



### CIRCULAR

Ref. No.: GU/Acad –PG/BoS -NEP/2025-26/214 dated 02.07.2025

In supersession to the above referred Circular, the syllabus of Semester III and IV of the **Master of Science in Applied Geology** Programme approved by the Standing Committee of the Academic Council in its meeting held 24<sup>th</sup> & 25<sup>th</sup> November 2025 is attached.

Further, the Syllabus of Semester I and II approved earlier by the Academic Council in its meeting held on 13<sup>th</sup> & 14<sup>th</sup> June 2025 is also attached.

The Dean & Vice-Dean (Academic) of the School of Earth, Ocean and Atmospheric Sciences are requested to take note of the above and bring the contents of the Circular to the notice of all concerned.

(Ashwin V. Lawande)  
Deputy Registrar – Academic

To,

1. The Dean, School of Earth, Ocean and Atmospheric Sciences, Goa University.
2. The Vice-Dean (Academic), School of Earth, Ocean and Atmospheric Science, Goa University.

Copy to:

3. Chairperson, BoS in Earth Science, Goa University.
4. Programme Director, M.Sc. Applied Geology, Goa University.
5. Controller of Examinations, Goa University.
6. Assistant Registrar Examinations (PG), Goa University.
7. Directorate of Internal Quality Assurance, Goa University for uploading the Syllabus on the University website.

# GOA UNIVERSITY

## **Master of Science in Applied Geology** (Effective from the academic year 2025-2026)

### **ABOUT THE PROGRAMME**

Geology is one of the fundamental scientific disciplines of study which deals with understanding the earth and its processes - both operating on the earth as well as in its interior. Its study helps to manage resources and prepare for natural disasters. It provides insights into the earth's history, improves our knowledge of environmental challenges and is essential for resource exploration and extraction. This discipline is important in order to know how geological processes affect our lives and will continue to affect. Geologists play a very important role in various fields like natural resource exploration, environmental protection and hazard assessment, locating valuable mineral deposits, and predicting earthquakes and others. Geologists use their expertise to safeguard our planet and its inhabitants.

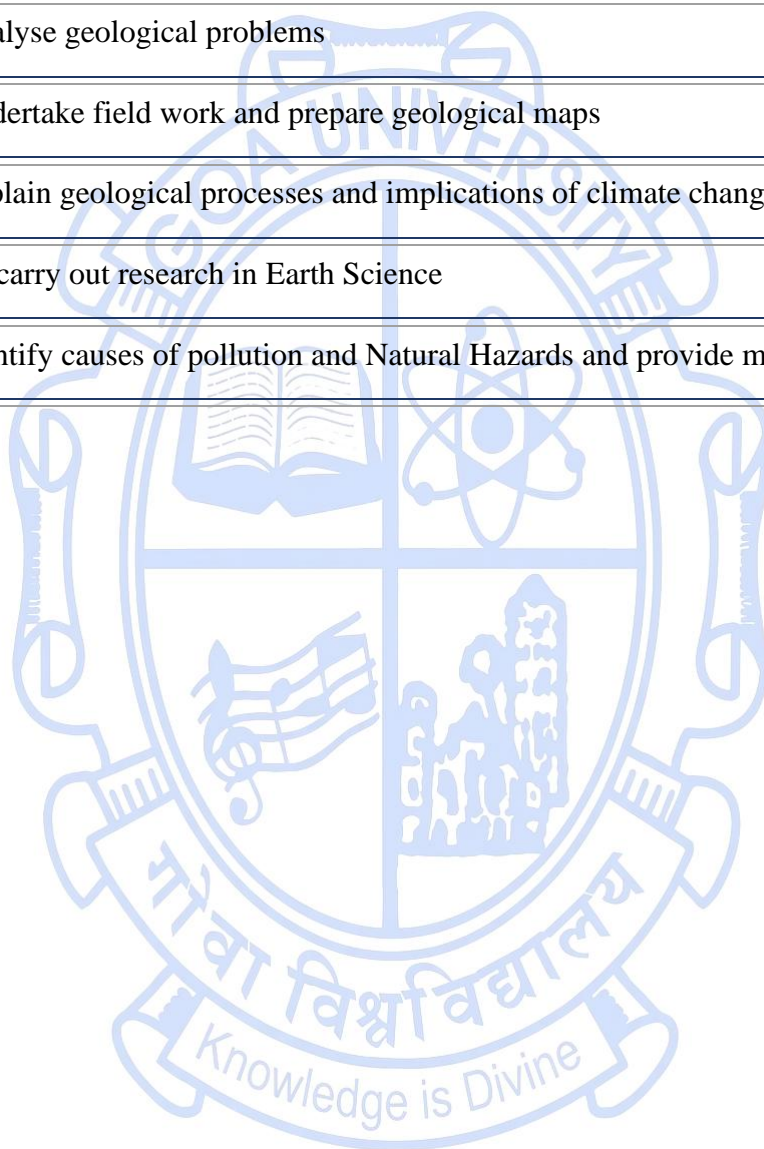
The program offers courses and research opportunities for advanced study in geology, mineralogy, petrology, remote sensing, GIS, petroleum geology, groundwater geology, structural geology, environmental geology, mining geology, climate geology, engineering geology and microplastic pollution. The program has an established museum featuring an extensive collection of minerals, rocks, ores and fossils.

### **OBJECTIVES OF THE PROGRAMME**

To focus on understanding fundamental principles and concepts and to gain theoretical and practical knowledge of geological science which will enable recognition, evaluation, carry out interpretation, and understanding and solving of issues in the geological domain.

**PROGRAMME SPECIFIC OUTCOMES (PSO)**

<b>PSO 1.</b>	Describe the science of the origin, composition, age and evolution of the Earth and/or other objects in the universe.
<b>PSO 2.</b>	Interpret the geological processes that lead to changes in the interior and exterior of the Earth
<b>PSO 3.</b>	Analyse geological problems
<b>PSO 4.</b>	Undertake field work and prepare geological maps
<b>PSO 5.</b>	Explain geological processes and implications of climate change
<b>PSO 6.</b>	To carry out research in Earth Science
<b>PSO 7.</b>	Identify causes of pollution and Natural Hazards and provide mitigation



## PROGRAMME STRUCTURE

### Master of Science in Applied Geology Effective from the Academic Year 2025-2026

<b>Bridge Course</b>			
Sr. No.	Course Code	Title of the Course	Credits
1	<a href="#"><u>GEO-1000</u></a>	Bridge course in Applied Geology	2

<b>SEMESTER I</b>				
<b>Discipline Specific Core (DSC) Courses (16 credits)</b>				
Sr. No.	Course Code	Title of the Course	Credits (s)	Level
1	<a href="#"><u>GEO-5000</u></a>	Mineralogy and Geochemistry	3T	400
2	<a href="#"><u>GEO-5001</u></a>	Practical of Mineralogy and Geochemistry	1P	400
3	<a href="#"><u>GEO-5002</u></a>	Structural Geology and Geotectonics	3T	400
4	<a href="#"><u>GEO-5003</u></a>	Practical of Structural Geology and Geotectonics	1P	400
5	<a href="#"><u>GEO-5004</u></a>	Igneous Petrology	3T	400
6	<a href="#"><u>GEO-5005</u></a>	Practical of Igneous Petrology	1P	400
7	<a href="#"><u>GEO-5006</u></a>	Economic Geology	3T	400
8	<a href="#"><u>GEO-5007</u></a>	Practical of Economic Geology	1P	400
<b>Total Credits for DSC Courses in Semester I</b>			<b>16</b>	
<b>Discipline Specific Elective (DSE) (4 Credits)</b>				
Sr. No.	Course Code	Title of the Course	Credits (s)	Level
1	<a href="#"><u>GEO-5201</u></a>	Marine Geology	3T	400
2	<a href="#"><u>GEO-5202</u></a>	Practical of Marine Geology	1P	400
3	<a href="#"><u>GEO-5203</u></a>	Environmental Geology	3T	400
4	<a href="#"><u>GEO-5204</u></a>	Practical of Environmental Geology	1P	400
<b>Total Credits for DSE Courses in Semester I</b>			<b>4</b>	
<b>Total Credits in Semester I</b>			<b>20</b>	

<b>SEMESTER II</b>				
<b>Discipline Specific Core (DSC) Courses (16 credits)</b>				
<b>Sr. No.</b>	<b>Course Code</b>	<b>Title of the Course</b>	<b>Credits (s)</b>	<b>Level</b>
1	<a href="#">GEO-5008</a>	Sedimentology	3T	500
2	<a href="#">GEO-5009</a>	Practical of Sedimentology	1P	500
3	<a href="#">GEO-5010</a>	Metamorphic Petrology	3T	500
4	<a href="#">GEO-5011</a>	Practical of Metamorphic Petrology	1P	500
5	<a href="#">GEO-5012</a>	Stratigraphy and Indian Geology	3T	500
6	<a href="#">GEO-5013</a>	Practical of Stratigraphy and Indian Geology	1P	500
7	<a href="#">GEO-5014</a>	Geological Field Mapping (Skilled Based Course)	1T	500
8	<a href="#">GEO-5015</a>	Practical Geological Field Mapping (Skilled Based Course)	3P	500
<b>Total Credits for DSC Courses in Semester II</b>			<b>16</b>	
<b>Discipline Specific Elective (DSE) (4 Credits)</b>				
<b>Sr. No.</b>	<b>Course Code</b>	<b>Title of the Course</b>	<b>Credits (s)</b>	<b>Level</b>
1	<a href="#">GEO-5205</a>	Exploration Geophysics	3T	400
2	<a href="#">GEO-5206</a>	Practical of Exploration Geophysics	1P	400
3	<a href="#">GEO-5207</a>	Petroleum Geology (Skill Based Course)	3T	400
4	<a href="#">GEO-5208</a>	Practical of Petroleum Geology (Skill Based Course)	1P	400
<b>Total Credits for DSE Courses in Semester II</b>			<b>4</b>	
<b>Total Credits in Semester II</b>			<b>20</b>	

**SEMESTER III****Research Specific Elective (RSE) Courses (12 credits)**

Sr. No.	Course Code	Title of the Course	Credits	Level
1	<a href="#">GEO-6000</a>	Groundwater Geology	3T	500
2	<a href="#">GEO-6001</a>	Practical of Groundwater Geology	1P	500
3	<a href="#">GEO-6002</a>	Microtectonics	3T	500
4	<a href="#">GEO-6003</a>	Practical of Microtectonics	1P	500
5	<a href="#">GEO-6004</a>	Paleontology	3T	500
6	<a href="#">GEO-6005</a>	Practical of Paleontology	1P	500
7	<a href="#">GEO-6006</a>	Trace Element Geochemistry	3T	500
8	<a href="#">GEO-6007</a>	Practical of Trace Element Geochemistry	1P	500
9	<a href="#">GEO-6008</a>	Micropaleontology	3T	500
10	<a href="#">GEO-6009</a>	Practical of Micropaleontology	1P	500
11	<a href="#">GEO-6010</a>	Research Methodology in Geology	4T	500
12	<a href="#">GEO-6011</a>	Precambrian Crustal Evolution	2T	500
13	<a href="#">GEO-6012</a>	Radiometric Isotope Dating	2T	500
14	<a href="#">GEO-6013</a>	Climate Geology	2T	500
15	<a href="#">GEO-6014</a>	Microplastic Pollution Studies	2T	500
16	<a href="#">GEO-6015</a>	Basics of RS, GIS and GNSS (IIRS-ISRO online Edusat course)	3T	500
17	<a href="#">GEO-6016</a>	Practical of Basics of RS, GIS and GNSS (IIRS-ISRO online Edusat course)	1P	500
18	<a href="#">GEO-6017</a>	Statistical Methods in Geology	3T	500
19	<a href="#">GEO-6018</a>	Practical of Statistical Methods in Geology	1P	500
<b>Total Credits for RSE Courses in Semester III</b>			<b>12</b>	

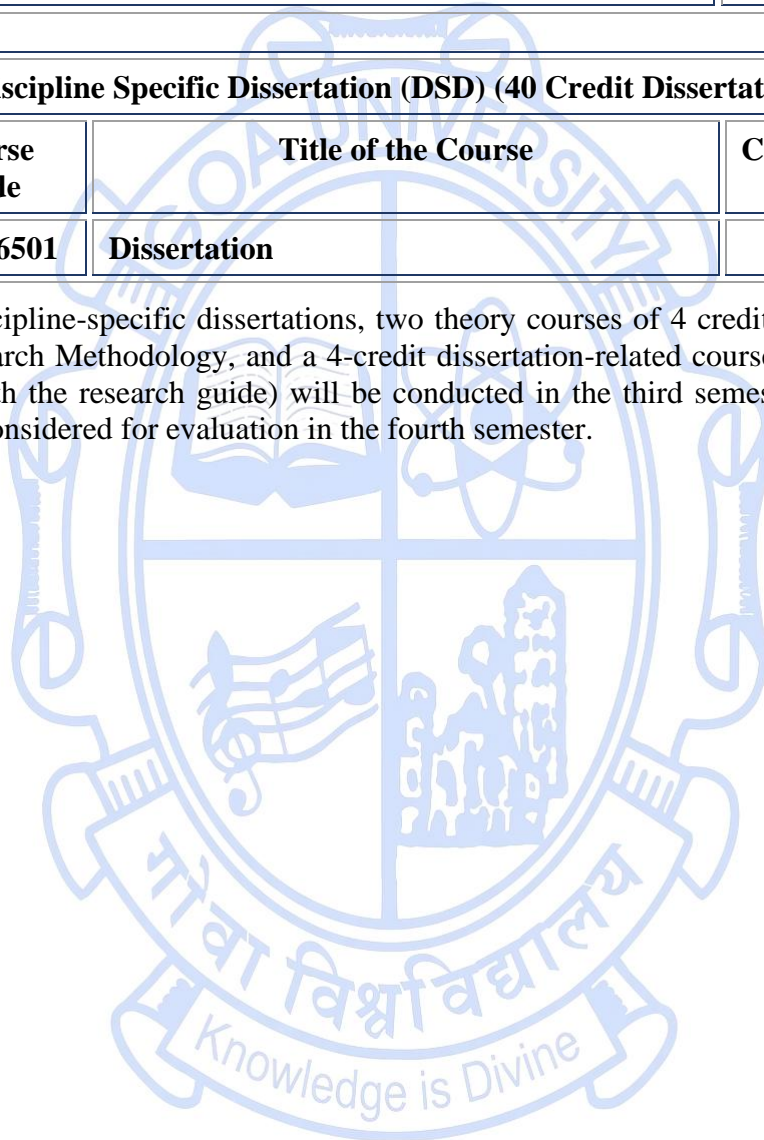
**Discipline Specific Vocational Elective (DSVE) Courses (8 credits)**

Sr. No.	Course Code	Title of the Course	Credits	Level
1	<a href="#">GEO-6401</a>	Geological Field Training	4P	500
2	<a href="#">GEO-6402</a>	Mining Geology	2T-2P	500

3	<a href="#">GEO-6403</a>	Advanced Engineering Geology	2T-2P	500
4	<a href="#">GEO-6404</a>	Water Quality Analysis	2P	500
5	<a href="#">GEO-6405</a>	Glaciology	1T-1P	500
6	<a href="#">GEO-6406</a>	Industrial Training	2P	500
<b>Total Credits for DSVE Courses in Semester III</b>			<b>8</b>	
<b>Total Credits in Semester III</b>			<b>20</b>	

<b>Discipline Specific Dissertation (DSD) (40 Credit Dissertation)</b>				
<b>Sr. No.</b>	<b>Course Code</b>	<b>Title of the Course</b>	<b>Credits</b>	<b>Level</b>
1	GEO-6501	Dissertation	40	500

NOTE: For discipline-specific dissertations, two theory courses of 4 credits each, a 4-credit course on Research Methodology, and a 4-credit dissertation-related course (to be chosen in consultation with the research guide) will be conducted in the third semester; however, the marks will be considered for evaluation in the fourth semester.



<b>SEMESTER IV</b>				
<b>Generic Elective (GE) Courses (20 credits)</b>				
<b>Sr. No.</b>	<b>Course Code</b>	<b>Title of the Course</b>	<b>Credits</b>	<b>Level</b>
1	<a href="#">GEO-6201</a>	Quaternary Geology	2T	500
2	<a href="#">GEO-6202</a>	Geoheritage and Geotourism	2T	500
3	<a href="#">GEO-6203</a>	Coal Geology	2T	500
4	<a href="#">GEO-6204</a>	Soil Science	2T	500
5	<a href="#">GEO-6205</a>	Advanced Geomorphology and Landscape Evolution	2T	500
6	<a href="#">GEO-6206</a>	Disaster Risk Reduction	2T	500
7	<a href="#">GEO-6207</a>	Petroliferous Basins of India	2T	500
8	<a href="#">GEO-6208</a>	Polar Geoscience	2T	500
9	<a href="#">GEO-6209</a>	Planetary Geology	2T	500
10	<a href="#">GEO-6210</a>	Geoarcheology	2T	500
11	<a href="#">GEO-6211</a>	Forensic Geology	2T	500
12	<a href="#">GEO-6212</a>	Medical Geology	2T	500
<b>Total Credits for GE Courses in Semester IV</b>			<b>20</b>	

<b>Discipline Specific Dissertation (DSD)/ Internship (20 Credit Dissertation)</b>				
<b>Sr. No.</b>	<b>Course Code</b>	<b>Title of the Course</b>	<b>Credits</b>	<b>Level</b>
1	<b>GEO-6502</b>	Dissertation	20	500
<b>Total Credits in Semester IV</b>			<b>20</b>	

<b>Blooms Taxonomy Cognitive Levels</b>	
<b>Cognitive Level</b>	<b>Notations</b>
K1	Remembering
K2	Understanding
K3	Applying
K4	Analyzing
K5	Evaluating
K6	Create

## BRIDGE COURSE

<b>Title of the Course</b>	Bridge Course in Applied Geology	
<b>Course Code</b>	GEO-1000	
<b>Number of Credits</b>	02	
<b>Theory/Practical</b>	Theory	
<b>Level</b>	100	
<b>Effective from AY</b>	2025-26	
<b>New Course</b>	Yes	
<b>Bridge Course/ Value added Course</b>	Yes	
<b>Course for advanced learners</b>	No	
<b>Pre-requisites for the Course:</b>	Nil	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. The student will learn to describe minerals and rocks.</li> <li>2. Describe the various structural elements in rocks.</li> <li>3. Understand the various ore forming processes.</li> <li>4. To study the water cycle and its distribution.</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, the student will be able to:	<b>Mapped to PSO</b>
	CO 1. Identify and classify minerals and rocks and the process leading to their formation.	PSO1, PSO2
	CO 2. Explore the various structural aspects that rocks are subjected to.	PSO1, PSO2

	CO 3. Describe the various ore forming processes.		PSO1, PSO2
	CO 4. Discuss the movement of groundwater and its societal relevance.		PSO1, PSO2
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b> <b>Cognitive Level</b>
<b>Module 1:</b>	<p>Importance and scope of Igneous Petrology in Earth Sciences. Source regions of magma:mantle and crust. Processes of magma generation (partial melting). Types of magma (basaltic, andesitic, rhyolitic). Texture and composition of common igneous rocks. Intrusive and extrusive igneous rocks. Classification of igneous rocks.</p> <p>Basics of Sedimentary Rocks: Classification, textures, and structures of clastic and non-clastic rocks.Sedimentary Processes: Weathering, erosion, transport, deposition (Hjulstrom diagram), and diagenesis.Sedimentary Environments: Overview of terrestrial and marine depositional settings and controlling factors.</p> <p>Classification of Minerals: Silicates and Non-silicates. Opaque and transparent minerals. Structure of silicate minerals - Nesosilicates, sorosilicates, inosilicates, cyclosilicates, phyllosilicates and tectosilicates. Description of following silicate mineral groups with respect to chemical composition, structure, physical properties and paragenesis: olivine, pyroxene, amphibole and mica.</p> <p>Definition of metamorphism, upper and lower limits of metamorphism, Migmatites: components, classification into metatexite and ditexite, structures: dilation, stromatic, net, agmatite, Schlieren, schollen, nebulitic, raft-like, vein. Factors responsible for metamorphism: Heat (radioactive, magmatic, tectonic heat), geothermal gradient (in different crustal regions); pressure (P) (directed and load pressure); composition of the parent rock- Protolith (X); fluids (H2O and CO2) (Xf); Role of time in metamorphism.</p>	<b>15</b>	<b>CO1</b> <b>K1,K2</b>

<p><b>Module 2:</b></p>	<p>Contours, contour reading and contour patterns; Scale and compass bearing, Stratification, Strike, Dip (true and apparent dip), Strike and Dip symbols. Folds: Causes and geometric classification of folds; importance of folds Joints: Geometric classification, importance; Faults: general characteristics, geometric classification and importance, Horst, Graben and Thrust faults.</p> <p>Ore deposits and ore minerals; Magmatic processes of ore mineralization - Orthomagmatic, pegmatitic, pyro metasomatic and hydrothermal deposits. Wall rock alteration. Oxidation and supergene sulphide enrichment.; Plate tectonics in relation to ore genesis. Secondary processes of ore formation- placer deposits, residual deposits, deposits associated with metamorphic rocks.; Formation of coal, oil and natural gas.</p> <p>Stratigraphy: scope and importance; Principles of Stratigraphy: Laws of uniformitarianism, original horizontality, order of superposition, faunal succession, cross-cutting relationship, inclusions; Standard Stratigraphic timescale; Indian stratigraphic timescale; Geological Time Units: - Eon, Era, Period, Epoch, Age, Phase. Chronostratigraphic Units: - Erathem, System, Series, Stage and Zone. Lithostratigraphic Units: - Group, Formation, Member, Bed and laminae.</p> <p>Introduction. Scope of hydrogeology and its societal relevance, Hydrological cycle and its components: precipitation, evaporation, transpiration, evapotranspiration, surface storage, overland flow, infiltration, soil moisture, interflow, percolation, groundwater recharge and storage, baseflow and surface runoff, Instruments for measurement of precipitation, evapotranspiration, infiltration and streamflow. Concepts of watershed, drainage network, and their relation to surface runoff and infiltration.</p>	<p>15</p>	<p>CO2</p>	<p>K1, K2</p>
<p><b>Pedagogy:</b></p>	<p>Lectures/ tutorials/assignments</p>			
<p><b>Text</b></p>	<p>1. Best, M. G. (2013). Igneous and metamorphic petrology. John Wiley &amp; Sons.</p>			

2. Winter, J. D. (2013). Principles of igneous and metamorphic petrology: Pearson New International Edition. Pearson Higher Ed.
3. Tucker, M. E. (2013). Sedimentary petrology: An Introduction to the Origin of Sedimentary Rocks. John Wiley & Sons.
4. Pettijohn, F. J. (1969). Sedimentary rocks. CBS Publication and distribution.
5. Boggs, S., Jr, & Boggs, S. (2009). Petrology of sedimentary rocks. Cambridge University Press.
6. Greensmith, J. (2012). Petrology of the sedimentary rocks. Springer Science & Business Media.
7. Folk, R. L. (1980). Petrology of sedimentary rocks. Hemphill Publishing Company 6. Nichols, G. (1999). Sedimentology and Stratigraphy. John Wiley & Sons.
8. Berry and Mason: Mineralogy. CBS Publ. and Distr.
9. Deer, W. A., Howie, R. A., & Zussman, J. (1978). Rock-forming minerals: Feldspars, Volume 4A. Geological Society of London.
10. Klein, C., & Hurlbut, C. S. Jr. (2021). Dana manual of mineralogy. Wiley.
11. Duff, P. M. D. (1993). Holmes' Principles of Physical Geology. Springer.
12. Jain, S. (2014). Fundamentals of Physical Geology. Springer Geology
13. Taylor, R. (2010). Ore textures: recognition and interpretation. Springer Science & Business Media.
14. Arndt, N., Kesler, S., & Ganino, C. (2015). Metals and society: An introduction to economic geology. Springer.
15. Brookfield, M. E. (2008). Principles of Stratigraphy. John Wiley & Sons.
16. Hiscock, K. M. (2005). Hydrogeology: Principles and practice. Blackwell Publishing.
17. Todd, D.K. (2006). Groundwater Hydrology, 2nd Ed., John Wiley & Sons, N.Y.

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## SEMESTER I

### Discipline Specific Core Courses

<b>Title of the Course</b>	Mineralogy and Geochemistry	
<b>Course Code</b>	GEO-5000	
<b>Number of Credits</b>	03	
<b>Theory/Practical</b>	Theory	
<b>Level</b>	400	
<b>Effective from AY</b>	2025-26	
<b>New Course</b>	No	
<b>Bridge Course/ Value added Course</b>	No	
<b>Course for advanced learners</b>	No	
<b>Pre-requisites for the Course:</b>	Nil	
<b>Course Objectives:</b>	The objectives of this course are to: <ol style="list-style-type: none"><li>1. Explain the principles of crystal chemistry, including atomic structures, bonding, and mineral stability.</li><li>2. Explore the structural, chemical, and paragenetic characteristics of major mineral groups</li><li>3. Describe the behaviour and distribution of elements through geochemical processes across different tectonic settings.</li><li>4. Discuss analytical techniques for mineralogical and geochemical investigations.</li></ol>	
<b>Course Outcomes:</b>	At the end of the course, the student will be able to:	<b>Mapped to PSO</b>

	CO 1. Apply crystallographic principles to explain crystal structures.		PSO1, PSO2, PSO6
	CO 2. Analyze phase equilibrium relationships and mechanisms of polymorphic transformations.		PSO1, PSO2, PSO3, PSO6
	CO 3. Identify and classify rock-forming minerals using optical and analytical methods.		PSO1, PSO2, PSO4, PSO6
	CO 4. Analyze the geochemical signatures of igneous, sedimentary, and metamorphic rocks in relation to trace element behaviour and isotopic systems.		PSO, PSO2, PSO3, PSO4, PSO6
	CO 5. Apply instrumental techniques (SEM-EDX, XRD, XRF, ICP-MS) to interpret mineralogical and geochemical data.		PSO1, PSO2, PSO3, PSO4, PSO6, PSO7
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b> <b>Cognitive Level</b>
<b>Module 1:</b>	Crystal chemistry: atom, atomic and ionic radii, coordination of ions, Pauling's Rules, different types of chemical bonding, crystal growth, crystal defects, external and internal symmetry, XRD: powder and single crystal diffraction. Twinning, polymorphism: types of polymorphic transformation, polytypism and pseudomorphism. Mineral stability and phase diagram, two-component eutectic systems (Di–An; Fo–Si), incongruent melting, fractional crystallization in the system, solid solution systems (Ab–An; Fo–Fa), and exsolution. Crystallization in ternary systems: Equilibrium crystallization involving binary eutectic subsystems (Ab–An–Di), systems with a congruently melting compound (Di–An–Fo; An–Al–Or), systems with an incongruently melting compound (Fo–An–Qz; Leucite in the Leucite–Nepheline–Silica system; equilibrium and fractional crystallization), and systems with binary solid solutions (diopside–enstatite–ferrosilite).	<b>15</b>	CO1    K2, K3, K4
<b>Module 2:</b>	Mineralogy: Mineralogy and phase transition of the mantle, Mineral evolution, biological-mineralogical interactions, medical mineralogy, Composition, structure, chemistry, and paragenesis of the mineral groups: olivine, pyroxene, amphibole, mica, feldspar, garnet, sulphide, sulphate, carbonate, and oxides. Optical	<b>15</b>	CO2    K1, K2

	mineralogy: behaviour of light in mineral, Study of isotropic and anisotropic determinative tables and mineral identification. Purpose and working principles of analytical techniques: SEM-EDX, XRD, XRF, and ICP-MS.			
<b>Module 3:</b>	Geochemistry: Introduction and scope of geochemistry, geochemical classification of elements, and Goldschmidt's rule for trace element substitution. Distribution and behaviour of major and trace elements and REE in igneous, sedimentary, and metamorphic processes and products. REE composition and mantle melting condition. Geochemical characteristics of magma formed in MOR settings, subduction zone settings, and intraplate tectonic settings. Introduction to isotope geochemistry: definition and types of isotopes (stable vs. radiogenic), atomic structure and isotopic notation, isotope abundance and atomic weight, and analytical techniques (TIMS, IC PMS).	15	CO3, CO4	K3, K4, K5
<b>Pedagogy:</b>	Lectures/ tutorials/assignments/field study/discussion/ demonstration			
<b>Text</b>	<ol style="list-style-type: none"> <li>Deer, W. A., Howie, R. A., &amp; Zussman, J. (1992). An introduction to the rock-forming minerals (2nd ed.). Longman Scientific and Technical.</li> <li>Klein, C., Hurlbut, C. S., &amp; Dana, J. D. (1999). Manual of mineralogy (after James D. Dana). John Wiley &amp; Sons.</li> <li>Winchell, A. N. (1991). Elements of optical mineralogy: An introduction to microscopic petrography. Wiley.</li> <li>Nesse, W. D. (2012). Introduction to optical mineralogy (4th ed.). Oxford University Press.</li> <li>Kerr, P. F. (1977). Optical mineralogy. McGraw-Hill Book Company.</li> <li>Mason, B., &amp; Moore, C. B. (1982). Principles of geochemistry (4th ed.). John Wiley &amp; Sons.</li> <li>Krauskopf, K. B., &amp; Bird, D. K. (1995). Introduction to geochemistry. McGraw-Hill.</li> <li>Klein, C., &amp; Dutrow, B. (2007). Manual of mineral science. John Wiley &amp; Sons.</li> <li>Mason, B., &amp; Moore, C. B. (1982). Principles of geochemistry. Wiley.</li> <li>Walther, J. V. (2009). Essentials of geochemistry. Jones &amp; Bartlett Publishers.</li> <li>White, W. M. (2014). Isotope geochemistry. Wiley.</li> <li>Faure, G. (1986). Principles of isotope geology (2nd ed.). John Wiley &amp; Sons.</li> <li>Dyar, M. D., &amp; Gunter, M. E. (2008). Mineralogy and optical mineralogy. Mineralogical Society of America.</li> <li>Perkins, D. (2011). <i>Mineralogy</i> (3rd ed.). Pearson.</li> </ol>			

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<b>Title of the Course</b>	Practical of Mineralogy and Geochemistry
<b>Course Code</b>	GEO-5001
<b>Number of Credits</b>	01
<b>Theory/Practical</b>	Practical
<b>Level</b>	400
<b>Effective from AY</b>	2025-26
<b>New Course</b>	No
<b>Bridge Course/ Value added Course</b>	No
<b>Course for advanced learners</b>	No

<b>Pre-requisites for the Course:</b>	Nil	
<b>Course Objectives:</b>	<p>The objectives of this course are to</p> <ol style="list-style-type: none"> <li>1. Develop skills in identifying and documenting the physical and optical properties of rock-forming minerals using hand specimens and microscopes.</li> <li>2. Demonstrate the operation and application of analytical instruments such as flame photometers and spectrophotometers for geochemical analyses.</li> <li>3. Train students in interpreting geochemical plots and solving numerical problems related to geochemical partitioning and trace element behavior.</li> <li>4. Describe geochemical processes for interpretation of trace element and REE (rare earth element) data.</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, the student will be able to:	<b>Mapped to PSO</b>
	CO 1. Identify and describe minerals in hand specimens and using the microscope.	PSO1, PSO2, PSO6

	CO 2. Determine major and trace chemical constituents in geological samples using flame photometers and spectrophotometers		PSO1, PSO2, PSO4, PSO6
	CO 3. Solve problems related to partition coefficients and elemental distribution.		PSO1, PSO2, PSO3, PSO4, PSO6, PSO7
	CO 4. Analyze trace element and REE plots to understand geological processes and tectonic settings.		PSO1, PSO2, PSO3, PSO4, PSO6
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b> <b>Cognitive Level</b>
<b>Module 1:</b>	Observing and recording properties of representative minerals in hand specimens and using the microscope	<b>18</b>	CO1 K1, K2, K3, K4
<b>Module 2:</b>	Determination of different chemical constituents in water/soil/rock using a flame photometer and spectrophotometer. Reading of plots/graphs.	<b>4</b>	CO2 K3, K4, K5
<b>Module 3:</b>	Solving numerical problems on partition coefficient	<b>4</b>	CO3 K4, K6
<b>Module 4:</b>	Plotting and Interpreting trace element and REE data	<b>4</b>	CO3, CO4 K4, K5, K6
<b>Pedagogy</b>	Lectures/tutorials/assignments/field study/discussion/demonstration		
<b>Text</b>	<ol style="list-style-type: none"> <li>1. Mackenzie, W. S. (2015). Atlas of the rock-forming minerals in thin section. Routledge.</li> <li>2. Barker, A. J. (2017). A key for identification of rock-forming minerals in thin section. Wiley-Blackwell.</li> <li>3. Deer, W. A., Howie, R. A., &amp; Zussman, J. (1992). An introduction to the rock-forming minerals (2nd ed.). Longman Scientific and Technical.</li> <li>4. Khandpur, R. S. (2006). Handbook of analytical instruments. McGraw-Hill Education LLC.</li> <li>5. Klein, C., Hurlbut, C. S., &amp; Dana, J. D. (1999). Manual of mineralogy (after James D. Dana). John Wiley &amp; Sons.</li> <li>6. Winchell, A. N. (1991). Elements of optical mineralogy: An introduction to microscopic petrography. Wiley.</li> <li>7. Nesse, W. D. (2012). Introduction to optical mineralogy (4th ed.). Oxford University Press.</li> <li>8. Kerr, P. F. (1977). Optical mineralogy. McGraw-Hill Book Company.</li> <li>9. Mason, B., &amp; Moore, C. B. (1982). Principles of geochemistry. Wiley.</li> <li>10. Dyar, M. D., &amp; Gunter, M. E. (2008). Mineralogy and optical mineralogy. Mineralogical Society of America.</li> </ol>		

<b>Title of the Course</b>	Structural Geology and Geotectonics	
<b>Course Code</b>	GEO-5002	
<b>Number of Credits</b>	03	
<b>Theory/Practical</b>	Theory	
<b>Level</b>	400	
<b>Effective from AY</b>	2025-2026	
<b>New Course</b>	No	
<b>Bridge Course/ Value added Course</b>	No	
<b>Course for advanced learners</b>	No	
<b>Pre-requisites for the Course:</b>	Nil	
<b>Course Objectives:</b>	<p>The objectives of the course are to:</p> <ol style="list-style-type: none"> <li>1. Describe the fundamental concepts of rock deformation and rheology, including stress-strain relationships and deformation mechanisms.</li> <li>2. Analyze structural features such as faults, folds, foliations, and lineations, and interpret their kinematics and formation processes.</li> <li>3. Evaluate the rheological behaviour of the lithosphere and apply microstructural observations to infer deformation conditions.</li> <li>4. Apply tectonic theories to explain large-scale structural and geodynamic features of the Earth, including plate boundaries and intraplate settings.</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, the student will be able to:	<b>Mapped to PSO</b>

	CO 1. Explain the key components of deformation and rock mechanics, including stress, strain, and rheological properties of Earth materials.		PSO 1, PSO 2	
	CO 2. Interpret structural features in rocks such as folds, faults, and shear zones using appropriate classification schemes and field-based observations.		PSO 2, PSO 3, PSO 4	
	CO 3. Assess the significance of deformation microstructures and mechanisms in understanding deformation processes and tectonic environments.		PSO 2, PSO 3, PSO 6	
	CO 4. Construct tectonic models to explain major geological structures and the dynamics of plate margins and intraplate deformation zones.		PSO 1, PSO 2, PSO 7	
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>	<b>Cognitive Level</b>
<b>Module 1:</b>	Introduction to Deformation and Rock Mechanics: Components of deformation, Strain in 1D, 2D and 3D, strain ellipsoid, Pure shear and simple shear, progressive deformation, strain analysis. Introduction to stress, deviatoric and mean stress, Mohr Circle diagram. Rheology: elastic, viscous and plastic deformation, rheologic stratification of the lithosphere. Deformation microstructures and mechanisms, recovery and recrystallization. Fractures: brittle deformation mechanisms, failure and fracture criteria, types of fractures and joints.	<b>15</b>	CO1, CO3	K2, K3, K5
<b>Module 2:</b>	Fault and Fold Mechanics: Faults: Characteristics of faults and fault planes, movement mechanisms, role of fluids, brittle versus ductile faults, mylonites, shear sense indicators, shear zone kinematics. Folds: Mechanisms of folding, kinematic models of folding, Ramsay's classification of folds, superposed folding, occurrence and recognition. Cleavage and foliations. Linear structures and their interpretation. An overview of structures in contractional and extensional regimes with field examples.	<b>15</b>	CO2, CO3, CO4	K3, K4, K5
<b>Module 3:</b>	Geotectonics: Fundamental concepts of Geotectonics, Isostasy and geoid. Continental drift, Sea floor spreading, paleomagnetism and Plate tectonics. Supercontinent cycles. Volcanic and seismic belts of the Earth. Major tectonic	<b>15</b>	CO1, CO4	K2, K3, K5

	features in intraplate settings and at convergent, divergent and transform plate margins.			
<b>Pedagogy:</b>	Lectures/ tutorials/ assignments/ self-study			
<b>Text</b>	<ol style="list-style-type: none"> <li>1. Condie, K. C. (1997). <i>Plate tectonics and crustal evolution</i> (4th ed.). Butterworth-Heinemann.</li> <li>2. Davis, G. H., Reynolds, S. J., &amp; Kluth, C. F. (2011). <i>Structural geology of rocks and regions</i> (3rd ed.). Wiley.</li> <li>3. Fossen, H. (2016). <i>Structural geology</i> (2nd ed.). Cambridge University Press.</li> <li>4. Ghosh, S. K. (1993). <i>Structural geology: Fundamentals and modern developments</i>. Pergamon Press.</li> <li>5. Hobbs, B. E., Means, W. D., &amp; Williams, P. F. (1976). <i>An outline of structural geology</i>. Wiley.</li> <li>6. Passchier, C. W., &amp; Trouw, R. A. J. (2005). <i>Microtectonics</i>. Springer. <a href="#">SpringerLink</a></li> <li>7. Pollard, D. D., &amp; Fletcher, R. C. (2005). <i>Fundamentals of structural geology</i>. Cambridge University Press.</li> <li>8. Ramsay, J. G., &amp; Huber, M. I. (1983). <i>The techniques of modern structural geology: Vol. 1. Strain analysis; Vol. 2. Folds and fractures</i>. Academic Press.</li> <li>9. Ramsay, J. G. (1967). <i>Folding and fracturing of rocks</i>. McGraw-Hill.</li> <li>10. Turcotte, D. L., &amp; Schubert, G. (2014). <i>Geodynamics</i> (3rd ed.). Cambridge University Press.</li> <li>11. Twiss, R. J., &amp; Moores, E. M. (2006). <i>Structural geology</i> (2nd ed.). W. H. Freeman.</li> <li>12. Van der Pluijm, B. A., &amp; Marshak, S. (2004). <i>Earth structure: An introduction to structural geology and tectonics</i> (2nd ed.). W. W. Norton &amp; Company.</li> <li>13. Frisch, W., Meschede, M., &amp; Blakey, R. C. (2011). Plate tectonics. Continental Drift and Mountain Building. Springer Berlin, Heidelberg. <a href="https://doi.org/10.1007/978-3-540-76504-2">https://doi.org/10.1007/978-3-540-76504-2</a></li> <li>14. Windley, B.F. (1996). The evolving continents. <i>Oceanographic Literature Review</i>, 8(43), 785.</li> </ol>			
<b>Web Resources:</b>	<ol style="list-style-type: none"> <li>1. <a href="https://www.iris.edu/hq/">https://www.iris.edu/hq/</a></li> <li>2. <a href="https://tectonicstudiesgroup.org/virtual-geology/">https://tectonicstudiesgroup.org/virtual-geology/</a></li> <li>3. <a href="https://www.earthbyte.org/">https://www.earthbyte.org/</a></li> <li>4. <a href="https://www.earthlearningidea.com/">https://www.earthlearningidea.com/</a></li> </ol>			

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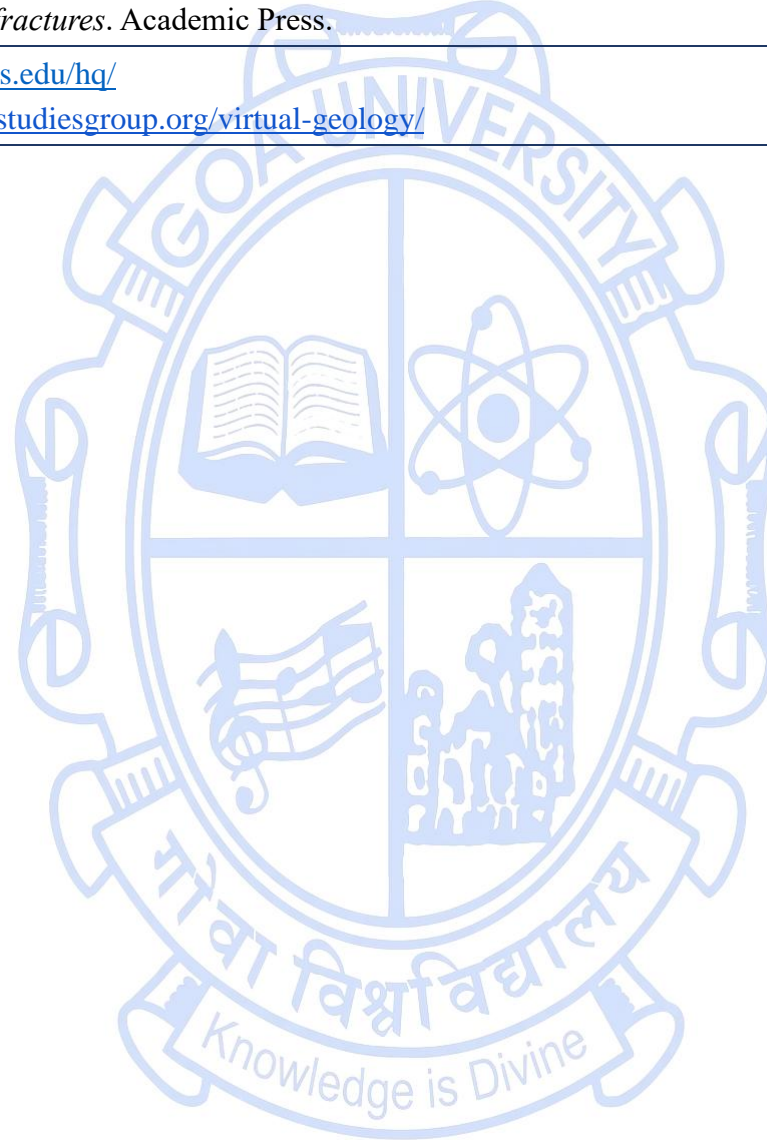
<b>Title of the Course</b>	Practical of Structural Geology and Geotectonics
<b>Course Code</b>	GEO-5003
<b>Number of Credits</b>	01
<b>Theory/Practical</b>	Practical
<b>Level</b>	400
<b>Effective from AY</b>	2025-2026
<b>New Course</b>	No
<b>Bridge Course/ Value added Course</b>	No
<b>Course for advanced learners</b>	No

<b>Pre-requisites for the Course:</b>	Nil	
<b>Course Objectives:</b>	<p>The objectives of the course are to:</p> <ol style="list-style-type: none"> <li>1. Demonstrate the utility of the geological maps and their interpretations, practice methods of completing outcrops and interpreting structural data in geological maps and cross-sections.</li> <li>2. Train students in stereographic projection techniques and petro-fabric analysis to interpret rock deformation and field measurements.</li> <li>3. Explain strain and structural geometries using field data, hand specimens, and graphical techniques.</li> <li>4. Determine geological structures using satellite imagery and photographs, enhancing remote observation skills</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, students will be able to:	<b>Mapped to PSO</b>
	CO 1. Interpret and complete geological outcrops and sections, integrating field data with map-based observations.	PSO 2, PSO 3, PSO 4

	CO 2. Construct and analyze stereographic projections and petro-fabric diagrams to assess structural orientation.		PSO 3, PSO 4, PSO 6
	CO 3. Estimate strain and recognize deformation patterns from field/ microscopic data.		PSO 2, PSO 3, PSO 6
	CO 4. Evaluate and interpret structural features using satellite imagery and remote datasets.		PSO 2, PSO 6
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b> <b>Cognitive Level</b>
<b>Module 1:</b>	Geological mapping and Outcrop Interpretation: <ul style="list-style-type: none"> <li>• Preparation and interpretation of geological maps.</li> <li>• Completion of geological outcrop patterns.</li> <li>• Construction of geological cross-sections.</li> </ul>	<b>10</b>	CO1   K3, K4, K5, K6
<b>Module 2:</b>	Field Data Recording and Graphical Techniques: <ul style="list-style-type: none"> <li>• Recording structural field data (strike, dip, plunge, rake).</li> <li>• Plotting of field data using maps and rose diagrams.</li> <li>• Stereographic projection of planes and lines.</li> <li>• Graphical solutions to structural problems.</li> </ul>	<b>10</b>	CO2   K3, K4, K5
<b>Module 3:</b>	Petro-fabric Analysis, Strain Estimation and Tectonic Interpretation: <ul style="list-style-type: none"> <li>• Identification and description of mesoscopic structural features in hand specimens.</li> <li>• Strain estimation from field and map data (e.g., Rf/φ method, Fry method).</li> <li>• Study and interpretation of tectonic and structural features from satellite imagery and/or aerial photographs.</li> </ul>	<b>10</b>	CO3, CO4   K2, K3, K5
<b>Pedagogy:</b>	Demonstrations /Laboratory observations / Plotting and Interpretations		
<b>Text</b>	<ol style="list-style-type: none"> <li>1. Davis, G.H. &amp; Reynolds, S.J. (1996). <i>Structural Geology of rocks and regions</i>. John Wiley and Sons.</li> <li>2. Marshak, S., and Mitra, G. (1988). <i>Basic methods of Structural geology</i>. Prentice Hall.</li> <li>3. Rowland, S.M., Duebendorfer, E. &amp; Schiefelbein, I.M. (2007). <i>Structural analysis and synthesis: a laboratory course in structural geology</i>. Blackwell Pub.</li> </ol>		

	4. Ramsay, J. G., & Huber, M. I. (1983). <i>The techniques of modern structural geology: Vol. 1. Strain analysis; Vol. 2. Folds and fractures</i> . Academic Press.
<b>Web Resources:</b>	<a href="https://www.iris.edu/hq/">https://www.iris.edu/hq/</a> <a href="https://tectonicstudiesgroup.org/virtual-geology/">https://tectonicstudiesgroup.org/virtual-geology/</a>

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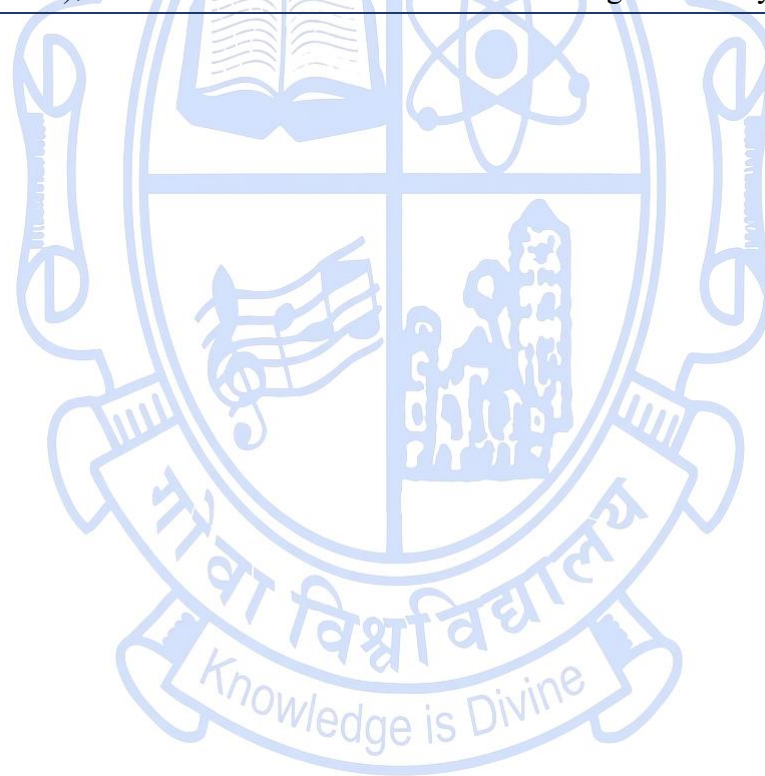
<b>Title of the Course</b>	Igneous Petrology
<b>Course Code</b>	GEO-5004
<b>Number of Credits</b>	03
<b>Theory/Practical</b>	Theory
<b>Level</b>	400
<b>Effective from AY</b>	2025-2026
<b>New Course</b>	No
<b>Bridge Course/ Value added Course</b>	No
<b>Course for advanced learners</b>	No

<b>Pre-requisites for the Course:</b>	Nil	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Describe the textures and structures of igneous rocks</li> <li>2. Explain magmatic processes in different tectonic settings.</li> <li>3. Discuss classifications of Igneous rocks.</li> <li>4. Explain geological settings of various igneous rocks.</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, students will be able to:	<b>Mapped to PSO</b>
	CO 1. Classify igneous rocks.	PSO 1, PSO 2, PSO 4, PSO 7
	CO 2. Explain the processes of formation of the rocks.	PSO 1, PSO 2, PSO 3
	CO 3. Interpret the geological settings of various types of igneous rocks.	PSO 2, PSO 4, PSO 7

	CO 4. Infer magmatic evolution of rocks.		PSO 1, PSO 3, PSO 6	
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>	<b>Cognitive Level</b>
<b>Module 1:</b>	Introduction to Magmas and Magmatic Processes; Process of formation and description of Textures and Structures of volcanic and plutonic rocks; Classification of igneous rocks: modal, chemical, quasi-chemical-schemes: their merits and demerits. Working principles of XRF and EPMA.	<b>15</b>	CO1, CO2, CO3, CO4	K1, K2
<b>Module 2:</b>	Composition of the mantle; Enriched- and Depleted mantle and their characteristics; Magma generation: Heat source and the factors responsible to bring about melting, Fractional melting, Batch melting and Zone melting; Magmatic Evolution; Magmatic differentiation: crystal fractionation, gravitational differentiation, flowage differentiation, filter pressing, liquid immiscibility; Magmatic assimilation, Magma mixing and contamination.	<b>15</b>	CO2, CO3, CO4	K1, K2, K3
<b>Module 3:</b>	Magma Associations in relation to Plate Tectonics: Alkaline rocks-Nephelinites and Ijolites, Lamprophyres and Lamproites, Carbonatites and Kimberlites; Continental flood basalts such as the Deccan Traps, Paranas, Karoo; Mid Ocean Ridge Basalts and hydrothermal activity, Ocean Island basalts, Continental as well as Ocean Arc magmatism and back arc magmatism; Alpine type intrusions and Ophiolites; Granites and Granitic rocks: I-type, S-type, A-type and M-type granites, anatexis and Granitization; Anorthosites. Continental Layered Intrusions: Mineralogical and Petrological characteristics with special reference to the Bushveld, Skaergaard, Stillwater Complexes.	<b>15</b>	CO1, CO2, CO3, CO4	K3, K4, K5
<b>Pedagogy:</b>	Lectures, case studies, discussions and assignments.			
<b>Text</b>	<ol style="list-style-type: none"> <li>1. Barker, F. (Ed.). (2013). <i>Trondhjemites, dacites, and related rocks</i>. Elsevier.</li> <li>2. Best, M. G., &amp; Christiansen, E. H. (2002). <i>Igneous petrology: Petrology of igneous rocks</i>. Wiley-Blackwell.</li> <li>3. Dawson, J. B. (2012). <i>Kimberlites and their xenoliths</i> (Vol. 15). Springer Science &amp; Business Media.</li> <li>4. Middlemost, E. A. K. (1986). <i>Magmas and magmatic rocks: An introduction to igneous petrology</i>. Longman.</li> </ol>			

5. Moorhouse, W. W. (1959). *The study of rocks in thin sections*. Harper.
6. Philpotts, A. R., & Ague, J. J. (2022). *Principles of igneous and metamorphic petrology* (2nd ed.). Cambridge University Press.
7. Rock, N. M. S. (2013). *Lamprophyres*. Springer Science & Business Media.
8. Wager, L. R., & Brown, G. M. (1967). *Layered igneous rocks*. W. H. Freeman.
9. Williams, H., Turner, F. J., & Gilbert, C. M. (1954). *Petrography: An introduction to the study of rocks in thin sections*. W. H. Freeman.
10. Wilson, M. (Ed.). (1989). *Igneous petrogenesis*. Springer Netherlands.
11. Winter, J. D. (2013). *Principles of igneous and metamorphic petrology* (2nd ed.). Pearson Education.
12. Woolley, A. R. (2019). *Alkaline rocks and carbonatites of the world. Part 4: Antarctica, Asia and Europe (excluding the former USSR), Australasia and Oceanic Islands*. Geological Society of London.

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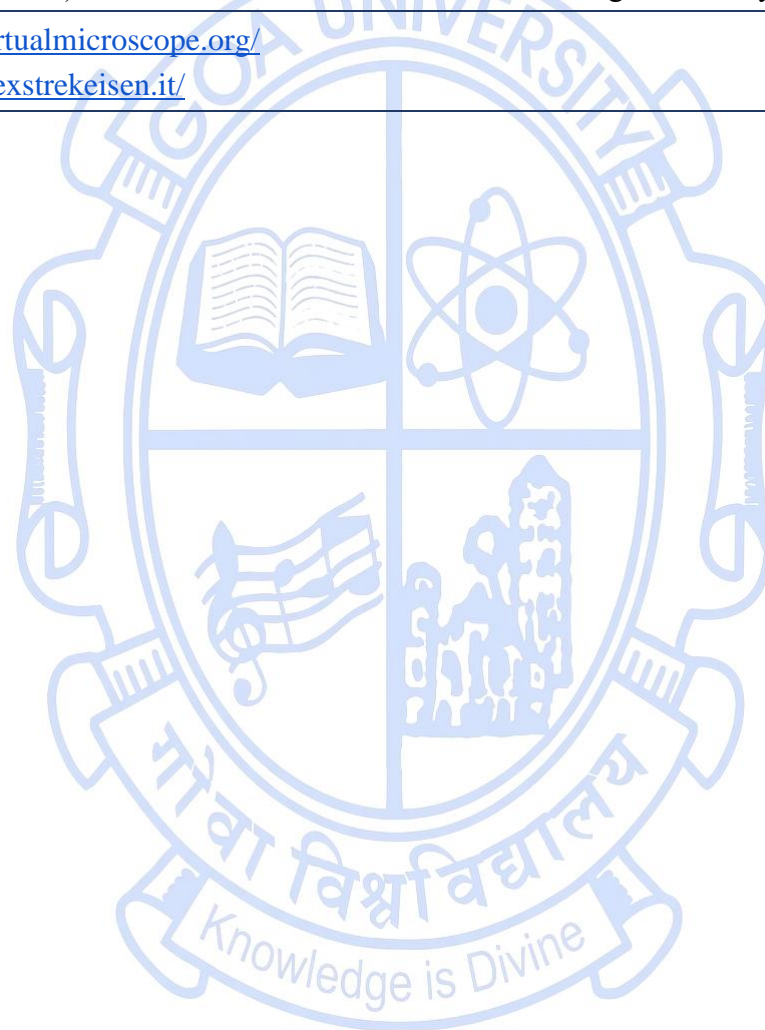
<b>Title of the Course</b>	Practical of Igneous Petrology
<b>Course Code</b>	GEO-5005
<b>Number of Credits</b>	01
<b>Theory/Practical</b>	Practical
<b>Level</b>	400
<b>Effective from AY</b>	2025-2026
<b>New Course</b>	No
<b>Bridge Course/ Value added Course</b>	No
<b>Course for advanced learners</b>	No

<b>Pre-requisites for the Course:</b>	Nil	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Describe the textures and structures of igneous rocks.</li> <li>2. Train to classify the igneous rocks.</li> <li>3. Discuss the processes of formation from the mineral assemblage, texture, and tectonic setting</li> <li>4. Demonstrate the relationship between geochemical plots and tectonic settings</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, students will be able to:	<b>Mapped to PSO</b>
	CO 1. Identify the igneous rock in hand specimen and using a microscope.	PSO 1, PSO 3, PSO 4
	CO 2. Solve CIPW Norm to determine the type of rock.	PSO 1, PSO 2, PSO 4

	CO 3. Deduce magmatic processes such as crystallization sequence, cooling rates, and magma mixing using mineral assemblage and textures.		PSO 1, PSO 2, PSO 3	
	CO 4. Infer tectonic settings based on geochemical plots		PSO 1, PSO 2, PSO 3	
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>	<b>Cognitive Level</b>
<b>Module 1:</b>	Study of the textures and structures and identification of rocks in hand specimens.	<b>6</b>	CO 1, CO 2, CO 3	K1, K2, K3
<b>Module 2:</b>	Characterization of the following suites of rocks from micro-sections: ultramafic rocks, mafic igneous rocks, intermediate rocks, granitic rocks and alkaline igneous rocks.	<b>8</b>	CO 1, CO 3	K2, K4
<b>Module 3:</b>	CIPW normative calculations of minerals based on available compositional data using MS excel.	<b>8</b>	CO 1, CO 3	K3, K4, K5
<b>Module 4:</b>	Applications of trace elements in igneous petrology, such as spider diagrams, REE distribution patterns and implications in deducing origin, source and evolution of magma, and tectonic diagrams-trace element ratio plots.	<b>8</b>	CO 2, CO 3	K1, K2, K3, K4, K5
<b>Pedagogy:</b>	Lectures, problem-solving, hands-on experience in megascopic and microscopic identification of rocks and discussions.			
<b>Text</b>	<ol style="list-style-type: none"> <li>1. Barker, F. (Ed.). (2013). <i>Trondhjemites, dacites, and related rocks</i>. Elsevier.</li> <li>2. Best, M. G., &amp; Christiansen, E. H. (2002). <i>Igneous petrology: Petrology of igneous rocks</i>. Wiley-Blackwell.</li> <li>3. Dawson, J. B. (2012). <i>Kimberlites and their xenoliths</i> (Vol. 15). Springer Science &amp; Business Media.</li> <li>4. MacKenzie, W. S., Adams, A. E., &amp; Brodie, K. H. (2017). <i>Rocks and Minerals in Thin Section: A Colour Atlas</i>. Taylor &amp; Francis.</li> <li>5. Middlemost, E. A. K. (1986). <i>Magmas and magmatic rocks: An introduction to igneous petrology</i>. Longman.</li> <li>6. Philpotts, A. R., &amp; Ague, J. J. (2022). <i>Principles of igneous and metamorphic petrology</i> (2nd ed.). Cambridge University Press.</li> <li>7. Rock, N. M. S. (2013). <i>Lamprophyres</i>. Springer Science &amp; Business Media.</li> <li>8. Wager, L. R., &amp; Brown, G. M. (1967). <i>Layered igneous rocks</i>. W. H. Freeman.</li> </ol>			

	<p>9. Wilson, M. (1989). <i>Igneous petrogenesis: A global tectonic approach</i> (Reprinted 2007). Springer Netherlands.</p> <p>10. Winter, J. D. (2013). <i>Principles of igneous and metamorphic petrology</i> (2nd ed.). Pearson Education.</p> <p>11. Woolley, A. R. (2019). <i>Alaline rocks and carbonatites of the world. Part 4: Antarctica, Asia and Europe (excluding the former USSR), Australasia and Oceanic Islands</i>. Geological Society of London.</p>
<b>Web Resources:</b>	<p><a href="https://www.virtualmicroscope.org/">https://www.virtualmicroscope.org/</a></p> <p><a href="https://www.alexstrekeisen.it/">https://www.alexstrekeisen.it/</a></p>

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<b>Title of the Course</b>	Economic Geology
<b>Course Code</b>	GEO-5006
<b>Number of Credits</b>	03
<b>Theory/Practical</b>	Theory
<b>Level</b>	400
<b>Effective from AY</b>	2025-2026
<b>New Course</b>	No
<b>Bridge Course/ Value added Course</b>	No
<b>Course for advanced learners</b>	No

<b>Pre-requisites for the Course:</b>	Nil	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Classify different types of ore deposits</li> <li>2. Explain the processes of ore mineralization</li> <li>3. Discuss the distribution of ore deposits</li> <li>4. Familiarize with the ore deposits of Goa</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, students will be able to:	<b>Mapped to PSO</b>
	CO 1. Classify different types of ore deposits	PSO 1, PSO 2, PSO 4, PSO 7
	CO 2. Describe the processes of ore mineralization.	PSO 1, PSO 2, PSO 3
	CO 3. Identify potential ore deposits.	PSO 2, PSO 4, PSO 7

	CO 4. Describe the ore deposits of Goa		PSO 1, PSO 4, PSO 5	
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>	<b>Cognitive Level</b>
<b>Module 1:</b>	Introduction: Scope of economic geology. Mineral economics. Ore, tenor, gangue, resource, reserves, Textures and structures of the ore deposits. Classification of ore deposits.	<b>15</b>	CO1, CO2, CO3, CO4	K1, K2
<b>Module 2:</b>	Ore bearing fluids: Type, nature, chemistry. Physicochemical controls of ore deposition; Wall-rock alteration. Controls of ore localization. Distribution of ore deposits in relation to plate tectonic settings. Magmatic and hydrothermal deposits.	<b>15</b>	CO2, CO3, CO4	K1, K2, K3
<b>Module 3:</b>	Distribution, genesis and ore deposits of India: Iron ore, Manganese ore, Polymetallic ore, copper, lead, zinc, Chromite, Laterite and Bauxite, Asbestos, Barite, Gold and Diamond. Offshore and deep-sea deposits. Mineral deposits of Goa.	<b>15</b>	CO1, CO2, CO3, CO4	K3, K4, K5
<b>Pedagogy:</b>	Lectures/ tutorials/assignments/field study/discussion			
<b>Text</b>	<ol style="list-style-type: none"> <li>1. Guilbert, J. M., and Park Jr, C. F. (2007). The geology of ore deposits. Waveland Press.</li> <li>2. Jensen, M. L., and Bateman, A. M. (1991). Economic Mineral Deposits 3rd edition-Revised Printing.</li> <li>3. Brown, J. C., &amp; Dey, A. K. (1976). Mineral and nuclear fuels of the Indian subcontinent and Burma.</li> <li>5. Roy, B. C. (1973). Indian Mineral Resources, Industries, and Economics. Calcutta: Editions Indian.</li> <li>6. Arndt, N., Kesler, S., and Ganino, C. (2015). Metals and society: An introduction to Economic geology. Springer.</li> <li>7. Taylor, R. (2010). Ore textures: recognition and interpretation. Springer Science &amp; Business Media.</li> </ol>			

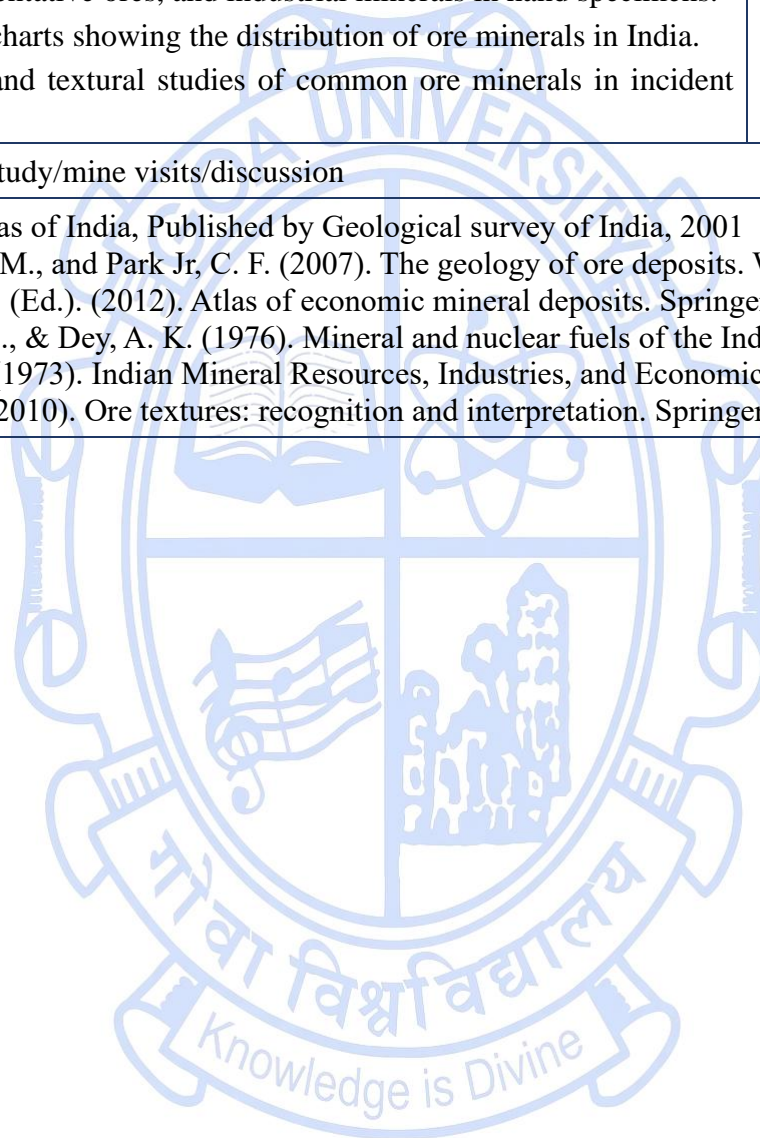
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<b>Title of the Course</b>	Practical of Economic Geology
<b>Course Code</b>	GEO-5007
<b>Number of Credits</b>	01
<b>Theory/Practical</b>	Practical
<b>Level</b>	400
<b>Effective from AY</b>	2025-26
<b>New Course</b>	No
<b>Bridge Course/ Value added Course</b>	No
<b>Course for advanced learners</b>	No

<b>Pre-requisites for the Course:</b>	Nil		
<b>Course Objectives:</b>	The objectives of this course are to: 1. Describe the properties of the ore minerals in hand specimen 2. Plotting ore mineral deposits on the outline map of India		
<b>Course Outcomes:</b>	At the end of the course, students will be able to:	<b>Mapped to PSO</b>	
	CO 1. Identify the ore minerals in hand specimen and under the microscope	PSO 1, PSO 2, PSO 4, PSO 6	
	CO 2. Locate ore mineral deposits of India.	PSO 1, PSO 2, PSO 4, PSO 6, PSO 7	
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>
			<b>Cognitive Level</b>

<b>Module 1:</b>	Study of representative ores, and industrial minerals in hand specimens. Preparation of charts showing the distribution of ore minerals in India. Mineralogical and textural studies of common ore minerals in incident light.	<b>30</b>	CO1, CO2	K1, K2, K4, K6
<b>Pedagogy:</b>	Lectures/field study/mine visits/discussion			
<b>Text</b>	<ol style="list-style-type: none"> <li>1. Mineral Atlas of India, Published by Geological survey of India, 2001</li> <li>2. Guilbert, J. M., and Park Jr, C. F. (2007). The geology of ore deposits. Waveland Press.</li> <li>3. Dixon, C. J. (Ed.). (2012). Atlas of economic mineral deposits. Springer Science &amp; Business Media.</li> <li>4. Brown, J. C., &amp; Dey, A. K. (1976). Mineral and nuclear fuels of the Indian subcontinent</li> <li>5. Roy, B. C. (1973). Indian Mineral Resources, Industries, and Economics. Calcutta: Editions Indian.</li> <li>6. Taylor, R. (2010). Ore textures: recognition and interpretation. Springer Science &amp; Business Media.</li> </ol>			

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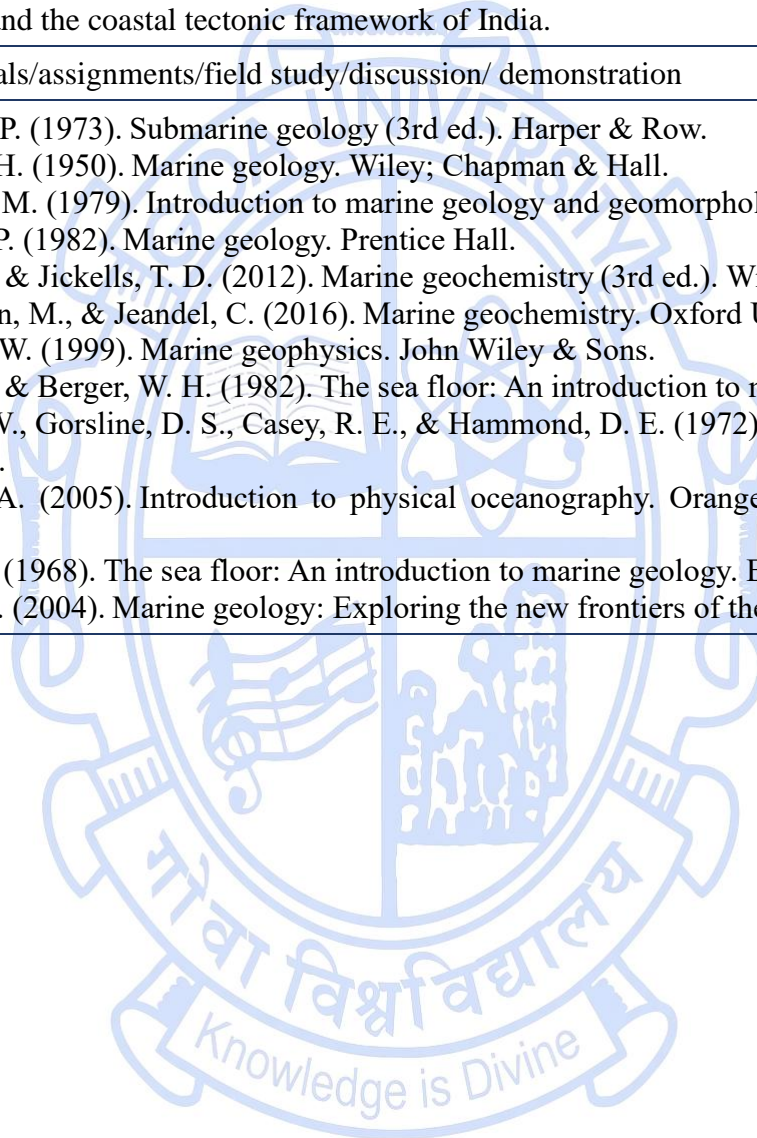
### Discipline Specific Elective Courses

<b>Title of the Course</b>	Marine Geology	
<b>Course Code</b>	GEO-5201	
<b>Number of Credits</b>	03	
<b>Theory/Practical</b>	Theory	
<b>Level</b>	400	
<b>Effective from AY</b>	2025-26	
<b>New Course</b>	No	
<b>Bridge Course/ Value added Course</b>	No	
<b>Course for advanced learners</b>	No	
<b>Pre-requisites for the Course:</b>	Nil	
<b>Course Objectives:</b>	<p>The objectives of this course are to</p> <ol style="list-style-type: none"> <li>1. Impart foundational knowledge of coastal processes and oceanic features.</li> <li>2. Familiarize students with marine mineral resources, their genesis, classification, and economic significance.</li> <li>3. Introduce techniques in marine geophysics for seabed mapping and resource exploration.</li> <li>4. Understand coastal zone management, marine policies, and strategies for addressing coastal hazards and environmental concerns.</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, the student will be able to:	<b>Mapped to PSO</b>
	CO 1. Identify key geomorphological and tectonic features of the ocean floor and coastal zones.	PSO1, PSO2, PSO4

	CO 2. Classify marine sediments and mineral resources and assess their economic potential, particularly in the Indian context.		PSO1, PSO2, PSO4, PSO6	
	CO 3. Apply basic geophysical methods for marine exploration and data analysis.		PSO1, PSO2, PSO3, PSO4, PSO6	
	CO 4. Evaluate coastal management practices and legal frameworks addressing coastal hazards, resource use, and environmental protection.		PSO1, PSO2, PSO3, PSO6, PSO7	
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>	<b>Cognitive Level</b>
<b>Module 1:</b>	Introduction and scope of marine geology, coastal zone and coastline classifications, beaches, types of beaches and beach landforms, oceanic and landform features. Morphologic and tectonic domain of the ocean floor: deep ocean floor and various topographic features—ridges, seamounts, coral reefs, continental shelf, continental slope, trenches, and canyons. Origin of oceanic crust, oceanic circulation, waves and currents, pelagic sediments, abyssal plain sediments, classification of sediment, and ocean tectonics.	<b>15</b>	CO1, CO2	K1, K2, K4
<b>Module 2:</b>	Classification of marine mineral deposits, origin and depositional system of marine resources, beach placers, shelf deposits, phosphorites, carbonates, polymetallic nodules, gas hydrates, hydrocarbon deposits, sulphide deposits, hydrothermal deposits, reserves, and economics of marine resources with special reference to India. AI and digital technology in ocean exploration and innovation. Introduction to marine geophysics, methods of geophysical surveys for seabed mapping and mineral exploration. Introduction to Marine Geochemistry. Laboratory methods for sample analyses.	<b>15</b>	CO1, CO2, CO3	K2, K3, K4, K5
<b>Module 3</b>	Coastal zone management, coastal erosion and protection measures, coastal natural disasters and management, saltwater intrusion and submarine groundwater discharge, marine spatial planning, coastal zone regulation and acts, and the law of the seas. Coastal surveys including beach profiling, exclusive economic zones	<b>15</b>	CO4	K4, K5

	(EEZ), concept and causes of sea level changes and measurements, Introduction to paleo-beaches and the coastal tectonic framework of India.			
<b>Pedagogy:</b>	Lectures/ tutorials/assignments/field study/discussion/ demonstration			
<b>Text</b>	<ol style="list-style-type: none"> <li>1. Shepard, F. P. (1973). Submarine geology (3rd ed.). Harper &amp; Row.</li> <li>2. Kuenen, P. H. (1950). Marine geology. Wiley; Chapman &amp; Hall.</li> <li>3. King, C. A. M. (1979). Introduction to marine geology and geomorphology. The English Language Book Society.</li> <li>4. Kennett, J. P. (1982). Marine geology. Prentice Hall.</li> <li>5. Chester, R., &amp; Jickells, T. D. (2012). Marine geochemistry (3rd ed.). Wiley-Blackwell.</li> <li>6. Roy-Barman, M., &amp; Jeandel, C. (2016). Marine geochemistry. Oxford University Press.</li> <li>7. Jones, E. J. W. (1999). Marine geophysics. John Wiley &amp; Sons.</li> <li>8. Seibold, E., &amp; Berger, W. H. (1982). The sea floor: An introduction to marine geology. Springer-Verlag.</li> <li>9. Pipkin, B. W., Gorsline, D. S., Casey, R. E., &amp; Hammond, D. E. (1972). Laboratory exercises in oceanography. W. H. Freeman.</li> <li>10. Knauss, J. A. (2005). Introduction to physical oceanography. Orange Grove Books. (Original work published earlier)</li> <li>11. Keen, M. J. (1968). The sea floor: An introduction to marine geology. Elsevier.</li> <li>12. Levin, H. L. (2004). Marine geology: Exploring the new frontiers of the ocean (The Living Earth). Facts On File.</li> </ol>			

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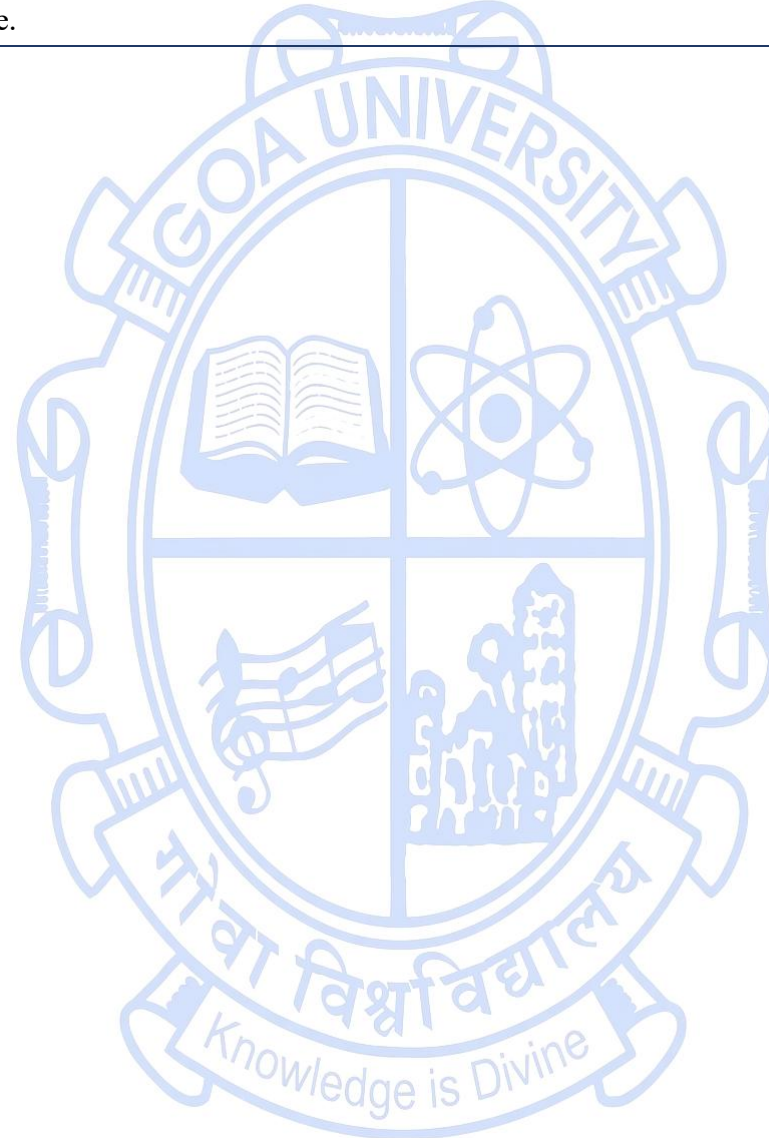
<b>Title of the Course</b>	Practical of Marine Geology
<b>Course Code</b>	GEO-5202
<b>Number of Credits</b>	01
<b>Theory/Practical</b>	Practical
<b>Level</b>	400
<b>Effective from AY</b>	2025-26
<b>New Course</b>	No
<b>Bridge Course/ Value added Course</b>	No
<b>Course for advanced learners</b>	No

<b>Pre-requisites for the Course:</b>	Nil	
<b>Course Objectives:</b>	<p>The objectives of this course are to</p> <ol style="list-style-type: none"> <li>1. Understand the principles and functions of marine geological tools and navigation instruments.</li> <li>2. Demonstrate techniques for beach profiling, coastal mapping, and marine mineral sampling.</li> <li>3. Explain the methodology for analyzing marine sediments and heavy minerals.</li> <li>4. Evaluate ocean floor features and tectonic settings using geomorphological and bathymetric data.</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, the student will be able to:	<b>Mapped to PSO</b>
	CO 1. Describe the usage of GPS, compass, depth sounder, and various marine survey systems	PSO1, PSO2, PSO3,
	CO 2. Carry out beach profiling and heavy mineral separation techniques in field and lab settings.	PSO1, PSO2, PSO3, PSO4, PSO6

	CO 3. Analyze sediment samples for grain size and mineral composition through microscopy and slide preparation		PSO1, PSO2, PSO4, PSO6
	CO 4. Interpret marine geomorphological features such as trenches, seamounts, and ridges using bathymetric maps.		PSO1, PSO2, PSO3, PSO4,
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b> <b>Cognitive Level</b>
<b>Module 1:</b>	Introduction to Marine Geological Tools: Familiarization with nautical charts and bathymetric maps, Use of GPS, compass, and depth sounder. Introduction to marine survey equipment: echo sounder, sub-bottom profiler, side-scan sonar, multibeam systems.	<b>4</b>	CO1      K1, K2, K3
<b>Module 2:</b>	Study of marine minerals in hand specimens and under the microscope.	<b>4</b>	CO1, CO3      K2, K3, K4
<b>Module 3:</b>	Beach profile mapping and beach survey. Separation and identification of heavy minerals in marine sediments; preparation and examination of smear slides.	<b>10</b>	CO2      K4, K5, K6
<b>Module 4:</b>	Preparation of coastal geomorphology map, ocean morphometry, resources, and tectonics. Identification of features like submarine canyons, seamounts, guyots, mid-ocean ridges, and trenches.	<b>12</b>	CO4      K2, K3, K4
<b>Pedagogy:</b>	Lectures/ tutorials/assignments/field study/discussion/ demonstration		
<b>Text</b>	<ol style="list-style-type: none"> <li>1. Kennett, J. P. (2001). <i>Marine geology</i> (2nd ed.). Upper Saddle River, NJ: Prentice Hall.</li> <li>2. Pinet, P. R. (2019). <i>Invitation to oceanography</i> (8th ed.). Burlington, MA: Jones &amp; Bartlett Learning.</li> <li>3. Trujillo, A. P., &amp; Thurman, H. V. (2020). <i>Essentials of oceanography</i> (13th ed.). New York, NY: Pearson.</li> <li>4. Davis, R. A. (2012). <i>Principles of oceanography</i> (1st ed.). Boston, MA: Pearson.</li> <li>5. Sharma, R. (2010). <i>Deep-sea mining: Resource potential, technical and environmental considerations</i>. Berlin: Springer. (Useful for understanding marine mineral resources and sampling techniques)</li> <li>6. Seibold, E., &amp; Berger, W. H. (1996). <i>The sea floor: An introduction to marine geology</i> (3rd ed.). Berlin: Springer-Verlag.</li> </ol>		

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|  | 7. Emery, K. O. (1968). <i>The sea off southern California: A modern sedimentary environment</i> . New York: Wiley-Interscience. |
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<b>Title of the Course</b>	Environmental Geology
<b>Course Code</b>	GEO-5203
<b>Number of Credits</b>	03
<b>Theory/Practical</b>	Theory
<b>Level</b>	500
<b>Effective from AY</b>	2025-2026
<b>New Course</b>	No
<b>Bridge Course/ Value added Course</b>	No
<b>Course for advanced learners</b>	No

<b>Pre-requisites for the Course:</b>	Bachelor of Science in Geology from a UGC recognized University.	
<b>Course Objectives:</b>	<p>The objectives of this course are to;</p> <ol style="list-style-type: none"> <li>1. Understand the fundamentals of natural and man-made hazards.</li> <li>2. Discuss environmental issues associated with industrialization and urbanization.</li> <li>3. Apply principles of hydrology in water resource management.</li> <li>4. Explain causes of pollution and discuss preventive measures.</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, the student will be able to;	<b>Mapped to PSO</b>
	CO 1. Describe geological processes affecting the environment.	PSO1, PSO2
	CO 2. Identify environmental issues associated with industrialization and urbanization.	PSO1, PSO3
	CO 3. Examine hydrological processes to manage water resources.	PSO1, PSO3, PSO4

	CO 4. Evaluate causes of pollution and suggest remedial measures.		PSO1, PSO2, PSO4	
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>	<b>Cognitive Level</b>
<b>Module 1:</b>	Scope and concepts of environmental geology, human population growth and sustainability. Ecosystems, lithos-pHERE, hydrosphere, cryosphere and atmosphere. Natural and manmade hazards, risks and their mitigations: Mass movements, deforestation, volcanic eruptions, earthquakes, tsunamis, floods and droughts. Case studies	<b>15</b>	CO1	K1. K2
<b>Module 2:</b>	Global warming - Industrialization, urbanization, urban heat island, urban environments and their impact. Exploitation of fossil fuels. Coal mining and related hazards. Sea level changes and causative factors. Coastal processes: Natural and anthropogenic hazards and mitigation. Trace elements and their implications on health, controls on elemental intake.	<b>15</b>	CO2, CO4	KI, K2, K3
<b>Module 3:</b>	Impact assessment of degradation and contamination of surface and groundwater quality due to industrialization and urbanization. Organic and inorganic contamination of groundwater and its remedial measures. Geological and hydrogeological aspects of waste disposal, site selection for solid waste disposal-sanitary landfills. Surface and subsurface disposal of toxic, metallic and radioactive wastes. Planning and management of hazardous waste. Environmental legislation and EIA in India.	<b>15</b>	CO2, CO3, CO4.	K2, K3, K4
<b>Pedagogy:</b>	Lectures, case studies, discussions and assignments.			
<b>Text</b>	<ol style="list-style-type: none"> <li>1. Keller, E. A. (2012). <i>Introduction to Environmental Geology</i> (5th ed). Prentice Hall.</li> <li>2. Merritts. D., De Wet, A., &amp; Menking, K. (1997). <i>Environmental Geology: an earth system science approach</i>. W. H. Freeman, New York.</li> <li>3. Montgomery, C. W. (2020). <i>Environmental geology</i>. (11th ed). Professor Emerita, Northern Illinois University.</li> <li>4. Pipkin, B. W., Trent, D. D., Hazlett, R., &amp; Bierman, P. (2013). <i>Geology and the Environment</i>. Cengage Learning.</li> <li>5. Valdiya, K. S. (2013). <i>Environmental Geology: Ecology, Resource and Hazard Management</i>. McGraw-Hill Education.</li> </ol>			

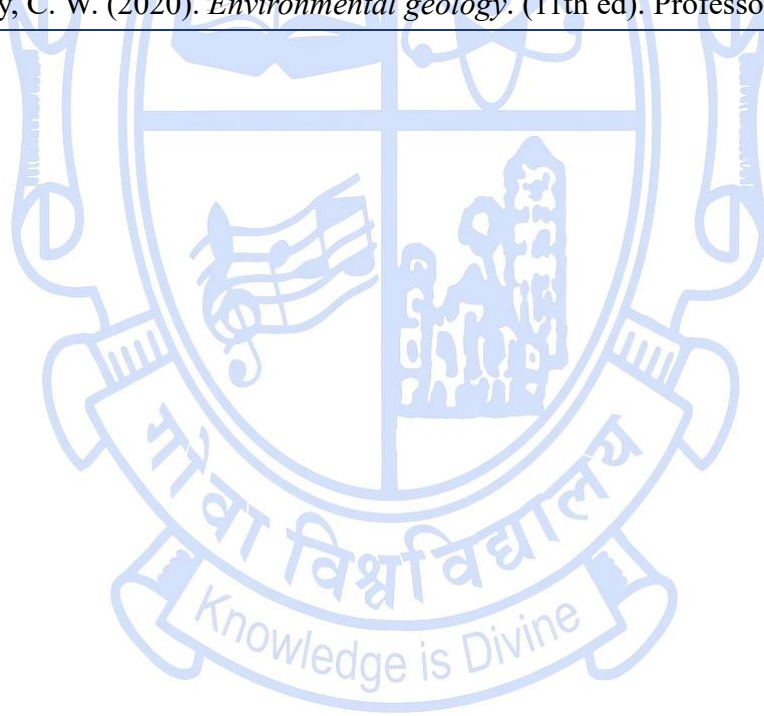
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<b>Title of the Course</b>	Practical of Environmental Geology
<b>Course Code</b>	GEO-5204
<b>Number of Credits</b>	01
<b>Theory/Practical</b>	Practical
<b>Level</b>	500
<b>Effective from AY</b>	2025-26
<b>New Course</b>	No
<b>Bridge Course/ Value added Course</b>	No
<b>Course for advanced learners</b>	No

<b>Pre-requisites for the Course:</b>	Bachelor of Science in Geology from a UGC recognized University.		
<b>Course Objectives:</b>	The objectives of this course are; 1. Identify distribution of natural and anthropogenic hazards prone regions in India. 2. Predicting movement of groundwater and pollutants in the subsurface		
<b>Course Outcomes:</b>	At the end of the course, the student will be able to;	<b>Mapped to PSO</b>	
	CO1: Identify natural and anthropogenic hazard-prone regions in India.	PSO5	
	CO 2: Plot groundwater flow and subsurface movement of pollutants.	PSO6	
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>
			<b>Cognitive Level</b>

<b>Module 1:</b>	Preparation of global and Indian natural hazard maps; Plotting of following on the map of India: Seismic zone, regions affected by contamination of water, soil map, landslide susceptible zones, flood prone areas, Coastal regulatory zones.	<b>12</b>	CO1, CO2, CO3, CO4.	K1, K2, K3
<b>Module 2:</b>	Interpretation of transport of pollutants in the subsurface based on given data. Preparation of groundwater flow nets.	<b>10</b>	CO2, CO3, CO4	K2, K3
<b>Module 3:</b>	Assessment of probable contaminant movement in the subsurface. Solving problems on movement of pollutants using simple computer assisted models.	<b>8</b>	CO2, CO4	K2, K3
<b>Pedagogy:</b>	Lectures, case studies, discussions and assignments.			
<b>Text</b>	<ol style="list-style-type: none"> <li>1. Keller, E. A. (2012). <i>Introduction to Environmental Geology</i> (5th). Prentice Hall.</li> <li>2. Pipkin, B. W., Trent, D. D., Hazlett, R., &amp; Bierman, P. (2013). <i>Geology and the Environment</i>. Cengage Learning.</li> <li>3. Montgomery, C. W. (2020). <i>Environmental geology</i>. (11th ed). Professor Emerita, Northern Illinois University</li> </ol>			

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## SEMESTER II

### Discipline Specific Core Course

<b>Title of the Course</b>	Sedimentology
<b>Course Code</b>	GEO-5008
<b>Number of Credits</b>	03
<b>Theory/Practical</b>	Theory
<b>Level</b>	500
<b>Effective from AY</b>	2025-2026
<b>New Course</b>	No
<b>Bridge Course/ Value added Course</b>	No
<b>Course for advanced learners</b>	No

<b>Pre-requisites for the Course:</b>	Nil
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"><li>1. Explain the fundamental processes of weathering, transportation, and deposition that shape sedimentary environments.</li><li>2. Learn various sedimentary rocks, their petrographic features and provenance.</li><li>3. Study terrestrial and marine depositional environments.</li><li>4. Understand the formation, tectonic settings and evolution of sedimentary basin.</li></ol>

<b>Course Outcomes:</b>	At the end of the course, student will be able to:	<b>Mapped to PSO</b>		
	CO 1. Describe the key sedimentary processes.	PSO 1, PSO 2, PSO 3		
	CO 2. Classify sedimentary rocks based on texture, composition and petrographic characteristics.	PSO 1, PSO 2, PSO 3, PSO 6		
	CO 3. Differentiate between different terrestrial and marine depositional environments.	PSO 2, PSO 3, PSO 4, PSO 6		
	CO 4. Analyze sedimentary basin types and assess their geological significance.	PSO 1, PSO 2, PSO 3, PSO 7		
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>	<b>Cognitive Level</b>
<b>Module 1:</b>	<p>Introduction to sedimentology, temporal and spatial distribution of sedimentary rocks and their applications.</p> <p>Sedimentary processes:</p> <p>Weathering: Types and their products, soils and paleosols; transportation and deposition, Fundamentals of fluid flow, particle transport by fluid and by sediment gravity flows.</p> <p>Textures and structures of sedimentary rocks and their origin.</p>	<b>15</b>	CO1	K1, K2, K3,
<b>Module 2:</b>	<p>Sediments and Sedimentary rocks: Petrography, classification and provenance of - Terrigenous/clastic sedimentary rocks: Conglomerate, breccia, sandstones and mud rocks.</p> <p>Heavy minerals in clastic sediments: Mineralogy, separation techniques, and significance.</p> <p>Carbonate rocks: Limestones and dolomites.</p> <p>Evaporites, silicious, phosphatic, iron and manganese-rich sedimentary rocks and volcanoclastic sediments.</p>	<b>15</b>	CO2	K1, K2, K3, K4, K5

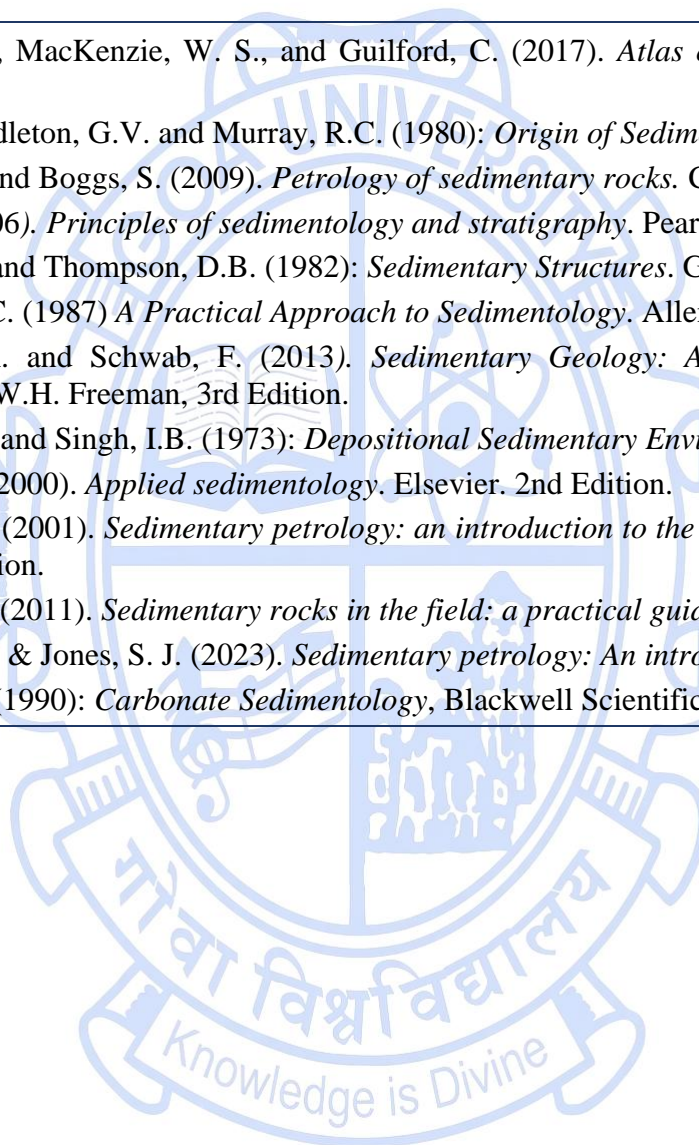
	Coal, oil shale and petroleum.			
<b>Module 3:</b>	<p>Depositional environments and sedimentary basins</p> <p>Introduction and classification: Terrestrial environment - fluvial system, eolian (desert) system, lacustrine system and glacial system.</p> <p>Marine environment: Deltaic system, beach and barriers island system, estuarine system, lagoonal system, tidal flat system; shelf and deep-water environment.</p> <p>Types of sedimentary basins.</p>	<b>15</b>	CO3, CO4	K1, K2, K3, K4, K5
<b>Pedagogy:</b>	Lectures, case studies, discussions and assignments.			
<b>Text</b>	<ol style="list-style-type: none"> <li>1. Boggs Jr, S., and Boggs, S. (2009). <i>Petrology of sedimentary rocks</i>. Cambridge university press. 2nd Edition.</li> <li>2. Boggs, S. (2006). <i>Principles of sedimentology and stratigraphy</i>. Pearson Prentice Hall. 4th Edition.</li> <li>3. Collinson, J. (2006). <i>Sedimentary structures</i>. Dunedin Academic Press Ltd.</li> <li>4. Çiner, A., Banerjee, S., Lucci, F., Radwan, A. E., Shah, A. A., Doronzo, D. M., ... &amp; Bauer, W. (2023). <i>Recent Research on Sedimentology, Stratigraphy, Paleontology, Tectonics, Geochemistry, Volcanology and Petroleum Geology</i>.</li> <li>5. Greensmith, J. T. (1989). <i>Petrology of the sedimentary rocks</i> (7th ed.). Unwin Hyman.</li> <li>6. Nichols, G. (2009). <i>Sedimentology and stratigraphy</i>. John Wiley and Sons.</li> <li>7. Pettijohn, F. J. (2004). <i>Sedimentary rocks</i> (3rd ed.). CBS Publishers.</li> <li>8. Prothero, D.R. and Schwab, F. (2013). <i>Sedimentary Geology: An Introduction to Sedimentary Rocks and Stratigraphy</i>. W.H. Freeman, 3rd Edition.</li> <li>9. Selley, R. C. (2000). <i>Applied sedimentology</i>. Elsevier. 2nd Edition.</li> <li>10. Sengupta, S. (2017). <i>Introduction to sedimentology</i>. Routledge.</li> <li>11. Tucker, M. E., &amp; Jones, S. J. (2023). <i>Sedimentary petrology</i>. John Wiley &amp; Sons.</li> <li>12. Tucker, M. E. (2001). <i>Sedimentary petrology: an introduction to the origin of sedimentary rocks</i>. John Wiley and Sons. 3rd Edition.</li> </ol>			

<b>Title of the Course</b>	Practical of Sedimentology	
<b>Course Code</b>	GEO-5009	
<b>Number of Credits</b>	01	
<b>Theory/Practical</b>	Practical	
<b>Level</b>	500	
<b>Effective from AY</b>	2025-2026	
<b>New Course</b>	No	
<b>Bridge Course/ Value added Course</b>	No	
<b>Course for advanced learners</b>	No	
<b>Pre-requisites for the Course:</b>	Nil	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Study granulometric sieving method to understand the grain size distribution.</li> <li>2. Construct paleocurrent plots to illustrate spatial sediment transport patterns.</li> <li>3. Identify sedimentary rocks and their textural as well as structural features through hand specimen and thin section analysis.</li> <li>4. Perform heavy mineral analysis.</li> <li>5. Study core logs to infer depositional environments and provenance.</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, student will be able to:	<b>Mapped to PSO</b>

	CO 1. Perform granulometric and statistical analyses on sediments.		PSO1, PSO2, PSO3, PSO4, PSO6, PSO7	
	CO 2. Interpret paleocurrent data.			
	CO 3. Classify sedimentary rocks in hand specimen and using a microscope.			
	CO 4. Analyze heavy mineral assemblages.			
	CO 5. Interpret core logs.			
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>	<b>Cognitive Level</b>
<b>Module 1:</b>	Granulometric analysis by sieving method: Textural analyses of sediments, plotting of grain size data and statistical analyses and interpretation.	<b>8</b>	CO1	K1, K2, K3, K4, K5
<b>Module 2:</b>	Paleocurrent analysis: Exercises using sets of directional data to understand spatial variation in vectorial data.	<b>4</b>	CO2	K1, K2, K3, K4, K5
<b>Module 3:</b>	Study of hand specimens: Megascopic identification of sedimentary rocks, observation of texture, structure and diagenetic changes; inferences on depositional environment.	<b>4</b>	CO3	K3, K4, K5
<b>Module 4:</b>	Study of thin sections: microscopic identification of sedimentary rocks, observation of texture, mineralogy and diagenetic changes.	<b>4</b>	CO3	K3, K4, K5
<b>Module 5:</b>	Heavy mineral separation and analysis for provenance interpretation: Sample collection and preparation, Heavy liquid separation, identification under binocular microscope and provenance interpretation using mineral assemblages.	<b>6</b>	CO4	K2, K3, K4
<b>Module 6:</b>	Sedimentological interpretation of core logs: Examination of sediment characteristics and variation using either existing data sets or collected sediment cores.	<b>4</b>	CO5	K2, K3, K4, K5, K6
<b>Pedagogy:</b>	Lectures, demonstrations, problem-solving, hands-on experience in megascopic and microscopic identification of rocks			

	and discussions.
<b>Text</b>	<ol style="list-style-type: none"> <li>1. Adams, A. E., MacKenzie, W. S., and Guilford, C. (2017). <i>Atlas of sedimentary rocks under the microscope</i>. Routledge.</li> <li>2. Blatt, H., Middleton, G.V. and Murray, R.C. (1980): <i>Origin of Sedimentary Rocks</i>, Prentice-Hall Inc.</li> <li>3. Boggs Jr, S., and Boggs, S. (2009). <i>Petrology of sedimentary rocks</i>. Cambridge University Press. 2nd Edition.</li> <li>4. Boggs, S. (2006). <i>Principles of sedimentology and stratigraphy</i>. Pearson Prentice Hall. 4th Edition.</li> <li>5. Collins, J.D., and Thompson, D.B. (1982): <i>Sedimentary Structures</i>. George Allen &amp; Unwin, London.</li> <li>6. Lindholm, R.C. (1987) <i>A Practical Approach to Sedimentology</i>. Allen &amp; Unwin, London.</li> <li>7. Prothero, D.R. and Schwab, F. (2013). <i>Sedimentary Geology: An Introduction to Sedimentary Rocks and Stratigraphy</i>. W.H. Freeman, 3rd Edition.</li> <li>8. Reineck, H.E. and Singh, I.B. (1973): <i>Depositional Sedimentary Environments</i>. Springer-Verlag.</li> <li>9. Selley, R. C. (2000). <i>Applied sedimentology</i>. Elsevier. 2nd Edition.</li> <li>10. Tucker, M. E. (2001). <i>Sedimentary petrology: an introduction to the origin of sedimentary rocks</i>. John Wiley and Sons. 3rd Edition.</li> <li>11. Tucker, M. E. (2011). <i>Sedimentary rocks in the field: a practical guide</i> (Vol. 38). John Wiley and Sons.</li> <li>12. Tucker, M. E., &amp; Jones, S. J. (2023). <i>Sedimentary petrology: An introduction</i> (4th ed.). Wiley.</li> <li>13. Tucker, M.E. (1990): <i>Carbonate Sedimentology</i>, Blackwell Scientific Publication.</li> </ol>

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<b>Title of the Course</b>	Metamorphic Petrology
<b>Course Code</b>	GEO-5010
<b>Number of Credits</b>	03
<b>Theory/Practical</b>	Theory
<b>Level</b>	500
<b>Effective from AY</b>	2025-2026
<b>New Course</b>	No
<b>Bridge Course/ Value added Course</b>	No
<b>Course for advanced learners</b>	No

<b>Pre-requisites for the Course:</b>	Nil	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Understand the types, facies, textures, and field characteristics of metamorphic rocks and the factors influencing metamorphism.</li> <li>2. Learn and apply thermodynamic principles to interpret equilibrium conditions and phase relations in metamorphic systems.</li> <li>3. Study metamorphic reactions and employ chemographic diagrams to understand progressive metamorphism in different rock types.</li> <li>4. Understand metamorphic petrology concepts with reference to plate tectonic settings and geodynamic processes.</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, the student will be able to:	<b>Mapped to PSO</b>
	CO 1. Interpret the types, facies, and textures of metamorphic rocks and their formation.	PSO 1, PSO 2

	CO 2. Apply thermodynamic principles to metamorphic phase equilibria and geothermobarometry.		PSO 1, PSO 3, PSO 6	
	CO 3. Interpret metamorphic reactions and chemographic projections of various lithologies.		PSO 2, PSO 3, PSO 6	
	CO 4. Evaluate the relationship between metamorphism and plate tectonics and its implications for crustal processes.		PSO 1, PSO 2, PSO 7	
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>	<b>Cognitive Level</b>
<b>Module 1:</b>	Types, Facies and Textures of metamorphic rocks: Definitions, factors and conditions of metamorphism; pressure and temperature limits of metamorphism; Types of metamorphism - orogenic, ocean-floor, regional, contact, cataclastic, hydrothermal, and other types of small-scale metamorphism. Facies and facies series; Zones of Metamorphism; Concept and origin of isograds; General characteristics of contact and regional metamorphic rocks; Classification and types of textures; Interpretation of porphyroblast–inclusion relations.	<b>15</b>	CO1, CO4	K2, K5
<b>Module 2:</b>	Thermodynamics Related to Mineral Science: Concept of equilibrium in metamorphic systems; Gibbs phase rule and mineralogical phase rule and their application in simple and complex systems. First law of thermodynamics, second law of thermodynamics—definition of entropy, third law of thermodynamics, thermodynamic equations, free energy of formation of minerals at any temperature and pressure, free energy surface in G–T–P–X space, free energy of ideal and non-ideal solutions, the regular solution model, equilibrium constant of a reaction and its relation with Gibbs free energy. Geothermometry.	<b>15</b>	CO2	K2, K3, K4
<b>Module 3:</b>	Metamorphic Reactions, Chemographic Projections and Progressive metamorphism in pelitic, carbonate and mafic rocks: Different types of metamorphic reactions, reactions among solid phase components, reactions involving	<b>15</b>	CO2, CO3, CO4	K3, K4, K5

	volatiles as reacting species, controls of pressure, temperature and chemical compositions on the metamorphic reactions, time scale of metamorphism; ACF, AKF and AFM diagrams; Progressive metamorphism in pelitic, carbonate and mafic rocks; Metamorphism in the context of plate tectonics.			
<b>Pedagogy:</b>	Lectures/ tutorials/ assignments.			
<b>Text</b>	<ol style="list-style-type: none"> <li>1. Winter, J. D. (2010). <i>An Introduction to Igneous and Metamorphic Petrology (2nd Edition)</i>, Pearson Education, Inc.</li> <li>2. Philpotts, A., &amp; Ague, J. (2009). <i>Principles of Igneous and Metamorphic Petrology (2nd ed.)</i>. Cambridge: Cambridge University Press. doi:10.1017/CBO9780511813429.</li> <li>3. Bucher, K., &amp; Grapes, R. (2011). <i>Petrogenesis of Metamorphic Rocks (8th Edition)</i>, Springer.</li> <li>5. Best, M. (2002). <i>Igneous and Metamorphic Petrology (2nd Edition)</i>. Blackwell Science Ltd.</li> <li>6. Frost, R., and Frost, C., (2014). <i>Essentials of Igneous and Metamorphic Petrology</i>. Cambridge University Press, New York.</li> <li>7. Vernon, R., (2018). <i>A Practical Guide to Rock Microstructure (2nd Ed.)</i>, Cambridge University Press, <a href="https://doi.org/10.1017/9781108654609">https://doi.org/10.1017/9781108654609</a>.</li> <li>8. Winkler, H.G.F., (1979). <i>Metamorphic Petrogenesis (5th Ed.)</i>. Springer Verlag, New York.</li> <li>9. Spear, F., (1993). <i>Metamorphic Phase Equilibria and Pressure Temperature-Time Paths</i>. Mineralogical Society of America, Washington, D.C.</li> </ol>			
<b>Web Resources:</b>	<a href="https://www.virtualmicroscope.org/">https://www.virtualmicroscope.org/</a> <a href="https://atlas-of-metamorphic-minerals.netlify.app">https://atlas-of-metamorphic-minerals.netlify.app</a> <a href="https://www.perplex.ethz.ch/">https://www.perplex.ethz.ch/</a> <a href="https://www.gplates.org/">https://www.gplates.org/</a>			

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<b>Title of the Course</b>	Practical of Metamorphic Petrology
<b>Course Code</b>	GEO-5011
<b>Number of Credits</b>	01
<b>Theory/Practical</b>	Practical
<b>Level</b>	500
<b>Effective from AY</b>	2025-2026
<b>New Course</b>	No
<b>Bridge Course/ Value added Course</b>	No
<b>Course for advanced learners</b>	No

<b>Pre-requisites for the Course:</b>	Nil	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Learn to identify common metamorphic minerals and rocks in hand specimens and thin sections.</li> <li>2. Understand and apply techniques for calculating ionic radius ratios and mineral structural formulae.</li> <li>3. Study metamorphic rocks based on mineral assemblages, textures, and fabric both macroscopically and microscopically.</li> <li>4. Impart skills of correlating the mineralogy and texture with metamorphic conditions and processes.</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, the student will be able to:	<b>Mapped to PSO</b>
	CO 1. Classify common metamorphic minerals in hand specimens and using a microscope.	PSO 1, PSO 2, PSO 4
	CO 2. Calculate ionic radius ratios and derive structural formulae of commonly occurring metamorphic minerals.	PSO 1, PSO 3, PSO 6

	CO 3. Classify metamorphic rocks based on mineral assemblages, texture, and fabric observed under the microscope and in hand specimen.		PSO 2, PSO 3, PSO 6
	CO 4. Interpret metamorphic conditions and rock histories based on mineralogy and textural relationships.		PSO 1, PSO 2, PSO 7
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b> <b>Cognitive Level</b>
<b>Module 1:</b>	Identification of typical metamorphic minerals in hand specimen and thin section.	<b>6</b>	CO1 K2
<b>Module 2:</b>	Calculation of ionic radius ratios in common silicate crystal structures. Calculation of structural formulae of commonly occurring minerals	<b>6</b>	CO2 K2, K3
<b>Module 3:</b>	Description, identification and classification of commonly occurring metamorphic rocks and their fabrics and textures in hand specimen	<b>8</b>	CO3, CO4 K3, K4, K5
<b>Module 4:</b>	Description, identification, and classification of commonly occurring metamorphic rocks and their fabrics and textures in thin section.	<b>10</b>	CO3, CO4 K3, K4, K5
<b>Pedagogy:</b>	Demonstrations /Laboratory observations / Plotting and Interpretations.		
<b>Text</b>	<ol style="list-style-type: none"> <li>1. Yardley, B. W., MacKenzie, W. S., and Guilford, C. (1997). <i>Atlas of metamorphic rocks and their textures</i>. Longman.</li> <li>2. Vernon, R. H. (2018). <i>A practical guide to rock microstructure</i>. Cambridge University Press.</li> <li>3. Dana, E. S., and Ford, W. E. (1952). <i>Dana's textbook of mineralogy</i>. Wiley Eastern Limited</li> <li>4. Winter, J. D. (2010). <i>An Introduction to Igneous and Metamorphic Petrology (2nd Edition)</i>, Pearson Education, Inc.</li> <li>5. Phillips W. R. and Griffen, D.T. (1981). <i>Optical Mineralogy: The Non-opaque Minerals</i>. W. H. Freeman and Co., Ltd. New York.</li> </ol>		
<b>Web Resources:</b>	<a href="https://www.virtualmicroscope.org/">https://www.virtualmicroscope.org/</a> <a href="https://atlas-of-metamorphic-minerals.netlify.app">https://atlas-of-metamorphic-minerals.netlify.app</a> <a href="https://www.alexstrekeisen.it/">https://www.alexstrekeisen.it/</a>		

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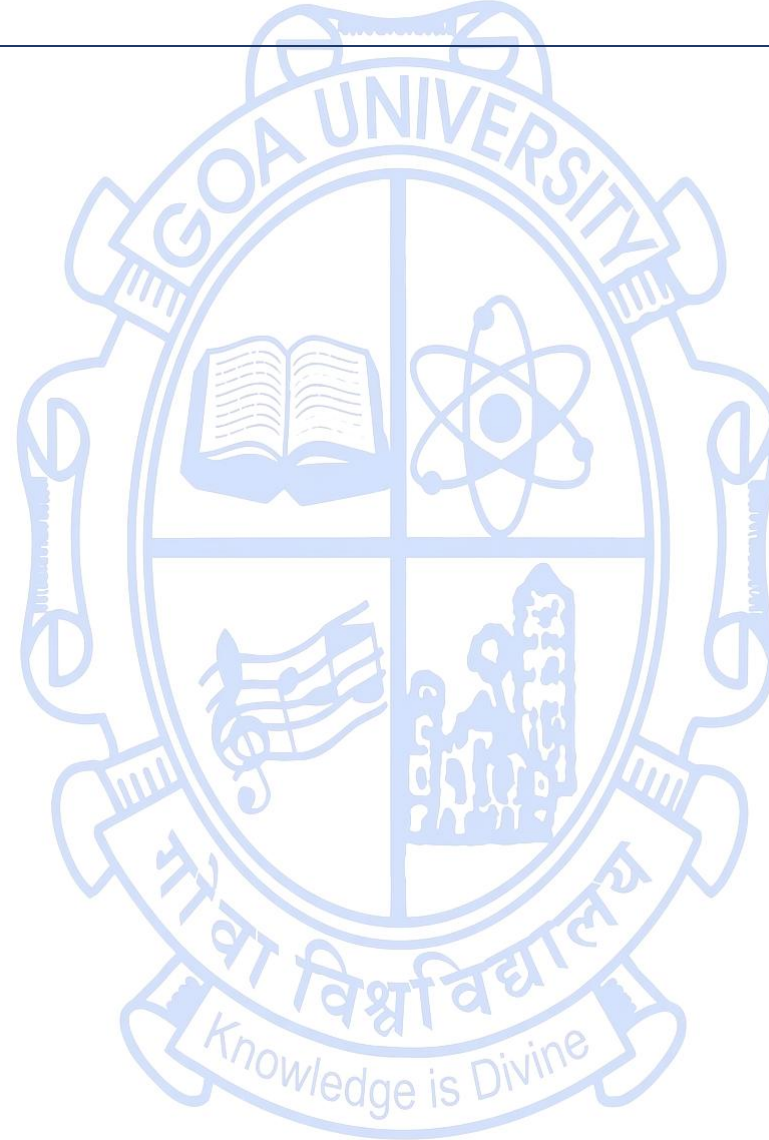
<b>Title of the Course</b>	Stratigraphy and Indian Geology
<b>Course Code</b>	GEO-5012
<b>Number of Credits</b>	03
<b>Theory/Practical</b>	Theory
<b>Level</b>	500
<b>Effective from AY</b>	2025-2026
<b>New Course</b>	No
<b>Bridge Course/ Value added Course</b>	No
<b>Course for advanced learners</b>	No

<b>Pre-requisites for the Course:</b>	Nil	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Describe key concepts of stratigraphy and their applications.</li> <li>2. Understand sedimentary sequences and recognize the depositional environment.</li> <li>3. Learn to relate geological events with stratigraphic records of India.</li> <li>4. Explain various stratigraphic units with their present geographic locations.</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, the student will be able to:	<b>Mapped to PSO</b>
	CO 1. Apply key concepts of stratigraphy for constructing stratigraphic sequences.	PSO1, PSO2
	CO 2. Interpret sedimentary sequences.	PSO1, PSO3
	CO 3. Correlate geological events with stratigraphic sequences of India.	PSO3, PSO4

	CO 4. Categorize various stratigraphic units with their geographic locations.		PSO1, PSO4
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b> <b>Cognitive Level</b>
<b>Module 1:</b>	Stratigraphic principles and their applications. Stratigraphic (Lithostratigraphic, Chronostratigraphic and Biostratigraphic) nomenclature and their inter-relationships. Depositional systems and system tracts. Palaeomagnetism and time correlation. Concepts of Magnetostratigraphy, Seismic stratigraphy, Chemostratigraphy and event stratigraphy.	<b>15</b>	CO1 K1, K2
<b>Module 2:</b>	Cratons and mobile belts, Archaean-Proterozoic boundary. Important Proterozoic basins of India. Precambrian/Cambrian boundary. Palaeozoic rocks in Himalayas. Mesozoic of Peninsular and Extra-Peninsular India. K-T boundary. Paleocene-Eocene Thermal Maxima (PETM), Cenozoic successions, Quaternary and Holocene stratigraphy.	<b>15</b>	CO2, CO4 K1, K2, K3
<b>Module 3:</b>	Important Stratigraphic Units of India: Stratigraphy of Gondwana Supergroup with special emphasis on fossils, climate and economic minerals. Deccan Volcanic Province: its distribution and lithological characteristics. Siwalik: Basin evolution, stratigraphy, and significant vertebrate fauna. Geology of Goa.	<b>15</b>	CO2, CO3, CO4. K2, K3, K4, K5
<b>Pedagogy:</b>	Lectures, case studies, discussions and assignments.		
<b>Text</b>	<ol style="list-style-type: none"> <li>1. Ramakrishnan, M., and Vaidyanadhan, R. (2010). Geology of India (vol. 1 and 2). <i>GSI Publications</i>, 2(1).</li> <li>2. Miall, A. D. (2010). <i>The geology of stratigraphic sequences</i>. Springer Science &amp; Business Media.</li> <li>3. Babin, C. (1996). Global events and event stratigraphy in the phanerozoic. <i>Geobios</i>, 29(3).</li> <li>4. Catuneanu, O. (2022). <i>Principles of sequence stratigraphy</i>. Newnes.</li> <li>5. Brookfield, M. E. (2008). <i>Principles of stratigraphy</i>. John Wiley &amp; Sons.</li> <li>6. Dessai, A.G. (2018) <i>Geology and Mineral resources of Goa</i>. New Delhi Publishers.</li> <li>7. Dessai, A. G. (2023). <i>Environment, resources and sustainable tourism: Goa as a case study</i>. Springer Nature.</li> <li>8. Salvador, A. (Ed.). (1994). <i>International stratigraphic guide: a guide to stratigraphic classification, terminology, and procedure</i> (No. 30). Geological Society of America.</li> </ol>		

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|--|---|
|  | 9. Saha, S., Das, S. S., Mondal, S., Banerjee, S., & Sarkar, S. (2021). <i>Mesozoic Stratigraphy of India</i> . A Multi-proxy Approach. |
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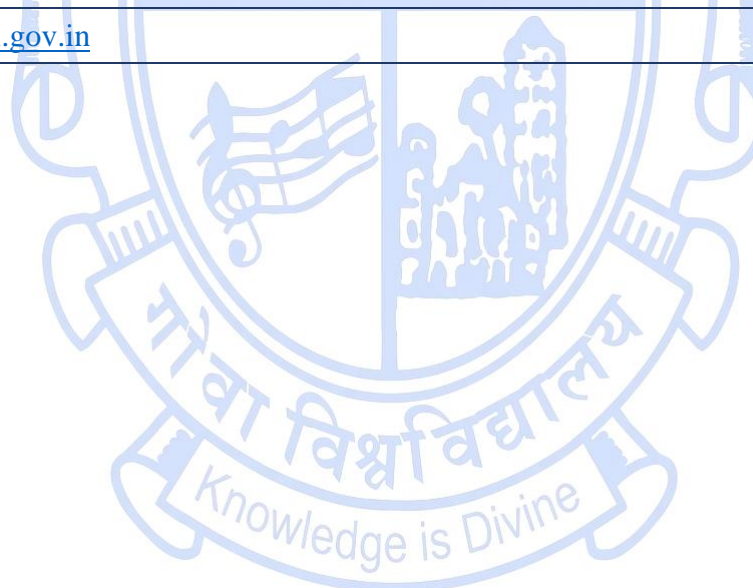


<b>Title of the Course</b>	Practical of Stratigraphy and Indian Geology
<b>Course Code</b>	GEO-5013
<b>Number of Credits</b>	01
<b>Theory/Practical</b>	Practical
<b>Level</b>	500
<b>Effective from AY</b>	2025-26
<b>New Course</b>	No
<b>Bridge Course/ Value added Course</b>	No
<b>Course for advanced learners</b>	No

<b>Pre-requisites for the Course:</b>	Nil			
<b>Course Objectives:</b>	The objectives of this course are to; 1. Understand the stratigraphic subdivisions and important geological formations in India. 2. Learn to prepare geological sections and correlate lithologic data.			
<b>Course Outcomes:</b>	At the end of the course, the student will be able to:		<b>Mapped to PSO</b>	
	CO 1. Plot stratigraphic subdivisions and important geological formations in India.		PSO1, PSO3	
	CO 2. Draw geological sections and correlate lithologic data.		PSO3, PSO4	
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>	<b>Cognitive Level</b>

<b>Module 1:</b>	Exercises on stratigraphic classification and correlation. Preparation of stratigraphic range charts.	<b>8</b>	CO1, CO2, CO3, CO4.	K1, K2, K3
<b>Module 2</b>	Study of rocks in hand specimens from Indian stratigraphic horizons and type localities.	<b>10</b>	CO2, CO3, CO4	K2, K3, K4
<b>Module 3</b>	Study of the geological maps of India and identification of major stratigraphic units. Locating/drawing of stratigraphic units on the outline map of Goa and India.	<b>12</b>	CO2, CO3, CO4	K2, K3, K4
<b>Pedagogy:</b>	Lectures, case studies, discussions and assignments.			
<b>Text</b>	<ol style="list-style-type: none"> <li>1. Ramakrishnan, M., and Vaidyanadhan, R. (2010). Geology of India (Vol. 1 and 2). <i>GSI Publications</i>, 2(1).</li> <li>2. Brookfield, M. E. (2008). <i>Principles of stratigraphy</i>. John Wiley &amp; Sons.</li> <li>3. Salvador, A. (Ed.). (1994). <i>International stratigraphic guide: a guide to stratigraphic classification, terminology, and procedure</i> (No. 30). Geological Society of America.</li> <li>4. Babin, C. (1996). Global events and event stratigraphy in the phanerozoic. <i>Geobios</i>, 29(3).</li> </ol>			
<b>Web Resources:</b>	<a href="https://www.gsi.gov.in">https://www.gsi.gov.in</a>			

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<b>Title of the Course</b>	Geological Field Mapping
<b>Course Code</b>	GEO-5014
<b>Number of Credits</b>	1
<b>Theory/Practical</b>	Theory
<b>Level</b>	500
<b>Effective from AY</b>	2025-2026
<b>New Course</b>	No
<b>Bridge Course/ Value added Course</b>	No
<b>Course for advanced learners</b>	No

<b>Pre-requisites for the Course:</b>	Nil	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Learn to use clinometer and brunton compass.</li> <li>2. Understand the lithology, structure and their position in stratigraphic succession.</li> <li>3. Learn to construct stratigraphic sequence.</li> <li>4. Learn techniques of field mapping.</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, the student will be able to:	<b>Mapped to PSO</b>
	CO 1. Identify geological features, minerals, rocks and structures in the field.	PSO1
	CO 2. Use techniques of field mapping.	PSO1, PSO2, PSO4
	CO 3. Undertake independent field mapping	PSO3, PSO4, PSO6,

	CO 4. Prepare geological maps.		PSO1, PSO4
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b> <b>Cognitive Level</b>
<b>Unit/Module 1:</b>	Use of clinometer and brunton compass. Use of GPS, DGPS, GNSS for spatial data collection. Techniques of field mapping. Techniques of field data collection. Recording the attitude of beds, foliation, lineation, joints and their analysis. Introduction to the stratigraphy of the study area.	<b>15</b>	CO1, CO2, CO3, CO4 K2, K3, K4
<b>Pedagogy:</b>	Lectures, case studies, discussions and assignments.		
<b>Text</b>	<ol style="list-style-type: none"> <li>1. Dessai, A. G. (2023). <i>Geology and environment of Goa</i>. Qurate Publishers</li> <li>2. Dessai, A.G. (2018) <i>Geology and Mineral resources of Goa</i>. New Delhi Publishers.</li> <li>3. Mehr S.S. (1991) <i>Geology of Gujarat</i>. Geological Society of India</li> <li>4. Radharishnan, B.P. and Vaidhyanadhan R., (1977) <i>Geology of Karnataka</i>. Geological Society of India.</li> <li>5. Raman, P.K. and Murty, V. N. (2012). <i>Geological Society of India</i>.</li> <li>6. Roy, A. B., &amp; Jakhar, S. R. (2002). <i>Geology of Rajasthan (Northwest India) precambrian to recent</i>. Scientific Publishers.</li> <li>7. Sinha-Roy, S. (2004). Precambrian Terranes of Rajasthan, India. <i>Sediment Hosted Lead-Zinc Sulphide Deposits</i>, 222.</li> </ol>		
<b>Web Resources:</b>	<a href="https://www.gsi.gov.in">https://www.gsi.gov.in</a>		

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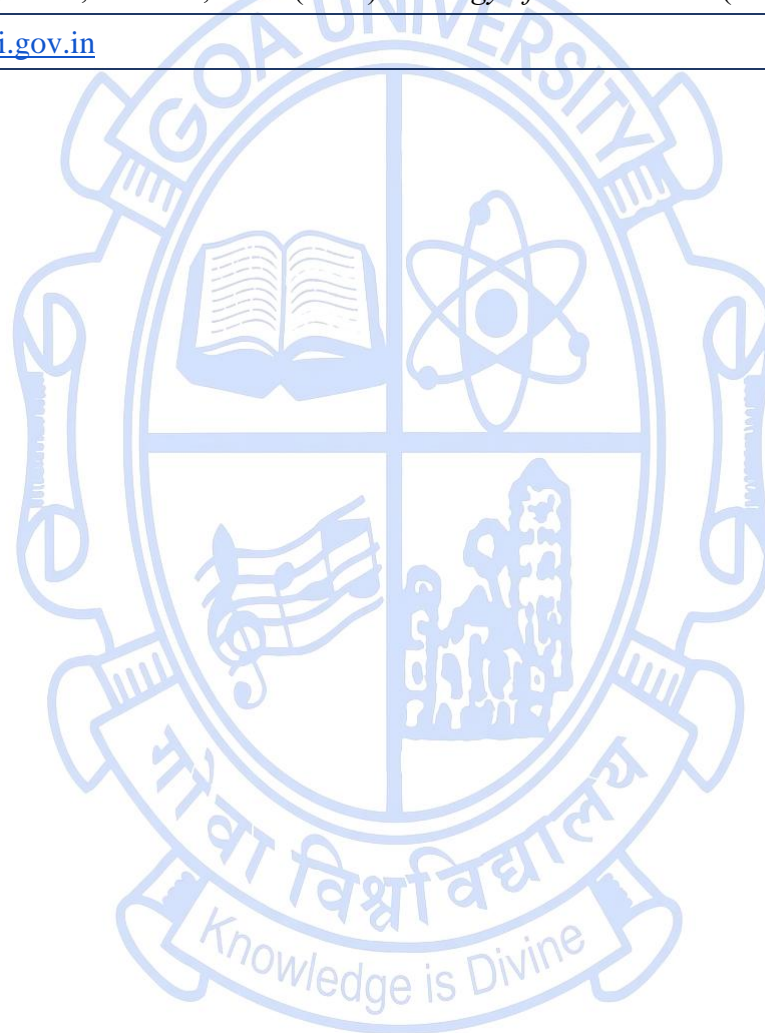
<b>Title of the Course</b>	Practical of Geological Field Mapping
<b>Course Code</b>	GEO-5015
<b>Number of Credits</b>	3
<b>Theory/Practical</b>	Practical
<b>Level</b>	500
<b>Effective from AY</b>	2025-2026
<b>New Course</b>	No
<b>Bridge Course/ Value added Course</b>	No
<b>Course for advanced learners</b>	No

<b>Pre-requisites for the Course:</b>	Nil	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Provide hands-on experience in the field.</li> <li>2. Understand the lithology, structure, and their position in stratigraphic succession.</li> <li>3. Understand the importance of working as a team.</li> <li>4. Learn to construct a stratigraphic sequence.</li> <li>5. Learn techniques of field mapping.</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, the student will be able to:	<b>Mapped to PSO</b>
	CO1: Identify geological features, minerals, rocks and structures in the field.	PSO1,

	CO2: Use techniques of field mapping.		PSO1, PSO2, PSO4
	CO3: Undertake independent field mapping		PSO3, PSO4, PSO6
	CO4: Prepare geological maps		PSO1, PSO4
	CO5: Prepare a detailed technical report of the study area.		PSO1, PSO2, PSO6, PSO7
<b>Content:</b>		<b>No. of hours</b>	<b>Mapped to CO</b> <b>Cognitive Level</b>
<b>Module 1:</b>	Techniques of geological mapping, field data collection: recording the attitude of beds, foliation, lineation, joints, and their analysis.	<b>30</b>	CO1, CO2, CO3, CO4 K2, K3, K4
<b>Module 2:</b>	Use of GPS, GNSS for spatial data collection. Sampling of rocks, preparation of geological field report.	<b>30</b>	CO1, CO2, CO3, CO4 K2, K3, K4, K5, K6
<b>Module 3:</b>	Preparation of map and technical report. Note 1: The record of data will be maintained in a field diary. Note 2: Fieldwork will be carried out under the supervision of teachers who will accompany the students during the course of the field traverse. Note 3: There will be a viva voce examination based on the field report.	<b>30</b>	CO1, CO2, CO3, CO4 K1, K2, K3, K4, K5, K6
<b>Pedagogy:</b>	Fieldwork, lectures, case studies, discussions, and assignments.		
<b>Text</b>	<ol style="list-style-type: none"> <li>Dessai, A. G. (2023). <i>Geology and environment of Goa</i>. Qurate Publishers</li> <li>Dessai, A. G. (2018). <i>Geology and Mineral Resources of Goa</i>. New Delhi Publishers.</li> <li>Merh, S. S. (1995). <i>Geology of Gujarat</i>. Geological Society of India.</li> <li>Radhakrishna, B. P., &amp; Vaidyanadhan, R. (1997). <i>Geology of Karnataka</i> (2nd rev. and enl. ed.). Geological Society of India.</li> <li>Sinha-Roy, S., Malhotra, G., &amp; Mohanty, M. (1998). <i>Geology of Rajasthan</i>. Geological Society of India.</li> <li>Roy, A. B., &amp; Jakhar, S. R. (2002). <i>Geology of Rajasthan (Northwest India): Precambrian to Recent</i>. Scientific Publishers.</li> </ol>		

	<ol style="list-style-type: none"><li>7. Ramam, P. K., &amp; Murty, V. N. (1997). <i>Geology of Andhra Pradesh</i>. Geological Society of India.</li><li>8. Biswas, S. K., Mahender, K., &amp; Chauhan, G. D. (2021). <i>Field Guide Book of Geology of Kutch (Kachchh) Basin, Gujarat, India</i>. Springer International Publishing.</li><li>9. Deshpande, G. G., &amp; Pitale, U. L. (2014). <i>Geology of Maharashtra</i> (2nd ed.). Geological Society of India.</li></ol>
<b>Web Resources:</b>	<a href="https://www.gsi.gov.in">https://www.gsi.gov.in</a>

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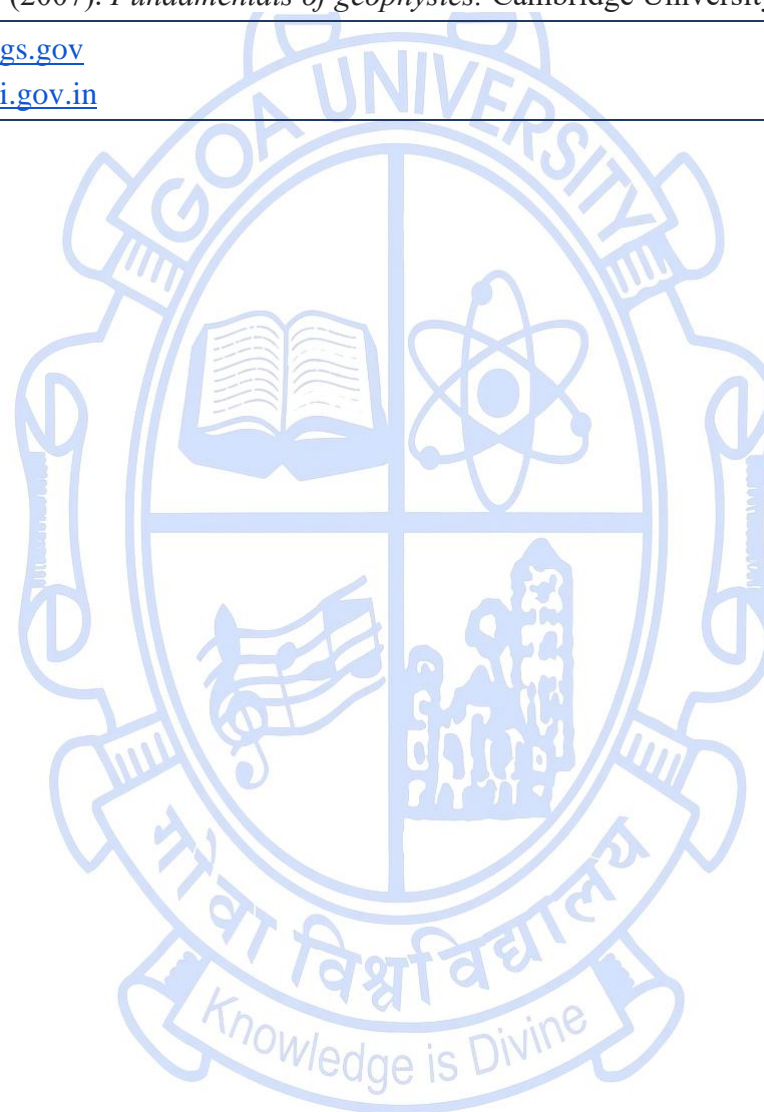
### Discipline Specific Elective (DSE) Courses

<b>Title of the Course</b>	Exploration Geophysics	
<b>Course Code</b>	GEO-5205	
<b>Number of Credits</b>	03	
<b>Theory/Practical</b>	Theory	
<b>Level</b>	400	
<b>Effective from AY</b>	2025-2026	
<b>New Course</b>	No	
<b>Bridge Course/ Value added Course</b>	No	
<b>Course for advanced learners</b>	No	
<b>Pre-requisites for the Course:</b>	Nil	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Describe the use of geophysical instruments and methods in subsurface exploration.</li> <li>2. Understand the application of seismic methods, well logging techniques, and airborne geophysical methods and data corrections.</li> <li>3. Understand the application of gravity, magnetic, and GPR methods and data corrections.</li> <li>4. Learn to interpret geophysical data.</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, the student will be able to:	<b>Mapped to PSO</b>
	CO1. Use various geophysical techniques	PSO 1, PSO 2

	CO2. Use various geophysical instruments.		PSO 6	
	CO3. Record geophysical data.		PSO 2, PSO 6	
	CO4. Interpret geophysical data.		PSO 3, PSO 6	
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>	<b>Cognitive Level</b>
<b>Module 1:</b>	Introduction to exploration geophysics: Electromagnetic spectrum, usefulness of various methods, Electrical methods: instrumentation, field procedure and interpretation using electrical methods. Electrical profiling and sounding using Wenner and Schlumberger configurations. Principles and fundamental procedures of data collection and interpretation.	<b>15</b>	CO 1, CO 2, CO 4	K1, K2, K3, K4
<b>Module 2:</b>	Seismic Methods: Principles, instrumentation, survey procedures and interpretation using seismic methods: terrestrial and marine surveys. Correction applied to seismic data. Geophysical well logging: Introduction well logging methods, porosity logs, well log interpretation. Techniques commonly used in hydrocarbon exploration. Airborne geophysical methods using drones and helicopters.	<b>15</b>	CO 2, CO 3, CO 4	K1, K2, K3, K4, K5
<b>Module 3:</b>	Gravity and Magnetic methods: Principles-field methods gravimeters-corrections, interpretation of gravity data. Principles, instrumentation, field procedures, data analysis and interpretation of magnetic data. Principles and field application of Ground Penetrating Radar (GPR) for sub-surface studies. Data analysis and interpretation.	<b>15</b>	CO 2, CO 3, CO 4	K1, K2, K3, K4, K5
<b>Pedagogy:</b>	Lectures, case studies, discussions and assignments.			
<b>Text</b>	<ol style="list-style-type: none"> <li>Kearey, P., Brooks, M., &amp; Hill, I. (2002). <i>An introduction to geophysical exploration</i> (3rd ed.). Wiley-Blackwell.</li> <li>Lowrie, W., &amp; Fichtner, A. (2020). <i>Fundamentals of geophysics</i>. Cambridge university press.</li> <li>Mussett, A. E., Khan, M. A., &amp; Button, S. (2000). <i>Looking into the Earth: An introduction to geological geophysics</i>. Cambridge University Press.</li> </ol>			

	5. Telford, W. M., Geldart, L. P., & Sheriff, R. E. (1990). <i>Applied geophysics</i> (2nd ed.). Cambridge University Press. 6. William, L. (2007). <i>Fundamentals of geophysics</i> . Cambridge University Press
<b>Web Resources:</b>	<a href="https://www.usgs.gov">https://www.usgs.gov</a> <a href="https://www.gsi.gov.in">https://www.gsi.gov.in</a>

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<b>Title of the Course</b>	Practical of Exploration Geophysics
<b>Course Code</b>	GEO-5206
<b>Number of Credits</b>	01
<b>Theory/Practical</b>	Practical
<b>Level</b>	400
<b>Effective from AY</b>	2025-2026
<b>New Course</b>	No
<b>Bridge Course/ Value added Course</b>	No
<b>Course for advanced learners</b>	No

<b>Pre-requisites for the Course:</b>	Nil	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Describe various method of Geophysical exploration.</li> <li>2. Learn to use geophysical instruments.</li> <li>3. Learn to record data.</li> <li>4. Learn to interpret geophysical data.</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, the student will be able to:	<b>Mapped to PSO</b>
	CO1: Use the geophysical instruments.	PSO 1, PSO 2, PSO 6
	CO2: Select appropriate instruments for geological investigation.	PSO 2, PSO 4, PSO 6

	CO3: Record data collected through geophysical methods		PSO 3, PSO 6	
	CO4: Interpret the data.		PSO 2, PSO 3, PSO 6	
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>	<b>Cognitive Level</b>
<b>Module 1:</b>	Field survey using resistivity methods. problem solving and interpretation of resistivity data using master curves matching and digital techniques	15	CO 2, CO 3, CO 4	K1, K2, K3, K4, K5
<b>Module 2:</b>	Seismic refraction and reflection; magnetometers and gravimeter, GPR, well logs application and data interpretation for hydrocarbon exploration, mineral exploration, structural and geotechnical studies.	15	CO 1, CO 2, CO 3, CO 4	K1, K2, K3, K4, K5
<b>Pedagogy:</b>	Case studies, discussions, hands on experience in data interpretation			
<b>Text</b>	<ol style="list-style-type: none"> <li>1. Kearey, P., Brooks, M., &amp; Hill, I. (2002). <i>An introduction to geophysical exploration</i> (3rd ed.). Wiley-Blackwell.</li> <li>2. Lowrie, W., &amp; Fichtner, A. (2020). <i>Fundamentals of geophysics</i>. Cambridge university press.</li> <li>3. Loke, M. H. (2011). <i>Electrical imaging surveys for environmental and engineering studies: A practical guide to 2D and 3D surveys</i>. Geotomo Software.</li> <li>4. Mussett, A. E., Khan, M. A., &amp; Button, S. (2000). <i>Looking into the Earth: An introduction to geological geophysics</i>. Cambridge University Press.</li> <li>5. Shearer, P. M. (2009). <i>Introduction to seismology</i> (2nd ed.). Cambridge University Press.</li> <li>6. Telford, W. M., Geldart, L. P., &amp; Sheriff, R. E. (1990). <i>Applied geophysics</i> (2nd ed.). Cambridge University Press.</li> <li>7. William, L. (2007). <i>Fundamentals of geophysics</i>. Cambridge University Press</li> </ol>			
<b>Web Resources:</b>	<a href="https://www.usgs.gov">https://www.usgs.gov</a> <a href="https://www.gsi.gov.in">https://www.gsi.gov.in</a> <a href="https://www.sciencedirect.com">https://www.sciencedirect.com</a>			

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<b>Title of the Course</b>	Petroleum Geology
<b>Course Code</b>	GEO-5207
<b>Number of Credits</b>	03
<b>Theory/Practical</b>	Theory
<b>Level</b>	400
<b>Effective from AY</b>	2025-26
<b>New Course</b>	No
<b>Bridge Course/ Value added Course</b>	No
<b>Course for advanced learners</b>	No

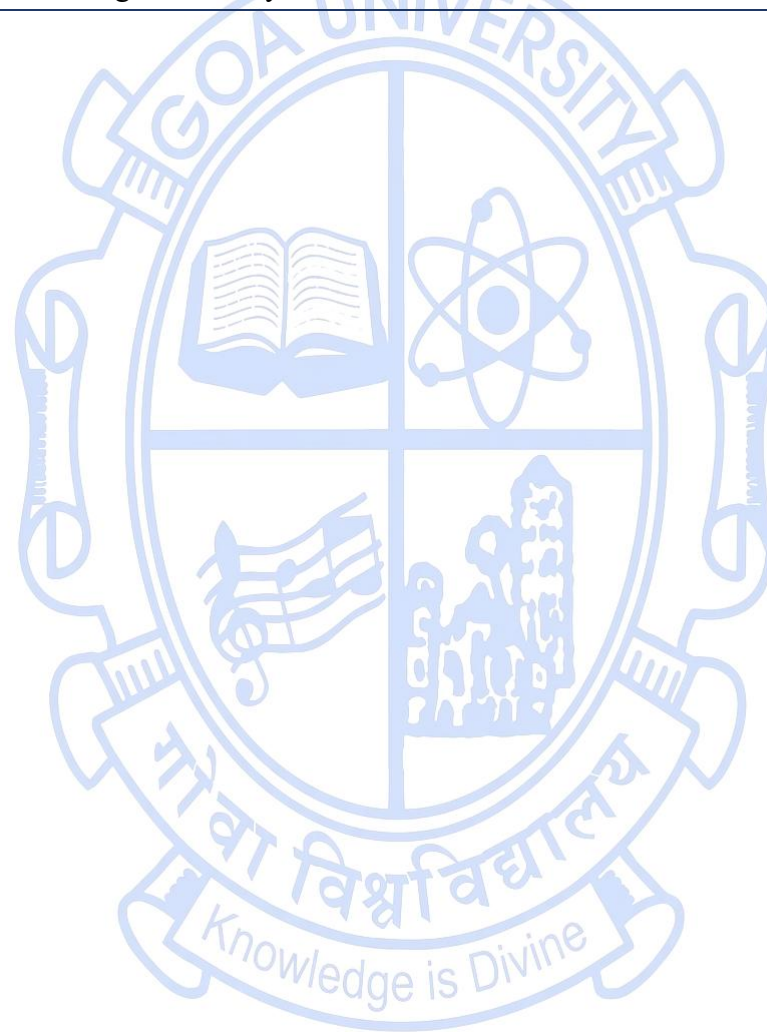
<b>Pre-requisites for the Course:</b>	Nil	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Understand the fundamentals of petroleum geology, including historical evolution, global petroleum distribution, and categorization of Indian petroliferous basins.</li> <li>2. Explain the physical, chemical, and optical properties of petroleum and their implications for petroleum exploration and processing.</li> <li>3. Learn the theories of petroleum origin, migration, and accumulation.</li> <li>4. Learn geological and geophysical methods in petroleum exploration.</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, the student will be able to:	<b>Mapped to PSO</b>
	CO 1. Describe the origin, types, global distribution of petroleum and the petroliferous basins of India.	PSO1, PSO2, PSO4

	CO 2. Analyze the geochemical and geological processes involved in the formation, transformation, and accumulation of hydrocarbons.		PSO1, PSO2, PSO4, PSO6	
	CO 3. Evaluate different migration mechanisms and reservoir characteristics for identifying suitable hydrocarbon traps.		PSO1, PSO2, PSO3, PSO4, PSO6	
	CO 4. Recommend suitable exploration strategies.		PSO1, PSO2, PSO3, PSO6	
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>	<b>Cognitive Level</b>
<b>Module 1:</b>	Introduction to petroleum Geology, petroleum system, historical review of petroleum, and global petroleum scenario. Categorization of petroliferous basins of India. Chemical composition of petroleum: organic and inorganic compounds. Physical properties of petroleum: colour, odour, density, specific gravity, API value, volume, boiling point, cloud point, pour points, flash point, and fire point. Optical properties: Fluorescence, refractive index, optical activity. Occurrences of petroleum: surface and subsurface occurrences. Origin of Petroleum: Inorganic Hypothesis—Theory of Cosmic Origin, Theory of Magmatic Origin/Hydrocarbon in Igneous Rock as Evidence, and Mantle Degassing. Problems with inorganic theories. Genesis of Petroleum by Fischer-Tropsch Synthesis.	<b>15</b>	CO1, CO2	K1, K2, K4
<b>Module 2:</b>	Organic origin of hydrocarbons: diagenesis, catagenesis, metagenesis, and metamorphism. Production and composition of organic matter: geological facts, chemical facts, compelling reasons for organic origin of petroleum, similarity in chemical composition of biomass and petroleum. Production of organic matter: factors influencing primary productivity, Chemical constituents in organic matter. Accumulation of organic matter: sedimentation of organic matter, factors determining organic carbon contents in marine sediments - hydrographical, biological, chemical, geological.	<b>15</b>	CO1, CO2, CO3	K2, K3, K4, K5

	Favorable depositional conditions; role of dissolved and particulate organic matter; accumulation mechanism of sedimentary organic matter. Transformations of organic matter and formation of kerogen: Significance and main steps of early transformations, biochemical degradation, microbial activity, polycondensation, insolubilization, kerogen, and factors influencing maturation of kerogen.			
<b>Module 3:</b>	<p>Migration: types of migration, primary migration, physicochemical aspects of primary migration, possible mode of primary migration, and geological and geochemical aspects of primary migration. Secondary migration, Buoyancy and Capillary Pressures, Hydrodynamics and secondary migration, Geological and geochemical implications of secondary migration, termination of secondary migration, and accumulation of oil and gas; distance of secondary migration. Reservoir: porosity, permeability, relationship between porosity, permeability, and texture, effects of diagenesis on reservoir quality, reservoir continuity, reservoir characterization, reserve calculations, and production methods. Traps and Seals: Types of traps and their classification — structural, stratigraphic, hydrodynamic, diapiric, combination, and astrobleme traps.</p> <p>Drilling: cable tool drilling and rotary drilling; formation evaluation; electric log, spontaneous potential log, resistivity log; radioactivity log gamma-ray, neutron, and density logs. Petroliferous basins of India: categories and potential. Krishna-Godavari basin, Mumbai offshore, Cambay basin, Rajasthan, Assam-Arakan fold belt, oil belts of the world.</p>	<b>15</b>	CO4	K4, K5
<b>Pedagogy:</b>	Lectures/ tutorials/assignments/field study/discussion/ demonstration			
<b>Text</b>	<ol style="list-style-type: none"> <li>Selley, R.C., (1998). Elements of Petroleum Geology: W.H. Freeman &amp; Company, New York.</li> <li>Levorsen, A.I. (1967). Geology of Petroleum: W.H. Freeman and Company.</li> <li>Tissot, B. P., &amp; Welte, D. H. (1984). Petroleum formation and occurrence (2nd ed.). Springer-Verlag.</li> <li>Hyne, N. J. (2012). Nontechnical guide to petroleum geology, exploration, drilling, and production (3rd ed.). PennWell Books.</li> <li>Barker, C. (Ed.). (1996). Organic Geochemistry (Vol. 1). American Association of Petroleum Geologists (AAPG).</li> <li>Sellami, A., &amp; Rahmouni, A. (2022). Petroleum geology: Basin systems and models. Springer.</li> <li>North, F. K. (1985). Petroleum geology. Allen &amp; Unwin.</li> </ol>			

8. Bjorlykke, K. (2015). Petroleum geoscience: From sedimentary environments to rock physics (2nd ed.). Springer.
9. Ravi, R. (2014). Petroleum systems of India: Onshore basins. Geological Society of India.
10. Biswas, S. K. (1993). Tectonic framework, structure and petroleum prospects of Cambay Basin, western India. *Journal of the Geological Society of India*, 41, 325–346.

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<b>Title of the Course</b>	Practical of Petroleum Geology
<b>Course Code</b>	GEO-5208
<b>Number of Credits</b>	01
<b>Theory/Practical</b>	Practical
<b>Level</b>	400
<b>Effective from AY</b>	2025-26
<b>New Course</b>	No
<b>Bridge Course/ Value added Course</b>	No
<b>Course for advanced learners</b>	No

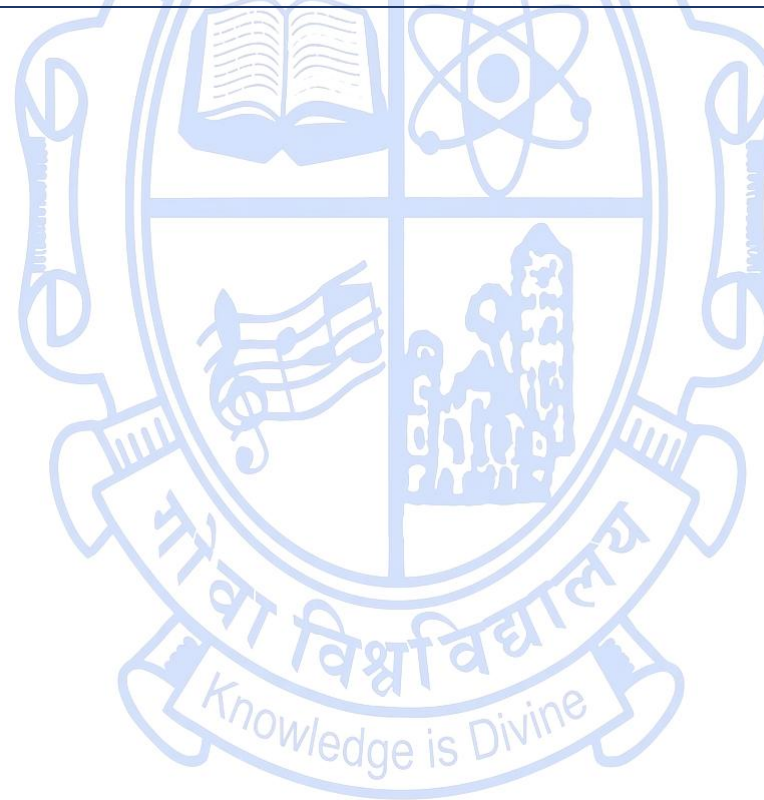
<b>Pre-requisites for the Course:</b>	Nil	
<b>Course Objectives:</b>	<p>The objectives of this course are to</p> <ol style="list-style-type: none"> <li>1. Understand the application of the three-point method in determining subsurface geological structures.</li> <li>2. Develop skills to interpret subsurface data and construct structural contour maps for hydrocarbon exploration.</li> <li>3. Learn methods for calculating porosity and permeability of the reservoirs.</li> <li>4. Learn to assess geophysical well logs for lithology, fluid content, and hydrocarbon potential in sedimentary basins.</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, the student will be able to:	<b>Mapped to PSO</b>
	CO 1. Apply the three-point problem method to borehole data for determining strike and dip of subsurface formations.	PSO1, PSO2, PSO4
	CO 2. Analyze well log data to differentiate between lithologies, identify fluid types, and delineate hydrocarbon-bearing zones.	PSO1, PSO2, PSO4, PSO6

	CO 3. Evaluate porosity and permeability data to assess reservoir rock characteristics and predict fluid flow behaviour.		PSO1, PSO2, PSO3, PSO4, PSO6
	CO 4. Construct and interpret structural contour maps using subsurface geological data to identify potential hydrocarbon traps.		PSO1, PSO2, PSO3, PSO6
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b> <b>Cognitive Level</b>
<b>Module 1:</b>	Three-Point Problems in Borehole Data Analysis: Application of the three-point method to determine the attitude (strike and dip) of subsurface geological layers using borehole information.	<b>6</b>	CO1, CO2      K1, K2, K4, K6
<b>Module 2:</b>	Interpretative Contouring Techniques: Use of subsurface data to create structural contour maps for identifying the depth and geometry of oil-bearing horizons.	<b>6</b>	CO4      K2, K3, K4, K5, K6
<b>Module 3:</b>	Porosity and Permeability Calculations: Solving numerical problems related to primary and secondary porosity, effective and total porosity, and permeability of reservoir rocks.	<b>6</b>	CO3      K4, K5
<b>Module 4:</b>	Proliferous Basin Mapping and Evaluation: plotting major prolific basins on the map of India and evaluating them based on geological setting, stratigraphy, and hydrocarbon potential.	<b>6</b>	CO2, CO4      K2, K3, K4
<b>Module 5:</b>	Well Log Interpretation: Analysis of well logs (e.g., gamma ray, resistivity, sonic, density, and neutron logs) for lithology identification, fluid content estimation, and delineation of hydrocarbon zones.	<b>6</b>	CO2, CO4      K3, K4, K5, K6
<b>Pedagogy:</b>	Lectures/ tutorials/assignments/field study/discussion/ demonstration		

**Text**

1. Selley, R. C. (1998). Elements of petroleum geology. W. H. Freeman & Company.
2. Tissot, B. P., & Welte, D. H. (1978). Petroleum formation and occurrence: A new approach to oil and gas exploration. Springer-Verlag.
3. Levorsen, A. I. (1967). Geology of petroleum. W. H. Freeman and Company.
4. North, F. K. (1986). Petroleum geology (p. 607). Allen & Unwin. Allen, P. A., & Allen, J. R. (2013). Basin analysis: Principles and application to petroleum play assessment (3rd ed.). Wiley-Blackwell.
5. Hyne, N. J. (2018). Nontechnical guide to petroleum geology, exploration, drilling, and production (4th ed.). PennWell Corporation.
6. Gluyas, J., & Swarbrick, R. (2021). Petroleum geoscience (3rd ed.). Wiley-Blackwell.
7. Mann, R. (2022). Practical petroleum geology. Springer.

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### SEMESTER III

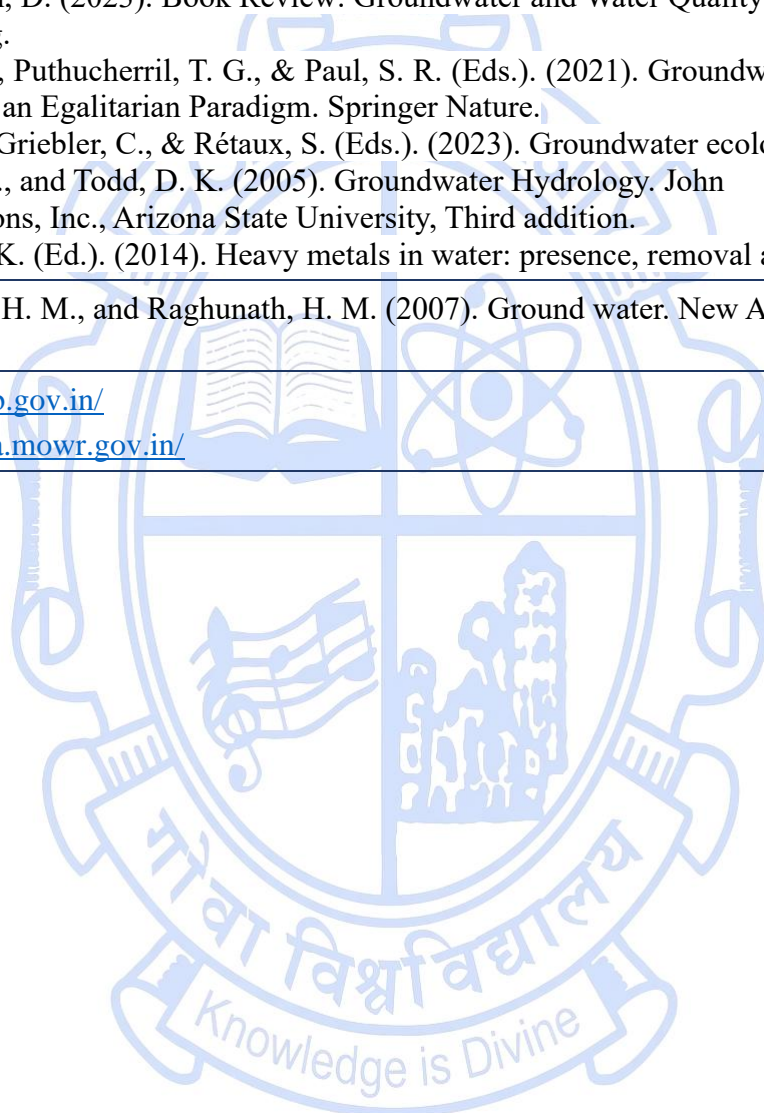
#### Research Specific Elective (RSE) Courses

<b>Title of the Course</b>	Groundwater Geology	
<b>Course Code</b>	GEO-6000	
<b>Number of Credits</b>	03	
<b>Theory/Practical</b>	Theory	
<b>Level</b>	500	
<b>Effective from AY</b>	2026-27	
<b>New Course:</b>	No	
<b>Bridge Course/ Value added Course:</b>	No	
<b>Course for advanced learners:</b>	No	
<b>Pre-requisites for the Course:</b>	NIL	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Study the processes involved in the movement of groundwater in the subsurface.</li> <li>2. Introduce techniques used in groundwater exploration.</li> <li>3. Understand the geogenic and anthropogenic causes of groundwater pollution.</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, the student will be able to:	<b>Mapped to PSO</b>
	CO 1. Explain the occurrence and movement of groundwater in the subsurface.	PSO1, PSO2

	CO 2. Apply techniques for groundwater exploration.		PSO1, PSO3	
	CO 3. Investigate aquifer properties.		PSO1, PSO2,	
	CO 4. Evaluate the geogenic and anthropogenic causes of groundwater pollution.		PSO3, PSO5, PSO6	
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>	<b>Cognitive Level</b>
<b>Module 1:</b>	Genetic classification of water, Global distribution of water. Hydrologic cycle: Precipitation, runoff, infiltration and evapotranspiration. Historical developments in science of hydrogeology. Vertical distribution of sub surface water, Water table and piezometric surface, Classification of rocks with respect to their water bearing characteristics. Classification of aquifers and confining layers, hydraulic properties of aquifers, water table fluctuations. Concepts of drainage and groundwater basins.	15	CO1, CO2	K1, K2, K4
<b>Module 2</b>	Theory of groundwater flow, Darcy's law, its validity and applications, determination of permeability in laboratory and in field. Types of wells, drilling methods, construction, design, development and maintenance of wells. Specific capacity and its determination steady and unsteady and radial flow conditions. Pumping tests-methods, data analysis and interpretations. Rainwater Harvesting and conservation.	15	CO1, CO3	K1, K2, K4, K5
<b>Module 3:</b>	Groundwater Chemistry: Groundwater quality, physical, chemical, biological properties of water quality criteria for different uses, graphical presentation of water quality data. Groundwater contamination. Problems of arsenic and fluoride in India. Aquifer modelling and groundwater provinces of India. Saline water intrusion and Sub-marine Groundwater Discharge (SGD) in coastal aquifers and its modelling. Groundwater exploration techniques. Salient features of The Water (Prevention and control of pollution) Act, 1974 and Goa water (Prevention and Control of Pollution) Rules, 1988.	15	CO2, CO4	K2, K3, K5, K6
<b>Pedagogy:</b>	Lectures, case studies, discussions and assignments.			
<b>Texts:</b>	<ol style="list-style-type: none"> <li>1. Davis, S. N., and De Wiest, R. J. (1966). Hydrogeology New York:Wiley.</li> <li>2. Fetter, C. W. (2018). Applied hydrogeology. Waveland Press.</li> <li>3. Hiscock, K. M., and Bense, V. F. (2021). Hydrogeology: principles and practice. John Wiley and Sons.</li> </ol>			

	<ol style="list-style-type: none"> <li>4. Islam, M. S. (2023). Hydrogeochemical Evaluation and Groundwater Quality. Springer.</li> <li>5. Kaesmentan, D. (2023). Book Review: Groundwater and Water Quality: Hydraulics, Water Resources and Coastal Engineering.</li> <li>6. Khan, S. A., Puthucherril, T. G., &amp; Paul, S. R. (Eds.). (2021). Groundwater Law and Management in India: From an Elitist to an Egalitarian Paradigm. Springer Nature.</li> <li>7. Malard, F., Griebler, C., &amp; Rétaux, S. (Eds.). (2023). Groundwater ecology and evolution. Elsevier.</li> <li>8. Mays, L. W., and Todd, D. K. (2005). Groundwater Hydrology. John Wily and Sons, Inc., Arizona State University, Third addition.</li> <li>9. Sharma, S. K. (Ed.). (2014). Heavy metals in water: presence, removal and safety. Royal Society of Chemistry.</li> </ol>
<b>References/ Readings:</b>	<ol style="list-style-type: none"> <li>1. Raghunath, H. M., and Raghunath, H. M. (2007). Ground water. New Age International (P) Limited Publishers.</li> </ol>
<b>Web Resources:</b>	<ol style="list-style-type: none"> <li>1. <a href="https://cgwb.gov.in/">https://cgwb.gov.in/</a></li> <li>2. <a href="https://cgwa.mowr.gov.in/">https://cgwa.mowr.gov.in/</a></li> </ol>

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<b>Title of the Course</b>	Groundwater Geology
<b>Course Code</b>	GEO-6001
<b>Number of Credits</b>	01
<b>Theory/Practical</b>	Practical
<b>Level</b>	500
<b>Effective from AY</b>	2026-27
<b>New Course:</b>	No
<b>Bridge Course/ Value added Course:</b>	No
<b>Course for advanced learners:</b>	No

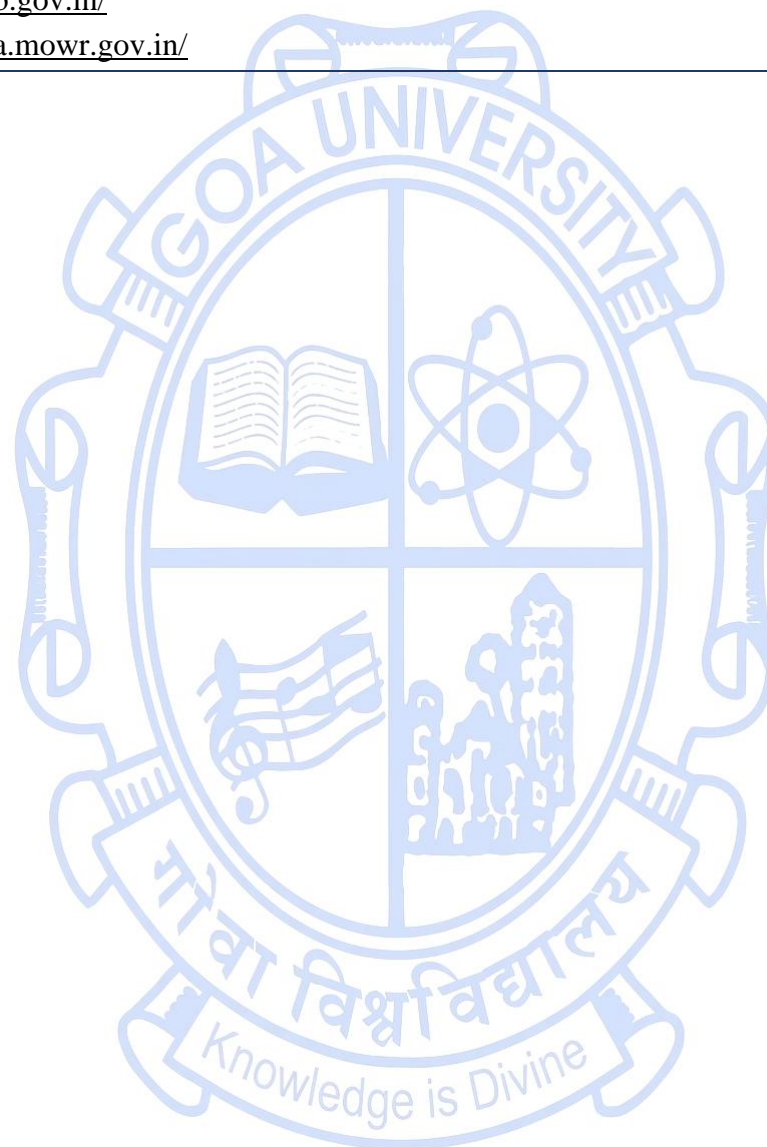
<b>Pre-requisites for the Course:</b>	NIL	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Study the processes involved in the movement of groundwater in various lithologies.</li> <li>2. Understand problems related to groundwater chemistry.</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, the student will be able to:	<b>Mapped to PSO</b>
	CO1. Explain the processes involved in the movement of groundwater.	PSO1, PSO4,
	CO2. Perform well test to investigate hydraulic properties of the aquifer.	PSO1, PSO2,
	CO3. Solve problems related to hydraulic conductivity and transmissivity	PSO1, PSO2,
	CO4. Assess groundwater quality.	PSO1, PSO2,

<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>	<b>Cognitive Level</b>
<b>Module 1:</b>	<p>Exercises on Groundwater flownet construction and interpretations of equipotential line and groundwater flow direction. Interaction between groundwater and surface water. Movement of contaminants related to groundwater flow.</p> <p>Problem related to aquifer parameters such as hydraulic conductivity, transmissivity and specific yield.</p> <p>Analysis of aquifer using test data: Theis method, Jacob-Cooper method and Chow's method. Problem solving on groundwater recharge and groundwater volume. Problems related to wells under various hydraulic conditions.</p> <p>Analysis of groundwater for major ions using volumetric analysis, flame photometer and UV spectrophotometer.</p> <p>Graphical representation and interpretation of chemical quality data of waters: Hill Piper diagram, Schoeller diagram.</p>	<b>30</b>	CO1	K1, K2
<b>Pedagogy:</b>	Practical, case studies, discussions and assignments.			
<b>Texts:</b>	<ol style="list-style-type: none"> <li>1. Fetter, C. W. (2018). Applied hydrogeology. Waveland Press.</li> <li>2. Hiscock, K. M., and Bense, V. F. (2021). Hydrogeology: principles and practice. John Wiley and Sons.</li> <li>3. Islam, M. S. (2023). Hydrogeochemical Evaluation and Groundwater Quality. Springer.</li> <li>4. Kaesmentan, D. (2023). Book Review: Groundwater and Water Quality: Hydraulics, Water Resources and Coastal Engineering.</li> <li>5. Mays, L. W., and Todd, D. K. (2005). Groundwater Hydrology. John Wiley and Sons, Inc., Arizona State University, Third addition.</li> <li>6. Sharma, S. K. (Ed.). (2014). Heavy metals in water: presence, removal and safety. Royal Society of Chemistry.</li> </ol>			
<b>References/ Readings:</b>	Davis, S. N., and De Wiest, R. J. (1966). Hydrogeology New York:Wiley.			

**Web Resources:**

1. <https://cgwb.gov.in/>
2. <https://cgwa.mowr.gov.in/>

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<b>Title of the Course</b>	Microtectonics
<b>Course Code</b>	GEO-6002
<b>Number of Credits</b>	03
<b>Theory/Practical</b>	Theory
<b>Level</b>	500
<b>Effective from AY</b>	2026-27
<b>New Course:</b>	No
<b>Bridge Course/ Value added Course:</b>	No
<b>Course for advanced learners:</b>	Yes

<b>Pre-requisites for the Course:</b>	Completion of 400 level course on Structural Geology.	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Provide students with a comprehensive understanding of rock deformation processes, rheology, and deformation mechanisms of common rock-forming minerals at the micro-scale.</li> <li>2. Train students in the identification, classification, and interpretation of microstructures, shear zones, and shear sense indicators in ductile and brittle regimes.</li> <li>3. Develop the ability to critically analyze porphyroblast–matrix relations, reaction textures, and complex microstructures for tectono-metamorphic interpretation.</li> <li>4. Acquaint students with advanced microscopic, analytical, and digital techniques for quantitative fabric studies and integration of microstructural data with large-scale tectonic processes</li> </ol>	
<b>Course Outcomes:</b>	By the end of this course, students will be able to:	<b>Mapped to PSO</b>
	CO 1. Explain principles of rock deformation, rheology and deformation mechanisms in	PSO 1, PSO2, PSO

	minerals.			3
	CO 2. Identify and analyze microstructures and shear sense indicators in ductile and brittle regimes.			PSO 2, PSO 3, PSO 4
	CO 3. Interpret porphyroblast–matrix relations and complex microstructures in metamorphic rocks.			PSO 1, PSO 2, PSO 6
	CO 4. Apply advanced microscopic and analytical techniques to quantify fabrics and deduce tectono-metamorphic histories.			PSO 3, PSO 5, PSO 6, PSO 7
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>	<b>Cognitive Level</b>
<b>Module1:</b>	Principles of Rock Deformation and Microstructures: Introduction to Microtectonics, Stress, strain, flow and deformation; Progressive and finite deformation; Rheology of rocks and deformation mechanisms; Diffusion creep, dislocation creep, grain-boundary sliding, intracrystalline deformation; Recovery, recrystallisation, grain boundary area reduction, static recrystallisation; Deformation of rock-forming minerals – quartz, feldspar, calcite, olivine, pyroxenes, garnet, amphiboles, micas; Microstructural elements – foliation, lineation, lattice preferred orientation, crystallographic fabrics, CPO	<b>15</b>	CO1	K2, K3, K4, K5, K6
<b>Module2:</b>	Shear Zones and Microstructural Indicators: Geometry and kinematics of ductile shear zones; Shear sense indicators in mylonites – S-C fabrics, $\delta$ and $\sigma$ clasts, mica fish, oblique foliations; Shear sense indicators in brittle regime – Riedel shears, tension gashes, microfaults; Dilatational and extensional features – veins, strain shadows, pressure fringes, boudins; Primary and secondary microstructures and overprinting relationships; Linking microstructures with tectonic transport directions and regional kinematics	<b>15</b>	CO2	K2, K3, K4, K5, K6
<b>Module3:</b>	Porphyroblast–Matrix Relations and Advanced Methods: Nucleation and growth of porphyroblasts; Syn-kinematic, pre-kinematic and post-kinematic porphyroblast–matrix relations; Complex porphyroblast microstructures – snowball garnets, staurolite cruciform; Reaction rims, coronas and natural microgauges; Optical microscopy, universal stage and microstructural studies; Electron microscopy – SEM, TEM and cathodoluminescence; EBSD crystallographic orientation mapping; Digital image	<b>15</b>	CO3, CO4	K2, K3, K4, K5, K6

	analysis and quantitative fabric studies; Integration of microstructural and metamorphic data to reconstruct tectono-metamorphic histories.			
<b>Pedagogy:</b>	Lectures/ tutorials/ assignments/ discussions			
<b>Texts:</b>	<ol style="list-style-type: none"> <li>1. Philpotts, A. R., and Ague, J. J. (2022). Principles of igneous and metamorphic petrology. Cambridge University Press.</li> <li>2. Kornprobst, J. (2006). Metamorphic rocks and their geodynamic significance: a petrological handbook (Vol. 12). Springer Science &amp; Business Media.</li> <li>3. Passchier, C. W., and Trouw, R. A. (2005). Microtectonics. Springer Science &amp; Business Media.</li> <li>4. Trouw, R. A., Passchier, C. W., and Wiersma, D. J. (2009). Atlas of Mylonites and related microstructures. Springer Science &amp; Business Media.</li> <li>5. Vernon, R. H., and Clarke, G. L. (2008). Principles of metamorphic petrology. Cambridge University Press.</li> <li>6. Vernon, R. H. (2018). A practical guide to rock microstructure. Cambridge university press.</li> </ol>			
<b>References/ Readings:</b>	<ol style="list-style-type: none"> <li>1. Saha, D. (2021). Universal stage measurements in petrofabric analysis revisited. Journal of Earth Syst. Science 130:116, <a href="https://doi.org/10.1007/s12040-021-01618-x">https://doi.org/10.1007/s12040-021-01618-x</a></li> </ol>			
<b>Web Resources:</b>	<ol style="list-style-type: none"> <li>1. <a href="https://www.thermofisher.com/us/en/home/materials-science/learning-center/electron-backscatter-diffraction.html">https://www.thermofisher.com/us/en/home/materials-science/learning-center/electron-backscatter-diffraction.html</a></li> <li>2. <a href="https://blogs.egu.eu/divisions/ts/tag/microtectonics/">https://blogs.egu.eu/divisions/ts/tag/microtectonics/</a></li> <li>3. <a href="https://www.geosciences.uni-mainz.de/teaching-in-tekonophysics-group/masterclass-microtectonics/">https://www.geosciences.uni-mainz.de/teaching-in-tekonophysics-group/masterclass-microtectonics/</a></li> <li>4. <a href="https://serc.carleton.edu/NAGTWorkshops/structure/computer_resources.html">https://serc.carleton.edu/NAGTWorkshops/structure/computer_resources.html</a></li> </ol>			

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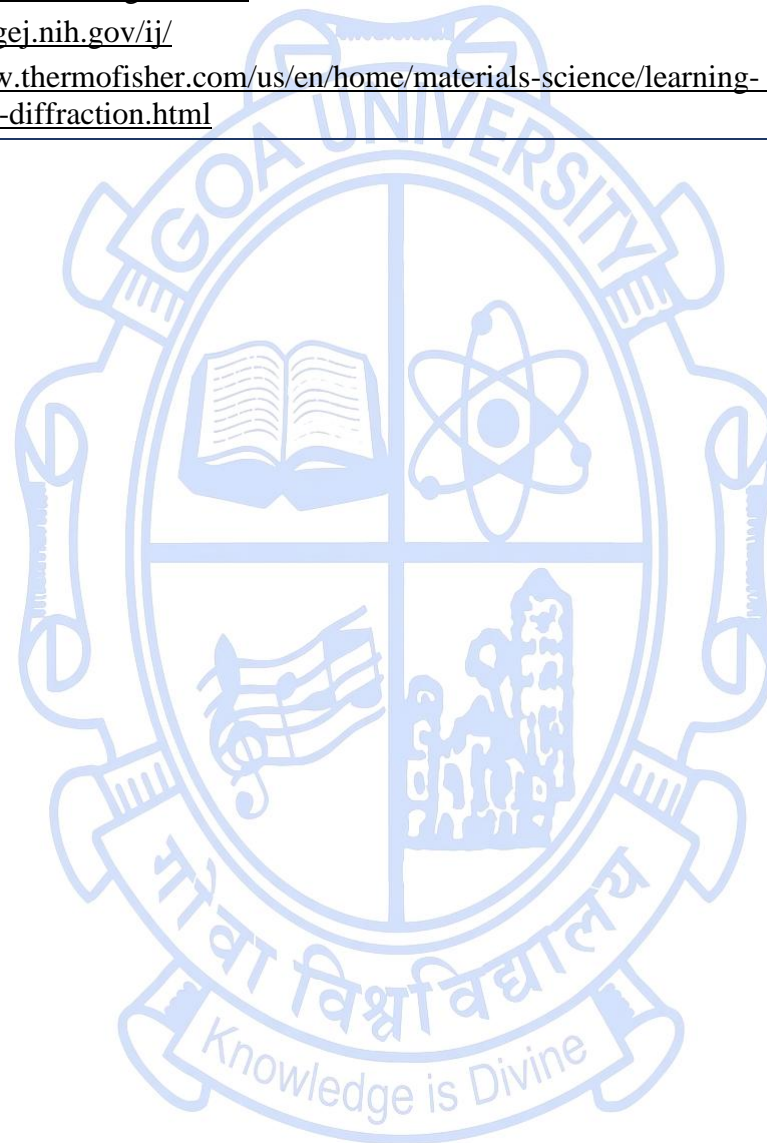
<b>Title of the Course</b>	Practical of Microtectonics
<b>Course Code</b>	GEO-6003
<b>Number of Credits</b>	01
<b>Theory/Practical</b>	Practical
<b>Level</b>	500
<b>Effective from AY</b>	2026-27
<b>New Course:</b>	No
<b>Bridge Course/ Value added Course:</b>	No
<b>Course for advanced learners:</b>	Yes

<b>Pre-requisites for the Course:</b>	Completion of 400 level course on Structural Geology.	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Train students to identify diagnostic deformation microstructures and fabric elements under the microscope.</li> <li>2. Provide hands-on experience in identifying shear sense indicators and deformation features in hand specimens.</li> <li>3. Introduce quantitative methods of strain analysis using thin section data.</li> <li>4. Acquaint students with digital tools for image analysis and orientation data interpretation.</li> </ol>	
<b>Course Outcomes:</b>	By the end of this course, students will be able to:	<b>Mapped to PSO</b>
	CO 1. Identify diagnostic microstructures and fabric elements in thin sections.	PSO 1, PSO2, PSO 3
	CO 2. Recognize shear sense indicators and deformation features in hand specimens.	PSO 2, PSO 3, PSO 4
	CO 3. Apply strain analysis methods to quantify deformation from rock samples.	PSO 3, PSO 2, PSO 6

	CO 4. Interpret microstructural fabrics using basic digital image analysis and orientation datasets.		PSO 3, PSO 5, PSO 6
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b> <b>Cognitive Level</b>
<b>Module1:</b>	Observation and identification of diagnostic microstructures in thin sections. Identification of fabric elements in quartz, feldspar, calcite, micas, and garnet. Identification of porphyroblast–matrix relations and complex microstructures.	<b>10</b>	CO1      K2, K3, K4, K5, K6
<b>Module2:</b>	Observation of deformation features and shear sense indicators in hand specimens. Measurement of finite strain using Fry method and Rf/φ method. Identification of boudins, veins, strain shadows, and pressure fringes.	<b>10</b>	CO2, CO3      K2, K3, K4, K5, K6
<b>Module3:</b>	Basic digital image analysis of microstructures using ImageJ or similar software. Introduction to EBSD datasets and crystallographic preferred orientation (demonstration-based). Integration of microstructural observations with field structural data from shear zones and faults.	<b>10</b>	CO4      K2, K3, K4, K5, K6
<b>Pedagogy:</b>	Laboratory exercises, hands-on experience in megascopic and microscopic petrography, lectures, discussions, demonstrations		
<b>Texts:</b>	<ol style="list-style-type: none"> <li>1. Philpotts, A. R., and Ague, J. J. (2022). Principles of igneous and metamorphic petrology. Cambridge University Press.</li> <li>2. Nicolas, A., &amp; Poirier, J. P. (1976). Crystalline plasticity and solid state flow in metamorphic rocks. New York: Wiley.</li> <li>3. Passchier, C. W., &amp; Trouw, R. A. J. (2005). Microtectonics (2nd ed.). Berlin: Springer.</li> <li>4. Vernon, R. H. (2004). A practical guide to rock microstructure. Cambridge: Cambridge University Press.</li> </ol>		
<b>Web Resources:</b>	<ol style="list-style-type: none"> <li>1. <a href="https://www.tulane.edu/~sanelson/eens212/thinsect.htm">https://www.tulane.edu/~sanelson/eens212/thinsect.htm</a></li> <li>2. <a href="https://www.geosciences.uni-mainz.de/teaching-in-tektionophysics-group/masterclass-microtectonics/">https://www.geosciences.uni-mainz.de/teaching-in-tektionophysics-group/masterclass-microtectonics/</a></li> <li>3. <a href="https://blogs.egu.eu/divisions/ts/tag/microtectonics/">https://blogs.egu.eu/divisions/ts/tag/microtectonics/</a></li> </ol>		

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|  | <ol style="list-style-type: none"><li>4. <a href="https://mtex-toolbox.github.io/">https://mtex-toolbox.github.io/</a></li><li>5. <a href="https://imagej.nih.gov/ij/">https://imagej.nih.gov/ij/</a></li><li>6. <a href="https://www.thermofisher.com/us/en/home/materials-science/learning-center/electron-backscatter-diffraction.html">https://www.thermofisher.com/us/en/home/materials-science/learning-center/electron-backscatter-diffraction.html</a></li></ol> |
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<b>Title of the Course</b>	Paleontology	
<b>Course Code</b>	GEO-6004	
<b>Number of Credits</b>	3	
<b>Theory/Practical</b>	Theory	
<b>Level</b>	500	
<b>Effective from AY</b>	2026-27	
<b>New Course:</b>	Yes	
<b>Bridge Course/ Value added Course:</b>	No	
<b>Course for advanced learners:</b>	No	
<b>Pre-requisites for the Course:</b>	NIL	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Understand concepts of paleontology, systematics, and taphonomy in Earth sciences.</li> <li>2. Study evolutionary mechanisms, fossil variations, and extinction patterns.</li> <li>3. Understand quantitative and functional approaches in paleoecology and paleobiogeography.</li> <li>4. Learn fossil records, stratigraphic applications, and paleoenvironmental reconstructions.</li> <li>5. Study modern analytical tools for advanced paleontological research and applications.</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, the student will be able to:	<b>Mapped to PSO</b>
	CO 1. Classify fossils using systematics and morphometric methods.	PSO1, PSO2, PSO3
	CO 2. Interpret taphonomic processes and evaluate fossil preservation potential.	PSO1, PSO2, PSO3, PSO6

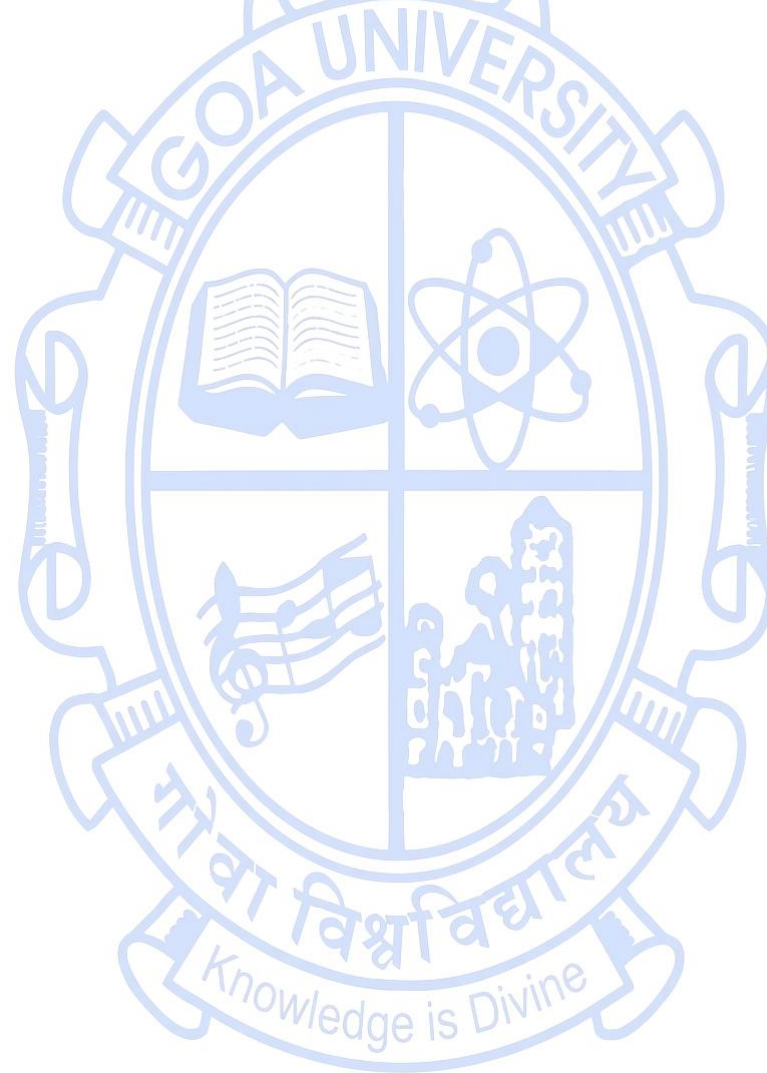
	CO 3. Analyze evolutionary case studies and extinction events using fossil evidence.		PSO1, PSO2, PSO3, PSO5, PSO6
	CO 4. Apply paleoecological and paleobiogeographic principles to reconstruct past environments.		PSO1, PSO2, PSO3, PSO5, PSO6
	CO 5. Integrate modern analytical tools and quantitative data for paleontological reconstructions.		PSO1, PSO2, PSO3, PSO6
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b> <b>Cognitive Level</b>
<b>Module 1:</b>	<p>Scope of paleontology in Earth sciences; integration with stratigraphy, sedimentology, paleoenvironmental analysis.</p> <p>Advanced taxonomy: phylogenetic systematics, cladistics, evolutionary classification, morphometrics.</p> <p>Concepts of species, speciation, and extinction in the fossil record.</p> <p>Taphonomy: Post-mortem processes, biostratigraphy, diagenesis, preservation biases; Fossil Lagerstätten (exceptional preservation sites); Factors affecting fossilization potential of organisms (morphology, composition, environment).</p> <p>Fossil variations: ontogeny, polymorphism, sexual dimorphism, ecophenotypic variation, evolutionary trends.</p> <p>Quantitative paleontology: sampling, diversity measures, ecological guilds. Functional morphology and paleoecological interpretations.</p> <p>Fossil record: completeness, fidelity, and limitations.</p>	<b>15</b>	CO1, CO2, CO3, CO4      K1, K2, K3, K4, K5, K6
<b>Module 2:</b>	<p>Major mass extinctions: end-Ordovician, Late Devonian, end-Permian, end-Cretaceous, Quaternary megafauna – causes, consequences, and recovery events.</p> <p>Mechanisms of evolution: phyletic gradualism, punctuated equilibrium, adaptive radiations, evolutionary innovations, and exaptations (skeletons, shells, flight, endothermy, terrestrial adaptation).</p> <p>Macroinvertebrate evolutionary case studies: Trilobites, Brachiopods, Cephalopods.</p>	<b>15</b>	CO1, CO2, CO3, CO4      K1, K2, K3, K4, K5, K6

	Vertebrate evolution: Fishes to tetrapods: key adaptations for land colonization; Reptilian radiations, mammalian origins and diversification; Human evolution. Macroevolutionary patterns: global diversity trends, background extinctions, evolutionary recovery.			
<b>Module 3:</b>	<p>Paleoecology: reconstruction of ancient life habits, ecosystems, and community structures; functional morphology and trophic interactions.</p> <p>Trace fossils and ichnology: classification, environmental significance, and applications in paleoenvironmental analysis.</p> <p>Paleobiogeography: patterns of faunal and floral distribution, dispersal and migration, vicariance; India's paleobiogeographic evolution during Gondwana break-up and plate movements.</p> <p>Fossils in stratigraphy: correlation, index fossils, event stratigraphy, and applications in sequence stratigraphy.</p> <p>Paleoclimate and paleoenvironmental reconstruction using isotopes, plant fossils, and vertebrate records.</p> <p>Applied paleontology: fossil data in resource exploration (coal, hydrocarbons, minerals) and in reconstructing Earth's history.</p> <p>Modern tools and approaches in paleontology: imaging techniques (CT scanning, 3D modeling), geochemical analyses, and quantitative methods in diversity studies.</p>	<b>15</b>	CO3, CO4, CO5	K1, K2, K3, K4, K5, K6
<b>Pedagogy:</b>	Lectures, Practical sessions, Group seminars, Problem-solving exercises, Mini projects and assignments.			
<b>Texts:</b>	<ol style="list-style-type: none"> <li>Allison, P. A., &amp; Bottjer, D. J. (Eds.). (2010). Taphonomy: process and bias through time (Vol. 32). Springer.</li> <li>Benton, M. J., &amp; Harper, D. A. (2020). Introduction to paleobiology and the fossil record. John Wiley &amp; Sons.</li> <li>Klug, C., Korn, D., De Baets, K., Kruta, I., &amp; Mapes, R. H. (Eds.). (2015). Ammonoid paleobiology: from anatomy to ecology (Vol. 43). Springer.</li> <li>Louys, J. (2012). Paleontology in ecology and conservation: an introduction. In Paleontology in ecology and conservation (pp. 1-7). Berlin, Heidelberg: Springer Berlin Heidelberg.</li> <li>Moore, R. C., Lalicker, C. G., &amp; Fischer, A. G. (1952). Invertebrate fossils..</li> <li>Prothero, D. R. (2013). Bringing fossils to life: An introduction to paleobiology. Columbia University Press.</li> <li>Thomason, J. (Ed.). (1997). Functional morphology in vertebrate paleontology. Cambridge University Press.</li> </ol>			

**References/  
Readings:**

1. Benton, M. J. (2014). Vertebrate palaeontology. John Wiley & Sons.
2. Raup, D., & Stanley, S. M. (1978). Principles of paleontology. Macmillan.

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<b>Title of the Course</b>	Practical of Paleontology
<b>Course Code</b>	GEO-6005
<b>Number of Credits</b>	1
<b>Theory/Practical</b>	Practical
<b>Level</b>	500
<b>Effective from AY</b>	2026-27
<b>New Course:</b>	Yes
<b>Bridge Course/ Value added Course:</b>	No
<b>Course for advanced learners:</b>	No

<b>Pre-requisites for the Course:</b>	NIL	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Develop skills in identification and classification of invertebrate, plant, and vertebrate fossils.</li> <li>2. Train students in morphological, ecological, and functional analysis of fossils.</li> <li>3. Identify fossil assemblages for biostratigraphic correlation and age determination.</li> <li>4. Understand patterns of fossil distribution and evaluate causes of mass extinctions.</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, the student will be able to:	<b>Mapped to PSO</b>
	CO 1. Identify and classify invertebrate plant and vertebrate fossils.	PSO1, PSO2, PSO3, PSO4
	CO 2. Examine ecological adaptations and functional morphology of fossils.	PSO1, PSO2, PSO3, PSO5
	CO 3. Apply fossil assemblage data for biostratigraphic correlation.	PSO1, PSO2, PSO3, PSO6
	CO 4. Analyze fossil distribution patterns and extinction events.	PSO1, PSO2, PSO3, PSO5,

			PSO6	
	CO 5. Perform quantitative morphometric and functional analysis of fossils.		PSO1, PSO2, PSO3, PSO6	
Content:		No of hours	Mapped to CO	Cognitive Level
<b>Module 1:</b>	Morphology, Classification, and Ecological Study of Invertebrate Fossils. Megascopic Study of Plant Fossils. Study of Vertebrate Fossils and Fish Teeth. Fossil Assemblage Analysis and Biostratigraphic Correlation. Fossil Distribution and Mass Extinction Analysis. Quantitative Morphology & Functional Analysis.	<b>30</b>	CO1, CO2, CO3, CO4, CO5	K1, K2, K3, K4, K5, K6
<b>Pedagogy:</b>	Demonstrations, field visits, Hands-on identification, Problem-solving, Data analysis.			
<b>Texts:</b>	<ol style="list-style-type: none"> <li>Allison, P. A., &amp; Bottjer, D. J. (Eds.). (2010). Taphonomy: process and bias through time (Vol. 32). Springer.</li> <li>Benton, M. J., &amp; Harper, D. A. (2020). Introduction to paleobiology and the fossil record. John Wiley &amp; Sons.</li> <li>Klug, C., Korn, D., De Baets, K., Kruta, I., &amp; Mapes, R. H. (Eds.). (2015). Ammonoid paleobiology: from anatomy to ecology (Vol. 43). Springer.</li> <li>Louys, J. (2012). Paleontology in ecology and conservation: an introduction. In Paleontology in ecology and conservation (pp. 1-7). Berlin, Heidelberg: Springer Berlin Heidelberg.</li> <li>Moore, R. C., Lalicker, C. G., &amp; Fischer, A. G. (1952). Invertebrate fossils.</li> <li>Prothero, D. R. (2013). Bringing fossils to life: An introduction to paleobiology. Columbia University Press.</li> <li>Thomason, J. (Ed.). (1997). Functional morphology in vertebrate paleontology. Cambridge University Press.</li> </ol>			
<b>References/ Readings:</b>	<ol style="list-style-type: none"> <li>Benton, M. J. (2014). Vertebrate palaeontology. John Wiley &amp; Sons.</li> <li>Raup, D., &amp; Stanley, S. M. (1978). Principles of paleontology. Macmillan.</li> </ol>			

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<b>Title of the Course</b>	Trace Element Geochemistry
<b>Course Code</b>	GEO-6006
<b>Number of Credits</b>	3
<b>Theory/Practical</b>	Theory
<b>Level</b>	500
<b>Effective from AY</b>	2026-27
<b>New Course:</b>	No
<b>Bridge Course/ Value added Course:</b>	No
<b>Course for advanced learners:</b>	Yes

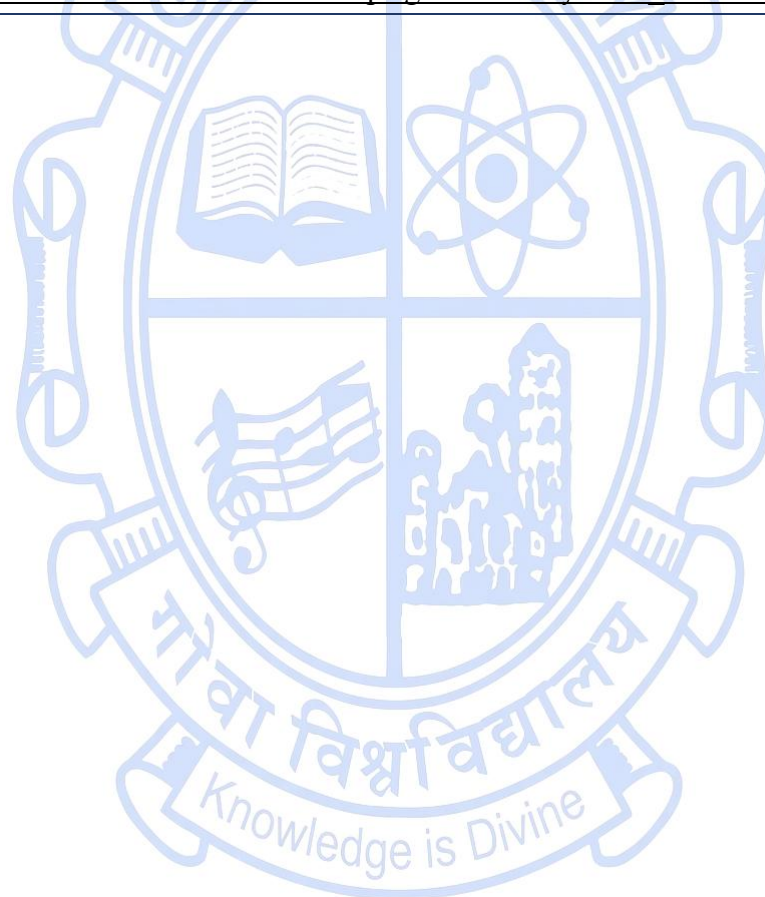
<b>Pre-requisites for the Course:</b>	Completion of 400 level course on Mineralogy	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Provide a foundational understanding of geochemical principles, elemental distribution, and isotope systems in Earth materials.</li> <li>2. Develop skills in analysing chemical and isotopic compositions of rocks, sediments, and waters.</li> <li>3. Introduce the principles of hydro geochemistry and the factors controlling water–rock interactions.</li> <li>4. Enable students to apply geochemical and isotopic tools in studying petrogenesis, provenance, environmental, and hydrogeological problems.</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, the student will be able to:	<b>Mapped to PSO</b>
	CO 1. Explain the geochemical behavior of elements, trace element systematics, and REE patterns in rocks.	PSO1, PSO2, PSO3, PSO4, PSO6
	CO 2. Apply isotopic techniques to study geochronology, petrogenesis, and mantle–crust	PSO1, PSO2, PSO3,

	evolution.		PSO6	
	CO 3. Analyse groundwater chemistry, hydro chemical facies, and assess contamination and water–rock interactions.		PSO1, PSO2, PSO3, PSO4, PSO6	
	CO 4. Interpret geochemical data using classification diagrams, geochemical indices, and modelling tools for research and practical applications.		PSO1, PSO2, PSO3, PSO6	
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>	<b>Cognitive Level</b>
<b>Module 1:</b>	Historical perspective of geochemistry; cosmic abundance of elements; classification of elements and their geochemical behaviour; geochemical cycles and distribution of elements in the Earth’s crust, mantle and core; major, minor and trace elements in igneous, sedimentary and metamorphic rocks; trace element systematics and partition coefficients; Rare Earth Elements (REE) geochemistry, normalization and anomalies; geochemical classification and tectonic discrimination diagrams for igneous rocks; elemental mobility during weathering and diagenesis; geochemical characteristics of sedimentary and metamorphic rocks; use of immobile elements and geochemical indices in provenance studies; fluid–rock interaction and metasomatism; application of geochemical modelling in understanding rock-forming processes.	15	CO1, CO4	K1, K2, K3, K4, K5, K6
<b>Module 2:</b>	Fundamentals of isotopes, radioactive decay schemes, decay laws, half-life, isotope notations, principles of isotopic fractionation, equilibrium and kinetic fractionation, mass-dependent and mass-independent fractionation, stable isotopes of oxygen, hydrogen, carbon, sulphur and nitrogen with their applications, radiogenic isotope systems including Rb–Sr, Sm–Nd, U–Th–Pb, K–Ar, Ar–Ar, Lu–Hf and Re–Os with applications in geochronology and petrogenesis, applications of isotopes in mantle–crust evolution, magma genesis, metamorphism, sediment provenance, ore deposits, hydrothermal systems, palaeoclimate reconstruction, isotope hydrology and cosmogenic isotopes, and analytical techniques including sample preparation, TIMS, SIMS, ICP-MS, MC-ICP-MS, LA-ICP-MS and in-situ methods.	15	CO2, CO4	K1, K2, K3, K4, K5, K6
<b>Module 3:</b>	Structure, bonding, and physico-chemical properties of water; isotopic composition of waters; solution chemistry, solubility, mineral dissolution, and association/dissociation	15	CO3, CO4	K1, K2, K3, K4,

	of dissolved species; evolution of groundwater hydrochemical sequences and facies; mechanisms controlling groundwater chemistry; geochemical classification of waters; geochemical cycle of carbon; groundwater in crystalline and sedimentary rocks; rock–water interaction at low temperatures; chemistry of thermal springs; hydrochemical exploration of mineral deposits; groundwater contamination, sources, and hydrogeochemical behavior of contaminants; measurement of physical and chemical parameters, dissolved constituents,			K5, K6
<b>Pedagogy:</b>	Lectures/tutorials/assignments/field study/discussion			
<b>Texts:</b>	<ol style="list-style-type: none"> <li>1. Albarede, F. (1995). Introduction to geochemical modelling. Cambridge University Press.</li> <li>2. Faure, G., &amp; Mensing, T. M. (2005). Isotopes: Principles and applications (3rd ed.). John Wiley &amp; Sons.</li> <li>3. Freeze, R. A., &amp; Cherry, J. A. (1979). Groundwater. Prentice Hall.</li> <li>4. Gasper, E., &amp; Onescu, M. (1972). Radioactive tracers in hydrology. Elsevier.</li> <li>5. Hiscock, K. M., &amp; Bense, V. F. (2021). Hydrogeology: Principles and practice. John Wiley &amp; Sons.</li> <li>6. McSween, H. Y., Jr., Richardson, S. M., &amp; Uhle, M. E. (2003). Geochemistry: Pathways and processes. Columbia University Press.</li> <li>7. Rollinson, H. R. (1993). Using geochemical data: Evaluation, presentation, interpretation. Longman.</li> <li>8. Shaw, D. M. (2006). Trace elements in magmas. Cambridge University Press.</li> <li>9. Sharp, Z. (2006). Principles of stable isotope geochemistry. Prentice Hall.</li> <li>10. Stumm, W., &amp; Morgan, J. J. (1981). Aquatic chemistry: Chemical equilibria and rates in natural waters (3rd ed.). John Wiley &amp; Sons.</li> <li>11. White, M. W. (2014). Isotope geochemistry. Wiley-Blackwell.</li> <li>12. Wood, B. J., &amp; Fraser, D. G. (1977). Elementary thermodynamics for geologists. Oxford University Press</li> </ol>			
<b>References/ Readings:</b>	<ol style="list-style-type: none"> <li>1. Condie, K. C. (1993). Chemical composition and evolution of the upper continental crust: Contrasting results from surface samples and shales. <i>Chemical Geology</i>, 104(1–4), 1–37. <a href="https://doi.org/10.1016/0009-2541(93)90140-E">https://doi.org/10.1016/0009-2541(93)90140-E</a></li> <li>2. Hofmann, A. W. (1988). Chemical differentiation of the Earth: The relationship between mantle, continental crust, and oceanic crust. <i>Earth and Planetary Science Letters</i>, 90(3), 297–314. <a href="https://doi.org/10.1016/0012-821X(88)90132-X">https://doi.org/10.1016/0012-821X(88)90132-X</a></li> <li>3. McDonough, W. F., &amp; Sun, S. S. (1995). The composition of the Earth. <i>Chemical Geology</i>, 120(3–4), 223–253. <a href="https://doi.org/10.1016/0009-2541(94)00140-4">https://doi.org/10.1016/0009-2541(94)00140-4</a></li> </ol>			

	<p>4. Pearce, J. A. (1983). Role of the sub-continental lithosphere in magma genesis at active continental margins. In C. J. Hawkesworth &amp; M. J. Norry (Eds.), <i>Continental basalts and mantle xenoliths</i> (pp. 230–249). Shiva Publishing.</p> <p>5. Rudnick, R. L., &amp; Gao, S. (2003). Composition of the continental crust. In R. L. Rudnick (Ed.), <i>The crust</i> (Vol. 3, pp. 1–64). Elsevier.</p>
<b>Web Resources:</b>	<p>1. <a href="https://georoc.eu/georoc/new-start.asp">https://georoc.eu/georoc/new-start.asp</a></p> <p>2. <a href="https://web.archive.org/web/20080820010048/http://www.petdb.org/">https://web.archive.org/web/20080820010048/http://www.petdb.org/</a></p> <p>3. <a href="https://serc.carleton.edu/NAGTWorkshops/geochemistry/table_contents.html">https://serc.carleton.edu/NAGTWorkshops/geochemistry/table_contents.html</a></p>

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<b>Title of the Course</b>	Practical of Trace Element Geochemistry
<b>Course Code</b>	GEO-6007
<b>Number of Credits</b>	1
<b>Theory/Practical</b>	Practical
<b>Level</b>	500
<b>Effective from AY</b>	2026-27
<b>New Course:</b>	No
<b>Bridge Course/ Value added Course:</b>	No
<b>Course for advanced learners:</b>	Yes

<b>Pre-requisites for the Course:</b>	Completion of 400 level course on Mineralogy	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Develop skills in collection, preparation, and chemical analysis of geological and water samples.</li> <li>2. Train students in plotting, interpreting geochemical and hydrochemical data.</li> <li>3. Familiarize students with graphical and statistical tools for geochemical and hydrochemical data interpretation.</li> <li>4. Provide hands-on training in analytical instruments such as flame photometer and spectrophotometers.</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, the student will be able to:	<b>Mapped to PSO</b>
	CO 1. Analyze rocks, minerals, sediments, and water for major, minor, and trace components, and calculate geochemical indices.	PSO 2, PSO 3, PSO 4, PSO 6
	CO 2. Classify water types and interpret geochemical data.	PSO 1, PSO 2, PSO 3, PSO 4, PSO 6
	CO 3. Prepare and interpret discrimination diagrams and geochemical plots to deduce	PSO 1, PSO 2, PSO 3, PSO

	petrogenetic and hydro chemical processes.		4, PSO 6	
	CO 4. Operate and apply analytical instruments (flame photometer, spectrophotometer) for quantitative estimation of major cations and anions in natural waters		PSO 1, PSO 2, PSO 3, PSO 4, PSO 6	
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>	<b>Cognitive Level</b>
<b>Module 1:</b>	Sample collection and processing, Calculation of geochemical indices and plotting discrimination diagrams, Calculation of element ratios, partition coefficients, and isotopic fractionation; Plotting and interpretation of geochemical and hydro chemical data, Hands-on training with flame photometer and spectrophotometers; Determination of major cations and anions of water sample	<b>30</b>	CO1, CO2, CO3, CO4	K1, K2, K3, K4, K5, K6
<b>Pedagogy:</b>	Laboratory exercises/plotting/ lectures/discussions/ demonstrations/Field visits			
<b>Texts:</b>	<ol style="list-style-type: none"> <li>Alexandre, P. (2021). Practical geochemistry. Springer.</li> <li>Ewing, G. W., &amp; McGraw-Hill. (1981). Instrumental methods of chemical analysis. New York.</li> <li>Freeze, R. A., &amp; Cherry, J. A. (1979). Groundwater. Prentice Hall.</li> <li>Gong, Q. G., &amp; Shi, Z. (Eds.). (2025). New advances, challenges, and illustrations in applied geochemistry. MDPI Books.</li> <li>Rollinson, H. R. (1993). Using geochemical data: Evaluation, presentation, interpretation. Harlow, Essex, England: Longman Group.</li> </ol>			
<b>References/ Readings:</b>	<ol style="list-style-type: none"> <li>Rasilainen, K., Lahtinen, R., &amp; Bornhorst, T. J. (2007). The rock geochemical database of Finland manual. Geological Survey of Finland.</li> <li>Vermeesch, P. (2006). Tectonic discrimination diagrams revisited. <i>Geochemistry, Geophysics, Geosystems</i>, 7(6).</li> <li>Su, B. X., et al. (2022). Element partitioning and Li–O isotope fractionation between olivine and carbonatite melts. <i>Journal of Geophysical Research: Solid Earth</i>, 127(7).</li> </ol>			
<b>Web Resources:</b>	<ol style="list-style-type: none"> <li><a href="https://www.researchgate.net/figure/Sample-collection-preparation-and-analysis_fig2_392539135">https://www.researchgate.net/figure/Sample-collection-preparation-and-analysis_fig2_392539135</a></li> <li><a href="https://www.geosocindia.org/index.php/jgsi/article/view/69308">https://www.geosocindia.org/index.php/jgsi/article/view/69308</a></li> <li><a href="https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/2022JB024563">https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/2022JB024563</a></li> </ol>			

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<b>Title of the Course</b>	Micropaleontology
<b>Course Code</b>	GEO-6008
<b>Number of Credits</b>	03
<b>Theory/Practical</b>	Theory
<b>Level</b>	500
<b>Effective from AY</b>	2026-27
<b>New Course:</b>	No
<b>Bridge Course/ Value added Course:</b>	No
<b>Course for advanced learners:</b>	Yes

<b>Pre-requisites for the Course:</b>	NIL	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Introduce fundamentals and scope of micropaleontology.</li> <li>2. Develop skills in identification and classification of microfossils.</li> <li>3. Use microfossils in biostratigraphy, paleoecology, and basin studies.</li> <li>4. Familiarize with techniques of sampling, processing, and analysis.</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, the student will be able to:	<b>Mapped to PSO</b>
	CO 1. Classify microfossils using taxonomic principles.	PSO1, PSO3
	CO 2. Apply First Appearance Datum (FAD), Last Appearance Datum (LAD) and biozones for correlation and age determination.	PSO1, PSO3, PSO6
	CO 3. Interpret microfossil assemblages for paleoenvironment and resource studies.	PSO3, PSO4, PSO6

	CO 4. Evaluate applied and advanced approaches in micropaleontological research.		PSO3, PSO5, PSO6	
Content:		No of hours	Mapped to CO	Cognitive Level
<b>Module 1:</b>	<p>Scope and significance in stratigraphy, petroleum exploration, and basin studies.</p> <p>Principles of classification, taxonomy, and systematics of microfossils. Techniques of collection, processing, and extraction of microfossils from sediments, and rock samples; methods of deep-ocean exploration, research vessels, and deep-ocean drilling programs.</p> <p>Micropaleontological tools: light microscopy, SEM, imaging techniques.</p> <p>Biostratigraphy and chronostratigraphy: concepts of biozones, marker species, First Appearance Datum (FAD), Last Appearance Datum (LAD) and their significance in correlation.</p> <p>Preservation, fossilization, and taphonomic controls on microfossil records.</p>	15	CO1, CO2, CO3, CO4	K1, K2, K3, K4, K5, K6
<b>Module 2:</b>	<p>Foraminifera: test morphology, wall structure, chamber growth, classification, evolutionary trends, paleoecological indicators, stratigraphic significance.</p> <p>Calcareous Nannofossils: Morphology, life cycle, ecology, geological record, and applications in biostratigraphy and sediment studies.</p> <p>Radiolaria: skeletal features, taxonomy, biogeography, and stratigraphic utility.</p> <p>Diatoms &amp; Silicoflagellates: morphology, ecology, distribution, and stratigraphic applications.</p> <p>Sponge Spicules: occurrence, morphology, and paleoenvironmental relevance.</p> <p>Ostracods: carapace morphology, ontogeny, articulation, ecological traits, and stratigraphic applications.</p> <p>Conodonts: element morphology, classification, Conodont Colour Alteration Index (CAI), and stratigraphic significance.</p> <p>Organic-walled Microfossils: Acritarchs, Dinoflagellate cysts, Pollen, and Spores — morphology, taxonomy, and stratigraphic use.</p>	15	CO2, CO3, CO4	K1, K2, K3, K4, K5, K6

<b>Module 3:</b>	<p>Biostratigraphy: use of FAD, LAD, and assemblage zones for correlation and chronostratigraphic frameworks.</p> <p>Petroleum exploration: microfossils in age determination, basin analysis, depositional environment interpretation, and reservoir correlation.</p> <p>Paleoecology: reconstruction of depositional settings, salinity, oxygenation, and ecological shifts using microfossil assemblages.</p> <p>Mineral and sedimentary basin studies: applications in provenance analysis, stratigraphic subdivision, and mineral exploration.</p> <p>Quaternary and applied concepts: site dating, sediment correlation, archaeological applications, and environmental monitoring.</p> <p>Recent advances: quantitative micropaleontology, biomineralization studies, molecular micropaleontology, and statistical approaches in microfossil research.</p>	<b>15</b>	CO1, CO2, CO3, CO4	K1, K2, K3, K4, K5, K6
<b>Pedagogy:</b>	Lectures, discussions, case studies, mini projects and assignments			
<b>Texts:</b>	<ol style="list-style-type: none"> <li>1. Bignot, G. (Ed.). (1985). Elements of micropalaeontology. Springer Science &amp; Business Media.</li> <li>2. Brasier, M. D. (1980). Microfossils George Allen and Unwin.</li> <li>3. Gross, M. G. (1977). Oceanography: a view of the earth.</li> <li>4. Haq, B. U., &amp; Boersma, A. (Eds.). (1998). Introduction to marine micropaleontology. Elsevier.</li> <li>5. Hart, M. (2006). ARMSTRONG HA &amp; BRASIER MD 2005. Microfossils. Geological Magazine, 143(3), 411-411.</li> <li>6. Hillaire-Marcel, C., &amp; De Vernal, A. (Eds.). (2007). Proxies in late cenozoic paleoceanography (Vol. 1). Elsevier.</li> <li>7. Jones, R. W. (1996). Micropalaeontology in petroleum exploration. Oxford University Press.</li> <li>8. Lowe, J. J., &amp; Walker, M. (2014). Reconstructing quaternary environments. Routledge.</li> <li>9. Martin, R. E. (Ed.). (2000). Environmental micropaleontology: the application of microfossils to environmental geology (Vol. 15). Springer Science &amp; Business Media.</li> </ol>			
<b>References/ Readings:</b>	<ol style="list-style-type: none"> <li>1. Berggren, W. A., Kennett, J. P., &amp; Srinivasan, M. S. (1985). Neogene planktonic foraminifera: a phylogenetic atlas. Micropaleontology, 31(1), 94.</li> <li>2. Sinha, D. K. (2007). Micropaleontology: application in stratigraphy and paleoceanography. Narosa Publishing House.</li> </ol>			

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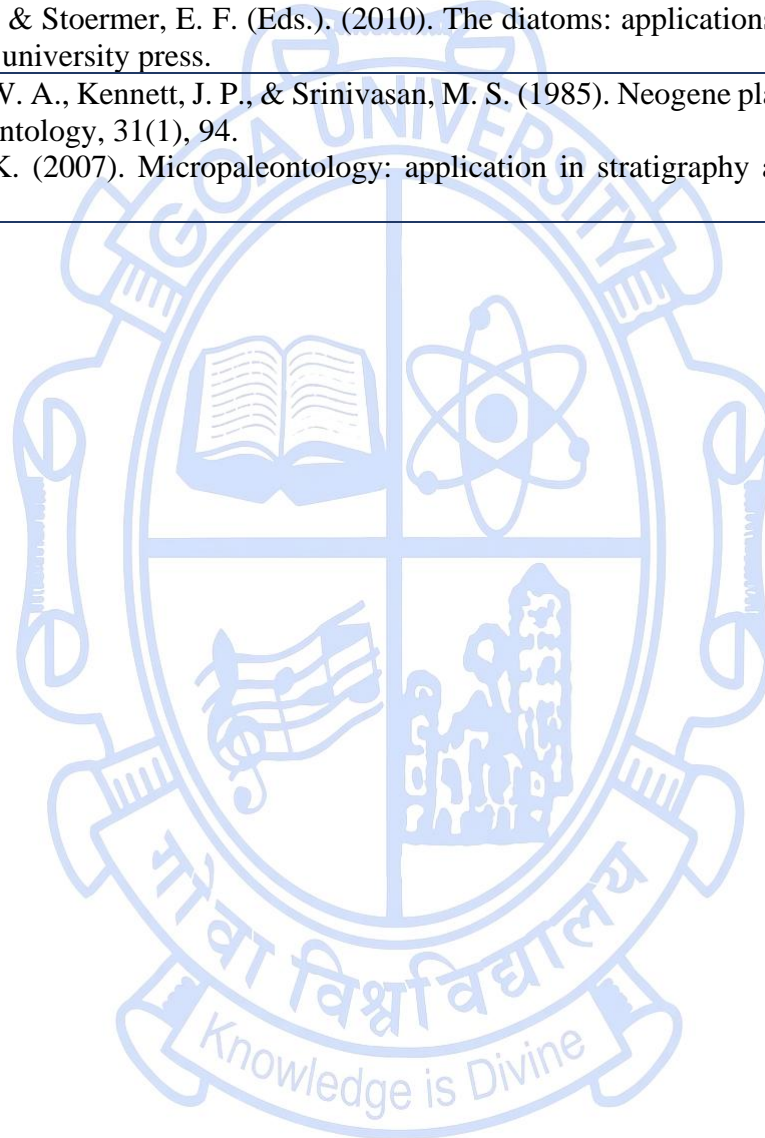
<b>Title of the Course</b>	Practical of Micropaleontology
<b>Course Code</b>	GEO-6009
<b>Number of Credits</b>	01
<b>Theory/Practical</b>	Practical
<b>Level</b>	500
<b>Effective from AY</b>	2026-27
<b>New Course:</b>	No
<b>Bridge Course/ Value added Course:</b>	No
<b>Course for advanced learners:</b>	No

<b>Pre-requisites for the Course:</b>	NIL	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Provide hands-on training in sediment sampling techniques from diverse depositional settings.</li> <li>2. Impart practical skills in microfossil extraction and slide preparation.</li> <li>3. Develop competence in identifying and classifying key microfossil groups.</li> <li>4. Train students in quantitative analysis of microfossil assemblages.</li> <li>5. Enable interpretation of paleoenvironmental conditions using microfossil data.</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, the student will be able to:	<b>Mapped to PSO</b>
	CO 1. Apply appropriate sediment sampling methods for riverine, lacustrine, and shallow marine environments.	PSO1, PSO4
	CO 2. Perform microfossil extraction, slide preparation, and demonstrate laboratory handling skills.	PSO4, PSO6

	CO 3. Classify major microfossil groups		PSO1, PSO6
	CO 4. Analyze microfossil assemblages through species counting, relative abundance, and FAD/LAD plotting.		PSO3, PSO6
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b> <b>Cognitive Level</b>
<b>Module 1:</b>	<p>Field Sampling of Sediments: Sediment collection from riverine/ lacustrine/shallow marine environments using different samplers.</p> <p>Extraction of Microfossils and slide/mount preparation for laboratory observation; Standard procedures for:</p> <ul style="list-style-type: none"> <li>- Diatoms</li> <li>- Foraminifera,</li> <li>- Silicoflagellates and</li> <li>- Radiolaria.</li> </ul> <p>Microfossil Identification and Taxonomy:</p> <ul style="list-style-type: none"> <li>- Diatoms</li> <li>- Foraminifera</li> <li>- Silicoflagellates and</li> <li>- Radiolaria.</li> </ul> <p>Quantitative Analysis: Species counting, relative abundance calculation, FAD/LAD determination.</p> <p>Plotting assemblages and constructing biozones.</p> <p>Paleoenvironmental Interpretation using microfossil assemblages.</p>	<b>30</b>	<p>CO1, CO2, CO3, CO4</p> <p>K1, K2, K3, K4, K5, K6</p>
<b>Pedagogy:</b>	Field visits, Demonstration, laboratory exercises, Microscopy-based Identification, Data analysis.		
<b>Texts:</b>	<ol style="list-style-type: none"> <li>1. Haq, B. U., &amp; Boersma, A. (Eds.). (1998). Introduction to marine micropaleontology. Elsevier.</li> <li>2. Hart, M. (2006). ARMSTRONG HA &amp; BRASIER MD 2005. Microfossils. Geological Magazine, 143(3), 411-411.</li> <li>3. Hillaire-Marcel, C., &amp; De Vernal, A. (Eds.). (2007). Proxies in late cenozoic paleoceanography (Vol. 1). Elsevier.</li> <li>4. Jenkins, D. G. (Ed.). (1993). Applied micropalaeontology. Springer Science &amp; Business Media.</li> </ol>		

	<p>5. Scott, F. J., &amp; Marchant, H. J. (2005). Antarctic marine protists.</p> <p>6. Smol, J. P., &amp; Stoermer, E. F. (Eds.). (2010). The diatoms: applications for the environmental and earth sciences. Cambridge university press.</p>
<b>References/ Readings:</b>	<p>1. Berggren, W. A., Kennett, J. P., &amp; Srinivasan, M. S. (1985). Neogene planktonic foraminifera: a phylogenetic atlas. Micropaleontology, 31(1), 94.</p> <p>2. Sinha, D. K. (2007). Micropaleontology: application in stratigraphy and paleoceanography. Narosa Publishing House.</p>

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<b>Title of the Course</b>	Research Methodology in Geology
<b>Course Code</b>	GEO-6010
<b>Number of Credits</b>	4
<b>Theory/Practical</b>	Theory
<b>Level</b>	500
<b>Effective from AY</b>	2026-27
<b>New Course:</b>	Yes
<b>Bridge Course/ Value added Course:</b>	No
<b>Course for advanced learners:</b>	No

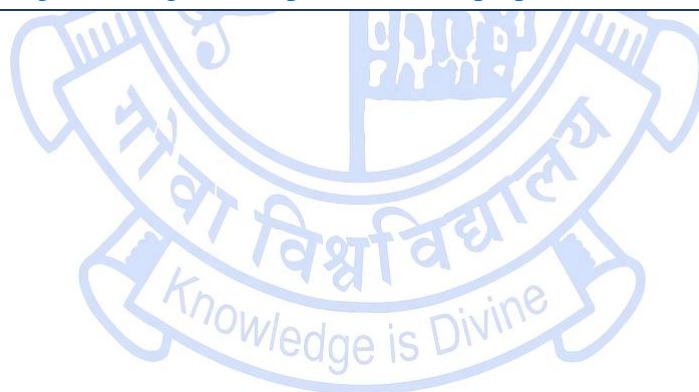
<b>Pre-requisites for the Course:</b>	NIL	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Introduce students to the fundamentals of scientific research and academic writing in geology.</li> <li>2. Develop skills in field data collection, sampling methods, and geological mapping.</li> <li>3. Familiarize students with laboratory techniques and analytical instruments used in geoscience research.</li> <li>4. Train students in data analysis, interpretation, and presentation using modern tools and software.</li> <li>5. Prepare students for independent research through applied studies, project design, and proposal writing.</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, the student will be able to:	<b>Mapped to PSO</b>
	CO 1. Identify research problems and design a structured research plan.	PSO1, PSO3,
	CO 2. Undertake geological fieldwork, sampling, and documentation.	PSO1, PSO2, PSO3, PSO4, PSO6, PSO 7
	CO 3. Explain major analytical techniques used in geology.	PSO1, PSO2, PSO3,

			PSO4, PSO6	
	CO 4. Interpret geoscientific data effectively.		PSO1, PSO2, PSO3, PSO4, PSO6	
	CO 5. Conduct research ethically and communicate findings through scientific writing		PSO1, PSO2, PSO3, PSO4, PSO6, PSO 7	
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>	<b>Cognitive Level</b>
<b>Module 1:</b>	Concept of scientific research; identifying and defining research problems; setting objectives and formulating hypotheses; designing a research plan; literature review and database search techniques; sources of geological data; use of online journals and reference management tools; fundamentals of data analysis and graphical presentation; components of a scientific paper; writing reports, dissertations, and articles; structure of a thesis; ethics in research, plagiarism and self-plagiarism; citation and referencing styles; presentation of research outcomes in seminars and conferences.	15	CO1	K1, K2, K3, K4, K5, K6
<b>Module 2:</b>	Field data collection methods; geological mapping principles; sampling techniques for rocks, soils, sediments, and water; preparation and labeling of samples; field notebooks and report preparation; use of GPS and remote sensing data in field studies; preparation of thin sections and polished mounts; basics of petrographic and mineral identification; introduction to analytical instruments used in geology; preparation of geological maps, cross-sections, and stratigraphic columns.	15	CO2	K1, K2, K3, K4, K5, K6
<b>Module 3:</b>	Overview of laboratory safety and sample handling; working principles and applications of XRD, XRF, SEM, EPMA, ICP-MS, FTIR, and Raman spectroscopy; basics of stable and radiogenic isotope analysis; geochemical data representation and interpretation; use of spreadsheets and graphing software; introduction to GIS and data integration; understanding precision, accuracy, and quality control in analytical work; environmental sampling and testing for water and soil quality parameters.	15	CO3	K1, K2, K3, K4, K5, K6
<b>Module 4:</b>	Application of research in petrology, mineralogy, geochemistry, geomorphology, hydrogeology, and environmental geology; basics of aquifer characterization, groundwater sampling, and quality assessment; introduction to marine and coastal	15	CO4, CO5	K1, K2, K3, K4, K5, K6

	geological research; microfossils and their applications in paleoenvironmental studies; introduction to microplastic and pollution indices; project formulation, funding agencies, and proposal writing; statistical data analysis and interpretation, discussion, and conclusion in geological research.			
<b>Pedagogy:</b>	Lectures/tutorials/assignments/field study/discussion			
<b>Texts:</b>	<ol style="list-style-type: none"> <li>1. Alley, M. (1996). The craft of scientific writing (No. 808.0666/A435). New York: Springer.</li> <li>2. Appelo, C. A. J., &amp; Postma, D. (2004). Geochemistry, groundwater and pollution. CRC Press.</li> <li>3. Clough, P., &amp; Nutbrown, C. (2012). A student's guide to methodology. SAGE Publications Ltd.</li> <li>4. Crawford, B. C., &amp; Quinn, B. (2016). Microplastic pollutants (1st ed.). Elsevier Science.</li> <li>5. Dickin, A. P. (2005). Radiogenic isotope geology. Cambridge University Press.</li> <li>6. Edmunds, W. M., &amp; Smedley, P. L. (1996). Groundwater geochemistry and health: An overview. Geological Society, London, Special Publications, 113(1), 91–105.</li> <li>7. Faure, G., &amp; Mensing, T. M. (2009). Isotopes: Principles and applications. Wiley.</li> <li>8. Fetter, C. W. (2018). Applied hydrogeology. Waveland Press.</li> <li>9. Goldberg, S. (2006). Geochemistry, groundwater and pollution.</li> <li>10. Hoefs, J. (2013). Stable isotope geochemistry. Springer Science &amp; Business Media.</li> <li>11. Hren, J. (2013). Introduction to analytical electron microscopy. Springer.</li> <li>12. Jenkins, R., &amp; Snyder, R. (1996). Introduction to X-ray powder diffractometry. Wiley-Interscience.</li> <li>13. Jones, R. W. (2004). Micropalaeontology in petroleum exploration. Oxford University Press.</li> <li>14. Kathal, P. (2012). Applied geological micropalaeontology. Scientific Publishers.</li> <li>15. Kuenen, P. (2008). Marine geology. John Wiley.</li> <li>16. Kumar, R. (2018). Research methodology: A step-by-step guide for beginners. SAGE Publications Ltd.</li> <li>17. Passchier, C., &amp; Trouw, R. A. J. (2005). Microtectonics. Springer.</li> <li>18. Philpotts, A., &amp; Ague, J. (2009). Principles of igneous and metamorphic petrology (2nd ed.). Cambridge University Press. <a href="https://doi.org/10.1017/CBO9780511813429">https://doi.org/10.1017/CBO9780511813429</a></li> <li>19. Ramsay, J. G., &amp; Huber, M. I. (1983). Techniques of modern structural geology: Vol. I &amp; II. Academic Press.</li> <li>20. Reed, S. J. (2010). Electron microprobe analysis and scanning electron microscopy in geology. Cambridge University Press.</li> <li>21. Rocha-Santos, T., Costa, M., &amp; Mouneyrac, C. (Eds.). (2022). Handbook of microplastics in the environment (1st ed.). Springer.</li> </ol>			

	<p>22. Rocha-Santos, T. A. P., &amp; Duarte, A. C. (Eds.). (2017). Characterization and analysis of microplastics (1st ed.). Elsevier Science.</p> <p>23. Rollinson, H. R. (1993). Using geochemical data: Evaluation, presentation, interpretation. Longman Group.</p> <p>24. Roy-Barman, M., &amp; Jeandel, C. (2016). Marine geochemistry. Oxford University Press.</p> <p>25. Sinha, D. K. (2007). Micropaleontology: Application in stratigraphy and palaeoceanography. Narosa Publishing House.</p> <p>26. Spear, F. (1993). Metamorphic phase equilibria and pressure-temperature-time paths. Mineralogical Society of America.</p> <p>27. Thomas, C. G. (2021). Research methodology and scientific writing. Springer.</p> <p>28. Van der Pluijm, B. A., &amp; Marshak, S. (2004). Earth structure: An introduction to structural geology and tectonics. W. W. Norton &amp; Company Ltd.</p> <p>29. Vernon, R. (2018). A practical guide to rock microstructure (2nd ed.). Cambridge University Press. <a href="https://doi.org/10.1017/9781108654609">https://doi.org/10.1017/9781108654609</a></p> <p>30. Wilson, M. (1989). Igneous petrogenesis. Wiley.</p>
<b>References/ Readings:</b>	<p>1. Whitmeyer, S. J. (2019). Modern approaches to field data collection and mapping. <i>Geoscience Frontiers</i>, 10(5), 1573–1584. <a href="https://doi.org/10.1016/j.gsf.2019.03.010">https://doi.org/10.1016/j.gsf.2019.03.010</a></p> <p>2. Geological Society of London. (n.d.). Field techniques: GIS, GPS and remote sensing. Retrieved from <a href="https://www.rgs.org/media/trlkm2jo/gismanual.pdf">https://www.rgs.org/media/trlkm2jo/gismanual.pdf</a></p> <p>3. U.S. Environmental Protection Agency. (2025). <i>Microplastics research</i>. Retrieved from <a href="https://www.epa.gov/water-research/microplastics-research">https://www.epa.gov/water-research/microplastics-research</a></p>
<b>Web Resources:</b>	<a href="https://www.researchgate.net/figure/Sample-collection-preparation-and-analysis_fig2_392539135">https://www.researchgate.net/figure/Sample-collection-preparation-and-analysis_fig2_392539135</a>

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<b>Title of the Course</b>	Precambrian Crustal Evolution
<b>Course Code</b>	GEO-6011
<b>Number of Credits</b>	2
<b>Theory/Practical</b>	Theory
<b>Level</b>	500
<b>Effective from AY</b>	2026-27
<b>New Course:</b>	No
<b>Bridge Course/ Value added Course:</b>	No
<b>Course for advanced learners:</b>	Yes

<b>Pre-requisites for the Course:</b>	Completion of 400 level course on Stratigraphy, Structural Geology, Petrology and Mineralogy	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Understand the processes responsible for the formation and evolution of the Precambrian crust.</li> <li>2. Study the distribution, tectonic setting, and geological features of major Archean and Proterozoic cratons.</li> <li>3. Analyse supercontinent cycles, tectonic processes, and mineralization associated with Precambrian shields.</li> <li>4. Explore the links between crustal evolution, atmospheric changes, and biological innovations in the Precambrian.</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, the student will be able to:	<b>Mapped to PSO</b>
	CO 1. Explain the origin and evolution of the Precambrian crust and cratonic provinces.	PSO 1, PSO 2, PSO 5, PSO 6
	CO 2. Interpret the tectonic cycles, supercontinent assembly, and accretionary processes of the Precambrian.	PSO 1, PSO 2, PSO 6

	CO 3. Assess mineralization patterns such as Banded Iron Formations and uraniferous conglomerates in shield areas.		PSO 1, PSO 2, PSO 3, PSO 6
	CO 4. Correlate crustal evolution with the Great Oxidation Event, Snowball Earth glaciations, and early biological changes.		PSO 1, PSO 2, PSO 3, PSO 5, PSO 6
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b> <b>Cognitive Level</b>
<b>Module 1:</b>	Processes responsible for the formation of the early crust; Archean cratons and the origin of granite–greenstone belts; Archean atmosphere and hydrosphere; Archean heat flow and geotherms; nature and composition of the Archean continental crust; granitoid associations. Distribution and tectonic setting of the Archean crust – global distribution, paleomagnetism, and continental reconstructions; Archean–Proterozoic boundary and tectonic cycles. Geologic setting of Indian shield, Greenland shield, African shield, Antarctic craton; detailed study of the Dharwar craton, Southern Granulite Terrain, Eastern Ghat Belt, Singhbhum craton, Bundelkhand craton, and Bastar craton.	<b>15</b>	CO1, CO2 K1, K2, K3, K4, K5, K6
<b>Module 2:</b>	Archean–Proterozoic transition; Early Proterozoic crust and Mid-Proterozoic crust; evolution of the continental crust through time; high-grade metamorphic terrains. Large igneous provinces, dyke swarms, and anorogenic granites; supercontinent cycles including Columbia, Rodinia, Nuna and Pannotia; evolution of mobile belts and accretionary orogens. Mineralization associated with Precambrian shields including Banded Iron Formations and uraniferous conglomerates. Comparison of Paleoproterozoic and Neoproterozoic tectonics; the Great Oxidation Event and the rise of atmospheric oxygen; Neoproterozoic glaciations and the Snowball Earth hypothesis; biological innovations in the Proterozoic.	<b>15</b>	CO3, CO4 K1, K2, K3, K4, K5, K6
<b>Pedagogy:</b>	Lectures/tutorials/assignments/field study/discussion		
<b>Texts:</b>	<ol style="list-style-type: none"> <li>1. Condie, K. C. (1994). Archean crustal evolution. Elsevier.</li> <li>2. Condie, K. C. (2013). Plate tectonics &amp; crustal evolution. Elsevier.</li> <li>3. Coward, M. P., &amp; Ries, A. C. (1986). Collision tectonics (Geological Society of London Special Publication No. 19, 415 p.). Geological Society of London.</li> <li>4. Goodwin, A. M. (1996). Principles of Precambrian geology. Elsevier.</li> </ol>		

	<p>5. Holdsworth, R. E., Handa, M., Miller, J. A., &amp; Buick, I. S. (2001). Continental reactivation and reworking: An introduction. Geological Society, London, Special Publications, 184(1), 1–12. <a href="https://doi.org/10.1144/GSL.SP.2001.184.01.01">https://doi.org/10.1144/GSL.SP.2001.184.01.01</a></p> <p>6. Kearey, P., Klepeis, K. A., &amp; Vine, F. J. (2009). Global tectonics. John Wiley &amp; Sons.</p> <p>7. Moores, E. M., &amp; Twiss, R. J. (1995). Tectonics. Freeman and Company.</p> <p>8. Valdiya, K. S. (1984). Aspects of tectonics – Focus on south central Asia. Tata McGraw-Hill.</p> <p>9. Windley, B. (1977). The evolving continents. John Wiley &amp; Sons Ltd.</p>
<b>References/ Readings:</b>	<p>1. Smithies, R. H., &amp; Champion, D. C. (2018). Two distinct origins for Archean greenstone belts. Nature Geoscience, 11(11), 883–889. <a href="https://doi.org/10.1038/s41561-018-0222-1">https://doi.org/10.1038/s41561-018-0222-1</a></p> <p>2. Korenaga, J. (2006). Archean geodynamics and the thermal evolution of Earth. Geophysical Monograph Series, 164, 1–20. <a href="https://doi.org/10.1029/164GM03">https://doi.org/10.1029/164GM03</a></p> <p>3. Liu, S., &amp; Zhang, Y. (2022). Archean crust-mantle geodynamic regimes: A review. Geoscience Frontiers, 13(6), 101324. <a href="https://doi.org/10.1016/j.gsf.2022.101324">https://doi.org/10.1016/j.gsf.2022.101324</a></p> <p>4. Ge, R., et al. (2022). Formation and evolution of Archean continental crust: A review. Precambrian Research, 367, 106649. <a href="https://doi.org/10.1016/j.precamres.2022.106649">https://doi.org/10.1016/j.precamres.2022.106649</a></p> <p>5. Marimon, R. S. (2022). The generation and evolution of the Archean continental crust. Geoscience Frontiers, 13(6), 101324. <a href="https://doi.org/10.1016/j.gsf.2022.101324">https://doi.org/10.1016/j.gsf.2022.101324</a></p> <p>6. Windley, B. F. (1984). The Archaean-Proterozoic boundary. Precambrian Research, 24(1–2), 1–22. <a href="https://doi.org/10.1016/0301-9268(84)90193-8">https://doi.org/10.1016/0301-9268(84)90193-8</a></p> <p>7. Li, T., et al. (2025). Insights into changes in crust formation mechanisms during the Archean–Proterozoic transition. Science China Earth Sciences, 68(11), 1863–1877. <a href="https://doi.org/10.1007/s11430-025-9811-0">https://doi.org/10.1007/s11430-025-9811-0</a></p> <p>8. National Geophysical Research Institute. (n.d.). Structure and evolution of the Indian Shield. Retrieved October 16, 2025, from <a href="https://www.ngri.res.in/cms/structure-and-evolution-of-the-indian-shield.php">https://www.ngri.res.in/cms/structure-and-evolution-of-the-indian-shield.php</a></p> <p>9. Hofmann, A., et al. (2022). The Archaean geological history of the Singhbhum Craton, eastern India. Precambrian Research, 367, 106649. <a href="https://doi.org/10.1016/j.precamres.2022.106649">https://doi.org/10.1016/j.precamres.2022.106649</a></p>
<b>Web Resources:</b>	<a href="https://www.e-education.psu.edu/earth103/">https://www.e-education.psu.edu/earth103/</a>

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<b>Title of the Course</b>	Radiometric Isotope Dating
<b>Course Code</b>	GEO-6012
<b>Number of Credits</b>	02
<b>Theory/Practical</b>	Theory
<b>Level</b>	500
<b>Effective from AY</b>	2026-27
<b>New Course:</b>	No
<b>Bridge Course/ Value added Course:</b>	No
<b>Course for advanced learners:</b>	Yes

<b>Pre-requisites for the Course:</b>	Completion of 400/500 level courses in Mineralogy and Igneous, Sedimentary and Metamorphic Petrology	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Introduce students to the principles of radioactive decay, radiogenic growth, and isotopic systematics.</li> <li>2. Familiarize students with major radiogenic isotope dating techniques and their analytical foundations.</li> <li>3. Develop competence in interpreting isotopic data for geochronology, thermochronology, and isotope geochemistry.</li> <li>4. Train students to apply radiogenic isotope systems in reconstructing geological processes and evolution of the earth.</li> </ol>	
<b>Course Outcomes:</b>	By the end of this course, students will be able to:	<b>Mapped to PSO</b>
	CO 1. Explain the principles of radioactive decay, radiogenic growth equations, closure temperature, and isotopic systematics.	PSO 1, PSO2
	CO 2. Describe mass spectrometry techniques and evaluate the application of isotope dating methods (Rb-Sr, Sm-Nd, Lu-Hf, Re-Os, K-Ar, Ar-Ar, U-Th-Pb).	PSO 1, PSO 2, PSO 3, PSO 6

	CO 3. Analyze advanced isotope systems (U-series disequilibrium, fission track, U-Th/He) and their geological applications.		PSO 2; PSO 3, PSO 6
	CO 4. Interpret and integrate isotopic data (Sr, Nd, Pb, Hf) to reconstruct mantle-crust evolution, magmatism, provenance, planetary processes, and critically assess uncertainties.		PSO 1, PSO 2, PSO 3, PSO 5, PSO 6
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b> <b>Cognitive Level</b>
<b>Module1:</b>	Fundamentals and Isotope Systems: Nucleosynthesis and distribution of elements in the Solar System; Principles of radioactive decay, decay constants, radiogenic growth equations, and geochronometry. Concepts of closure temperature, isotopic resetting, and diffusion in minerals; Principles of mass spectrometry – TIMS, SIMS, LA-ICP-MS, MC-ICP-MS; sampling strategies and processing; Dating principles and applications of Rb-Sr, Sm-Nd, Lu-Hf, Re-Os, K-Ar, and Ar-Ar systems; U-Th-Pb geochronology – concordia and discordia, common Pb correction, high-precision U–Pb dating.	<b>15</b>	CO1, CO2      K2, K3, K4, K5, K6
<b>Module2:</b>	Advanced Systems, Applications, and Data Handling: Isotope systematics of Pb – evolution of the Earth’s mantle and crust, geochemical reservoirs; U-series disequilibrium dating and its applications (young volcanic rocks, carbonates, corals); Fission track thermochronology and (U-Th)/He dating – principles, applications, and limitations; Isotope tracers in petrogenetic studies – Sr, Nd, Pb, Hf isotopes in mantle-crust evolution, magmatic differentiation, crustal contamination, and provenance; Processing, presentation, and interpretation of isotope data – isochrons, error propagation, and age uncertainty; Case studies – applications in tectonics, ore deposits, planetary materials, and Earth system evolution	<b>15</b>	CO3, CO4      K2, K3, K4, K5, K6
<b>Pedagogy:</b>	Lectures/ tutorials/ assignments/ discussions		
<b>Texts:</b>	<ol style="list-style-type: none"> <li>Dickin, A. P. (2005). Radiogenic isotope geology (2nd ed.). Cambridge: Cambridge University Press.</li> <li>Faure, G., &amp; Mensing, T. M. (2005). Isotopes: Principles and applications (3rd ed.). Hoboken, NJ: John Wiley &amp; Sons.</li> <li>Halliday, A. N., Dickin, A. P., Fallick, A. E., &amp; Lee, D. C. (1992). Radiogenic isotope systems and geochemical</li> </ol>		

	<p>applications. Oxford: Blackwell.</p> <ol style="list-style-type: none"> <li>McDougall, I., &amp; Harrison, T. M. (1999). Geochronology and thermochronology by the <math>^{40}\text{Ar}/^{39}\text{Ar}</math> method (2nd ed.). New York: Oxford University Press.</li> <li>Villa, I. M. (2016). Isotopic dating of minerals: Principles and applications. Berlin: Springer.</li> <li>Reiners, P. W., Carlson, R. W., Renne, P. R., Cooper, K. M., Granger, D. E., McLean, N. M., &amp; Schoene, B. (2017). Geochronology and thermochronology. John Wiley &amp; Sons.</li> <li>Rasskazov, S. V., Brandt, S. B., &amp; Brandt, I. S. (2009). Radiogenic isotopes in geologic processes. Springer Science &amp; Business Media.</li> <li>Schmitz, M. D., Gradstein, F. M., &amp; Ogg, J. G. (2012). Radiogenic isotope geochronology. The geologic time scale, 2, 115-126.</li> </ol>
<b>References/ Readings:</b>	<ol style="list-style-type: none"> <li>Zartman, R. E. (Ed.). (1990). U-Th-Pb geochronology: Stable isotope geochemistry. Reviews in Mineralogy, 3, 493–543. Washington, DC: Mineralogical Society of America.</li> <li>Reiners, P. W., Ehlers, T. A., &amp; Zeitler, P. K. (2005). Past, present, and future of thermochronology. Reviews in Mineralogy and Geochemistry, 58(1), 1-18.</li> <li>Banner, J. L. (2004). Radiogenic isotopes: systematics and applications to earth surface processes and chemical stratigraphy. Earth-Science Reviews, 65(3-4), 141-194.</li> </ol>
<b>Web Resources:</b>	<ol style="list-style-type: none"> <li><a href="https://isoplotr.es.ucl.ac.uk/">https://isoplotr.es.ucl.ac.uk/</a></li> <li><a href="https://www.earth-time.org/">https://www.earth-time.org/</a></li> <li><a href="https://www.usgs.gov/labs/radiogenic-isotope-lab">https://www.usgs.gov/labs/radiogenic-isotope-lab</a></li> <li><a href="https://www.nature.com/subjects/geochronology">https://www.nature.com/subjects/geochronology</a></li> <li><a href="https://www.cambridge.org/core/journals/geological-magazine/collections/geochronology">https://www.cambridge.org/core/journals/geological-magazine/collections/geochronology</a></li> </ol>

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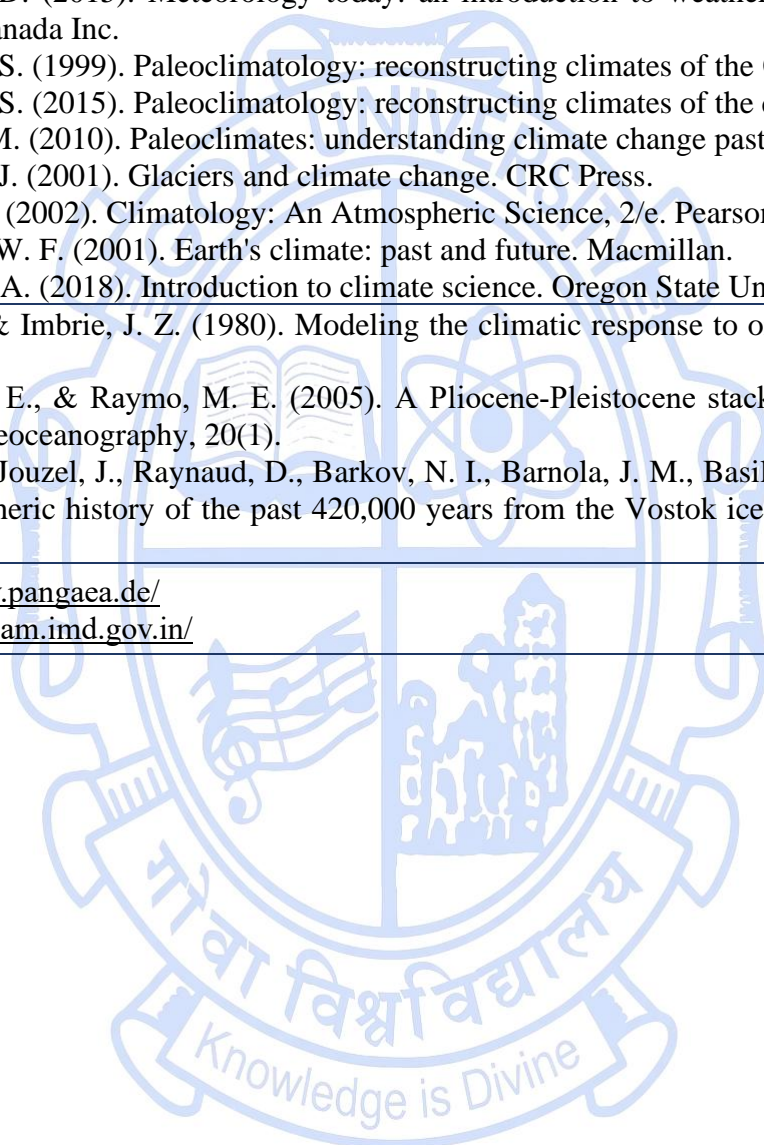
<b>Title of the Course</b>	Climate Geology
<b>Course Code</b>	GEO-6013
<b>Number of Credits</b>	02
<b>Theory/Practical</b>	Theory
<b>Level</b>	500
<b>Effective from AY</b>	2026-27
<b>New Course:</b>	No
<b>Bridge Course/ Value added Course:</b>	No
<b>Course for advanced learners:</b>	No

<b>Pre-requisites for the Course:</b>	Nil	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Introduce fundamental concepts of climate geology and climate dynamics.</li> <li>2. Understand paleoclimate reconstruction methods and proxies.</li> <li>3. Explain atmosphere-ocean circulation and regional climate systems.</li> <li>4. Study sea level changes and geological responses to climate variability.</li> <li>5. Familiarize students with datasets, analytical methods and applications of climate geology.</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, the student will be able to:	<b>Mapped to PSO</b>
	CO 1. Explain fundamental climate geology concepts.	PSO1, PSO2, PSO5
	CO 2. Describe atmosphere-ocean interactions and regional climate dynamics.	PSO1, PSO2, PSO3, PSO5, PSO6
	CO 3. Apply proxy data and geological archives to interpret paleoclimate.	PSO1, PSO2,

			PSO3, PSO5, PSO6
	CO 4. Analyze sea-level fluctuations and their geological evidence.		PSO1, PSO2, PSO3, PSO5, PSO6
	CO 5. Evaluate datasets and case studies for environmental and policy applications.		PSO1, PSO3, PSO5, PSO6
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>
<b>Module 1:</b>	<p>Introduction to climate geology: weather, climate, paleoclimate, geological scales. Atmospheric structure, composition, circulation, Coriolis effect, geostrophic balance. Orbital forcing: Milankovitch cycles, solar variability, Marine Isotope Stages, glacial–interglacial cycles, Last Glacial Maximum.</p> <p>Ocean dynamics: conveyor belt, Ekman spiral, upwelling, El Niño, La Niña, major currents.</p> <p>Regional climate systems: South Asian monsoon, drivers, variability, teleconnections. Climate extremes: droughts, floods, cyclones, heatwaves, teleconnection impacts.</p>	<b>15</b>	CO1, CO2, CO3 K1, K2, K3, K4, K5, K6
<b>Module 2:</b>	<p>Major archives: ice cores, corals, lake/ocean sediments, speleothems, pollen. Geochemical and isotopic proxies: <math>\delta^{18}\text{O}</math>, <math>\delta^{13}\text{C}</math>, biomarkers, trace elements. Linking proxies and instrumental records.</p> <p>Sea-level changes: eustatic vs relative, Quaternary fluctuations, coastal terraces, estuarine/deltaic sequences.</p> <p>Case studies: Younger Dryas, Holocene variability, South Asian monsoon evolution and geological footprint.</p> <p>Research methods and data sources: IMD, PANGAEA.</p> <p>Applications: geological impacts of climate change (sea-level rise, erosion, sediment redistribution), environmental management, climate policy.</p>	<b>15</b>	CO3, CO4, CO5 K1, K2, K3, K4, K5, K6
<b>Pedagogy:</b>	Lectures, discussion, case studies, problem solving, data analysis, seminars and presentations, policy-oriented discussions.		

<b>Texts:</b>	<ol style="list-style-type: none"> <li>1. Ahrens, C. D. (2015). Meteorology today: an introduction to weather, climate, and the environment. Cengage Learning Canada Inc.</li> <li>2. Bradley, R. S. (1999). Paleoclimatology: reconstructing climates of the Quaternary (Vol. 68). Elsevier.</li> <li>3. Bradley, R. S. (2015). Paleoclimatology: reconstructing climates of the quaternary.</li> <li>4. Cronin, T. M. (2010). Paleoclimates: understanding climate change past and present. Columbia University Press.</li> <li>5. Oerlemans, J. (2001). Glaciers and climate change. CRC Press.</li> <li>6. Oliver, J. E. (2002). Climatology: An Atmospheric Science, 2/e. Pearson Education India.</li> <li>7. Ruddiman, W. F. (2001). Earth's climate: past and future. Macmillan.</li> <li>8. Schmittner, A. (2018). Introduction to climate science. Oregon State University.</li> </ol>
<b>References/ Readings:</b>	<ol style="list-style-type: none"> <li>1. Imbrie, J., &amp; Imbrie, J. Z. (1980). Modeling the climatic response to orbital variations. Science, 207(4434), 943-953.</li> <li>2. Lisiecki, L. E., &amp; Raymo, M. E. (2005). A Pliocene-Pleistocene stack of 57 globally distributed benthic <math>\delta^{18}O</math> records. Paleoceanography, 20(1).</li> <li>3. Petit, J. R., Jouzel, J., Raynaud, D., Barkov, N. I., Barnola, J. M., Basile, I., ... &amp; Stievenard, M. (1999). Climate and atmospheric history of the past 420,000 years from the Vostok ice core, Antarctica. Nature, 399(6735), 429-436.</li> </ol>
<b>Web Resources:</b>	<ol style="list-style-type: none"> <li>1. <a href="https://www.pangaea.de/">https://www.pangaea.de/</a></li> <li>2. <a href="https://mausam.imd.gov.in/">https://mausam.imd.gov.in/</a></li> </ol>

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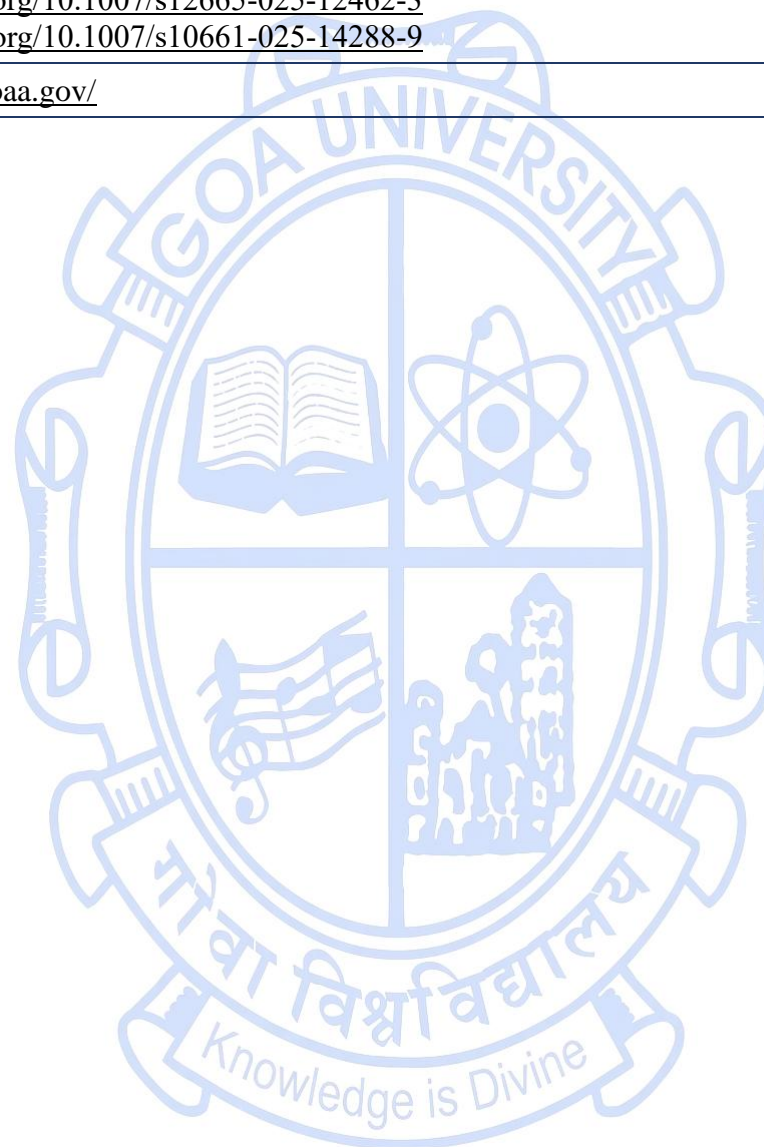
<b>Title of the Course</b>	Microplastic Pollution Studies
<b>Course Code</b>	GEO-6014
<b>Number of Credits</b>	2
<b>Theory/Practical</b>	Theory
<b>Level</b>	500
<b>Effective from AY</b>	2026-27
<b>New Course:</b>	No
<b>Bridge Course/ Value added Course:</b>	No
<b>Course for advanced learners:</b>	No

<b>Pre-requisites for the Course:</b>	NIL	
<b>Course Objectives:</b>	<ol style="list-style-type: none"> <li>1. Understand the formation of microplastics and their environmental impact.</li> <li>2. Raise awareness about microplastic pollution among students.</li> <li>3. Enable students to communicate the adverse effects of microplastics.</li> <li>4. Suggest effective strategies to mitigate microplastic pollution.</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, the student will be able to:	<b>Mapped to PSO</b>
	CO1: Explain the formation of microplastics and its impact on the environment.	PSO1, PSO6
	CO2: Classify Microplastics.	PSO4, PSO1
	CO3: Analyse the impact of microplastics on environment and human health.	PSO2, PSO5
	CO4: Suggest mitigation strategies.	PSO1, PSO3, PSO6

<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>	<b>Cognitive Level</b>
<b>Module 1:</b>	Introduction to Plastics and microplastics: Types of plastics: and microplastics types: fibres, microbeads, fragments, nurdles, foam. Primary and Secondary, microplastics and its formation. Distribution of microplastics: Global occurrence, sources of microplastics. Distribution and fate of plastic in the environment: land, fresh water and marine waters, air, snow. Adsorption and desorption of contaminants heavy metals, PAHs. Ecotoxicological impacts on aquatic and terrestrial organisms. Trophic transfer and biomagnification of microplastics and associated pollutants. Human exposure routes and assess potential health impacts based on emerging evidence. Uptake and accumulation of microplastics in plants, animals, and humans.	<b>15</b>	CO1, CO2, CO3, CO4	K1, K2, K3, K4, K5, K6
<b>Module 2:</b>	Interaction with sediment and soil particles. Vertical and horizontal transport in aquatic systems. Influence of particle size, shape, and density. Role of biofilms in mobility and fate. Sources and Transport of Airborne Microplastics. Microplastic and association with climate change. Sampling and characterization: Methods used for sampling, quantification of microplastics. Instrument for identification of microplastics- Fourier Transform Infrared Spectroscopy (FTIR) and Raman Spectroscopy. Scanning Electron Microscope (SEM). Mitigation measures. Case studies.	<b>15</b>	CO1, CO2, CO3, CO4	K1, K2, K3, K4, K5, K6
<b>Pedagogy:</b>	Lectures/tutorials/assignments/flip classroom/presentations			
<b>Texts:</b>	<ol style="list-style-type: none"> <li>1. Crawford, B. C., &amp; Quinn, B. (2016). Microplastic pollutants (1st ed., pp. xviii–315). Elsevier Science. <a href="https://doi.org/10.1016/C2015-0-06984-5">https://doi.org/10.1016/C2015-0-06984-5</a></li> <li>2. Rocha-Santos, T., Costa, M., &amp; Mouneyrac, C. (Eds.). (2022). Handbook of microplastics in the environment (1st ed., 1397 pp.). Springer Nature Switzerland. <a href="https://doi.org/10.1007/978-3-030-81659-8">https://doi.org/10.1007/978-3-030-81659-8</a></li> <li>3. Rocha-Santos, T. A. P., &amp; Duarte, A. C. (Eds.). (2017). Characterization and analysis of microplastics (1st ed., ~302 pp.). Elsevier Science. <a href="https://doi.org/10.1016/C2016-0-04106-7">https://doi.org/10.1016/C2016-0-04106-7</a></li> <li>4. Suriyanarayanan, S., Shivaraju, H. P., &amp; Pakeerathan, K. (Eds.). (2025). Combating Plastic Pollution in Terrestrial Environment: Challenges and Strategies for a Sustainable Future. Springer Nature Singapore. ISBN 978-981-96-2342-6.</li> </ol>			

<b>References/ Readings:</b>	1. <a href="https://doi.org/10.1007/s12665-025-12462-3">https://doi.org/10.1007/s12665-025-12462-3</a> 2. <a href="https://doi.org/10.1007/s10661-025-14288-9">https://doi.org/10.1007/s10661-025-14288-9</a>
<b>Web Resources:</b>	<a href="https://www.noaa.gov/">https://www.noaa.gov/</a>

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<b>Title of the Course</b>	Basics of RS, GIS and GNSS (IIRS-ISRO online Edusat course)
<b>Course Code</b>	GEO-6015
<b>Number of Credits</b>	3
<b>Theory/Practical</b>	Theory
<b>Level</b>	500
<b>Effective from AY</b>	2026-27
<b>New Course: Yes/No</b>	No
<b>Bridge Course/ Value added Course:</b>	No
<b>Course for advanced learners:</b>	No

<b>Pre-requisites for the Course:</b>	NIL	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Explain the fundamental principles and concepts of remote sensing and its applications in environmental and earth sciences.</li> <li>2. Enable the use of geospatial and scientific tools, including GIS and remote sensing software.</li> <li>3. Discuss environmental risks using geospatial information and develop appropriate mitigation strategies.</li> <li>4. Promote integrated resource management plans that combine remote sensing, GIS, and scientific analysis for sustainable development.</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, the student will be able to:	<b>Mapped to PSO</b>
	CO1: Understand fundamental principles of remote sensing	PSO 1, PSO 2, PSO 5
	CO2: Apply Geospatial and Scientific Tools	PSO 3, PSO 4, PSO 6

	CO3: Evaluate Environmental Risks and Develop Mitigation Strategies		PSO 3, PSO 5, PSO 7
	CO4: Design Integrated Resource Management Plans		PSO 3, PSO 6, PSO 7
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b> <b>Cognitive Level</b>
<b>Module 1:</b>	Remote Sensing and Digital Image Analysis: Basic Principles of Remote Sensing, Earth Observation Sensors and Platforms, Spectral Signature of different land cover features, Image interpretation, Thermal & Microwave Remote Sensing, Digital Image Processing: Basic Concepts of Rectification and Registration, Enhancement, Classification and accuracy assessment techniques	<b>15</b>	CO1, CO2, CO3, CO4 K1, K2, K3, K4, K5, K6
<b>Module 2:</b>	Overview of Global Navigation Satellite System: Introduction to GPS and GNSS, receivers, processing methods, errors and accuracy	<b>15</b>	CO1, CO2, CO3, CO4 K1, K2, K3, K4, K5, K6
<b>Module 3:</b>	Overview of Geographical Information System: GIS, databases, topology, spatial analysis and open source software.	<b>15</b>	CO1, CO2, CO3, CO4 K1, K2, K3, K4, K5, K6
<b>Pedagogy:</b>	Lectures/tutorials/assignments		
<b>Texts:</b>	<ol style="list-style-type: none"> <li>1. Bolstad, P. (2025). GIS fundamentals (7th ed.). XanEdu Publishing.</li> <li>2. Thenkabail, P. S. (Ed.). (2024). Remote sensing handbook (2nd ed., Vols. 1–6). Routledge.</li> <li>3. McHaffie, P., Hwang, S., &amp; Follett, C. (2023). GIS: An introduction to mapping technologies (2nd ed.). CRC Press.</li> <li>4. Prasad, S., Chanussot, J., &amp; Li, J. (2024). Advances in machine learning and image analysis for GeoAI. Elsevier.</li> <li>5. Wimberly, M. C. (2023). Geographic data science with R: Visualizing and analyzing environmental change. CRC Press.</li> </ol>		
<b>References/ Readings:</b>	<a href="https://www.scribd.com/document/427408034/remote-sensing">https://www.scribd.com/document/427408034/remote-sensing</a>		
<b>Web Resources:</b>	<a href="https://www.iirs.gov.in/EDUSAT-News">https://www.iirs.gov.in/EDUSAT-News</a>		

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<b>Title of the Course</b>	Practical of Basics of RS, GIS and GNSS (IIRS-ISRO online Edusat course)
<b>Course Code</b>	GEO-6016
<b>Number of Credits</b>	1
<b>Theory/Practical</b>	Practical
<b>Level</b>	500
<b>Effective from AY</b>	2026-27
<b>New Course:</b>	No
<b>Bridge Course/ Value added Course:</b>	No
<b>Course for advanced learners:</b>	No

<b>Pre-requisites for the Course:</b>	NIL	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Explain principles and applications of remote sensing in environmental and earth sciences.</li> <li>2. Utilize GIS and remote sensing tools for geospatial analysis.</li> <li>3. Assess environmental risks and design effective mitigation strategies using geospatial data.</li> <li>4. Integrate remote sensing, GIS, and scientific methods for sustainable resource management.</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, the student will be able to:	<b>Mapped to PSO</b>
	CO1: Understand fundamental principles of remote sensing	PSO 1, PSO 2, PSO 5
	CO2: Apply Geospatial and Scientific Tools	PSO2, PSO7
	CO3: Utilize QGIS and other open-source geospatial tools to perform basic image processing	PSO3, PSO4, PSO6

	CO4: Analyze spatial and temporal data using RS and GIS techniques		PSO 3, PSO 6, PSO 7
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b> <b>Cognitive Level</b>
<b>Module 1:</b>	Remote Sensing and Digital Image Analysis: RS & GIS Applications in Natural Resource Management: RS and Image Interpretation Practical, Image Processing using QGIS for Agriculture and Soil, Forestry and Ecology, Geoscience and Geo-hazards, Marine and Atmospheric Sciences, Urban and Regional Studies and Water Resources.	<b>30</b>	CO1, CO2, CO3, CO4 K1, K2, K3, K4, K5, K6
<b>Pedagogy:</b>	Lectures/tutorials/assignments		
<b>Texts:</b>	<ol style="list-style-type: none"> <li>1. Gautam, N. C. (2025). Remote sensing and GIS (3rd ed.). Oxford University Press.</li> <li>2. Lavender, S., &amp; Lavender, A. (2023). Practical handbook of remote sensing (2nd ed.). CRC Press.</li> <li>3. Liu, L., &amp; Wang, F. (2023). Computational methods and GIS applications in social science: A lab manual (3rd ed.). CRC Press.</li> <li>4. Madden, M., &amp; Bernardes, S. (Eds.). (2024). Manual of remote sensing (4th ed.). American Society for Photogrammetry and Remote Sensing.</li> <li>5. University of Ghana Remote Sensing &amp; GIS Laboratory. (2023). Practical handbook for remote sensing: GEOG 327. University of Ghana Press.</li> </ol>		
<b>References/ Readings:</b>	<a href="https://www.scribd.com/document/427408034/remote-sensing">https://www.scribd.com/document/427408034/remote-sensing</a>		
<b>Web Resources:</b>	<a href="https://www.iirs.gov.in/EDUSAT-News">https://www.iirs.gov.in/EDUSAT-News</a>		

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<b>Title of the Course</b>	Statistical Methods in Geology
<b>Course Code</b>	GEO-6017
<b>Number of Credits</b>	3
<b>Theory/Practical</b>	Theory
<b>Level</b>	500
<b>Effective from AY</b>	2025-26
<b>New Course:</b>	Yes
<b>Bridge Course/ Value added Course:</b>	No
<b>Course for advanced learners:</b>	No

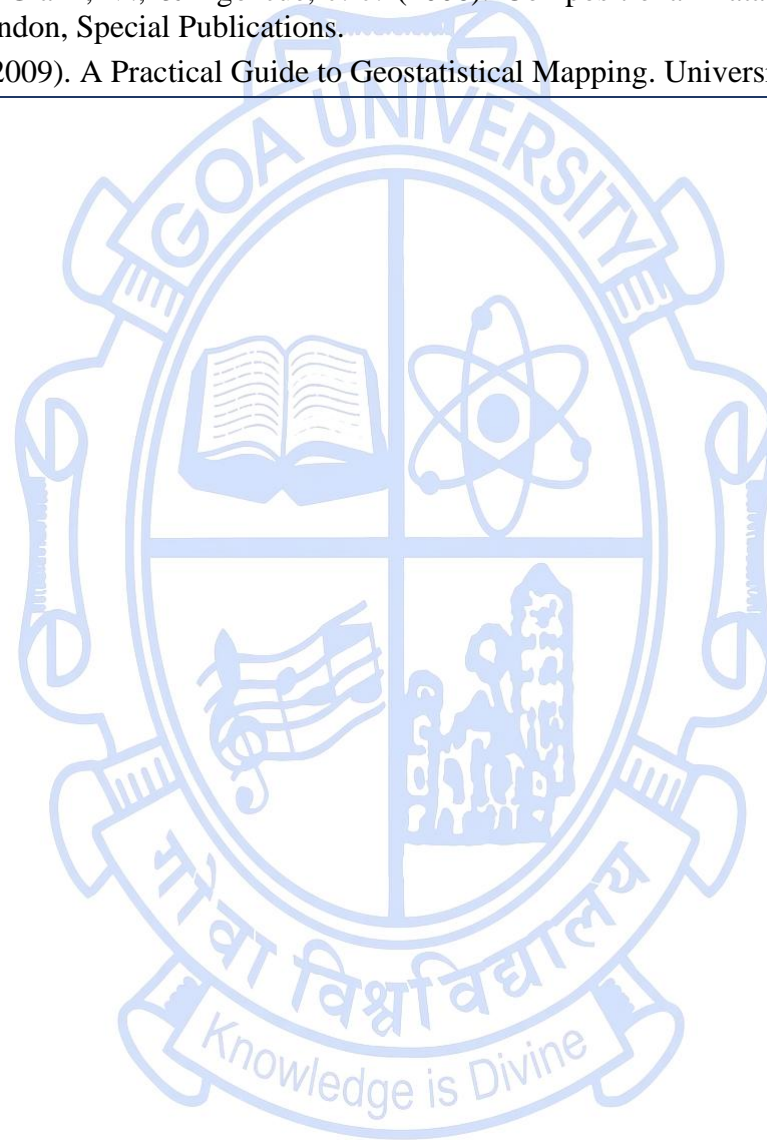
<b>Pre-requisites for the Course:</b>	Completion of 400 level courses in Geology	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1 To introduce the fundamental statistical concepts essential for analyzing diverse geological data types.</li> <li>2 To establish the theoretical framework of geostatistics.</li> <li>3 To explain the mathematical basis and application of multivariate analysis techniques.</li> <li>4 To discuss advanced computational methods in geosciences.</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, the student will be able to:	<b>Mapped to PSO</b>
	CO 1. Select appropriate statistical techniques and sampling strategies for geological research.	PSO1, PSO2, PSO3, PSO6
	CO 2. Interpret the parameters of a theoretical variogram model.	PSO1, PSO2, PSO3, PSO6
	CO 3. Differentiate between various multivariate techniques.	PSO1, PSO2, PSO3, PSO6

	CO 4. Evaluate geoscience data sets based on the statistical methods used.		PSO1, PSO2, PSO3, PSO6
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b> <b>Cognitive Level</b>
<b>Module 1:</b>	Types of data; data collection and data cleaning; Nature of geological data: spatial, compositional, directional; Measurement scales; Univariate analysis: mean, median, variance, standard deviation, skewness; Data visualization: Histograms, Box plots. Stereo nets for structural data; Rose diagrams for directional data; Ternary diagrams for compositional data. Normal and Lognormal distributions; Poisson and Binomial distributions; Introduction to Compositional Data Analysis (CoDA).	<b>15</b>	CO1, CO4 K1, K2, K3, K4, K5, K6
<b>Module 2:</b>	Sampling strategies; Sample size determination; Statistical inference; Confidence intervals and probability values. Spatial autocorrelation; Hypothesis; Concept of the variogram. Experimental variogram calculation; Variogram modelling: Spherical, Exponential, Gaussian. Theory of Kriging (Best Linear Unbiased Estimator - BLUE); Ordinary Kriging and Universal Kriging; Kriging variance and uncertainty mapping. Comparison with deterministic methods (IDW); Applications in ore reserve estimation and groundwater modelling.	<b>15</b>	CO2, CO3, CO4 K1, K2, K3, K4, K5, K6
<b>Module 3:</b>	Simple and Multiple Linear Regression; Non-linear regression; Trend surface analysis in structural geology. Principal Component Analysis (PCA); Factor Analysis. Cluster Analysis (Hierarchical and K-means) for lithofacies identification; Discriminant Function Analysis for provenance studies. Introduction to Time Series Analysis; Machine Learning in Geosciences.	<b>15</b>	CO3, CO4 K1, K2, K3, K4, K5, K6
<b>Pedagogy:</b>	Lectures/tutorials/assignments/discussion		
<b>Texts:</b>	<ol style="list-style-type: none"> <li>1 Davis, J. C. (2002). Statistics and Data Analysis in Geology. Wiley.</li> <li>2 Isaaks, E. H., &amp; Srivastava, R. M. (1989). An Introduction to Applied Geostatistics. Oxford University Press.</li> <li>3 Webster, R., &amp; Oliver, M. A. (2007). Geostatistics for Environmental Scientists. Wiley.</li> <li>4 Borradaile, G. (2003). Statistics of Earth Science Data: Their Distribution in Time, Space and Orientation. Springer.</li> </ol>		

**References/  
Readings:**

- 1 Pawlowsky-Glahn, V., & Egozcue, J. J. (2006). Compositional Data Analysis in the Geosciences. Geological Society, London, Special Publications.
- 2 Hengl, T. (2009). A Practical Guide to Geostatistical Mapping. University of Amsterdam.

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<b>Title of the Course</b>	Practical of Statistical Methods in Geology
<b>Course Code</b>	GEO-6018
<b>Number of Credits</b>	1
<b>Theory/Practical</b>	Practical
<b>Level</b>	500
<b>Effective from AY</b>	2025-26
<b>New Course:</b>	Yes
<b>Bridge Course/ Value added Course:</b>	No
<b>Course for advanced learners:</b>	No

<b>Pre-requisites for the Course:</b>	Completion of 400 level courses in Geology	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Provide hands-on experience in using statistical software.</li> <li>2. Develop proficiency in applying geostatistical methods to spatial data.</li> <li>3. To train students to interpretate multivariate analyses.</li> <li>4. To enable students to design, execute, and formally report a complete, statistically-driven mini-research project, integrating all learned skills.</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, the student will be able to:	<b>Mapped to PSO</b>
	CO 1. Analyse geological data using statistical tools.	PSO1, PSO2, PSO3, PSO6
	CO 2. Validate a Kriging model for a spatial variable.	PSO1, PSO2, PSO3, PSO6
	CO 3 Interpret the results of PCA	PSO1, PSO2, PSO3, PSO6

	CO 4. Synthesize statistical results into a formal research report.		PSO1, PSO2, PSO3, PSO6
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b> <b>Cognitive Level</b>
<b>Unit/Module 1:</b>	<p>Analyzing grain size distribution and data orientation (Rose/Ternary plots).</p> <p>Comparing geochemical signatures of two distinct rock formations (t-tests, ANOVA).</p> <p>Quantifying spatial continuity; Generating a contour map of groundwater level or ore grade using Kriging.</p> <p>Identifying petrogenetic processes using Principal Component Analysis (PCA) on whole-rock geochemistry.</p> <p>Developing a predictive model for porosity based on seismic attributes.</p>	<b>15</b>	<p>CO1, CO2, CO3, CO4</p> <p>K1, K2, K3, K4, K5, K6</p>
<b>Pedagogy:</b>	Software handling/plotting/ Lectures/tutorials/assignments/field study/discussion		
<b>Texts:</b>	<ol style="list-style-type: none"> <li>1. Nogueira, P. M. (2024). Spatial Analysis in Geology Using R. Routledge.</li> <li>2. Lovelace, R., Nowosad, J., &amp; Muenchow, J. (2019). Geocomputation with R. Chapman &amp; Hall/CRC.</li> <li>3. McWimberly, M. (2023). Geographic Data Science with R: Visualizing and Analyzing Environmental Data.</li> <li>4. Rey, S. J., Arribas-Bel, D., &amp; Wolf, L. J. (2023). Geographic Data Science with Python. Chapman &amp; Hall/CRC.</li> <li>5. Pyrcz, J. L. (2022). GeostatsPy: Well-documented Demonstration Geostatistical Workflows.</li> <li>6. Bivand, R. S., Pebesma, E., &amp; Gómez-Rubio, V. (2013). Applied Spatial Data Analysis with R. Springer.</li> </ol>		
<b>References/ Readings:</b>	Davis, J. C. (2002). Statistics and Data Analysis in Geology. Wiley.		

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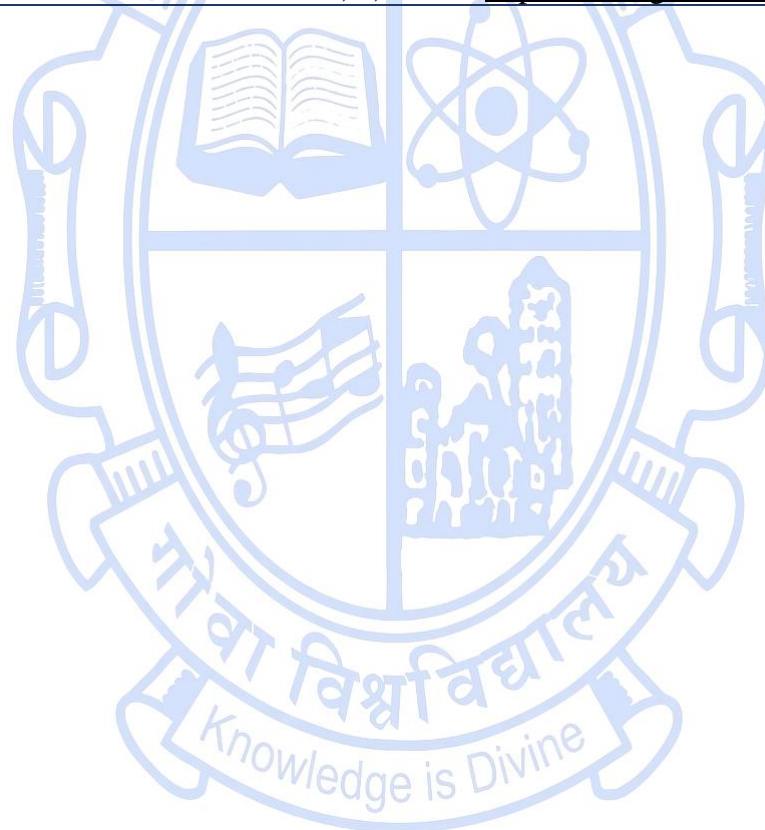
### Discipline Specific Vocational Elective (DSVE) Courses (8 credits)

<b>Title of the Course</b>	Geological Field Training	
<b>Course Code</b>	GEO-6401	
<b>Number of Credits</b>	4	
<b>Theory/Practical</b>	Practical	
<b>Level</b>	500	
<b>Effective from AY</b>	2026-27	
<b>New Course</b>	No	
<b>Bridge Course/ Value added Course</b>	No	
<b>Course for advanced learners</b>	No	
<b>Pre-requisites for the Course:</b>	NIL	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Provide students with practical exposure to mining, industrial, and research environments related to geology.</li> <li>2. Familiarize students with field techniques, laboratory methodologies, and analytical instruments used in professional practice.</li> <li>3. Develop observational, analytical, and practical skills relevant to the geosciences and allied industries.</li> <li>4. Enhance students' ability to document, analyse, and report scientific observations effectively.</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, the student will be able to:	<b>Mapped to PSO</b>
	CO 1. Explain geological field techniques used in industries and research laboratories.	PSO 1, PSO 2, PSO 3, PSO 4, PSO 6,

	CO 2. Apply field and laboratory techniques learned during industrial and institutional visits.	PSO 1, PSO 2, PSO 3, PSO 4, PSO 6,
	CO 3. Prepare a comprehensive field report	PSO 1, PSO 2, PSO 3, PSO 4, PSO 6,
	CO 4. Present field report demonstrating their practical understanding and observations	PSO 1, PSO 2, PSO 3, PSO 4, PSO 6,
<b>Content:</b>		<b>No of hours</b> <b>Mapped to CO</b> <b>Cognitive Level</b>
<b>Module 1:</b>	<p>Students will undertake visits to important mines, mineral deposits, industries, professional organizations, and national institutes. These visits may include short-term in-house training at the respective laboratories. The training program will be conducted under the supervision of faculty members.</p> <p>During the program, students are expected to observe and learn various techniques and methodologies employed on-site in professional and industrial settings. They will also gain practical knowledge related to instrumentation and analytical procedures used in the field.</p> <p>After the completion of the visit or training, each student is required to prepare a detailed report documenting their observations, learning outcomes, and experiences. A viva-voce examination will be conducted based on the field report to assess the student's understanding and participation.</p>	<p><b>120</b></p> <p>CO1, CO2, CO3, CO4</p> <p>K1, K2, K3, K4, K5, K6</p>
<b>Pedagogy:</b>	Lectures/tutorials /field study/discussion/report writing	
<b>Texts:</b>	<ol style="list-style-type: none"> <li>1. Deshpande, G. G., &amp; Pitale, U. L. (2012). Geology of Maharashtra (2nd ed.). Geological Society of India.</li> <li>2. Dessai, A. G. (2018). Geology and mineral resources of Goa.</li> <li>3. Mehr, S. S. (1991). Geology of Gujarat. Geological Society of India.</li> <li>4. Radharishnan, B. P., &amp; Vaidhyanadhan, R. (1977). Geology of Karnataka. Geological Society of India.</li> <li>5. Raman, P. K., &amp; Murty, V. N. (2012). Geology. Geological Society of India.</li> </ol>	

	<p>6. Roy, A. B., &amp; Jakhar, S. R. (2012). Geology of Rajasthan (North-West India: Precambrian to Recent). Scientific Publishers.</p> <p>7. Sinha Roy. (1991). Geology of Rajasthan. Geological Society of India.</p>
<b>References/ Readings:</b>	<p>1. Schiappa, T. A. (2019). Full article: Field experiences in geosciences: A case study. Journal of Geoscience Education, 67(1), 1–15. <a href="https://doi.org/10.1080/10899995.2018.1527618">https://doi.org/10.1080/10899995.2018.1527618</a></p> <p>2. Jolley, A. (2018). Motivation and connection to Earth on geology field trips. Frontiers in Earth Science, 6, 1–9. <a href="https://doi.org/10.3389/feart.2018.00001">https://doi.org/10.3389/feart.2018.00001</a></p> <p>3. Wong Hearing, T. W., et al. (2024). The Rock Garden: A preliminary assessment of campus-based field skills training. Geoscience Communications, 7, 17–33. <a href="https://doi.org/10.5194/gc-7-17-2024">https://doi.org/10.5194/gc-7-17-2024</a></p>

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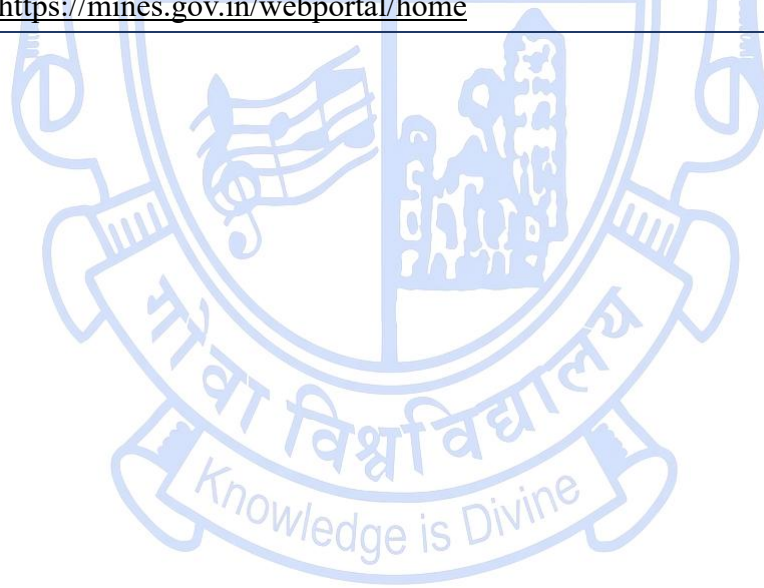


<b>Title of the Course</b>	Mining Geology	
<b>Course Code</b>	GEO-6402	
<b>Number of Credits</b>	2T +2P	
<b>Theory/Practical</b>	Theory and Practical	
<b>Level</b>	500	
<b>Effective from AY</b>	2026-27	
<b>New Course:</b>	No	
<b>Bridge Course/ Value added Course:</b>	No	
<b>Course for advanced learners:</b>	No	
<b>Pre-requisites for the Course:</b>	NIL	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Understand the different types of mining.</li> <li>2. Understand different sampling procedures in exploration.</li> <li>3. Get a comprehensive idea of drilling techniques.</li> <li>4. Get an overview of various mining related laws and compliances.</li> <li>5. Understand the various health issues related to mining and environment.</li> <li>6. Train students to prepare mining plans of both opencast and underground mines,</li> <li>7. Train to prepare bore logs as well as estimate ore reserves</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, the student will be able to:	<b>Mapped to PSO</b>
	CO 1. Understand the process of open cast, underground, quarrying and placer deposit mine.	PSO 1, PSO 2

	CO 2. Undertake mineral exploration		PSO 2, PSO 5	
	CO 3. Prepare borehole logs and geological sections		PSO 3, PSO 4	
	CO 4. Estimate ore reserves as well as ore to overburden ratio.		PSO 3, PSO 7	
	CO 5. Analyse the impact of mining on human health and environment.		PSO 3, PSO 7	
	CO 6. Understanding of Mining Laws and their implementation.		PSO 3, PSO 7	
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>	<b>Cognitive Level</b>
<b>Module 1:</b>	Introduction to mining geology and exploration methods. Role of geologists in mining. Mining methods for metal and coal mining. Outlines of surface methods of mining. Slope stability in open cast mines. Underground mining: Shaft sinking, stoping methods, mine ventilation, mine gases and associated health hazards. Principles of sampling and sampling methods.	<b>15</b>	CO1, CO2 CO3, CO4, CO5	K1, K2, K3, K4, K5, K6
<b>Module 2:</b>	Core drilling (wet and dry). Type of core bits. UNFC classification and estimation of ore reserves, using geostatistical methods, dewatering techniques in open cast and underground mines. Mineral beneficiation techniques. Impact of mining on environment. Pollution aspects, Environment management EIA. Mineral economics, legislation associated with mining. Conservation and substitution	<b>15</b>	CO1, CO3, CO5, CO6	K1, K2, K3, K4, K5, K6
<b>Module 3:</b>	Exercises on reading of open cast and underground mine plans. Preparation of mine plans. Preparation of borehole logs, geological sections, Calculation of ore reserves, ore to overburden ratio from sections.	<b>30</b>	CO1, CO2 CO3, CO4,	K1, K2, K3, K4, K5, K6
<b>Module 4:</b>	Mine visits to get acquainted with mining activities and. to understand working of mines, Preparation of mine pit sections, mine pit design and virgin area mapping. Laboratory exercises and mine visits.	<b>30</b>	CO1, CO4	K1, K2, K3, K4, K5, K6
<b>Pedagogy:</b>	Lectures, case studies, discussions and assignments.			
<b>Texts:</b>	<ol style="list-style-type: none"> <li>1. Arogyaswamy, R. N. P. (2017). Courses in mining geology. Oxford and IBH.</li> <li>2. McKinstry, H. E. (1962). Mining Geology. Asia Publishing House.</li> </ol>			

	<ol style="list-style-type: none"> <li>3. Peters, W. C. (1987). Exploration and mining geology.</li> <li>4. Lewis, Robert, (1964). Elements of Mining by John Wiley Sons New York</li> </ol>
<b>References/ Readings:</b>	<ol style="list-style-type: none"> <li>1. Armstrong, M. (1998). Basic linear geostatistics. Springer Science &amp; Business Media.</li> <li>2. Dhar, B. B. (2000). Mining Environment Scenario Beyond 2001. Mining, Challenges of the 21st Century, 73.</li> <li>3. Evans, A. M., Barrett, W. L., Bell, T., Milsom, J., Moon, C. J., &amp; Scott, B. C. (1993). Introduction to mineral exploration.</li> <li>4. Saxena, N. C., Singh, G., Pathak, P., Sarkar, B. C., &amp; Pal, A. K. (2004). Mining Environment Management Manual. Scientific Publishers.</li> <li>5. Sinha, Sharma (1970). Mineral Economics. Oxford &amp; IBH Publishers.</li> <li>6. 2. Taggart, (1945).: Mineral Ore Dressing</li> <li>7. Warhurst, Alyson. (2000). Environmental policy in mining: corporate strategy and planning for closure / by. Publication: Boca Raton: Lewis Publishers.</li> <li>8. Youn, G. J. (1984). Elements of Mining Geology. McGraw Hill.</li> </ol>
<b>Web Resources:</b>	<ol style="list-style-type: none"> <li>1. McKinstry, H. E. (1960). Mining Geology. Asia Publishing House. <a href="https://archive.org/details/in.ernet.dli.2015.476182/page/n35/mode/2up">https://archive.org/details/in.ernet.dli.2015.476182/page/n35/mode/2up</a></li> <li>2. Legislation <a href="https://mines.gov.in/webportal/home">https://mines.gov.in/webportal/home</a></li> </ol>

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<b>Title of the Course</b>	Advanced Engineering Geology
<b>Course Code</b>	GEO-6403
<b>Number of Credits</b>	2T + 2P
<b>Theory/Practical</b>	Theory and Practical
<b>Level</b>	500
<b>Effective from AY</b>	2026 - 27
<b>New Course:</b>	Yes
<b>Bridge Course/ Value added Course:</b>	No
<b>Course for advanced learners:</b>	No

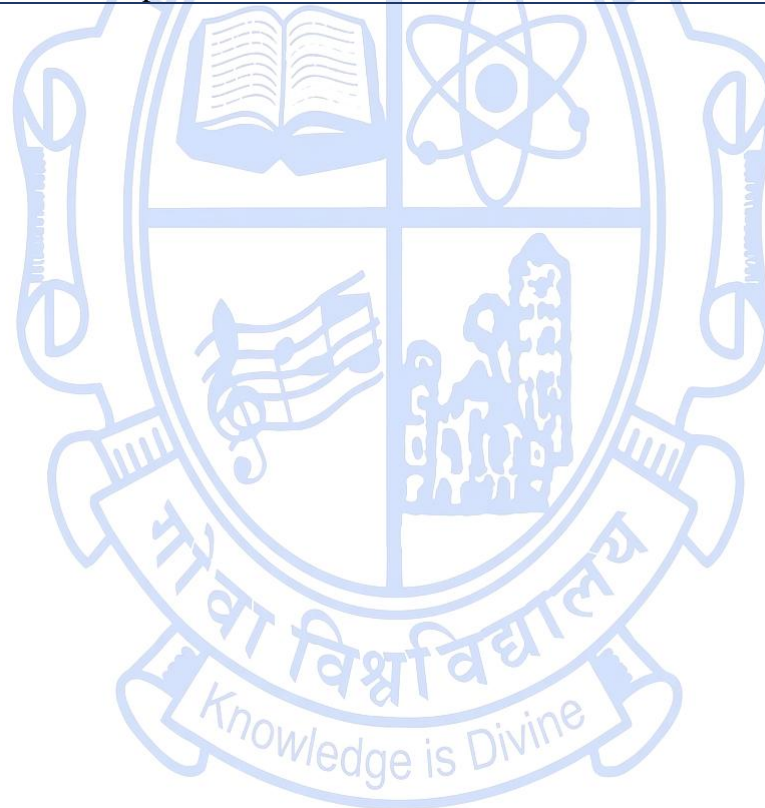
<b>Pre-requisites for the Course:</b>	NIL	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Understand the engineering properties of soils and rocks and their behavior under different conditions.</li> <li>2. Characterize sites and assess geological and geotechnical hazards for dams, tunnels, bridges, and foundations.</li> <li>3. Learn rock mass classification systems and geotechnical investigation data</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, the student will be able to:	<b>Mapped to PSO</b>
	CO 1. Describe engineering properties of soils and rocks	PSO1, PSO2
	CO 2. Undertake site investigation	PSO3, PSO4
	CO 3. Analyze hazards and stability risks	PSO3, PSO7
	CO 4. Evaluate infrastructure designs in complex terrains	PSO2, PSO3
	CO 5. Propose sustainable solutions and use smart monitoring	PSO5, PSO6, PSO7

Content:		No of hours	Mapped to CO	Cognitive Level
<b>Module 1:</b>	<p>Engineering properties of soils and rocks: strength, deformability, durability, weathering.</p> <p>Quantitative indices: porosity, void ratio, degree of saturation, Atterberg limits.</p> <p>Foundations in complex conditions: expansive/collapsible soils, karstic cavities, organic soils, anthropogenic fills.</p> <p>Site improvement: grouting, compaction, stabilization, backfilling.</p> <p>Sustainable foundation alternatives and eco-friendly ground improvement. Geological and geotechnical investigation: borehole logging, in-situ tests, geophysical surveys, RQD evaluation.</p> <p>Rock mass classification: RMR, Q-system, GSI, slope classifications; applications in tunnel and slope design. Hazard assessment: landslides, liquefaction, subsidence, coastal erosion; stability analysis and risk scoring.</p>	15	CO1, CO2, CO5	K1, K2, K3, K4, K5, K6
<b>Module 2:</b>	<p>Professional practice: regulatory frameworks, disaster management, and the role of geologists in geo-risk assessment.</p> <p>Dams and reservoirs – site selection, reservoir-induced seismicity, failure case studies.</p> <p>Tunnels – stress conditions, groundwater influence, support design using RMR/Q.</p> <p>Bridges and urban infrastructure – heterogeneous foundations. Coastal and river engineering structures – erosion, scouring, stability issues.</p> <p>Smart monitoring: InSAR, IoT sensors, extensometers, piezometers; applications in slopes, tunnels, and dams.</p> <p>Geo-environmental engineering: landfills, waste disposal, groundwater protection.</p> <p>Environmental Impact Assessment (EIA) for civil projects; mitigation planning.</p> <p>Sustainable approaches: eco-engineering, low-carbon materials, life-cycle assessment.</p>	15	CO2, CO3, CO4, CO5	K1, K2, K3, K4, K5, K6
<b>Module 3:</b>	<p>Study engineering properties of rocks and soils and analyze indices like porosity, void ratio, degree of saturation, and Atterberg limits.</p> <p>Determine Rock Quality Designation from core logs for rock mass assessment.</p>	30	CO1, CO2, CO3,	K1, K2, K3, K4, K5, K6

	<p>Determine rock strength and tensile properties from point load or Brazilian tests and interpret their engineering significance.</p> <p>Compute Rock Mass Rating and assess rock mass stability for tunnels and slopes.</p> <p>Calculate Q-system for tunnel support design using rock mass parameters.</p> <p>Record and interpret borehole logs and SPT data for engineering geology analysis and foundation assessment.</p>		CO4, CO5	
<b>Module 4:</b>	<p>Dam Site Selection and Failure Assessment</p> <p>Reservoir-Induced Seismicity Assessment</p> <p>Tunnel Site Selection and Failure Assessment</p> <p>Slope Stability &amp; Hazard Analysis</p> <p>Foundation Design Exercises to analyze bearing capacity, stress distribution, and foundation type selection for complex soils/rocks</p> <p>Bridge failure Assessment.</p> <p>Interpret geophysical data to identify subsurface layers, fractures, cavities, and groundwater for site evaluation.</p> <p>Coastal Hazards, Saltwater Intrusion, and Coastal Management</p> <p>Compute reservoir and catchment areas, storage capacity, and estimated life from cross-sections/contours, and assess geological suitability.</p> <p>Integrated Smart Monitoring and Sustainability Assessment</p>	<b>30</b>	CO1, CO2, CO3, CO4, CO5	K1, K2, K3, K4, K5, K6
<b>Pedagogy:</b>	Lectures, group discussions, assignments and mini-projects, Field-based exercises, Case studies, Data interpretation, Application-oriented tasks.			
<b>Texts:</b>	<ol style="list-style-type: none"> <li>1. Bell, F. G. (2007). Engineering geology. Elsevier.</li> <li>2. Bromhead, E. (1992). The stability of slopes. CRC Press.</li> <li>3. Coduto, D. P. (2015). Foundation design: principles and practices. Pearson.</li> <li>4. De Vallejo, L. G., &amp; Ferrer, M. (2011). Geological engineering. CRC press.</li> <li>5. Hudson, J. A., &amp; Harrison, J. P. (2000). Engineering rock mechanics: an introduction to the principles. Elsevier.</li> <li>6. Karakas, A. (2008). Practical rock engineering.</li> </ol>			

	<p>7. Krynine, D. P., &amp; Judd, W. R. (1957). Principles of engineering geology and geotechnics: geology, soil and rock mechanics, and other earth sciences as used in civil engineering.</p> <p>8. Montgomery, C. W., &amp; Szablewski, G. S. (2006). Environmental geology (p. 540). New York: McGraw-Hill.</p> <p>9. Popescu, M. E., &amp; Trandafir, A. C. (2014). Landslide risk assessment and mitigation. In Bridge Engineering Handbook (pp. 331-377). CRC Press.</p> <p>10. Singh, B., &amp; Goel, R. K. (2011). Engineering rock mass classification (pp. 45-142). Boston: Butterworth-Heinemann.</p>
<b>References/ Readings:</b>	<p>1. Hoek, E., Kaiser, P. K., &amp; Bawden, W. F. (2000). Support of underground excavations in hard rock. CRC Press.</p> <p>2. McGee, T. K., &amp; Penning-Rowsell, E. C. (Eds.). (2022). Routledge handbook of environmental hazards and society. Taylor &amp; Francis Group.</p>

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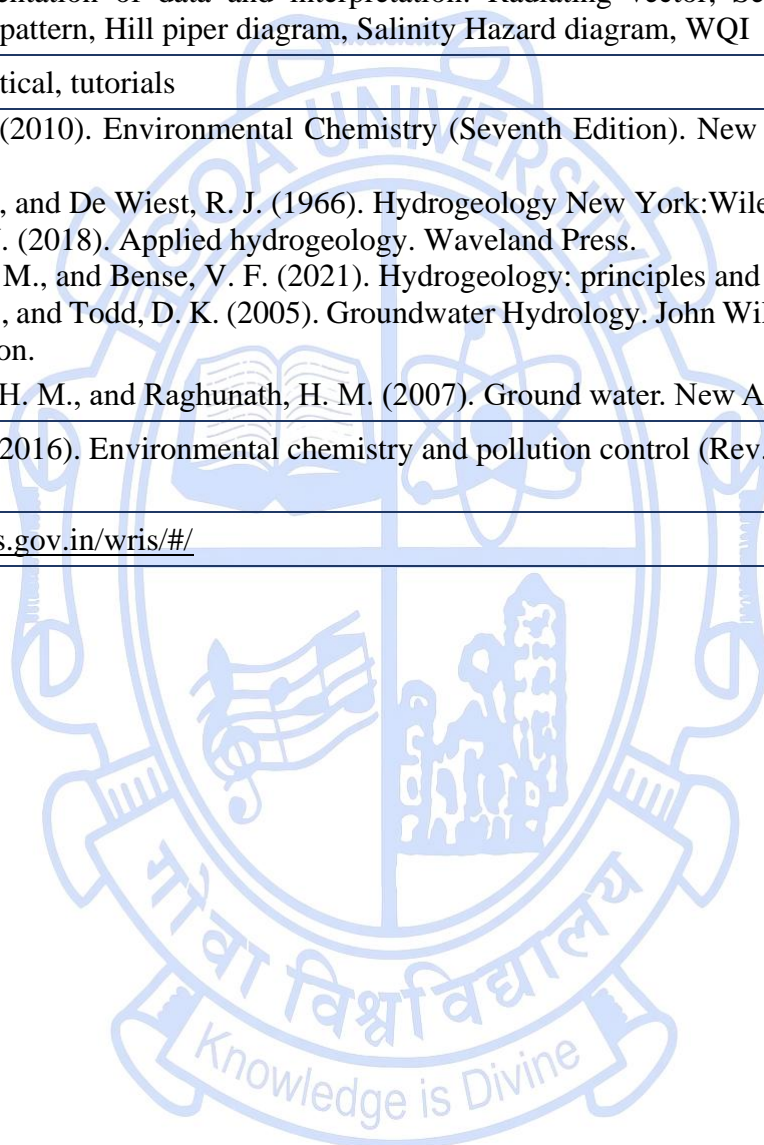
<b>Title of the Course</b>	Water Quality Analysis
<b>Course Code</b>	GEO-6404
<b>Number of Credits</b>	02
<b>Theory/Practical</b>	Practical
<b>Level</b>	500
<b>Effective from AY</b>	2026-27
<b>New Course:</b>	YES
<b>Bridge Course/ Value added Course:</b>	No
<b>Course for advanced learners:</b>	No

<b>Pre-requisites for the Course:</b>	NIL	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Train to perform physical and chemical analysis of water.</li> <li>2. Examine the quality of water with respect to important physical and chemical parameters</li> </ol>	
<b>Course Outcomes:</b>	By the end of this course, students will be able to:	Mapped to PSO
	CO1. Explain the significance of physical and chemical parameters.	PSO1,
	CO2. Undertake sampling using standard procedures and field test.	PSO1, PSO2,
	CO3. Analyze major ions in water.	PSO1, PSO2,
	CO4. Evaluate the quality of water	PSO1,

<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>	<b>Cognitive Level</b>
<b>Module 1:</b>	<p>Standard sampling procedures of surface and groundwater. Field visits for collection of samples and obtaining field data.</p> <p>Assessment of samples for pH, Electrical conductivity, Total dissolved solids, Dissolved oxygen.</p> <p>Determination of alkalinity and acidity of surface and ground water sample using titrimetric analysis.</p> <p>Preparation of reagents for conducting analysis for major cation and anion.</p> <p>Determination of hardness in water by examining calcium and magnesium by volumetric analysis.</p>	<b>30</b>	CO1, CO2	K1, K2
<b>Module 2:</b>	<p>Estimation of potassium by titrimetric analysis. Determination of sodium and potassium using flame photometer.</p> <p>Determination of Chloride and Nitrate by volumetric analysis.</p> <p>Acid-base titration for estimation of Bicarbonate in samples. Analysis of major ions using UV spectrophotometer.</p> <p>Data analysis considering drinking standards by Bureau of Indian Standards (BIS) and World Health Organization (WHO)</p>	<b>30</b>	CO1, CO2	K1, K2

	Graphic representation of data and interpretation: Radiating vector, Semi log by Schoeller, Stiff pattern, Hill piper diagram, Salinity Hazard diagram, WQI			
<b>Pedagogy:</b>	Field visit, Practical, tutorials			
<b>Texts:</b>	<ol style="list-style-type: none"> <li>1. Dey, A. K. (2010). Environmental Chemistry (Seventh Edition). New Age International Publishers. New Delhi, India.</li> <li>2. Davis, S. N., and De Wiest, R. J. (1966). Hydrogeology New York:Wiley.</li> <li>3. Fetter, C. W. (2018). Applied hydrogeology. Waveland Press.</li> <li>4. Hiscock, K. M., and Bense, V. F. (2021). Hydrogeology: principles and practice. John Wiley and Sons.</li> <li>5. Mays, L. W., and Todd, D. K. (2005). Groundwater Hydrology. John Wily and Sons, Inc., Arizona State University, Third addition.</li> <li>6. Raghunath, H. M., and Raghunath, H. M. (2007). Ground water. New Age International (P) Limited Publishers.</li> </ol>			
<b>References/ Readings:</b>	Sharma, B. K. (2016). Environmental chemistry and pollution control (Rev. ed.). Krishna Prakashan Media, Meerut, India.			
<b>Web Resources:</b>	<a href="https://indiawris.gov.in/wris/#/">https://indiawris.gov.in/wris/#/</a>			

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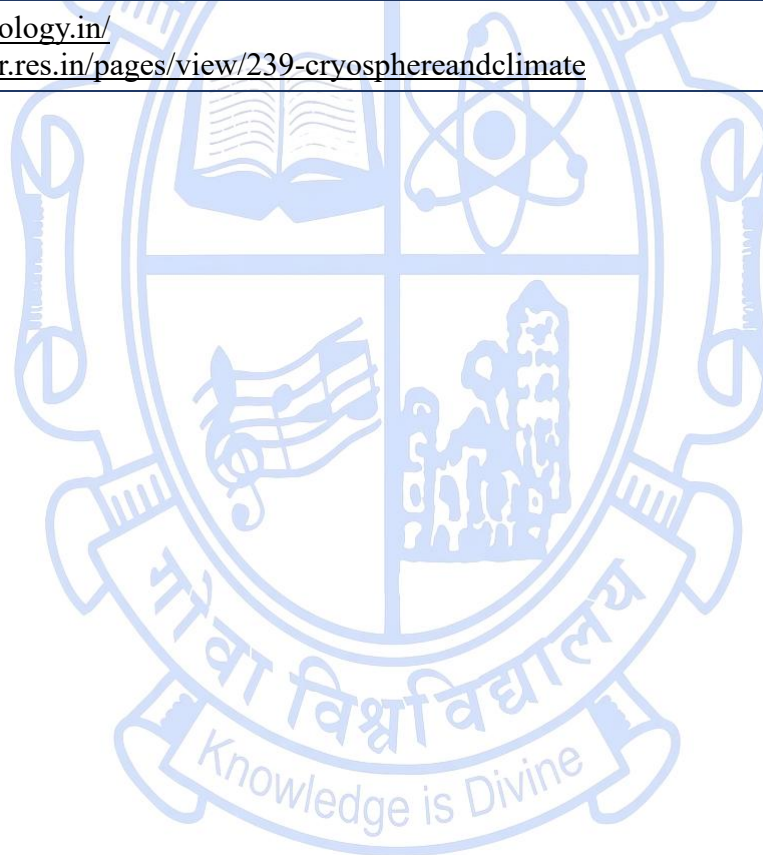
<b>Title of the Course</b>	Glaciology
<b>Course Code</b>	GEO-6405
<b>Number of Credits</b>	1T+1P
<b>Theory/Practical</b>	Theory and Practical
<b>Level</b>	500
<b>Effective from AY</b>	2026-27
<b>New Course:</b>	Yes
<b>Bridge Course/ Value added Course:</b>	No
<b>Course for advanced learners:</b>	No

<b>Pre-requisites for the Course:</b>	NIL	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Understand glacier formation and related processes.</li> <li>2. Identify erosional, weathering, and depositional glacial landforms.</li> <li>3. Explain the link between glaciers and climate change.</li> <li>4. Explore the environmental impacts of glacial processes.</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, the student will be able to:	<b>Mapped to PSO</b>
	CO 1. Discuss the processes involved in formation of glaciers	PSO1, PSO2
	CO 2. Identify erosional and weathering glacial landforms.	PSO2, PSO3, PSO4
	CO 3. Identify depositional glacial landforms	PSO2, PSO3, PSO4
	CO 4. Analyze and correlate the processes with climate change.	PSO2, PSO3,

		PSO5, PSO6, PSO7		
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>	<b>Cognitive Level</b>
<b>Module 1:</b>	<p>Fundamentals of Glaciology: classification, zones, crevasses, icefall. Mass balance and mechanisms of ice flow: deformation, flow, sliding, driving and resisting stresses. Mineralogy and metamorphism of ice; effect of metamorphism on albedo; grain growth. Glacial hydrology and thermodynamics: englacial, subglacial and proglacial water flow; role of meltwater in glacier motion and mass loss. Glacial processes: erosion, weathering, transport, and sedimentation. Glacial erosional and depositional landforms; Palaeoglaciation: Milankovitch cycles, Little Ice Age (LIA), glacial–interglacial cycles. Summer and winter mass balance.</p> <p>Ice cores as climate archives: sampling, stable isotopes, geochemical tracers, reconstruction of past climates. Dating of glacial samples.</p> <p>Response of Glacier to pollution, atmospheric chemical changes, global warming and sea level change. Glacial hazards: glacial lake outburst floods (GLOFs), avalanches. Remote sensing and GIS applications in glaciology for glacier monitoring.</p>	<b>15</b>	CO1, CO2, CO3, CO4	K1, K2, K3, K4, K5, K6
<b>Module 2:</b>	<p>Mapping glacier types and zones (accumulation, ablation, equilibrium line) using: Satellite imagery. Glacier Mass Balance Calculations. Fieldwork techniques (GPS, GPR, mass balance stakes, crevasse surveys). Paleoclimate studies using oxygen isotopes to identify cold (glacial) and warm (interglacial) periods. To calculate and analyse glacier retreat using stack data, Glacier Velocity Calculation, Estimation of Glacier Volume from ice thickness data. Snow Water Equivalent (SWE) Calculations and Calculation of Equilibrium Line Altitude (ELA).</p>	<b>30</b>	CO1, CO2, CO3, CO4	K1, K2, K3, K4, K5, K6
<b>Pedagogy:</b>	Lectures/tutorials/assignments/fieldwork			
<b>Texts:</b>	<ol style="list-style-type: none"> <li>1. Aber, J. S., Croot, D. G., &amp; Fenton, M. M. (2012). Glaciotectonic landforms and structures (Vol. 5). Springer Science &amp; Business Media.</li> <li>2. Benn, D. I., &amp; Evans, D. J. (2014). Glaciers &amp; glaciation. Routledge.</li> <li>3. Bennett, M. M., &amp; Glasser, N. F. (Eds.). (2011). Glacial geology: ice sheets and landforms. John Wiley &amp; Sons.</li> <li>4. Cuffey, K., &amp; Paterson, W. S. B. (2010). The physics of glaciers (4th ed.). Academic Press.</li> </ol>			

	<p>5. Drewry, D. J. (2016). Glacial geologic processes. Cambridge University Press. <a href="https://archive.org/details/dli.pahar.3591">https://archive.org/details/dli.pahar.3591</a></p> <p>6. Hambrey &amp; Alean (2004): Glaciers, 2nd edition. Cambridge University Press.</p> <p>7. Knight, P. J. (1999): Glacier Science and Environmental Change. Wiley.</p> <p>8. Marshall, S. J. (2011). The Cryosphere. Princeton University Press.</p> <p>9. 7. Van der Veen, C. J. (2013). Fundamentals of glacier dynamics. CRC press</p>
<b>References/ Readings:</b>	<p>1. <a href="https://archive.org/details/glaciersglaciati0000benn_d0t8">https://archive.org/details/glaciersglaciati0000benn_d0t8</a></p> <p>2. <a href="https://openlibrary.org/subjects/glaciology">https://openlibrary.org/subjects/glaciology</a></p>
<b>Web Resources:</b>	<p>1. <a href="https://glaciology.in/">https://glaciology.in/</a></p> <p>2. <a href="https://ncpor.res.in/pages/view/239-cryosphereandclimate">https://ncpor.res.in/pages/view/239-cryosphereandclimate</a></p>

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<b>Title of the Course</b>	Industrial Training
<b>Course Code</b>	GEO-6406
<b>Number of Credits</b>	2P
<b>Theory/Practical</b>	Practical
<b>Level</b>	500
<b>Effective from AY</b>	2026-27
<b>New Course:</b>	No
<b>Bridge Course/ Value added Course:</b>	No
<b>Course for advanced learners:</b>	No

<b>Pre-requisites for the Course:</b>	NIL	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Expose students to real-world geological, industrial, and research environments for practical learning.</li> <li>2. Train students in field and laboratory methodologies, data collection, and analytical techniques.</li> <li>3. Develop the ability to analyze, interpret, and present scientific or industrial data effectively.</li> <li>4. Encourage professional ethics, teamwork, and effective communication through collaborative project work and report preparation.</li> </ol>	
<b>Course Outcomes:</b>		<b>Mapped to PSO</b>
	CO 1. Apply theoretical geological knowledge to real-life industrial, research, or field situations.	PSO 1, PSO 2
	CO 2. Demonstrate proficiency in analytical and field-based methodologies used in geological investigations.	PSO 2, PSO 5

	CO 3. Analyze and interpret data to draw meaningful scientific or industrial conclusions.		PSO 3, PSO 4	
	CO 4. Prepare and present a comprehensive technical report demonstrating professional standards in research and communication		PSO 3, PSO 7	
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>	<b>Cognitive Level</b>
<b>Module 1:</b>	Hands-on training at Industry/Professional organization/National Research Labs/Well site/Mine site wherein the student/group of students is/are expected work under the guidance of a Scientist/Professional Geologist to gain experience in analytical/field methodologies, data analysis, presentation and interpretation. A report based on work will be submitted which will be evaluated by the Discipline Specific Committee.	<b>60</b>	CO1, CO2, CO3, CO4	K1, K2, K3, K4, K5, K6
<b>Pedagogy:</b>	Field visits/industrial visits/mine visits/laboratory experiment			
<b>Texts:</b>	<ol style="list-style-type: none"> <li>1. Boggs, S. (2006). Principles of sedimentology and stratigraphy (4th ed.). Pearson Prentice Hall.</li> <li>2. Compton, R. R. (1985). Geology in the field. John Wiley &amp; Sons.</li> <li>3. Davis, J. C. (2002). Statistics and data analysis in geology (3rd ed.). John Wiley &amp; Sons.</li> <li>4. Fetter, C. W. (2001). Applied hydrogeology (4th ed.). Prentice Hall.</li> <li>5. Kearey, P., Brooks, M., &amp; Hill, I. (2002). An introduction to geophysical exploration (3rd ed.). Blackwell Science.</li> <li>6. Lisle, R. J., Brabham, P. J., &amp; Barnes, J. W. (2011). Basic geological mapping (5th ed.). Wiley-Blackwell.</li> <li>7. Rollinson, H. R. (1993). Using geochemical data: Evaluation, presentation, interpretation. Longman Scientific &amp; Technical.</li> <li>8. Tucker, M. E. (2014). Sedimentary rocks in the field: A practical guide (4th ed.). Wiley-Blackwell.</li> <li>9. Nesse, W. D. (2016). Introduction to mineralogy (3rd ed.). Oxford University Press.</li> <li>10. Robb, L. (2005). Introduction to ore-forming processes. Blackwell Publishing.</li> </ol>			
<b>Web Resources:</b>	<ol style="list-style-type: none"> <li>1. Geological Society of India – <a href="https://www.geosocindia.org">https://www.geosocindia.org</a></li> <li>2. Geological Survey of India (GSI) – <a href="https://www.gsi.gov.in">https://www.gsi.gov.in</a></li> <li>3. Indian Bureau of Mines – <a href="https://ibm.gov.in">https://ibm.gov.in</a></li> <li>4. Ministry of Mines, Government of India – <a href="https://mines.gov.in">https://mines.gov.in</a></li> <li>5. U.S. Geological Survey (USGS) – <a href="https://www.usgs.gov">https://www.usgs.gov</a></li> </ol>			

## SEMESTER IV

### Generic Elective (GE) Courses

<b>Title of the Course</b>	Quaternary Geology	
<b>Course Code</b>	GEO-6201	
<b>Number of Credits</b>	2	
<b>Theory/Practical</b>	Theory	
<b>Level</b>	500	
<b>Effective from AY</b>	2026-27	
<b>New Course</b>	Yes	
<b>Bridge Course/ Value added Course</b>	No	
<b>Course for advanced learners</b>	No	
<b>Pre-requisites for the Course:</b>	NIL	
<b>Course Objectives:</b>	The objectives of this course are to: 1. Introduce scope and stratigraphy of the Quaternary Period. 2. Study geomorphic and tectonic processes. 3. Understand Quaternary records of India. 4. Explore human, faunal, floral, and applied aspects.	
<b>Course Outcomes:</b>	At the end of the course, the student will be able to:	<b>Mapped to PSO</b>
	CO 1. Explain Quaternary boundaries and stratigraphic framework.	PSO1, PSO2

	CO 2. Apply dating methods and interpret geomorphic features.		PSO2, PSO3, PSO6
	CO 3. Analyze Indian Quaternary stratigraphy and correlate with global records.		PSO1, PSO2, PSO3, PSO6
	CO 4. Evaluate human and biotic evolution, hazards and Anthropocene relevance.		PSO1, PSO5, PSO7
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b> <b>Cognitive Level</b>
<b>Module 1:</b>	<p>Geological boundaries: Neogene–Quaternary, Pleistocene–Holocene, Anthropocene concept.</p> <p>Stratigraphic markers: varves, paleosols, loess, tephra, glacial tills.</p> <p>Quaternary stratigraphy: lithostratigraphy, magnetostratigraphy, biostratigraphy, pedostratigraphy, event stratigraphy.</p> <p>Global divisions: Oxygen Isotope Stages (OIS) and their stratigraphic applications.</p> <p>Landscape evolution in the Quaternary: fluvial terraces, alluvial fans, glacial–periglacial landforms, aeolian and coastal systems.</p> <p>Neotectonics and active tectonics: fault scarps, uplift, morphotectonic indices, Holocene earthquakes.</p> <p>Dating methods unique to Quaternary: radiocarbon, uranium-series, luminescence, dendrochronology, varve chronology, amino-acid racemization, cosmogenic nuclides, lichenometry.</p>	<b>15</b>	CO1, CO2  K1, K2, K3, K4, K5, K6
<b>Module 2:</b>	<p>Stratigraphic correlation and geomorphic reconstruction.</p> <p>Quaternary tectonics and sedimentation in India: Himalayas — uplift, glaciations, river terraces, neotectonic activity. Indo-Gangetic Plains — stratigraphy, fluvial history, aquifers. Peninsular India — Narmada–Son valley, laterites, duricrusts, coastal plains and deltas, Kutch Quaternary sediments.</p> <p>Marine records from Indian Ocean margin and continental–marine correlation.</p> <p>Evolution of humans and Stone Age cultures in the Indian subcontinent.</p>	<b>15</b>	CO3, CO4  K1, K2, K3, K4, K5, K6

	Plant and animal life during Quaternary: faunal turnovers, responses to glacial–interglacial cycles. Applied Quaternary geology: hazard zonation, geoarchaeology, resource relevance, Anthropocene perspective.			
<b>Pedagogy:</b>	Lectures, case studies, discussions, problem-solving, field visits, seminars.			
<b>Texts:</b>	<ol style="list-style-type: none"> <li>1. Bhattacharya, H. N., Bhattacharya, S., Das, B. C., &amp; Islam, A. (Eds.). (2022). Himalayan Neotectonics and Channel Evolution. Springer.</li> <li>2. Das, B. C., Ghosh, S., &amp; Islam, A. (Eds.). (2019). Quaternary Geomorphology in India: Case Studies from the Lower Ganga Basin. Springer.</li> <li>3. Dawson, A. G. (2013). Ice age earth: late quaternary geology and climate. Routledge.</li> <li>4. De Terra, H., &amp; Paterson, T. T. (2003). The ice age in the Indian subcontinent and associated human cultures: with special reference to Jammu, Kashmir, Ladakh, Sind, Liddar &amp; Central and Peninsular India.</li> <li>5. Grapes, R. H., Grigelis, A., &amp; Oldroyd, D. (Eds.). (2008). History of geomorphology and Quaternary geology. Geological Society of London.</li> <li>6. Joshi, R. V. (1978). Stone Age cultures of central India.</li> <li>7. Khare, N. (Ed.). (2021). Quaternary climate change over the Indian Subcontinent. CRC Press.</li> <li>8. Rose, J. (1996). Himalaya to the sea: Geology, geomorphology and the Quaternary. The Geographical Journal, 162(1), 88.</li> <li>9. Tiwari, N., Singh, V., &amp; Mehra, S. B. (2023). An introduction to Quaternary geoarchaeology of India (Vol. 515, No. 1, pp. 1-7). The Geological Society of London.</li> <li>10. Walker, M. (2005). Quaternary dating methods. John Wiley &amp; Sons.</li> </ol>			
<b>References/ Readings:</b>	<ol style="list-style-type: none"> <li>1. Agrawal, D. P., &amp; Guzder, S. J. (1972). Quaternary studies on the western coast of India: preliminary observations. Journal of Palaeosciences, 21(1-3), 216-222.</li> <li>2. Das, B. C., Ghosh, S., &amp; Islam, A. (2018). Quaternary geomorphology in India: concepts, advances and applications. Quaternary Geomorphology in India: Case Studies from the Lower Ganga Basin, 1-24.</li> </ol>			

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<b>Title of the Course</b>	Geoheritage and Geotourism
<b>Course Code</b>	GEO-6202
<b>Number of Credits</b>	2
<b>Theory/Practical</b>	Theory
<b>Level</b>	500
<b>Effective from AY</b>	2026-27
<b>New Course:</b>	Yes
<b>Bridge Course/ Value added Course:</b>	No
<b>Course for advanced learners:</b>	No

<b>Pre-requisites for the Course:</b>	NIL	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Understand the concepts of geoheritage, geodiversity, geoparks and geotourism.</li> <li>2. Understand general concepts of global geological heritage with special emphasis on India.</li> <li>3. Learn about global and Indian geoheritage sites, monuments, and conservation efforts.</li> <li>4. Recognize the role of UNESCO, governments, and international networks in geopark development.</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, the student will be able to:	<b>Mapped to PSO</b>
	CO1. Explain the concepts of geoheritage, geodiversity, geoparks and geotourism.	PSO 1, PSO 2, PSO 5
	CO2. Examine the potential geoheritage sites.	PSO 1, PSO 3, PSO 5
	CO3. Classify geoheritage sites for geotourism	PSO 3, PSO 4, PSO 7

	CO4. Suggest conservation measures for geoh heritage sites.		PSO 6, PSO 7	
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>	<b>Cognitive Level</b>
<b>Module 1:</b>	Concept, definition, features, and classification of geoh heritage and geodiversity. Geotourism and its importance. Geodiversity: types and geodiversity index Geoh heritage and geotourism in relation to fundamental geology. Concepts of geodiversity, geosites, geoh heritage, geoconservation, geotourism, and geoparks. Classification and significance of geoh heritage and geodiversity. International geoconservation designations: World Heritage Sites, Ramsar Sites, European designations (SPA, SAC, ASSI, NNR, AONB). History of development of geoparks and the role of UNESCO; international promotional events.	15	CO1, CO2, CO3, CO4	K1, K2, K3, K4, K5, K6
<b>Module 2:</b>	Sustainable activities within geoparks: educational and leisure activities. Economic significance of geoparks and community engagement in geopark development. Geoh heritage elements across the Indian sub-continent. National Geological Monuments (NGM). Aspiring and prospective geopark localities of India. Organizational efforts towards geoconservation. Role of local, state, and national governments in conservation of geoh heritage sites in India. International Geopark Networks (GGN, EGN, APGN, AGN).	15	CO1, CO2, CO3, CO4	K1, K2, K3, K4, K5, K6
<b>Pedagogy:</b>	Lectures/tutorials/assignments			
<b>Texts:</b>	<ol style="list-style-type: none"> <li>1. Anze, C., Yunting, L., &amp; Ng, C. Y. (2015). The principles of geotourism. Science Press.</li> <li>2. Reddy, D. R. (2020). A monograph on potential geoparks of India. INTACH.</li> <li>3. Reynard, E., &amp; Brilha, J. (Eds.). (2017). Geoh heritage: Assessment, protection, and management. Elsevier.</li> <li>4. Singh, R., Wei, D., &amp; Anand, S. (2020). Global geographical heritage, geoparks and geotourism: Geoconservation and development. Springer Nature.</li> </ol>			
<b>References/ Readings:</b>	<a href="https://www.sciencedirect.com/journal/international-journal-of-geoh heritage-and-parks">https://www.sciencedirect.com/journal/international-journal-of-geoh heritage-and-parks</a>			
<b>Web Resources:</b>	<ol style="list-style-type: none"> <li>1. <a href="https://whc.unesco.org/en/list/">https://whc.unesco.org/en/list/</a></li> <li>2. <a href="https://www.gsi.gov.in/webcenter/portal/OCBIS">https://www.gsi.gov.in/webcenter/portal/OCBIS</a></li> </ol>			

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<b>Title of the Course</b>	Coal Geology
<b>Course Code</b>	GEO-6203
<b>Number of Credits</b>	02
<b>Theory/Practical</b>	Theory
<b>Level</b>	500
<b>Effective from AY</b>	2026-27
<b>New Course:</b>	No
<b>Bridge Course/ Value added Course:</b>	No
<b>Course for advanced learners:</b>	No

<b>Pre-requisites for the Course:</b>	Nil			
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Understand the processes involved in the formation of coal.</li> <li>2. Study the exploration and mining methods used for extraction of coal.</li> </ol>			
<b>Course Outcomes:</b>	By the end of this course, students will be able to:	<b>Mapped to PSO</b>		
	CO1. Describe the processes involved in the formation of coal.	PSO1, PSO2		
	CO2. Explain exploration techniques used for extraction of coal	PSO1, PSO2		
	CO3. Discuss the beneficiation methods used in coal mining.	PSO1, PSO4, PSO6		
	CO4. Analyze conservation and consumption pattern in coal mining	PSO1, PSO2, PSO5		
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>	<b>Cognitive Level</b>

<b>Module 1:</b>	Coal as rock, types of coal, mode of occurrence, structure in coal seams, coals through ages-physical and chemical characteristics of coal, macropetrographics and microlithotypes; Genetics and exploration: Origin-classification of coal, Coal grading and exploration, Modern drilling techniques, logging and assessment. Calculation of coal reserves, Beneficiation of Coal: Cleaning, sorting, washing and supporting operations.	15	CO1	K1, K2
<b>Module 2:</b>	Coal utilization, combustion, carbonization, gasification and hydrogenation. Resources and Environments: Production and consumption pattern. Energy policy: conservation, environmental pollution and hazards. World coal resources, Principal Indian Coal Fields: occurrences, geology and geographical distribution.	15	CO1	K1, K2
<b>Pedagogy:</b>	Lectures, case studies, discussions and assignments.			
<b>Texts:</b>	<ol style="list-style-type: none"> <li>1. Chandra, D., Singh, R. M., &amp; Singh, M. P. (2000). Text book of coal (Indian Context). Tara Book Agency, Varanasi.</li> <li>2. Francis, W. (1961). Coal: its formation and composition. E. Arnold.</li> <li>3. Larry, T. (2002). Coal geology. A John Wiley &amp; Sons, West Sussex, 273.</li> <li>4. Mackowsky, M. T., Teichmuller, M., Taylor, G. H., Chandra, D., Teichmuller, R., Bwnfraeger, G. &amp; Darfmoufh, N. S. (1997). Stach's textbook of coal petrology. Gebruder borntraeger.</li> </ol>			
<b>References/ Readings:</b>	<ol style="list-style-type: none"> <li>1. Thomas, L. (1992). A handbook on practical coal geology.</li> <li>2. Ward, C. R. (1984). Coal geology and coal technology.</li> </ol>			
<b>Web Resources:</b>	<ol style="list-style-type: none"> <li>1. <a href="https://coal.nic.in/">https://coal.nic.in/</a></li> <li>2. <a href="https://www.coalindia.in/">https://www.coalindia.in/</a></li> </ol>			

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<b>Title of the Course</b>	Soil Science
<b>Course Code</b>	GEO-6204
<b>Number of Credits</b>	2
<b>Theory/Practical</b>	Theory
<b>Level</b>	500
<b>Effective from AY</b>	2026-27
<b>New Course:</b>	No
<b>Bridge Course/ Value added Course:</b>	No
<b>Course for advanced learners:</b>	No

<b>Pre-requisites for the Course:</b>	NIL	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Understand the importance of soil and also the procedure to conduct soil survey.</li> <li>2. Determine the age of soils radiometrically.</li> <li>3. Understand the impact of soil quality on crop production.</li> <li>4. Address the issues of soil contamination and desertification</li> </ol>	
<b>Course Outcomes:</b>	By the end of this course, students will be able to:	<b>Mapped to PSO</b>
	CO 1. Explain the relationship between soil and organisms.	PSO2, PSO3, PSO5
	CO 2. Classify soils	PSO1, PSO2, PSO3
	CO 3. Undertake soil management	PSO2, PSO3, PSO5
	CO 4. Suggest soil conservation measures.	PSO3, PSO5, PSO6, PSO7

<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>	<b>Cognitive Level</b>
<b>Module 1:</b>	Introduction: Nature and importance of soil, soil formation, soil survey, physical, chemical and biological characters of soil. Relationship between soil and organisms. Various Soil types. Radiometric age determination of soils.	<b>15</b>	CO1, CO2	K1, K2, K3, K4, K5, K6
<b>Module 2:</b>	Soil and crop production: Elements essential for plants and animals, soil nutrients, nitrogen, phosphorus, potassium, calcium, magnesium, and Sulphur in soil and their significance in plant growth, micronutrients; Soil quality and landscape: cropping systems and fertility and case studies. Soil contamination and desertification. Soil management and conservation	<b>15</b>	CO3, CO4	K1, K2, K3, K4, K5, K6
<b>Pedagogy:</b>	Lectures, Case studies, Discussions and Assignments.			
<b>Texts:</b>	Huang, P. M., Li, Y., Sumner, M.E., (2012) Hand Book of Soil Science. University of Georgia. Second Edition			
<b>References/ Readings:</b>	<ol style="list-style-type: none"> <li>1. Brady, N. C., &amp; Weil, R. R. (2002). The nature and properties of soils 13th ed Prentice Hall. New Jersey, USA, 249.</li> <li>2. Raymond, B. D., &amp; Richard, D. (2000). Soil geomorphology, John Wiley &amp; Sons, 2000.</li> <li>3. Sparks, D. L. (2019). Fundamentals of soil chemistry. Encyclopedia of Water: Science, Technology, and Society, 1-11.</li> <li>4. Sparks, D. L. (2003). Environmental soil chemistry. Elsevier.</li> </ol>			
<b>Web Resources:</b>	<a href="https://api.pageplace.de/preview/DT0400.9781439803042_A38906343/preview-9781439803042_A38906343.pdf">https://api.pageplace.de/preview/DT0400.9781439803042_A38906343/preview-9781439803042_A38906343.pdf</a>			

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<b>Title of the Course</b>	Advanced Geomorphology and Landscape Evolution
<b>Course Code</b>	GEO-6205
<b>Number of Credits</b>	2
<b>Theory/Practical</b>	Theory
<b>Level</b>	500
<b>Effective from AY</b>	2026-27
<b>New Course</b>	Yes
<b>Bridge Course/ Value added Course</b>	No
<b>Course for advanced learners</b>	No

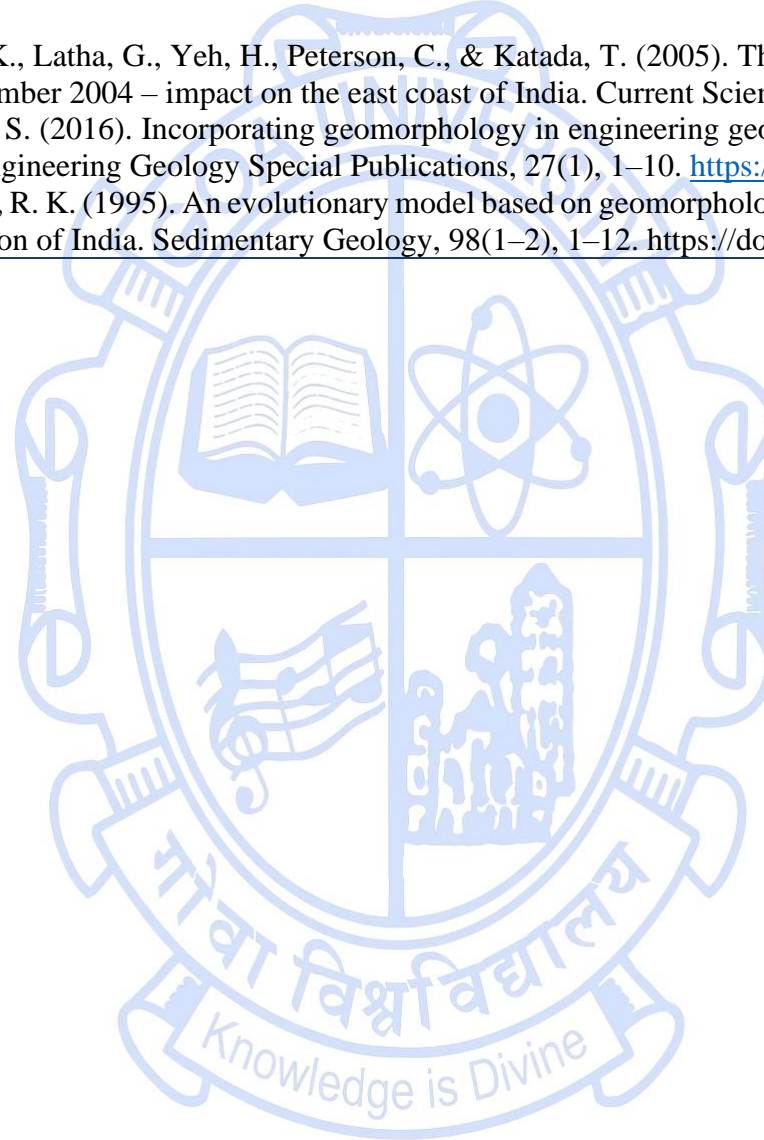
<b>Pre-requisites for the Course:</b>	NIL	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Introduce the fundamental concepts and processes of geomorphology, including morphotectonic, neotectonics, and surface dynamics.</li> <li>2. Explain the origin, evolution, and classification of various geomorphic features formed by fluvial, aeolian, glacial, karst, and coastal processes.</li> <li>3. Develop an understanding of the geomorphological framework of the Indian subcontinent and the use of modelling techniques in landscape analysis.</li> <li>4. Understand development and evolution of different landforms over time.</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, the student will be able to:	<b>Mapped to PSO</b>
	CO1. Explain key geomorphic processes and their role in shaping the Earth's surface.	PSO 1, PSO 5, PSO 6

	CO2. Identify landforms formed by different geomorphic processes.		PSO 1, PSO 4, PSO 5, PSO 6
	CO3. Interpret evolution of landforms.		
	CO4. Analyse drainage basins, landform evolution, and regional geomorphology through modelling and reconstruction techniques.		PSO 1, PSO 5, PSO 6, PSO 7
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b> <b>Cognitive Level</b>
<b>Module 1:</b>	Introduction to Geomorphology; Concepts of morphotectonic and neotectonics; Geomorphic processes: Epigene (gradation, degradation) and Hypogene (diastrophism, volcanism); Weathering: mechanical, chemical, biological, and controlling factors; Slope geomorphology: slope stability, slope profiles, hill slope development.	<b>15</b>	CO1, CO2      K1, K2, K3, K4, K5, K6
<b>Module 2:</b>	Drainage basin: channel initiation, drainage network, basin morphology, denudation and evolution; Fluvial processes: river channels, sediment transport, quasi-equilibrium, channel patterns, river equilibrium over time; Fluvial landforms: flood plains, fans, pediments, deltas; Aeolian processes: wind erosion and deposition, landforms; Glacial processes: erosion, deposition, and landforms; Karst processes: drainage, surface features, limestone caves; Coastal processes: shoreline dynamics, beaches, coastal topography, islands; Morphology of the Indian subcontinent, paleogeography, landscape reconstruction, and geomorphological modelling and simulations.	<b>15</b>	CO1, CO3      K1, K2, K3, K4, K5, K6
<b>Pedagogy:</b>	Lectures/tutorials/assignments/field study/discussion		
<b>Texts:</b>	<ol style="list-style-type: none"> <li>Ahmad, E. (1972). Coastal geomorphology of India. Orient Longman.</li> <li>Anderson, R. S., &amp; Anderson, S. P. (2010). Geomorphology: The mechanics and chemistry of landscapes. Cambridge University Press.</li> <li>Coates, D. R. (Ed.). (1976). Geomorphology and engineering: Binghamton Geomorphology Symposium 7. Dowden, Hutchinson &amp; Ross.</li> <li>Drury, G. H. (Ed.). (1966). Essays in geomorphology. Heinemann Educational Books Ltd.</li> <li>Thornbury, W. D. (2004). Principles of geomorphology (2nd ed.). Wiley Eastern.</li> <li>Thornbury, W. D. (2018). Principles of geomorphology. New Age International.</li> </ol>		

**References/  
Readings:**

1. Baba, M., & Thomas, K. V. (1999). Geomorphology of the Indian coast. Ministry of Environment and Forests, New Delhi.
2. Chada, R. K., Latha, G., Yeh, H., Peterson, C., & Katada, T. (2005). The tsunami of the great Sumatra earthquake on 26 December 2004 – impact on the east coast of India. *Current Science*, 88(8), 1297–1301.
3. Griffiths, J. S. (2016). Incorporating geomorphology in engineering geological investigations. Geological Society, London, *Engineering Geology Special Publications*, 27(1), 1–10. <https://doi.org/10.1144/egsp27.14>
4. Sukhtankar, R. K. (1995). An evolutionary model based on geomorphologic and sedimentologic data for the western coastal region of India. *Sedimentary Geology*, 98(1–2), 1–12. [https://doi.org/10.1016/1040-6182\(94\)00052-7](https://doi.org/10.1016/1040-6182(94)00052-7)

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<b>Title of the Course</b>	Disaster Risk Reduction	
<b>Course Code</b>	GEO-6206	
<b>Number of Credits</b>	02	
<b>Theory/Practical</b>	Theory	
<b>Level</b>	500	
<b>Effective from AY</b>	2026-27	
<b>New Course:</b>	Yes	
<b>Bridge Course/ Value added Course:</b>	No	
<b>Course for advanced learners:</b>	No	
<b>Pre-requisites for the Course:</b>	NIL	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Provide students with a clear understanding of the risk framework (hazard–exposure–vulnerability–capacity).</li> <li>2. Examine global and national Disaster Risk Reduction (DRR) frameworks, governance structures, and policy instruments.</li> <li>3. Analyze tools and approaches for risk assessment, early warning, and resilience building.</li> <li>4. Evaluate risk reduction strategies, including structural, non-structural, community-based, and nature-based solutions.</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, the student will be able to:	<b>Mapped to PSO</b>
	CO 1. Explain DRR concepts, Sendai priorities, and pathways of risk creation/reduction.	PSO 1, PSO2
	CO 2. Analyze multi-hazard and cascading risk scenarios in the context of climate change.	PSO 2, PSO 3, PSO 5

	CO 3. Evaluate governance systems and international/national DRR frameworks.		PSO 4, PSO 6	
	CO 4. Propose risk-informed strategies for resilience, preparedness, and sustainable recovery.		PSO 3, PSO 5, PSO 7	
<b>Content:</b>	By the end of this course, students will be able to:	<b>No of hours</b>	<b>Mapped to CO</b>	<b>Cognitive Level</b>
<b>Module1:</b>	Understanding Risk and Emerging Patterns: Concepts of risk: hazard, exposure, vulnerability, capacity, resilience. Multi-hazard risks: cascading and compound events, climate change linkages. Risk metrics and indicators: loss databases (EM-DAT, DesInventar), risk dashboards. Case studies: Global and Indian disaster trends, lessons learned from mega disasters. Community vulnerability and social dimensions of risk (poverty, gender, inequity).	<b>15</b>	CO1, CO2	K2, K3, K4, K5, K6
<b>Module2:</b>	Risk Governance, Frameworks, and Strategies: DRR paradigm shift- from disaster management cycle to proactive risk governance. Sendai Framework for DRR (2015–2030): priorities, targets, and monitoring indicators. Global actors: UNDRR, GFDRR, World Bank, Red Cross; local & NGO roles; Making Cities Resilient 2030. Indian DRR framework: DM Act 2005, NDMA, NIDM, state & local DRR strategies. Risk reduction tools: hazard zonation, risk assessment, early warning systems, land-use planning, resilient infrastructure. Emerging approaches: nature-based solutions, climate adaptation, CBDRR, Build Back Better, livelihood resilience. Monitoring & evaluation: resilience scorecards, risk governance audits, Sendai reporting.	<b>15</b>	CO3, CO4	K2, K3, K4, K5, K6
<b>Pedagogy:</b>	Lectures/ tutorials/ assignments/ discussions			
<b>Texts:</b>	<ol style="list-style-type: none"> <li>Alexander, D., (1999), Natural Disasters, Kluwer Academic London, 632 pages</li> <li>Coppola D P, (2007). Introduction to International Disaster Management, Elsevier Science (B/H), London.</li> <li>Disaster Management Act 2005, Published by Govt. of India</li> <li>Disaster Management Guidelines, GOI-UN Disaster Risk Program (2009–2020)</li> <li>Coppola, D. P. (2020). Introduction to International Disaster Management (4th ed.). Butterworth-Heinemann, Elsevier. ISBN: 978-0128171394.</li> <li>Kelman, I. (2015). Disaster Risk Reduction: Methods, Approaches and Practices. Routledge, London. ISBN: 978-</li> </ol>			

	<p>1138025683.</p> <p>7. Shaw, R., Pulhin, J. M., &amp; Pereira, J. (Eds.). (2010). Climate Change Adaptation and Disaster Risk Reduction: Issues and Challenges. Emerald Group Publishing, UK. ISBN: 978-0857244877.</p> <p>8. Wisner, B., Gaillard, J. C., &amp; Kelman, I. (Eds.). (2012). The Routledge Handbook of Hazards and Disaster Risk Reduction. Routledge, London. ISBN: 978-0415590655.</p> <p>9. Collins, A. E. (2009). Disaster and Development. Routledge Perspectives on Development. Routledge, London. ISBN: 978-0415411578.</p> <p>10. UNDRR (2015). Sendai Framework for Disaster Risk Reduction 2015–2030. United Nations Office for Disaster Risk Reduction, Geneva.</p> <p>11. Parasuraman, S., &amp; Unnikrishnan, P. V. (Eds.). (2000). India Disasters Report: Towards a Policy Initiative. Oxford University Press, New Delhi. ISBN: 978-0195645964.</p> <p>12. Ghosh, G. K. (2006). Disaster Management. APH Publishing Corporation, New Delhi. ISBN: 9788131300176.</p>
<b>References/ Readings:</b>	<p>1. Twigg, J. (2015). Disaster risk reduction. Good Practice Review 9, Humanitarian Policy Group.</p> <p>2. Izumi, T., Shaw, R., Djalante, R., Ishiwatari, M., &amp; Komino, T. (2019). Disaster risk reduction and innovations. Progress in Disaster Science, 2, 100033.</p> <p>3. Weichselgartner, J., &amp; Pigeon, P. (2015). The role of knowledge in disaster risk reduction. International Journal of Disaster Risk Science, 6(2), 107-116.</p>
<b>Web Resources:</b>	<p>1. <a href="https://www.undrr.org">https://www.undrr.org</a></p> <p>2. <a href="https://www.preventionweb.net">https://www.preventionweb.net</a></p> <p>3. <a href="https://www.ifrc.org/disaster-risk-reduction">https://www.ifrc.org/disaster-risk-reduction</a></p> <p>4. <a href="https://www.worldbank.org/en/topic/disasterriskmanagement">https://www.worldbank.org/en/topic/disasterriskmanagement</a></p> <p>5. <a href="https://ndma.gov.in">https://ndma.gov.in</a> <a href="https://nidm.gov.in">https://nidm.gov.in</a></p>

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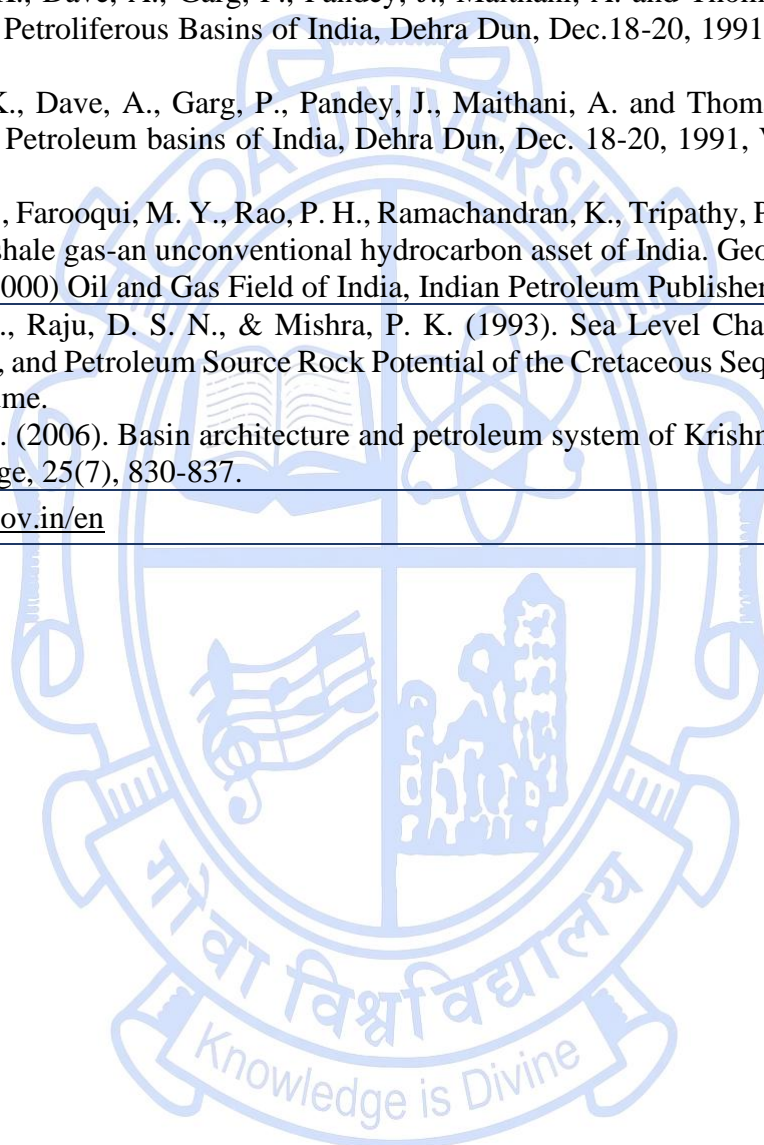
<b>Title of the Course</b>	Petroliferous basins of India
<b>Course Code</b>	GEO-6207
<b>Number of Credits</b>	02
<b>Theory/Practical</b>	Theory
<b>Level</b>	500
<b>Effective from AY</b>	2026-27
<b>New Course</b>	No
<b>Bridge Course/ Value added Course</b>	No
<b>Course for advanced learners</b>	No

<b>Pre-requisites for the Course:</b>	NIL	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Study the location and tectonic setting of petroliferous basin in India</li> <li>2. Understand the methods of exploration adopted and estimation of reserves in the basins</li> </ol>	
<b>Course Outcomes:</b>	By the end of this course, students will be able to:	<b>Mapped to PSO</b>
	CO1. locate the petroliferous basin in India	PSO1, PSO4.
	CO2: Provide details of the petroliferous basins of India	PSO1, PSO2
	CO3. Explain the methods of exploration and estimation of reserves.	PSO1, PSO2.
	CO4. Compare the petroliferous basin in India.	PSO1, PSO2, PSO5,

<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>	<b>Cognitive Level</b>
<b>Module 1:</b>	<p>Types of petroliferous basins, relations between basin type and hydrocarbon richness; classification of petroliferous basins of India in the framework of Plate tectonics.</p> <p>Cambay basin: Cambay rift and post rift deltaic sedimentation, Lithofacies, depositional environment, organic matter, palynological investigation and reservoir characteristics.</p> <p>Bombay offshore basin: Exploration, seismic study, transgressive-regressive cycle, carbonate facies, reservoir petrography, source rock geochemistry and future prospects along western slope of India.</p>	<b>15</b>	CO1	K1, K2
<b>Module 2:</b>	<p>Assam shelf: Depositional environment, structure, tectonics, bio-zonation, hydrocarbon prospects, source rock and associated lithology.</p> <p>Krishna-Godavari basin: Lithology, depositional pattern, petroleum systems and fossils.</p> <p>Bengal basin: Marine depositional environments, clay mineralogy, trace elements and fossil assemblages.</p> <p>Cauvery basin: General geology, tectonic history, sea level changes, modelling and basin analysis.</p> <p>Andaman basin: Structural analysis, its interpretation and evolution of forearc basin.</p> <p>Rajasthan Basin: Hydrogeochemical studies in Jaisalmer basin, Hydrocarbon entrapment conditions and related lithology.</p> <p>Kerala-Konkan basin.</p> <p>Hydrocarbon in Himalayan foothills, Vindhyan and Gondwana basin.</p>	<b>15</b>	CO1	K1, K2
<b>Pedagogy:</b>	Lectures, case studies, discussions and assignments.			
<b>Texts:</b>	1. Bhandari, L.L., Venkatachala, B.S., Kumar, R., Swamy, S.N., Garga, P. and Srivastava, D.C. (Eds.) (1983). Petroliferous Basins of India, Petroleum Asia Journal, Himachal Times Group.			

	<ol style="list-style-type: none"> <li>2. Biswas, S.K., Dave, A., Garg, P., Pandey, J., Maithani, A. and Thomas, N.J. (Eds.) (1993) Proceedings of 2nd Seminar on Petroliferous Basins of India, Dehra Dun, Dec.18-20, 1991, Vol. 1 &amp; 2, Indian Petroleum Publishers, Dehra Dun.</li> <li>3. Biswas, S.K., Dave, A., Garg, P., Pandey, J., Maithani, A. and Thomas, N.J. (Eds.) (1994) Proceedings of 2nd Seminar on Petroleum basins of India, Dehra Dun, Dec. 18-20, 1991, Vol.3, Indian Petroleum Publishers, Dehra Dun.</li> <li>4. Hasan, S. Z., Farooqui, M. Y., Rao, P. H., Ramachandran, K., Tripathy, P., &amp; Harinarayana, T. (2013). Petroliferous basins and shale gas-an unconventional hydrocarbon asset of India. Geosciences, 3(4), 108-118.</li> <li>5. Singh, L. (2000) Oil and Gas Field of India, Indian Petroleum Publishers, Dehra Dun.</li> </ol>
<b>References/ Readings:</b>	<ol style="list-style-type: none"> <li>1. Chandra, K., Raju, D. S. N., &amp; Mishra, P. K. (1993). Sea Level Changes, Anoxic Conditions, Organic Matter Enrichment, and Petroleum Source Rock Potential of the Cretaceous Sequences of the Cauvery Basin, India. AAPG special volume.</li> <li>2. Gupta, S. K. (2006). Basin architecture and petroleum system of Krishna Godavari Basin, east coast of India. The Leading Edge, 25(7), 830-837.</li> </ol>
<b>Web Resources:</b>	<a href="https://mopng.gov.in/en">https://mopng.gov.in/en</a>

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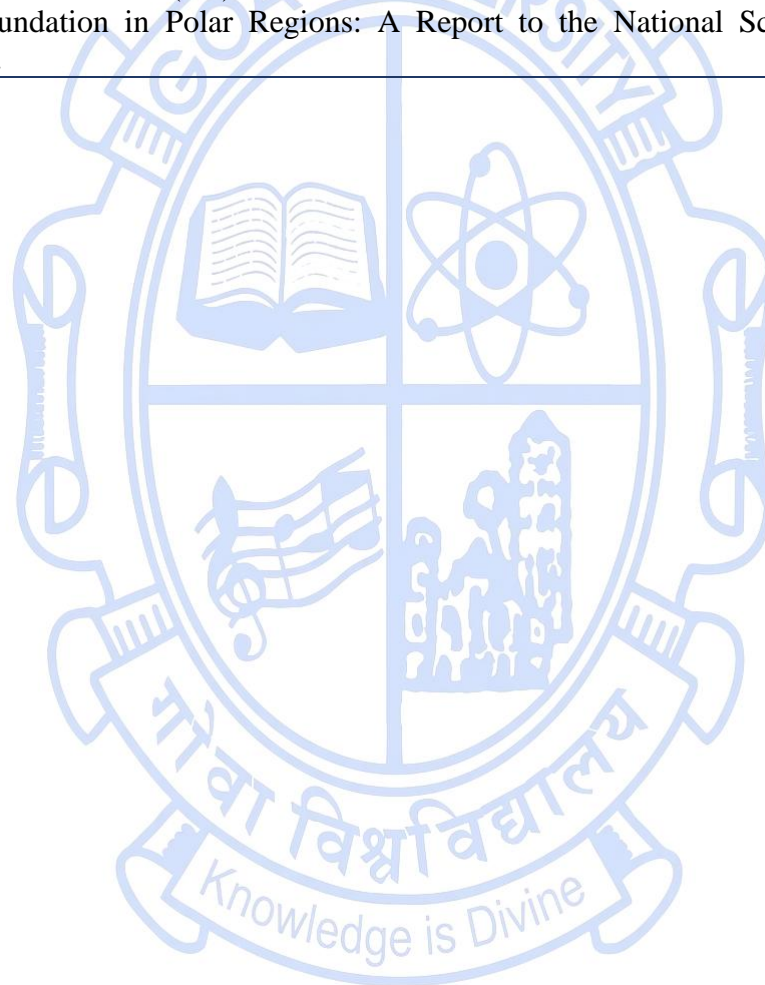
<b>Title of the Course</b>	Polar Geoscience
<b>Course Code</b>	GEO-6208
<b>Number of Credits</b>	02
<b>Theory/Practical</b>	Theory
<b>Level</b>	500
<b>Effective from AY</b>	2026-27
<b>New Course:</b>	Yes
<b>Bridge Course/ Value added Course:</b>	No
<b>Course for advanced learners:</b>	Yes

<b>Pre-requisites for the Course:</b>	Nil	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Understand the natural setting and importance of polar regions.</li> <li>2. Study the role geological and climatic processes in shaping high-latitude environments.</li> <li>3. Develop skills in analyzing evidence for past environmental change.</li> <li>4. Encourage critical thinking on national and global engagement in polar research.</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, the student will be able to:	<b>Mapped to PSO</b>
	CO 1. Describe physical and environmental features of polar regions.	PSO1
	CO 2. Explain major processes that influence polar landscapes and systems.	PSO1, PSO2
	CO 3. Analyze the connections between polar regions and global Earth processes.	PSO2, PSO3, PSO5
	CO 4. Evaluate different perspectives on the importance of polar regions for society and science.	PSO2, PSO3,

		PSO5, PO6		
Content:		No of hours	Mapped to CO	Cognitive Level
<b>Module 1:</b>	<p>Introduction to Polar Geology: Physiography of Arctic &amp; Antarctica; geological significance.</p> <p>Tectonic Evolution: Gondwana breakup; opening of the Southern Ocean; tectonic isolation of Antarctica. Ocean–Climate Interactions: Antarctic Circumpolar Current, Southern Ocean circulation, role in global heat and carbon transport. Stratigraphy and Sedimentary Basins: Depositional environments of glaciated margins; Cenozoic sedimentary records. Glacial History.</p> <p>Ice Sheet Evolution: Northern and Southern Hemisphere. Cryosphere–Lithosphere Interaction: Permafrost geology, glacial erosion, fjords, moraines, ice-rafted debris.</p>	15	CO1, CO2, CO3, CO4	K1, K2, K3, K4, K5, K6
<b>Module 2:</b>	<p>Geological Framework of Antarctica: Transantarctic Mountains, East–West Antarctica divide. Arctic Geology: Precambrian shield, Phanerozoic sedimentary basins, Lomonosov Ridge, tectonic framework of the Arctic Ocean.</p> <p>Role of Polar Regions in Global Tectonics. Comparative Glacial Histories: Arctic vs Antarctic sedimentary archives. Indian Polar Policy and Research: India and the Arctic; India and the Antarctic; India’s involvement in the Third Pole; sustainability perspectives. Polar regions in the context of global climate and sustainability challenges.</p>	15	CO1, CO2, CO4	K1, K2, K3, K4, K5, K6,
<b>Pedagogy:</b>	Lectures, case studies, group discussions, assignments			
<b>Texts:</b>	<ol style="list-style-type: none"> <li>Adie, R. J. (1962, January). The geology of Antarctica. In Antarctic research: the Matthew Fontaine Maury memorial symposium (Vol. 7, pp. 26-39). Washington DC: American Geophysical Union.</li> <li>Anderson, J. B. (1999). Antarctic marine geology. Cambridge University Press.</li> <li>Bennett, M. R., &amp; Glasser, N. F. (2022). Glacial Geology: Ice Sheets, Glaciers and Landforms.</li> <li>Khare, N. (Ed.). (2022). Climate Change and Geodynamics in Polar Regions. CRC Press.</li> <li>Khare, N. (Ed.). (2024). Polar Ice and Global Warming in Cryosphere Regions. CRC Press.</li> <li>Martin, A. P., van der Wal, W., &amp; de Boer, B. (2023). An introduction to the geochemistry and geophysics of the Antarctic mantle.</li> </ol>			

	7. Petrov, O. V., & Smelror, M. (Eds.). (2021). Tectonics of the Arctic. Springer Nature.
<b>References/ Readings:</b>	<ol style="list-style-type: none"> <li>1. Bisen, A. (2022). India's Arctic Policy: Building a partnership for sustainable development. IDSA Issue Briefs, 17.</li> <li>2. Jordan, T. A., Riley, T. R., &amp; Siddoway, C. S. (2020). The geological history and evolution of West Antarctica. Nature Reviews Earth &amp; Environment, 1(2), 117-133.</li> <li>3. National Science Board (US). Committee on the NSF Role in Polar Regions. (1987). The Role of the National Science Foundation in Polar Regions: A Report to the National Science Board (Vol. 87). National Science Foundation.</li> </ol>

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<b>Title of the Course</b>	Planetary Geology
<b>Course Code</b>	GEO-6209
<b>Number of Credits</b>	02
<b>Theory/Practical</b>	Theory
<b>Level</b>	500
<b>Effective from AY</b>	2026-27
<b>New Course:</b>	No
<b>Bridge Course/ Value added Course:</b>	No
<b>Course for advanced learners:</b>	No

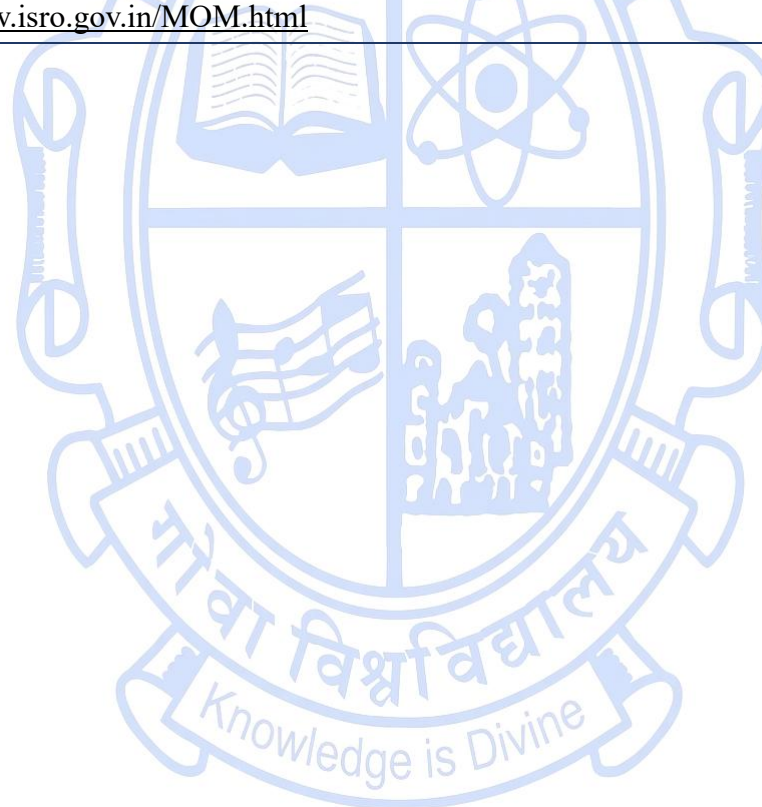
<b>Pre-requisites for the Course:</b>	NIL	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Provide students with an understanding of the origin, structure, and evolution of the Solar System and planetary bodies.</li> <li>2. Compare the geology and atmospheres of terrestrial and Jovian planets, with emphasis on planetary processes.</li> <li>3. Study asteroids, comets, meteorites and dwarf planets; and their role in planetary evolution.</li> <li>4. Familiarize students with modern tools, techniques, and space missions in planetary exploration, with emphasis on Indian contributions.</li> </ol>	
<b>Course Outcomes:</b>	By the end of this course, students will be able to:	<b>Mapped to PSO</b>
	CO 1. Explain the origin and evolution of planets and moons using key hypotheses and observational evidence.	PSO 1, PSO6

	CO 2. Compare geological and atmospheric features of terrestrial and Jovian planets.		PSO 1, PSO 2, PSO 5
	CO 3. Analyze the role of planetary processes (volcanism, tectonics, impacts) in shaping planetary surfaces.		PSO 1, PSO 2, PSO 3
	CO 4. Evaluate the significance of asteroids, comets, meteorites, and dwarf planets in understanding planetary history.		PSO 1, PSO 3, PSO 6, PSO 7
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b> <b>Cognitive Level</b>
<b>Module1:</b>	Solar System Origins, Planets, and Geological Processes: Universe & Solar System Overview- Big Bang, Milky Way, formation of the Solar System. Classification- Terrestrial vs. Jovian planets, moons, planetoids. Theories of Planetary Origin- condensation hypothesis, Urey's hypothesis, role of early collisions (Earth-Moon system). Evidence of Solar System Formation- meteorites, asteroids, comets. The Planetary Atmospheres and Volatiles- origin and retention. Terrestrial Planets- physical attributes, atmospheres, surface morphology, volcanism, tectonics, impact cratering. Jovian Planets- physical data, atmospheres, interiors, magnetic fields, rings and moons (Io, Europa, Titan, Enceladus). Comparative Planetary Geology- geological processes across planets—meteorite impacts, volcanism, tectonism, erosion. Earth's Moon- geology of surface features, volcanic flows, craters, internal structure. Habitability Perspectives- Mars, icy moons, exoplanets.	<b>15</b>	CO1, CO2      K2, K3, K4, K5, K6
<b>Module2:</b>	Small Cosmic Bodies, Exploration Techniques, and Human Challenges: Asteroids and Meteorites- types, classification, geological processes, asteroid belt zonation. Kuiper Belt and Dwarf Planets- Pluto, Eris, Ceres—structure, composition, orbits. Comets- structure, volatiles, activity, orbits, significance in planetary evolution. Tools and Techniques- telescopes, spectroscopy, remote sensing, rover instrumentation, computer modelling, planetary seismology. Planetary Exploration Missions- Indian initiatives: Chandrayaan-1, Chandrayaan-2, Chandrayaan-3, Mangalyaan, Aditya-L1, Shukrayaan (proposed), Gaganyaan; International programs: Apollo & Luna missions, Mars rovers (Curiosity, Perseverance), OSIRIS-REx, Hayabusa, James Webb Space Telescope, International Space Station. Planetary Resources and Human Exploration- significance, potential	<b>15</b>	CO2, CO3      K2, K3, K4, K5, K6

	utilization, risks, and challenges.			
<b>Pedagogy:</b>	Lectures/ tutorials/ assignments/ discussions			
<b>Texts:</b>	<ol style="list-style-type: none"> <li>1. Beatty, J., Petersen C., and Chaikin, A., (1999). The New Solar System. Cambridge University Press, Cambridge, England.</li> <li>2. Kaula, W.M., (1996). Theory of satellite geodesy. Blaisedell.</li> <li>3. Morrison, D., (1993). Exploring Planetary Worlds. Scientific American Library, New York.</li> <li>4. Bhardwaj A. (Ed). (2006). Advances in Geosciences: Planetary Science (Volume 3). World Scientific Publishing C. Pte. Ltd. Singapore. ISBN: 981-256-983-8.</li> <li>5. Christiansen E. H., and Hamblin, W. K., (1995) Exploring the Planets (2nd edition). Prentice-Hall</li> <li>6. Cook, A.H., (1973). Physics of Earth and planets. London: Macmillian</li> <li>7. Cook, A.H., (1980). Interiors of Planets. Cambridge University Press, London. ISBN: 978-0-521- 23214-2</li> <li>8. Gunter, F., and Teresa, M., (2007). Introduction to planetary science: The geological perspective. M. Springer, the Netherlands. ISBN: 13 978-1-4020-55447.</li> <li>9. McSween Jr, H. Y., Moersch, J.E.; Burr, D.M., Dunne, W. M., Emery, J. P., Kah, L. C., and McCanta, M. C., (2019). Planetary Geoscience. Cambridge University Press. ISBN: 1107145384</li> <li>10. Watters, T.R. and Schultz, R.A, (2010). Planetary Tectonics. Cambridge University Press. ISBN 978-0-521-76573-2.</li> <li>11. Wilhelms, D., (1993). To a Rocky Moon - A Geologist's History of Lunar Exploration. University of Arizona Press, Tucson.</li> <li>12. Wood, J. A. (2000). The Solar System (2nd edition) Prentice-Hall</li> <li>13. de Pater, I., and Lissauer, J. J., (2020). Planetary Sciences (3rd edition). Cambridge University Press, Cambridge, England. ISBN: 978-1-108-74581-0.</li> <li>14. Melosh, H. J., (2011). Planetary Surface Processes. Cambridge University Press, Cambridge, England. ISBN: 978-0-521-87379-6.</li> <li>15. McSween Jr, H. Y., Huss, G. R., and Shoemaker, E. M., (2022). Cosmochemistry. Cambridge University Press, Cambridge, England. ISBN: 978-1-108-47962-3.</li> </ol>			
<b>References/</b>	1. Goswami, J. N., and Annadurai, M., (2011). Chandrayaan-1: Science Results. Current Science, 100(10), 1515–			

<b>Readings:</b>	<p>1516.</p> <ol style="list-style-type: none"> <li>2. Reviews in Mineralogy and Geochemistry (2007). Planetary Materials, Volume 68. Mineralogical Society of America, Washington, D.C. ISBN: 978-0-939950-76-7</li> <li>3. Baker, V. R. (2014). Terrestrial analogs, planetary geology, and the nature of geological reasoning. Planetary and Space Science, 95, 5-10.</li> </ol>
<b>Web Resources:</b>	<ol style="list-style-type: none"> <li>1. <a href="https://science.nasa.gov/planetary-science/">https://science.nasa.gov/planetary-science/</a></li> <li>2. <a href="https://www.usgs.gov/centers/astrogeology-science-center/data">https://www.usgs.gov/centers/astrogeology-science-center/data</a></li> <li>3. <a href="https://pilot.wr.usgs.gov/">https://pilot.wr.usgs.gov/</a></li> <li>4. <a href="https://astrogeology-usgs.hub.arcgis.com/">https://astrogeology-usgs.hub.arcgis.com/</a> <a href="https://www.isro.gov.in/Chandrayaan2.html">https://www.isro.gov.in/Chandrayaan2.html</a></li> <li>5. <a href="https://www.isro.gov.in/MOM.html">https://www.isro.gov.in/MOM.html</a></li> </ol>

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<b>Title of the Course</b>	Geoarchaeology
<b>Course Code</b>	GEO-6210
<b>Number of Credits</b>	02
<b>Theory/Practical</b>	Theory
<b>Level</b>	500
<b>Effective from AY</b>	2026-27
<b>New Course:</b>	Yes
<b>Bridge Course/ Value added Course:</b>	No
<b>Course for advanced learners:</b>	No

<b>Pre-requisites for the Course:</b>	NIL	
<b>Course Objectives:</b>	<p>The objectives of this course are:</p> <ol style="list-style-type: none"> <li>1. Introduce the interdisciplinary principles and methods of geoarchaeology.</li> <li>2. Develop an understanding of site formation processes and dating tools used in archaeological contexts.</li> <li>3. Analyze human–environment interactions using geological, geochemical, and palaeoenvironmental evidence.</li> <li>4. Evaluate Indian and global case studies to highlight the role of geology in reconstructing cultural history.</li> </ol>	
<b>Course Outcomes:</b>	By the end of this course, students will be able to:	<b>Mapped to PSO</b>
	CO 1. Explain the scope and methods of geoarchaeology and their integration with archaeology.	PSO 1, PSO2, PSO 3
	CO 2. Describe and compare geoarchaeological dating methods and stratigraphic approaches.	PSO 1, PSO 2, PSO 3, PSO 6

	CO 3. Analyze palaeoenvironmental proxies and provenance studies for reconstructing past environments and resource use.		PSO 2, PSO 3, PSO 5, PSO 6
	CO 4. Evaluate case studies from India and abroad to understand how geoarchaeology informs human cultural evolution.		PSO 2, PSO 3, PSO 5, PSO 6, PSO 7
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b> <b>Cognitive Level</b>
<b>Module1:</b>	Foundations of Geoarchaeology: Definition, scope, and interdisciplinary nature of geoarchaeology. Geological materials in archaeology – soils, sediments, rocks, minerals. Methods of site formation analysis and depositional processes. Stratigraphy, chronology, and dating techniques in geoarchaeology (radiocarbon, OSL, U-series, archaeomagnetism). Remote sensing and GIS applications in archaeological site detection and landscape reconstruction. Human–environment interactions and landscape archaeology (deforestation, agriculture, water management). Quaternary stratigraphy of the Ganga plain; geoarchaeology of the Indus–Saraswati basin	<b>15</b>	CO1, CO2 K2, K3, K4, K5, K6
<b>Module2:</b>	Geoarchaeological Applications and Case Studies: Palaeoenvironmental reconstruction using sediments, pollen, phytoliths, and stable isotopes Provenance and sourcing studies (petrography, geochemistry, isotopes) of ceramics, lithics, metals. Archaeological sites and natural hazards (floods, earthquakes, volcanic events). Indian case studies- 1) Microlithic cultures in Gujarat and Rajasthan (Quaternary dune and lake records), 2) Rock art landscapes of central India and their geomorphic context, 3) Harappan urban water management systems (Dholavira, Lothal), 4) Geoarchaeology of coastal sites (Mahabalipuram, Konkan coast and Goa). Global parallels- Nile Valley geoarchaeology, Mediterranean landscape archaeology, Mayan lowlands	<b>15</b>	CO3, CO4 K2, K3, K4, K5, K6
<b>Pedagogy:</b>	Lectures/ tutorials/ assignments/ discussions		
<b>Texts:</b>	<ol style="list-style-type: none"> <li>Butzer, K. W. (1982). Archaeology as human ecology: Method and theory for a contextual approach. Cambridge: Cambridge University Press.</li> <li>Goldberg, P., Holliday, V. T., &amp; Ferring, C. R. (2017). Earth sciences and archaeology (2nd ed.). New York:</li> </ol>		

	<p>Springer.</p> <ol style="list-style-type: none"> <li>3. Rapp, G., &amp; Hill, C. L. (2006). <i>Geoarchaeology: The earth-science approach to archaeological interpretation</i> (2nd ed.). New Haven: Yale University Press.</li> <li>4. Renfrew, C., &amp; Bahn, P. (2016). <i>Archaeology: Theories, methods, and practice</i> (7th ed.). London: Thames &amp; Hudson.</li> <li>5. Schiffer, M. B. (1987). <i>Formation processes of the archaeological record</i>. Albuquerque: University of New Mexico Press.</li> </ol>
<b>References/ Readings:</b>	<ol style="list-style-type: none"> <li>1. Paddayya, K. (2014). Geoarchaeology in Indian context: Retrospect and prospect. <i>Man and Environment</i>, 39(1), 1–11.</li> <li>2. Rajaguru, S. N., &amp; Korisettar, R. (2000). Geoarchaeology of peninsular India. <i>Current Science</i>, 79(4), 513–515.</li> <li>3. Shahack-Gross, R. (2017). Archaeological formation theory and geoarchaeology: State-of-the-art in 2016. <i>Journal of Archaeological Science</i>, 79, 36-43.</li> <li>4. Singhvi, A. K., &amp; Krbetschek, M. R. (2014). Luminescence dating in archaeology, anthropology, and geoarchaeology: An overview. <i>Quaternary International</i>, 362, 1–4.</li> </ol>
<b>Web Resources:</b>	<ol style="list-style-type: none"> <li>1. <a href="https://www.geoarchaeology.org/">https://www.geoarchaeology.org/</a></li> <li>2. <a href="https://www.britishmuseum.org/our-research/departments/department-africa-oceania-andamericas/geoarchaeology">https://www.britishmuseum.org/our-research/departments/department-africa-oceania-andamericas/geoarchaeology</a></li> <li>3. <a href="https://archaeologydataservice.ac.uk/">https://archaeologydataservice.ac.uk/</a></li> <li>4. <a href="https://www.bsip.res.in/">https://www.bsip.res.in/</a></li> </ol>

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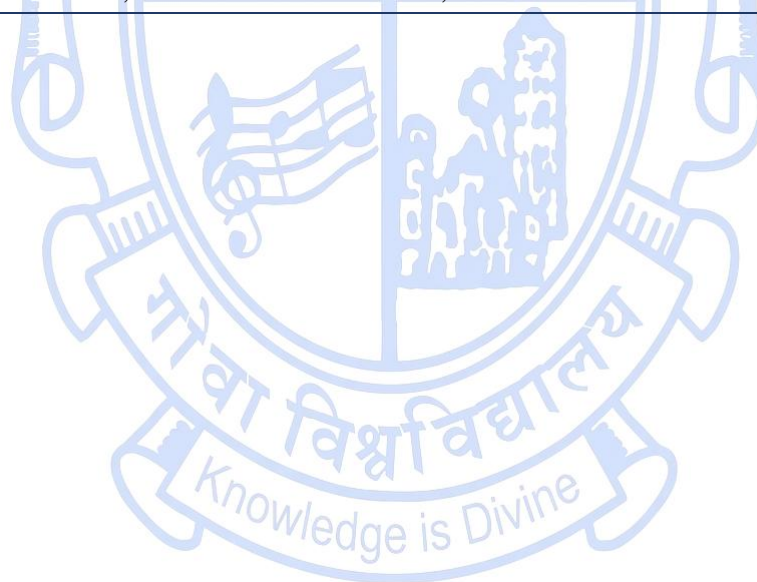
<b>Title of the Course</b>	Forensic Geology
<b>Course Code</b>	GEO-6211
<b>Number of Credits</b>	2
<b>Theory/Practical</b>	Theory
<b>Level</b>	500
<b>Effective from AY</b>	2026-27
<b>New Course:</b>	Yes
<b>Bridge Course/ Value added Course:</b>	No
<b>Course for advanced learners:</b>	No

<b>Pre-requisites for the Course:</b>	Nil	
<b>Course Objectives:</b>	<p>The objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Study applications of geology in forensic investigations.</li> <li>2. Train students in handling soils, sediments, microfossils, and geochemical/isotopic data as forensic evidence.</li> <li>3. Discuss real-world case studies.</li> <li>4. Familiarize students with documentation, reporting, and presentation of geological evidence.</li> </ol>	
<b>Course Outcomes:</b>	At the end of the course, the student will be able to:	<b>Mapped to PSO</b>
	CO 1. Evaluate soil, sediment, fossil, and isotopic signatures as forensic tools.	PSO1, PSO2, PSO3, PSO7
	CO 2. Interpret geochemical and isotopic evidence for provenance and contaminant tracing.	PSO2, PSO3, PSO6, PSO7
	CO 3. Analyze forensic case studies involving criminal, environmental, and fraud contexts.	PSO2, PSO3, PSO6,

		PSO7		
CO 4. Prepare and defend geological evidence within legal and ethical frameworks.		PSO3, PSO6, PSO7		
Content:		No of hours	Mapped to CO	Cognitive Level
<b>Module 1:</b>	<p>Soil characterization: color, texture, mineralogy, chemistry, heavy minerals.  Fingerprinting soils in crime investigation (provenance, matching samples).  Sediments in forensic contexts (river, coastal, aeolian deposits).  Microfossils, spores, pollen, diatoms as trace evidence.  Case studies: soil/sediment evidence in homicide, smuggling, and environmental crimes.  Geological Evidence in Practice  Soils in Forensics: Physical, mineralogical, and chemical characteristics; soil fingerprints.</p>	15	CO1, CO2, CO3	K1, K2, K3, K4, K5, K6
<b>Module 2:</b>	<p>Fossils, Spores &amp; Pollen: Role of biogenic materials in crime investigation.  Environmental Forensics: Groundwater contamination, heavy metals, tracing pollutants.  Material Identification: Rock/mineral provenance, sediment matching, laboratory tools overview.  Mini Exercise: Case review/discussion on soil or contaminant tracing.  Isotope Geochemistry: Stable isotopes, mass spectrometry, provenance tracing.  Fraud Investigations: Gemstones, mining fraud, archaeological artifacts, art forgery.  Documentation &amp; Reporting: Writing forensic reports, evidence presentation.  Expert Witnessing: Role of geologists in court; ethics and admissibility.  Future Trends &amp; Global Outlook: Remote sensing, AI, IoT in forensic geology.</p>	15	CO2, CO3, CO4	K1, K2, K3, K4, K5, K6
<b>Pedagogy:</b>	Case-based lectures, exercises, Seminars, Discussions, Mock reporting / expert witness roleplay.			

<b>Texts:</b>	<ol style="list-style-type: none"> <li>1. Donnelly, L. J., Pirrie, D., Harrison, M., Ruffell, A., &amp; Dawson, L. A. (Eds.). (2021, August). A guide to forensic geology. Geological Society of London.</li> <li>2. Fitzpatrick, R. W., &amp; Donnelly, L. J. (2021). An introduction to forensic soil science and forensic geology: A synthesis. Geological Society, London, Special Publications, 492(1), 1-32.</li> <li>3. Murray, R. C. (2004). Forensic geology: yesterday, today and tomorrow. Geological Society, London, Special Publications, 232(1), 7-9.</li> <li>4. Murray, R. C. (2004). Evidence from the earth: forensic geology and criminal investigation. Mountain Press Publishing.</li> <li>5. Pye, K., &amp; Croft, D. J. (Eds.). (2004). Forensic geoscience: principles, techniques and applications. Geological Society of London.</li> <li>6. Ruffell, A., &amp; McKinley, J. (2005). Forensic geoscience: applications of geology, geomorphology and geophysics to criminal investigations. Earth-Science Reviews, 69(3-4), 235-247.</li> <li>7. Siegel, J. A., &amp; Mirakovits, K. (2015). Forensic science: the basics. CRC Press.</li> </ol>
<b>References/ Readings:</b>	<p>Somma, R., &amp; Maniscalco, R. (2023). FORENSIC GEOLOGY APPLIED TO CRIMINAL INVESTIGATION: A CASE REPORT. <i>AAPP Physical, Mathematical &amp; Natural Sciences/Atti della Accademia Peloritana dei Pericolanti: Classe di Scienze Fisiche, Matematiche e Naturali</i>, 101.</p>

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<b>Title of the Course</b>	Medical Geology
<b>Course Code</b>	GEO-6212
<b>Number of Credits</b>	02
<b>Theory/Practical</b>	Theory
<b>Level</b>	500
<b>Effective from AY</b>	2026-27
<b>New Course:</b>	Yes
<b>Bridge Course/ Value added Course:</b>	No
<b>Course for advanced learners:</b>	No

<b>Pre-requisites for the Course:</b>	NIL	
<b>Course Objectives:</b>	<p>The objectives of this course are:</p> <ol style="list-style-type: none"> <li>1. Introduce the interdisciplinary field of medical geology linking Earth materials and processes with human health.</li> <li>2. Develop understanding of geogenic sources of essential and toxic elements, their pathways, and impacts.</li> <li>3. Provide students with knowledge of analytical and spatial tools used in investigating geological health problems.</li> <li>4. Evaluate case studies from India and worldwide to illustrate applications of medical geology in public health and environmental policy.</li> </ol>	
<b>Course Outcomes:</b>	By the end of this course, students will be able to:	<b>Mapped to PSO</b>
	CO 1. Explain the principles, scope, and interdisciplinary nature of medical geology.	PSO 1, PSO2, PSO 3
	CO 2. Identify geogenic sources and exposure pathways of essential and toxic elements and their health effects.	PSO 1, PSO 2, PSO 3, PSO 6

	CO 3. Analyze methods and tools used in medical geology for tracing, mapping, and evaluating contaminant exposure.		PSO 2, PSO 3, PSO 5, PSO 6
	CO 4. Evaluate case studies from India and abroad to understand the role of geology in addressing public health challenges.		PSO 2, PSO 3, PSO 5, PSO 6, PSO 7
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>
<b>Module1:</b>	Foundations of Medical Geology: Scope and definition of medical geology- global and regional perspectives; Natural distribution and occurrence of elements, Anthropogenic sources. Uptake of elements, particularly trace elements from the food to humans; Essential vs. toxic trace elements. Pathways of exposure: water, soil, air, food, dust, occupational hazards. Natural sources of contaminants: arsenic, fluoride, iodine, selenium, uranium, radon. Human health impacts of geogenic contaminants. Role of mineral dusts and aerosols in respiratory diseases (silicosis, asbestosis, coal dust, desert dust). Positive health impacts of geology – mineral springs, therapeutic clays, natural radioactivity in medicine	15	CO1, CO2 K2, K3, K4, K5, K6
<b>Module2:</b>	Tools, Applications, and Case Studies: Analytical tools and methods- hydrogeochemistry, isotope tracing, GIS mapping, remote sensing in medical geology; Epidemiology and geospatial correlation of diseases with geological environments; Climate change, extreme events, and health linkages in heat waves, floods, droughts, vector-borne diseases. Indian case studies- groundwater arsenic crisis in West Bengal and Bihar, fluorosis in Andhra Pradesh and Rajasthan, endosulfan tragedy in Kerala, coastal salinity and health in Gujarat/Goa. Global case studies: radon and lung cancer in Europe and USA, selenium and Keshan disease in China, iodine deficiency in African rift basins, volcanic emissions and health in Iceland and Hawaii	15	CO3, CO4 K2, K3, K4, K5, K6
<b>Pedagogy:</b>	Lectures/ tutorials/ assignments/ discussions		
<b>Texts:</b>	1. Finkelman, R. B., Centeno, J. A., & Selinus, O. (Eds.). (2005). Medical geology. Dordrecht: Springer. 2. Selinus, O. (Ed.). (2013). Essentials of medical geology: Revised edition. Dordrecht: Springer.		

	<ol style="list-style-type: none"> <li>3. Bowman, C., &amp; Bobrowsky, P. T. (2014). Medical geology: A regional synthesis. Dordrecht: Springer.</li> <li>4. Alloway, B., Centeno, J. A., Finkelman, R. B., Fuge, R., Lindh, U., &amp; Smedley, P. (2005). Essentials of medical geology. O. Selinus (Ed.). Academic Press.</li> <li>5. Dissanayake, C. B., &amp; Chandrajith, R. (2009). Introduction to medical geology. Springer science &amp; business media.</li> <li>6. Komatina, M. (2004). Medical geology: effects of geological environments on human health (Vol. 2). Elsevier.</li> </ol>
<b>References/ Readings:</b>	<ol style="list-style-type: none"> <li>1. Smith, K. R., &amp; Ezzati, M. (2005). How environmental health risks change with development: The epidemiologic and environmental risk transitions revisited. Annual Review of Environment and Resources, 30(1), 291–333.</li> <li>2. Singh, A. K. (2004). Arsenic contamination in groundwater of North Eastern India. Environmental Geology, 46(6–7), 871–879.</li> <li>3. Rao, N. S., &amp; Devadas, D. J. (2003). Fluoride incidence in groundwater in an area of Peninsular India. Environmental Geology, 45(2), 243–251.</li> <li>4. Rajagopalan, S., &amp; Baskar, A. (2012). Radon levels in groundwater and indoor air in South India: Health implications. Radiation Protection Dosimetry, 152(3), 244–251.</li> <li>5. Davies, B. E., Bowman, C., Davies, T. C., &amp; Selinus, O. (2012). Medical geology: Perspectives and prospects. Essentials of medical geology: Revised edition, 1-13.</li> <li>6. Gomes, C. D. S. F., &amp; Silva, J. B. P. (2007). Minerals and clay minerals in medical geology. Applied Clay Science, 36(1-3), 4-21.</li> </ol>
<b>Web Resources:</b>	<ol style="list-style-type: none"> <li>1. <a href="https://www.medicalgeology.org/">https://www.medicalgeology.org/</a></li> <li>2. <a href="https://www.cdc.gov/nceh/">https://www.cdc.gov/nceh/</a></li> <li>3. <a href="https://www.icmr.gov.in/">https://www.icmr.gov.in/</a></li> <li>4. <a href="https://www.cpcb.nic.in/">https://www.cpcb.nic.in/</a></li> <li>5. <a href="https://www.who.int/health-topics/environmental-health">https://www.who.int/health-topics/environmental-health</a></li> </ol>

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