Hunt, R., 2015. *Applied Groundwater Modelling*, Elsevier.
2. Thangarajan, M., Singh V.P., 2016. *Groundwater Assessment, Modelling and Management*, CRC Press.
3. Thangarajan, M., 2007. *Groundwater: Resource Evaluation, Augmentation, Contamination, Restoration, Modelling and Management*, Springer.
4. Schwartz, F.W. and Zhang, H., 2024. *Fundamentals of groundwater* (2nd Edition). John Wiley & Sons.
5. Hiscock, K.M. and Bense, V.F., 2021. *Hydrogeology: principles and practice* (3rd Edition). John Wiley & Sons.

DSE 15: Geo-Archaeology

Course Title and Code	**Total Credit**	**Credit distribution in course**		
Geo-Archeology	**4**	**Lecture**	**Tutorial**	**Practical**
		03	**0**	**01**

Learning Objective

- To introduce geoarchaeology from an Earth surface systems perspective.
- To introduce the concept of Anthropocene and debates around it.
- To introduce how geomorphic, sedimentary, and geochemical processes shape the archaeological record and human–environment interactions from the Quaternary to the Anthropocene.

Learning Outcomes

By the end of the course, students will be able to:

- Explain the relationship between Quaternary environmental change and human evolution
- Interpret archaeological sites using geomorphological and stratigraphic principles
- Apply basic geochronological and geochemical methods in geoarchaeological contexts
- Analyse site formation processes using sedimentological and biogeochemical evidence
- Evaluate human impacts on Earth systems from early agriculture to the Anthropocene

Unit I: Quaternary Framework and Human Evolution

Quaternary timescale: glacial–interglacial cycles and environmental variability; Human evolution in environmental context; Dispersal of humans: Africa to Asia and India; Out of India hypothesis; Megafaunal extinctions: climatic vs anthropogenic drivers; Archaeological signatures: stone tools and early fire in geomorphic context

Unit II: Dating Methods in Geoarchaeology

Principles of geochronology: relative vs absolute dating; Radiometric methods: Radiocarbon (AMS), U-series, Argon dating; Luminescence dating: OSL/IRSL and applications in sediments; Surface and exposure dating; Dendrochronology; Applications and limitations in archaeological contexts

Unit III: Geoarchaeological Methods, Site Formation Processes and Preservation

Stratigraphy and microstratigraphy in site interpretation; Sedimentology and depositional environments; Organic geochemistry and biomolecular evidence; Stable isotope analysis in archaeology; Provenance analysis: ceramics, lithics, and sediments; Applications: paleoclimate, paleoenvironment, fire history, and diet; Site formation processes: natural vs anthropogenic; Role of geomorphic processes (fluvial, aeolian, slope) in site preservation; Settlement patterns in relation to landforms and resources; Catchment analysis and landscape use; Case studies from Indian subcontinent (river valleys, plateaus, coasts)

Unit IV: Human–Environment Interactions and the Anthropocene

Origins of agriculture and landscape transformation; Domestication and environmental change; Early anthropogenic impacts (CO_2, CH_4, Early Anthropogenic Hypothesis); Land use change: agriculture, mining, and urbanisation; Sustainability and the Anthropocene

Practical

1. Stratigraphic logging and section interpretation
2. Grain size analysis (sieve + pipette)
3. Soil micromorphology (introductory)
4. Fluvial geomorphology: river terrace mapping and site context
5. Experimental sedimentation (flume/tray)
6. Charcoal identification and basic anthracology
7. Luminescence (OSL) sampling demonstration

8. GIS-based terrain analysis and site catchment modelling

Essential Readings:

1. Cordova, C., 2018. Geoarchaeology: the human-environmental approach. Bloomsbury Publishing.

2. Rapp, G.R., Hill, C.L. and Rapp, M.R., 2006. Geoarchaeology: the earth-science approach to archaeological interpretation. Yale University Press.

Suggested Readings:

1. Goldberg, Paul, and Richard I. Macphail. 2006. Practical and Theoretical Geoarchaeology. Blackwell Science, Malden, Massachusetts

2. Walker, M., 2005. Quaternary dating methods. John Wiley & Sons.

3. Ruddiman, W.F., 2017. Plows, plagues, and petroleum: how humans took control of climate. Princeton University Press.

4. Suggested Papers from Quaternary Science Reviews, Journal of Quaternary Science, Earth Science Reviews, Quaternary International, etc.

GE 3 Natural Hazard and Disaster Management Duration: 45 Hours (Lectures) + 30 Hours (Practical)

Course Title and Code	Total Credit	Credit distribution in course		
		Lecture	**Tutorial**	**Practical**
Natural Hazards and Disaster Mitigation	4	03	0	01

LEARNING OBJECTIVES:

- Understand the causes and types of major natural hazards and their impacts.
- Explain the relationship between Earth processes and environmental hazards.
- Learn basic principles of disaster risk reduction and mitigation strategies.
- Develop awareness of disaster preparedness, response, and management practices.

LEARNING OUTCOMES:

After completion of the course, the students will learn:

- What is the Earth's composition and what are the various processes that make it a dynamic planet?
- How do the earth's natural processes turn into hazards and disasters?
- How do the different factors interact to create disaster risk?
- What are the existing approaches and frameworks to minimise the risk?

LECTURE **3 Credit (45 Hrs)**

Unit I: Introduction to the Earth system and natural hazards (10 hours)

Earth's composition: minerals and rocks, internal and atmospheric structure of Earth, Earth's energy sources. Dynamic Earth: Endogenic and exogenic processes in Earth, Balance in mass and energy flow in the Earth system, Equilibrium and perturbations in the natural equilibrium. **Disaster terminology:** Hazard, physical and social vulnerability, exposure, risk, susceptibility, coping capacity and disaster. Introduction to major natural hazards and Human-induced hazards: Geological hazards, Hydrometeorological hazards, Pandemics, and wars.

Unit II: Understanding geological hazards (15 hours)

Geological hazards and their causes, types, impacts, and mitigation measures: landslides, earthquakes, floods, coastal hazards, and volcanoes. Secondary impacts of natural hazards/disasters.

Unit III: Understanding hydrometeorological and other hazards (10 hours)

Hydrometeorological hazards, their causes and impacts: cyclones, drought, heat and cold waves. Pandemics, their causes and impacts; Human-induced hazards: wars and technology failure; climate change and its impact; Urban heat islands. Cascading and compound disaster.

Unit IV: Disaster Risk Reduction approaches (10 hours)

Disaster management cycle: Disaster preparedness, Hazard mitigation-structural and non-structural measures, Rescue, Relief and Rehabilitation, Response; cost-benefit analysis, Institutional and policy framework for disaster risk reduction. Sustainable development. Risk communication and technology in disaster risk reduction.

PRACTICAL (30 Hrs)

- Introduction to rocks and minerals;
- Introduction to maps;
- Vulnerability assessment;
- Hazard maps and hazard matrix;
- Mitigation strategies
- Seismic data and epicentre location.

Suggested Readings:

1. Allen, P. A. (1997). *Earth surface processes*. Wiley-Blackwell.
2. Highland, L. M., & Bobrowsky, P. (2008). *The landslide handbook—A guide to understanding landslides* (U.S. Geological Survey Circular 1325). U.S. Geological Survey. https://doi.org/10.3133/cir1325
3. U.S. Geological Survey. "Earthquake Magnitude, Energy Release, and Shaking Intensity." Accessed October 19, 2025. https://www.usgs.gov/programs/earthquake-hazards/earthquake-magnitude-energy-release-and-shaking-intensity.
4. Hyndman, D., & Hyndman, D. (2016). *Natural hazards and disasters* (5th ed.). Cengage Learning.
5. Keller, E. A., & Blodgett, R. H. (2021). *Natural hazards: Earth's processes as hazards, disasters, and catastrophes* (6th ed.). Pearson Education.

6. PG Diploma in Disaster Management (Textbooks). Indira Gandhi National Open University, New Delhi.
7. PreventionWeb. "Understanding Disaster Risk: Key Concepts." Accessed October 19, 2025. https://www.preventionweb.net/understanding-disaster-risk#key-concepts.

SBC 4 Thematic Geological Mapping Duration: 15 Hours (Lecture) + 30 Hours (Practical)

Course Title and Code	**Total Credit**	**Credit distribution in the course**		
Thematic Geological Mapping	**2**	**Lecture**	**Tutorial**	**Practical**
		01	**0**	**01**

LEARNING OBJECTIVES

- This course will introduce students to geological mapping, focusing on rock types, their affinities, and patterns of occurrence.
- Students will develop skills in rock identification, structural measurements, and geological interpretation in the field.

LEARNING OUTCOMES:

- Students will develop basic skills to carry out geological fieldwork in different terrains.
- Students will prepare geological maps and cross-sections from field data and interpret them in terms of stratigraphy, structure, and tectonics.
- They will use geological instruments (such as the Brunton compass, GPS).
- Students will also learn to plot data on base maps or toposheets to create lithological and structural maps and prepare a report

LECTURE **(15 hours)**

Unit- I: Introduction to Geological Mapping and rock identification **(6 Hours)**

Importance and scope of geological fieldwork. Topographic sheets: scales, symbols, and interpretation. Use of Brunton compass, GPS, and other field instruments. Base map and field notebook maintenance. Field safety, ethics, and logistics. Beds in deformed and undeformed terrains – rule of V. Identification and description of igneous, sedimentary, and metamorphic rocks in the field. Methods of delineating contacts between lithological units. Textural features of different rocks through field study and microscopy. Sampling techniques and field photography.

Unit- II: Structural Features **(9 Hours)**

Identification of various structural features in the field. Identification and structural measurement of a fold in the field. Geometric classification of a fold based on field data and understanding the outcrop pattern of a fold. Overprinting nature of folds and metamorphic foliations. Distinguishing criteria of a fault in the field. Measurement and plotting of planar and linear structures (strike, dip, joints, faults, folds, foliations, lineations). Use of stereonets and structural symbols on maps. Construction of cross-sections and interpretation of structure from outcrop patterns. Preparation of geological maps. Writing a detailed geological report with an interpretation of geological history.

PRACTICAL **(30 Hrs)**

All the aforementioned techniques for measurement and identification will be demonstrated and practiced in the field. The practical classes of this course will take place through a field visit in a suitable geological terrain.

Essential Readings:

1. Lisle, R.J., Brabham, P., & Barnes, J.W. (2011) Basic Geological Mapping, Wiley-Blackwell.
2. Lisle, R. J. (2004). Geological structures and maps: A practical guide. Elsevier.
3. Park, R. G. (2004) Foundations of Structural Geology. Chapman & Hall.
4. Davis, G. R. (1984) Structural Geology of Rocks and Region. John Wiley.

Research Methods/ Tools/ Writing

TECHNIQUES OF RESEARCH WRITING

Course Title and Code	Total Credit	Credit distribution in the course		
		Lecture	Tutorial	Practical
Techniques of Research Writing	2	01	01	0

LEARNING OBJECTIVES:

- To introduce students to the principles of publication, impact factor, ethics and issues such as plagiarism, authorship, and conflicts of interest in research sponsoring and publishing.
- To develop students' knowledge of citation styles, data presentation techniques, and digital tools used in academic publishing and journal selection.

LEARNING OUTCOMES:

- Understand the purpose and structure of academic research writing.
- Develop skills in formulating research questions and thesis statements.
- Apply proper citation and referencing techniques and follow ethical standards in academic writing and publishing.
- Avoid plagiarism and maintain academic integrity.

LECTURE **1 credit (15 Hours)**

Unit- I: Fundamentals of effective research paper writing; Need and knowledge gap for writing any research paper; Types of research writing (analytical, descriptive, argumentative); Academic Language and Style-Strategies to improve the writing process and exploring disciplinary requirements: Vocabulary-Effective use of words and expansion of vocabulary, Crafting better sentences and paragraphs, Effective and varied use of punctuation marks in complex sentences, text structure: clarity, coherence, and conciseness; Organization and streamlining the writing process; Structure of manuscript: Title and abstract, Introduction and problem statement, Methodology, Results and discussion, Conclusion and recommendations; Introduction to publication misconduct: plagiarism, authorship, ghostwriting, reproducible research, conflicts of interest; Citation and Referencing Styles.

Unit-II: Introduction to data presentation, editing and proofreading; Peer Review and introduction to open access publication; Introduction to software tools to identify predatory publications and journal suggestion tools like Elsevier Journal Finder, Springer, Journal Suggestion, etc.; Use of plagiarism detection software.

Tutorial **1 Credit (30 Hours)**

- Topic Selection Exercise: Choose a research topic and justify its relevance;
- Research Question Development: Formulating research questions, objectives and a thesis statement;
- Data collection basics (primary and secondary sources): Conducting literature review;
- Annotated Bibliography: Prepare summaries of at least 5 scholarly sources;
- Paragraph Writing Practice: Write structured paragraphs (introduction, body, conclusion);
- Citation Practice: Format references in APA/MLA style;
- Mini Research Paper: Write a short research paper (1000–1500 words) following proper structure.

Essential Readings:

1) The Craft of Research – Wayne C. Booth, Gregory G. Colomb & Joseph M. Williams
2) Writing Your Dissertation in Fifteen Minutes a Day – Joan Bolker
3) MLA Handbook – Modern Language Association
4) Mason J. (2002) Qualitative Researching. London: SAGE.
5) Weissberg R. & Buker S. (1990) Writing up Research. Englewood Cliffs, NJ: Prentice Hall.
6) Wolcott H.F. (1990) Writing Up Qualitative Research. Newbury Park, CA: SAGE.
7) Holliday A. (2007) Doing and Writing Qualitative Research. London: SAGE.
8) Silverman D. (2012) Doing Qualitative Research: a practical handbook. 4th edition. London: SAGE
9) Hopkins A. & Dudley-Evans T. (1988) A genre-based investigation of discussion sections in articles and dissertations. ESP Journal 7: 113-21.