Two-Year Postgraduate Programme

Master of Science

M.Sc. Geology

Faculty of Applied Sciences

Parul University

Vadodara, Gujarat, India

Faculty of Applied Sciences
Master of Geology

1. Vision of the Department

The Geology Department envisions a future where it stands as a beacon of excellence in geoscience education and research. Committed to fostering a dynamic learning environment, we aspire to be a catalyst for knowledge dissemination and community engagement. Our vision encompasses the development of a robust geoscience network that extends beyond academia, involving faculty, students, alumni, and the wider public.

2. Mission of the Department

M1	The Geology Department is dedicated to delivering top-notch education in geological principles, fieldwork, and lab techniques, fostering students' career readiness in academia, industry, and government.
M2	The department is committed to advancing the frontiers of geological via research, impactful studies, scientific journal contributions, and participating in interdisciplinary projects for Earth processes understanding.
M3	The Geology Department aims to instill in its students a deep sense of stewardship for the planet. Through research and outreach programs, the department seeks to address environmental challenges, promote sustainability, and contribute to the conservation of natural resources.
M4	The department is dedicated to fostering connections with local and global communities. Through outreach programs, workshops, and collaborations with other institutions.
M5	The mission includes preparing students for successful professional careers by offering opportunities for internships, field experiences, and networking with industry professionals. The Geology Department is committed to producing graduates who are not only academically proficient but also well-equipped with practical skills and a deep sense of ethical responsibility in the field of geology.

3. Program Educational Objectives

The statements below indicate the career and professional achievements that the B.Sc. Geology curriculum enables graduates to attain:

PEO 1	Ensuring that the students exhibit a solid understanding of geological principles, field methods, and analytical techniques, ensuring their professional competence in the field.
PEO 2	Producing graduates skilled in critical thinking, data analysis, scientific research, decision-making, and innovative problem-solving for environmental management, resource exploration, and hazard assessment.
PEO 3	Preparing graduates skilled in effective communication across various audiences in academic and professional settings, to convey geological knowledge effectively.
PEO 4	Emphasizes ethical conduct, social responsibility, and community well-being, reflecting the department's commitment to responsible global citizenship

4. Program Learning Outcomes

Program Learning outcomes are statements conveying the intent of a program of study.

PLO 1	**Disciplinary Knowledge**	Execute strong theoretical and practical understanding generated from the specific programme in the area of work.
PLO 2	**Critical Thinking and Problem Solving**	Identify the problem by observing the situation closely, take actions and analytical skills to design the solutions.
PLO 3	**Social Competence**	Exhibit thoughts and ideas effectively, build effective interactive and presenting skills to meet global competencies.
PLO 4	**Research-related Skills and Scientific Temper**	Infer scientific literature, build sense of enquiry and identify and consult relevant sources to find answers.
PLO 5	**Trans-disciplinary Knowledge**	Create new conceptual, theoretical and specific approaches to address a common problem.
PLO 6	**Personal and Professional Competence**	Execute interpersonal relationships, self-motivation and adaptability skills and commit to professional ethics.
PLO 7	**Effective Citizenship and Ethics**	Demonstrate empathetic social to professional ethics and responsibility.

PLO 8	**Environment and Sustainability**	Understand the impact of the scientific solutions in societal and environmental contexts.
PLO 9	**Self-directed and Life-long learning**	Acquire the ability to engage in independent and life-long learning in broadest context of socio-technological changes.

5. Program Specific Learning Outcomes

PSO 1	**Recent Research Trends**	The department ensures graduates are well-equipped for modern geology-related industries and research by aligning learning outcomes with the demand for skilled professionals in advanced geotechnical and remote sensing technologies, emphasizing data-driven decision-making and sustainable resource management.
PSO 2	**Evaluation and Analysis**	Developing students' analytical skills, preparing them for impactful contributions in geological research, environmental assessments, and industry applications.

6. Credit Framework

Semester wise Credit distribution of the programme	
Semester-1	26
Semester-2	28
Semester-3	29
Semester-4	19
Total Credits:	**102**

Category wise Credit distribution of the programme	
Category	**Credit**
Major Core	102
Minor Stream	-
Multidisciplinary	-
Ability Enhancement Course	-
Total Credits:	**102**

7. Program Curriculum

Semester 1						
Sr. No.	**Subject Code**	**Subject Name**	**Credit**	**Lect**	**Lab**	**Tut**
1	11211102	Earth Surface Processes	3	3	-	-

2	11211103	Igneous Petrology	3	3	-	-
3	11211104	Metamorphic Petrology	3	3	-	-
4	11211106	Lab-1(Mineralogy and Crystallography)	2	-	4	-
5	11211107	Lab-2(Igneous Petrology)	2	-	4	-
6	11211108	Lab-3(Metamorphic Petrology)	2	-	4	
7	11211109	Lab-4(Sedimentary petrology and sedimentology)	2	-	4	-
8	11211110	Environmental Geology	3	3	-	-
9	11211132	Mineralogy & Crystallography	3	3	-	-
10	11211133	Sedimentology	3	3	-	-
		Total	**26**	**18**	**16**	**-**
Semester 2						
Sr. No.	**Subject Code**	**Subject Name**	**Credit**	**Lect**	**Lab**	**Tut**
11	11211148	Field Geology	4	-	60	-
12	11211149	Stratigraphy	3	3	-	-
13	11211150	Structural Geology & Tectonics	3	3	-	-
14	11211153	Paleontology	3	3	-	-
15	11211154	Remote Sensing and GIS	3	3	-	-
16	11211155	Marine Geology	3	3	-	-
17	11211157	Lab-1 (Structural Geology and Tectonics)	2	-	4	-
18	11211158	Lab-2 (Paleontology)	2	-	4	-
19	11211159	Lab-3 (Remote Sensing and GIS)	2	-	4	-
20	11211160	Engineering Geology	3	3	-	-
		Total	**28**	**18**	**72**	**-**
Semester 3						
Sr. No.	**Subject Code**	**Subject Name**	**Credit**	**Lect**	**Lab**	**Tut**

21	11211202	Mining Geology and Mineral Economics	4	4	-	-
22	11211203	Geochemistry	4	4	-	-
23	11211204	Exploration Geology	4	4	-	-
24	11211205	Hydrogeology	4	4	-	-
25	11211206	Petroleum and Coal Geology	3	3	-	-
26	11211207	Hydrogeology (Lab-1)	2	-	4	-
27	11211208	Instrumentation techniques in geology	3	3	-	-
28	11211209	Petroleum and Coal Geology (Lab 2)	2	-	4	-
29	11211210	Ore Geology	3	3	-	-
			29	**25**	**8**	**-**
Semester 4						
Sr. No.	**Subject Code**	**Subject Name**	**Credit**	**Lect**	**Lab**	**Tut**
30	11211250	Dissertation	15	-	22	-
31	11211256	Comprehensive Viva-Voce	4	-	-	-
		Total	**19**		**22**	**-**

ANNEXURE-III

Semester 1

(1)

a. **Course Name: Earth Surface Processes**

b. **Course Code:** 11211102

c. **Prerequisite:** A comprehensive understanding of the Earth's structure, landforms, and geological processes will provide a context for examining surface processes such as weathering, erosion, and sedimentation.

d. **Rationale:** Crucial for unravelling the intricate mechanisms (like weathering, erosion, sedimentation etc.) driving the transformation of the landscapes of our planet.

e. Course Learning Objective:

CLOBJ 1	Recognize and comprehend the fundamental processes such as erosion, weathering, and sedimentation that govern the dynamic changes on Earth's surface.
CLOBJ 2	Develop the ability to analyze and interpret various landforms, linking their formation to underlying geological and environmental processes.
CLOBJ 3	Acquire quantitative skills for measuring and analyzing Earth surface phenomena, facilitating precise assessments and predictions.
CLOBJ 4	Explore the environmental implications of surface processes, including their impact on ecosystems, water quality, and vulnerability to natural disasters.
CLOBJ 5	Foster an interdisciplinary approach by integrating knowledge from geology, geography, hydrology, and other relevant fields to understand Earth's surface dynamics.

f. Course Learning Outcomes:

CLO 1	Attain a comprehensive understanding of the key Earth surface processes, including erosion, weathering, and sedimentation.
CLO 2	Develop strong analytical skills to interpret and evaluate the formation of various landforms and the factors influencing their development.
CLO 3	Apply acquired knowledge to assess and address environmental challenges related to Earth surface dynamics.

CLO 4	Cultivate critical thinking abilities to analyze and synthesize information, fostering a deeper insight into the complex interactions shaping the Earth's surface.
CLO 5	Demonstrate effective communication skills in conveying scientific findings and insights related to Earth surface processes, both in written and oral formats.

g. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
3	0	0	3	20	20	-	60	-	100

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

h. Course Content:

Sr. No.	Content	Weightage	Teaching Hours
1	**Unit 1:** Introduction to Earth Surface System. Earth's energy balance, hydrological cycle, carbon cycle, heat transfer, topography and bathymetry.	33%	15
2	**Unit 2:** Origin of sediments: weathering and formation of soils, sediment routing systems, sediment and solute in drainage basins, importance and impact of climate change and tectonics on sediment yield and transport.	34%	15
3	**Unit 3:** Fluid and sediment dynamics and transport: Natural substances, settling of grains, types of flows and boundary separation layers, sediment continuity, modes of sediment transport, bedforms and stratification.	33%	15
Total		100%	45

i. Textbook and Reference Book:

1. Holmes, A. (1945). Principles of physical geology. Geologiska Föreningeni Stockholm Förhandlingar, 67(1), 115-116.
2. Strahler, A. N. (2006). Geomorphology: A Systematic Analysis of Late Cenozoic Landforms. Wiley.
3. Bridge, J., &Demicco, R. (2008). Earth Surface Processes, Landforms and Sediment Deposits. Cambridge University Press.
4. Anderson, R. S., & Anderson, S. P. (2010). Geomorphology: The Mechanics and Chemistry of Landscapes. Cambridge University Press.

(2)

Course Name: Igneous Petrology

a. **Course Code:** 11211103
b. **Prerequisite:** Understanding of the basic principles of rock classification, mineral identification, igneous petrology and related geological processes
c. **Rationale:** Provide insights into the Earth's deep-seated processes and the origins and evolution of igneous rocks, which constitute a significant portion of the Earth's crust.
d. **Course Learning Objective:**

CLOBJ 1	Develop the ability to classify igneous rocks based on their mineralogical composition, texture, and overall petrographic characteristics.
CLOBJ 2	Understand the geological processes involved in the formation of igneous rocks, including magma generation, differentiation, and crystallization.
CLOBJ 3	Identifying and characterising minerals within igneous rocks using optical microscopy and other analytical techniques.
CLOBJ 4	Explore the tectonic implications of igneous petrology by examining the relationships between magma generation, volcanic activity, and plate tectonics.
CLOBJ 5	Acquire geochemical analysis skills to interpret igneous rocks' composition and infer their origin, contributing to a broader understanding of Earth's geological history.

e. **Course Learning Outcomes:**

CLO 1	Demonstrate expertise in petrographic analysis for identifying minerals and textures in igneous rocks.
CLO 2	Develop skills in interpreting the geological history of igneous rocks, encompassing their origin, evolution, and formation conditions.
CLO 3	Understand the tectonic context of igneous processes, linking the characteristics of different rock types to specific plate tectonic settings.
CLO 4	Gain a deep understanding of geochemical principles and techniques, allowing for the interpretation of major and trace element compositions in igneous rocks.
CLO 5	Apply acquired knowledge to independent research projects, contributing to advancements in igneous petrology through critical analysis and scientific inquiry.

f. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
3	0	0	3	20	20	-	60	-	100

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

g. Course Content:

Sr. No.	Content	Weightage	Teaching Hours
1	**Unit 1:** Physics of magma generation in the mantle. Magma –Physical & chemical properties, Mechanism of magmatic intrusion. Physical processes related to the extrusive and intrusive forms of igneous bodies and cooling of magma	**33%**	**15**
2	**Unit 2:** Classification of igneous rocks Mode and norms, CIPW norm calculation, IUGS classification of volcanic and plutonic rocks, Le Bas et al and Irvine-Baragar classifications	**33%**	**15**
3	**Unit 3:** Thermodynamics Laws and Gibbs energy, phase equilibria in Binary system, ternary system and Quaternary system Magmatic processes Compositional variation, crystal setting, Magmatic assimilation, mixing and trace element fractionation	**34%**	**15**
Total		**100%**	**45**

h. Textbook and Reference Book:

1. Winter, J. D. (2001). An Introduction to Igneous and Metamorphic Petrology. Prentice Hall.
2. Best, M. G., & Christiansen, E. H. (2001). Igneous Petrology. Jones & Bartlett Learning.
3. Philpotts, A. R., & Ague, J. J. (2009). Principles of Igneous and Metamorphic Petrology. Cambridge University Press.

(3)

a. **Course Name: Metamorphic Petrology**
b. **Course Code:** 11211104
c. **Prerequisite:** Proficiency in recognizing and classifying different types of rocks, minerals, and their associated structures lays the groundwork for comprehending the complex processes involved in metamorphic transformations.
d. **Rationale:** This discipline offers a profound understanding of the mineralogical and structural changes that rocks undergo due to temperature, pressure, and chemical alterations, contributing significantly to deciphering regional tectonic events.
e. **Course Learning Objective:**

CLOBJ 1	Comprehensively understand metamorphic processes influenced by temperature, pressure, and chemically active fluids.
CLOBJ 2	Master the identification and characterization of metamorphic minerals and textures through microscopic analysis to recognize key indicators of metamorphic conditions.
CLOBJ 3	Classify metamorphic rocks by evaluating mineral assemblages, textures, and protolith features, enabling interpretation of their geological history and conditions.
CLOBJ 4	Examine metamorphic rocks in a broader geological context to understand Earth's dynamic processes, tectonics, and regional histories.
CLOBJ 5	Develop fieldwork skills to recognize and interpret metamorphic rocks in natural settings through mapping exercises, field observations, and correlating data with theoretical knowledge.

f. **Course Learning Outcomes:**

CLO 1	Understanding of the mechanisms and conditions leading to metamorphism, including the effects of temperature, pressure, and fluid interactions on rock formations.
CLO 2	Develop the ability to identify and interpret metamorphic minerals and textures, utilizing advanced microscopic techniques for accurate mineralogical analysis.

CLO 3	Acquire expertise in classifying metamorphic rocks using mineral assemblages, textures, and protolith characteristics to interpret geological histories and metamorphic environments.
CLO 4	Develop practical fieldwork skills to identify and document metamorphic rocks in natural settings, improving the ability to apply theoretical knowledge in real-world geological contexts.
CLO 5	Cultivate research skills to critically analyze and interpret metamorphic petrology data, enabling meaningful contributions to scientific inquiries and advancing understanding in the field.

g. Teaching & Examination Scheme:

Teaching Scheme				**Evaluation Scheme**					
L	**T**	**P**	**C**	**Internal Evaluation**			**ESE**		**Total**
				MSE	**CE**	**P**	**Theory**	**P**	
3	**0**	**0**	**3**	**20**	**20**	**-**	**60**	**-**	**100**

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

h. Course Content:

Sr. No.	**Content**	**Weightage**	**Teaching Hours**
1	**Unit 1:** Nature of Metamorphism: Introduction, Agents, types of metamorphism, types of protolith, Classification of metamorphic rocks, Famous case studies of the world.	**30%**	**15**
2	**Unit 2:** Structures and Textures of metamorphic rocks: process of deformation, recrystallization, Textures of dynamic, regional, contact, non-foliated rocks, Origin of fabrics in metamorphic system	**34%**	**15**
3	**Unit 3:** Metamorphic facies, metamorphism of mafic and ultramafic rocks, Field relation of metamorphic	**36%**	**15**

	bodies and metamorphic facies, Metamorphism of pelitic sediments: Diagenesis and low-grade metamorphism of pelites, medium grade, AFM diagrams, partial melting of pelites, High P/T metamorphism of pelites, migmatites.		
Total		**100%**	**45**

i. Textbook and Reference Book:

1. Winter, J. D. (2010). Principles of Igneous and Metamorphic Petrology (2nd ed.). Pearson.
2. Best, M. G. (2003). Igneous and Metamorphic Petrology. Wiley-Blackwell.
3. Vernon, R. H. (2004). A Practical Guide to Rock Microstructure. Cambridge University Press.
4. Yardley, B. W. D. (2018). An Introduction to Metamorphic Petrology. Cambridge University Press.
5. Philpotts, A. R., & Ague, J. J. (2009). Principles of Igneous and Metamorphic Petrology (2nd ed.). Cambridge University Press.

(4)

a. **Course: Environmental Geology**
b. **Course code: 11211110**
c. **Prerequisite:** Basic understanding geology, chemistry, biology, mathematics, and physics.
d. **Rationale:** Acquire knowledge about environmental challenges such as natural hazards, pollution, land use planning, and resource management.

e. **Course Learning Objective:**

CLOBJ 1	Acquire knowledge about Earth's geological processes and their impact on the environment.
CLOBJ 2	Understand the environmental hazards such as earthquakes, volcanic eruptions, and landslides.
CLOBJ 3	Evaluate the distribution and sustainable management of Earth's resources like minerals, water, and energy sources
CLOBJ 4	Understand the Impact of human activities such as pollution, deforestation, and climate change on geological systems

f. **Course Learning Outcomes:**

CLO 1	Analyze and evaluate geological processes and their impact on the environment, including natural hazards, resource management, and anthropogenic activities.
CLO 2	Develop strategies for sustainable management and exploration of natural resources, integrating principles of environmental stewardship and economic feasibility.
CLO 3	Apply advanced methods for conducting environmental assessments and designing mitigation plans to address soil, water, and air pollution caused by geological and human activities.
CLO 4	Utilize geospatial tools, modeling software, and laboratory techniques to investigate environmental geology issues, interpret data, and provide evidence-based solutions.

CLO 5	Conduct independent research in environmental geology, demonstrating critical thinking, effective communication, and adherence to ethical standards in addressing contemporary environmental challenges.

g. Teaching and Examination Scheme

Teaching Scheme				Examination Scheme					Total
Lecture Hrs / week	Tutorial Hrs / week	Lab Hrs / Week	Credit	Internal Marks			External Marks		
				T	P	CE	T	P	
3	-	-	3	20	-	20	60	-	100

Lect - Lecture, Tut - Tutorial, Lab - Lab, T - Theory, P - Practical, CE - CE, T - Theory, P - Practical

h. Course Content

Sr. No.	Topics	W	T
1	**Unit 1:** Fundamental Concepts of Environmental Geology. Environmental Degradation. Pollution- types, Factors. Air pollution, Surface and Ground Water Pollution. Water Management. Sediments and soil erosion. Sediment Pollution.	25%	11
2	**Unit 2:** Natural Hazards: Earthquakes, Volcanos, and Landslides. Environmental and Human Health: Biogeochemical factors in environmental health, Trace elements and health.	25%	11
3	**Unit 3:** Energy Resources and Crisis. Mining: Opencast, Underground, Solid Waste Generation, Dumping Stacking, Re-Handling, Management, Mineral Processing, Tailing Ponds, Acid Mine Drainage, Siltation, Case Studies.	25%	11
4	**Unit 4:** Alternative Energy Resources. Waste: Introduction, Types And Their Disposal. Role of Geology in Waste Disposal. Land use planning: Soil Surveys Land Use Impact. Greenhouse gases and CO_2 Sequestration	25%	12
Total		100%	45

i. Textbook and Reference Books

1. Ronald W. Tank, Environmental Geology, Oxford, 1983.
2. Keller, E. A., Environmental Geology, Printice Hall, 2010.
3. K. S. Valdiya, Environmental Geology: Indian Context, McGraw-Hill, 1987.

(5)

a. **Course Name:** Mineralogy & Crystallography

b. **Course Code:** 11211132

c. **Prerequisite:** Understanding of geology, mathematics, and chemistry is essential for studying Mineralogy and Crystallography, providing the necessary context for the examination of minerals.

d. **Rationale:** Studying "Mineralogy and Crystallography" is pivotal as it equips students with a deep understanding of the diverse compositions and crystal structures of the rock-forming minerals.

e. **Course Learning Objective:**

CLOBJ 1	Develop the ability to identify minerals based on their physical and optical properties, such as colour, hardness, cleavage, and crystal form.
CLOBJ 2	Grasp fundamental concepts of crystallography, including crystal systems, symmetry elements, and unit cell structures.
CLOBJ 3	Familiarize with polarizing microscopes to analyze mineral properties under different lighting, aiding in identifying minerals by their optical characteristics
CLOBJ 4	Gain practical skills in utilizing X-ray diffraction methods for the analysis of crystal structures, providing insights into the crystal lattice.
CLOBJ 5	Study geological and chemical processes shaping mineral formation, grasping the environmental factors impacting mineral evolution.

f. Course Learning Outcomes:

CLO 1	Demonstrate the ability to accurately identify minerals through comprehensive analysis of their physical and optical properties.
CLO 2	Exhibit a solid grasp of crystallography principles, including crystal systems, symmetry, and diffraction.
CLO 3	Develop practical skills in mineralogy and crystallography laboratory techniques, showcasing competence in using microscopy and X-ray diffraction for mineral characterization.

CLO 4	Develop ability to classify minerals based on chemical composition, crystal structure, and other relevant criteria, using established classification systems.
CLO 5	Applying mineralogical concepts to real-world scenarios, such as interpreting geological processes, identifying ore minerals, and understanding the role of minerals in various geological environments.

g. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
3	0	0	3	20	20	-	60	-	100

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

h. Course Content:

Sr. No.	Content	Weightage	Teaching Hours
1	**Unit 1: Mineralogy** Atomic structures and mineral chemistry and diagnostic properties of rock forming minerals including clay minerals techniques of mineral identification. All silicates, sulphates, carbonates, native minerals, sulphides, oxides etc.	**25%**	**12**
2	**Unit 2: Optics** Properties of light, polarization, interference of light waves, measurement of RI, Pleochroism, Birefringence, Optic orientation in different crystallographic systems. Determination of optic sign of uniaxial and biaxial minerals, determination of optic axial angle, principle of U-stage techniques.	**25%**	**11**
3	**Unit 3: Crystallography**	**25%**	**11**

	Elementary ideas about crystal morphology in relation to internal structures Crystal parameters and indices Crystal symmetry and classification of crystals into six systems and 32 point groups.		
4	**Unit 4: Crystal Symmetry and Projection** Elements of crystal chemistry and aspects of crystal structures Stereographic projections of symmetry elements and forms.	**25%**	**11**
Total		**100%**	**45**

i. Textbook and Reference Book:

1. Klein C. and Hurlbut (1993), Manual of Mineralogy (after James D. Dana), XXI, 700 p. Wiley.
2. Andrew Putnis (1992), Introduction to Mineral Sciences, Cambridge University Press.
3. William D. Nesse (2008), Introduction to Mineralogy, Oxford University Press
4. Deer, W. A., Howie, R. A., &Zussman, J. (2013). An introduction to the rock-forming minerals. Mineralogical Society of Great Britain and Ireland.

(6)

a. **Course Name:** Sedimentology
b. **Course Code:** 11211133
c. **Prerequisite:** Proficiency in the fundamental principles essential for interpreting sedimentary rocks, their formation mechanisms, and understanding the geological processes that shape them.
d. **Rationale:** The course offers essential knowledge for interpreting the geological history recorded in sedimentary rocks, unraveling past environmental conditions, and understanding the evolution of sedimentary basins.
e. **Course Learning Objective:**

CLOBJ 1	Develop a thorough comprehension of the processes governing the formation, transportation, and deposition of sediments, including the roles of weathering, erosion, and sediment transport mechanisms.
CLOBJ 2	Acquire skills in the systematic identification and classification of sedimentary rocks, including the ability to recognize key sedimentary structures and textures through microscopic analysis.
CLOBJ 3	Gain expertise in stratigraphic principles, allowing for the interpretation of sedimentary sequences, correlation of rock layers, and reconstruction of past environments based on stratigraphic relationships.
CLOBJ 4	Learn to infer paleoenvironments from sedimentary rocks, utilizing knowledge of sedimentary structures and fossil content to reconstruct past climatic and depositional conditions.
CLOBJ 5	Develop the ability to analyze sedimentary basins, including the identification of basin types, understanding tectonic controls, and interpreting the sedimentary fill to reconstruct the geological history of the basin.

f. **Course Learning Outcomes:**

CLO 1	Attain a high level of proficiency in identifying and characterizing sedimentary rocks, showcasing the ability to recognize and interpret key features, textures, and mineralogical compositions.

CLO 2	Demonstrate competence in interpreting stratigraphic sequences, correlating sedimentary layers, and reconstructing geological histories based on sedimentary principles, enhancing skills in chronological analysis.
CLO 3	Develop a nuanced understanding of paleoenvironments by analyzing sedimentary structures, fossils, and mineralogical content, allowing for the reconstruction of past climatic and depositional conditions.
CLO 4	Acquire skills in sedimentary basin analysis, including the identification of basin types, recognition of tectonic influences, and the interpretation of sedimentary fill, contributing to a comprehensive understanding of basin evolution.
CLO 5	Apply sedimentary petrology and sedimentology knowledge to solve practical geological problems, demonstrating the ability to analyze and interpret complex scenarios, enhancing problem-solving skills applicable to real-world geological challenges.

g. Teaching & Examination Scheme:

Teaching Scheme				**Evaluation Scheme**					
L	**T**	**P**	**C**	**Internal Evaluation**			**ESE**		**Total**
				MSE	**CE**	**P**	**Theory**	**P**	
3	**0**	**0**	**3**	**20**	**20**	**-**	**60**	**-**	**100**

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

h. Course Content:

Sr. No.	**Content**	**Weightage**	**Teaching Hours**
1	**Unit 1:** Textural elements of terrigenous rocks. Importance of structures and textures in basin studies. Sedimentary structures and hydrodynamic condition of sediments	**25%**	**10**
2	**Unit 2:** Gravels, Conglomerates &Breccias; Sands &Sandstones; Shales, Argillites & Siltstones; Limestones& Dolomites; Non-Clastic Sediments;	**25%**	**12**

	Diagenesis and fluid flow, Lithification; Provenance		
3	**Unit 3:** Sedimentary environments and facies: Physical and chemical parameters of depositional environments; Classification of environments	**25%**	**12**
4	**Unit 4:** Structures and vertical sequences formed in alluvial, deltaic, coastal, deep sea, aeolian& carbonate environments, Evolution of Sedimentary basins	**25%**	**11**
Total		**100%**	**45**

i. Textbook and Reference Book:

1. Nichols, G. (2009). Sedimentology and Stratigraphy. Wiley-Blackwell.
2. Pettijohn, F. J., Potter, P. E., & Siever, R. (1987). Sand and Sandstone. Springer.
3. Prothero, D. R., & Schwab, F. (2004). Sedimentary Geology: An Introduction to Sedimentary Rocks and Stratigraphy. W. H. Freeman.
4. Boggs, S. (2009). Principles of Sedimentology and Stratigraphy. Pearson.
5. Tucker, M. E. (2001). Sedimentary Petrology: An Introduction to the Origin of Sedimentary Rocks. Wiley.

Semester 2

(1)

a. **Course Name:** Field Geology

b. **Course Code:** 11211148

c. **Prerequisite:** A prerequisite for Geological Field Work is a strong foundation in basic geology and fieldwork techniques, ensuring students possess the necessary skills for effective geological observation and mapping in outdoor environments.

d. **Rationale:** Geological Field Work is essential as it provides hands-on experience for students to apply theoretical knowledge in real-world geological settings, enhancing observational skills, geological mapping proficiency, and fostering a practical understanding of geological processes.

e. **Course Learning Objective:**

CLOBJ 1	Develop proficiency in making detailed geological observations and collecting field data using appropriate tools and techniques, including compass, rock hammer, GPS, and field notebooks.
CLOBJ 2	Acquire skills in geological mapping, including the interpretation of rock outcrops, stratigraphic relationships, and structural features in the field.
CLOBJ 3	Analyze and interpret sedimentary rock sequences, identifying stratigraphic units, depositional environments, and potential indicators of paleoenvironments.
CLOBJ 4	Demonstrate an understanding of structural geology principles by recognizing and interpreting geological structures such as faults, folds, joints, and cleavage in field exposures.
CLOBJ 5	Enhance field safety awareness and navigation skills, assessing hazards, planning safe routes, and responding to emergencies. Identify rocks and minerals by distinguishing key characteristics for geological classification.

f. Course Learning Outcomes:

CLO 1	Demonstrating the ability to make accurate geological observations and collect relevant field data using appropriate tools and techniques.

CLO 2	Proficiency in geological mapping, interpreting rock outcrops, identifying stratigraphic sequences, and delineating structural features in the field.
CLO 3	Analyzing sedimentary rock sequences to identify and interpret stratigraphic units, depositional environments, and paleoenvironmental indicators.
CLO 4	Applying structural geology principles to interpret geological structures like faults, folds, joints, and cleavage in field exposures. Understanding safety by assessing hazards, planning safe routes, and responding to emergencies during fieldwork.
CLO 5	Identifying common rocks and minerals in the field, utilizing mineralogical and petrological characteristics for accurate classification. Analyzing field observations and data to construct geological interpretations, forming hypotheses about the geological history and evolution of the field area.

g. Teaching & Examination Scheme:

Teaching Scheme				**Evaluation Scheme**					
L	**T**	**P**	**C**	**Internal Evaluation**			**ESE**		**Total**
				MSE	**CE**	**P**	**Theory**	**P**	
-	**-**	**60**	**4**	**-**	**-**	**-**	**-**	**100**	**100**

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

h. Textbook and Reference Book:

1. "Geological Field Techniques" by Angela L. Coe
2. "Mapping Hacks: Tips & Tools for Electronic Cartography" by Schuyler Erle, Rich Gibson, and Jo Walsh
3. "The Mapping of Geological Structures" by Ken McClay
4. "Field Geology Illustrated" by Terry Maley
5. "Field Techniques for Geologists: A Guide to the Advanced Study of Field Geology" by John H. Dilles and Terry R. Naumann
6. "Field Hydrogeology" by Rick Brassington

(2)

a. **Course Name:** Stratigraphy
b. **Course Code:** 11211149
c. **Prerequisite:** A foundational understanding of general geology, petrology, structural geology and basic knowledge of the geological history of the Indian subcontinent.
d. **Rationale:** Offering valuable insights for interpreting regional stratigraphic sequences and understanding the geological evolution of this diverse and complex south asian continent.
e. **Course Learning Objective:**

CLOBJ 1	Define and explain the fundamental principles of stratigraphy, including the law of superposition, original horizontality, and lateral continuity.
CLOBJ 2	Demonstrate proficiency in using stratigraphic techniques, such as field mapping, core analysis, and stratigraphic correlation, to interpret geological history and reconstruct depositional environments.
CLOBJ 3	Evaluate the geological history of India, considering tectonic events, sedimentary processes, and the formation of major geological features.
CLOBJ 4	Recognize and differentiate key stratigraphic units in India, including major formations and their lithological characteristics.
CLOBJ 5	Explain the relationship between stratigraphy and tectonics, particularly in the context of India's dynamic geological setting, including the roles of plate tectonics and regional uplift.

f. **Course Learning Outcomes:**

CLO 1	Able to articulate and apply the fundamental principles of stratigraphy, including the law of superposition, original horizontality, and lateral continuity.
CLO 2	Demonstrating the ability to interpret and reconstruct past depositional environments using stratigraphic techniques such as facies analysis, sedimentary structures, and paleontological data.

CLO 3	Efficiency in analyzing and demonstrating the geological history of India, incorporating major tectonic events, sedimentary processes, and the development of key geological features.
CLO 4	Able to identify and differentiate major stratigraphic units in India, understanding their lithological characteristics and regional variations.
CLO 5	Evaluating the economic significance of various stratigraphic units in India, considering their implications for resource exploration, groundwater management, and geological hazard assessment.

g. Teaching & Examination Scheme:

Teaching Scheme				**Evaluation Scheme**					
L	**T**	**P**	**C**	**Internal Evaluation**			**ESE**		**Total**
				MSE	**CE**	**P**	**Theory**	**P**	
3	**0**	**0**	**3**	**20**	**20**	**-**	**60**	**-**	**100**

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

h. Course Content:

Sr. No.	**Content**	**Weightage**	**Teaching Hours**
1	**Unit 1** Precambrian, Palaeozoic, Mesozoic and Cenozoic Standard Stratigraphy. Various techniques adopted for Stratigraphical analysis: Lithostratigraphy and Chronostratigraphy, Biostratigraphy, Sequence Stratigraphy, Magnetostratigraphy, Seismostratigraphy	**25%**	**12**
2	**Unit 2:** Tectonic Framework of India: Tectonic divisions, Cratons (Dharwar and Aravalli), Mobile belts (Eastern Ghat, Satpura and Precambrian of Himalaya), Proterozoic Sedimentary basins: Paleoproterozoic (Bijawar, Gwaliar, Papaghni Sub-basin) and Mesoproterozoic Basins (Vindhyan, Chattisgarh, Parinatha-Godavari, Cuddapah)	**25%**	**11**

3	**Unit 3:** Proterozoic Sedimentary basins: Paleoproterozoic (Bijawar, Gwalior, Papaghni Sub-basin) and Mesoproterozoic Basins (Vindhyan, Chhattisgarh, Parinatha-Godavari, Cuddapah)	**25%**	**11**
4	**Unit 4:** Quaternary Developments in India: Himalayas, Indo-Gangetic Plains, Peninsular India	**25%**	**11**
Total		**100%**	**45**

i. Textbook and Reference Book:

1. "Stratigraphy: A Modern Synthesis" by Andrew D. Miall
2. "Principles of Sedimentology and Stratigraphy" by Sam Boggs Jr.
3. "Stratigraphy: Theory and Methods" by Philip C. Brenchley and Peter F. Rawson
4. "Stratigraphy and Timescales" by Mike O. Wood and Anthony D. Smith
5. "Geology of India" by V.P. Dimri, T. N. Singh, and R. K. Gaur
6. "Stratigraphic Reservoir Characterization for Petroleum Geologists, Geophysicists, and Engineers" by Roger M. Slatt and Raymond N. Pilcher
7. "Introduction to Stratigraphy" by Peter Doyle
8. "Indian Stratigraphy" by R. Vaidyanadhan
9. "Stratigraphy of Indian Basins" edited by G.S. Roonwal and V.P. Dimri

(3)

a. **Course Name:** Structural Geology & Tectonics
b. **Course Code:** 11211150
c. **Prerequisite:** A strong foundation in introductory geology courses, coupled with a comprehensive understanding of rock types, geological processes, and basic fieldwork skills. Prior knowledge of mineralogy and petrology is recommended for a deeper grasp of structural complexities.
d. **Rationale:** Provide a detailed understanding of various crustal deformation processes, enabling students to analyze geological structures and interpret tectonic events crucial for resource exploration, hazard assessment, and geological mapping.
e. **Course Learning Objective:**

CLOBJ 1	Define and explain fundamental concepts in structural geology, such as stress, strain, deformation, and geological structures.
CLOBJ 2	Develop the ability to recognize and classify various geological structures, including folds, faults, joints, and shear zones, using field observations, maps, and cross-sections.
CLOBJ 3	Use geological maps and cross-sections to interpret subsurface geological structures and gain insights into the three-dimensional geometry of the Earth's crust.
CLOBJ 4	Interpret the tectonic environments associated with different geological structures, recognizing the influence of plate tectonics on the formation of mountain belts, rift zones, and sedimentary basins.
CLOBJ 5	Examine the processes and mechanisms responsible for crustal deformation, including brittle and ductile deformation, and relate them to the tectonic setting.

f. **Course Learning Outcomes:**

CLO 1	Able to proficiently analyze geological structures, including folds, faults, and joints, using appropriate analytical techniques and tools.

CLO 2	Apply geological mapping skills to interpret and create geological maps, integrating structural geology principles to understand the spatial distribution of geological features.
CLO 3	Identify and interpret tectonic features on geological maps and cross-sections, correlating them with specific tectonic environments and processes.
CLO 4	Evaluate the different mechanisms of crustal deformation, distinguishing between brittle and ductile deformation, and recognizing their geological implications.
CLO 5	Effectively communicate geological findings and interpretations through written reports, presentations, and discussions, using appropriate scientific terminology.

g. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
3	0	0	3	20	20	-	60	-	100

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

h. Course Content:

Sr. No.	Content	Weightage	Teaching Hours
1	**Unit 1: Kinematic and dynamic analysis** Importance of primary and secondary structures. Stress and strain in deformational domains. Classification and mechanism of folding	**25%**	**11**
2	**Unit 2:** Application of linear and planar features. Shear zones. Mechanical aspects and classification of faults, strike slip and thrust fault systems. Fault propagated folding	**25%**	**11**
3	**Unit 3:** Balanced cross section. Classification and orientation analysis of joints. Crystallization and deformation.	**25%**	**12**

4	**Unit 4:** Plate Tectonics: Concepts and boundaries, seafloor spreading, case studies of the world, paleomagnetism, hot spots, mantle plumes, convection and mechanism, Tectonic Setting, Oceanic ridges, Ophiolites, Cratons and passive margins, Continental rifts, Arc systems, Orogens	**25%**	**11**
Total		**100%**	**45**

i. Textbook and Reference Book:

1. "Structural Geology" by Haakon Fossen
2. "Tectonics" by Eldridge M. Moores and Robert J. Twiss
3. "Principles of Structural Geology" by John Suppe
4. "Introduction to Structural Geology" by Richard H. Groshong
5. "Structural Geology: Fundamentals and Modern Developments" by S.K. Ghosh
6. "Tectonics and Structural Geology: An Introduction" by Christopher H. Scholz
7. "An Introduction to Geological Structures and Maps" by George M. Bennison
8. "Earth Structure: An Introduction to Structural Geology and Tectonics" by Ben A. van der Pluijm and Stephen Marshak
9. "Atlas of Structural Geology" by Soumyajit Mukherjee
10. "Structural Geology of Rocks and Regions" by George H. Davis and Stephen J. Reynolds

(4)

a. Course Name: Paleontology

b. Course Code: 11211153

c. Prerequisite: A prerequisite for Paleontology is a fundamental background in biology, geology, or related disciplines, providing students with a basic understanding of evolutionary principles and the Earth's history.

d. Rationale: Offer a unique exploration of Earth's history through the study of fossils, fostering a deeper understanding of evolutionary processes, biodiversity, and past ecosystems, with implications for modern biological and environmental sciences.

e. Course Learning Objective:

CLOBJ 1	Articulate a comprehensive understanding of geological and biological concepts essential to Paleontology, including sedimentary processes, fossilization, evolution, and stratigraphy.
CLOBJ 2	Develop proficiency in recognizing, describing, and classifying various fossil specimens, spanning different taxonomic groups and geological periods.
CLOBJ 3	Analyze and interpret paleoenvironments by integrating information from fossils, sedimentary rocks, and other geological indicators, enabling the reconstruction of past ecosystems.
CLOBJ 4	Evaluate and discuss evolutionary patterns, trends, and events revealed by the fossil record, considering the impact of major extinction events and adaptive radiations.
CLOBJ 5	Acquire skills in utilizing analytical techniques such as microscopy, isotopic analysis, and other modern tools employed in paleontological research to interpret fossil records.

f. Course Learning Outcomes:

CLO 1	Able to identify, describe, and classify fossil specimens across various taxonomic groups, demonstrating a comprehensive understanding of the diversity of ancient life forms.

CLO 2	Possess the skills to reconstruct and interpret past environments based on fossil assemblages, sedimentary rocks, and geological indicators, allowing for a nuanced understanding of ancient ecosystems.
CLO 3	Proficient in applying a range of analytical techniques, including microscopy, isotopic analysis, and digital tools, to conduct advanced paleontological research and draw meaningful conclusions.
CLO 4	Demonstrating the ability to think critically and solve complex problems related to paleontological research, incorporating geological and biological principles to address scientific inquiries.
CLO 5	Understanding the interdisciplinary nature of Paleontology, integrating knowledge from geology, biology, and other related fields to contribute to a holistic understanding of Earth's history and the evolution of life.

g. Teaching & Examination Scheme:

Teaching Scheme				**Evaluation Scheme**					
L	**T**	**P**	**C**	**Internal Evaluation**			**ESE**		**Total**
				MSE	**CE**	**P**	**Theory**	**P**	
3	**0**	**0**	**3**	**20**	**20**	**-**	**60**	**-**	**100**

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

h. Course Content:

Sr. No.	**Content**	**Weightage**	**Teaching Hours**
1	**Unit 1: Principles of Paleontology** Structural variations and diversity in fossils, theories of evolution of life, principles of taxonomic classification, species concepts, taxonomic nomenclature	**33%**	**15**
2	**Unit 2: Ichnology and micropaleontology** Classification and environmental significance of trace fossils, animal sediment relationship. Types of microfossils Collection and preparation techniques of microfossils, morphology and classification of foraminifera, study of some common	**34%**	**15**

	benthic and planktonic foraminifera, applications of micropalaeontology.		
3	**Unit 3: Application of fossils in age determination and correlation** Paleoecology, Paleobiogeography. Modes of preservation of fossils. Environmental significance of fossils and trace fossils. Use of microfossils in interpretation of sea floor tectonism. Important vertebrate fossils, plant fossils and microfossils in Indian stratigraphy.	**33%**	**15**
Total		**100%**	**45**

i. Textbook and Reference Book:

1. "The Fossil Book: A Record of Prehistoric Life" by Carroll L. Fenton and Mildred Adams Fenton
2. "The Complete Illustrated Guide to Minerals, Rocks & Fossils of the World" by John Farndon
3. "Fossil Invertebrates" by Raymond C. Moore and Curt Teichert
4. "Paleontology: The Record of Life" by Richard Cowen
5. "Principles of Paleontology" by Michael Foote
6. "Introduction to Paleobiology and the Fossil Record" by Michael J. Benton and David A. T. Harper
7. "Invertebrate Palaeontology and Evolution" by Euan N. K. Clarkson
8. "Vertebrate Paleontology" by Michael J. Benton
9. "Fossil Invertebrates" by Raymond C. Moore and Curt Teichert

(5)

a. **Course Name:** Remote Sensing and GIS
b. **Course Code:** 11211154
c. **Prerequisite:** A basic understanding of geography, environmental science, or a related field, providing students with basic knowledge in spatial analysis and mapping concepts.
d. **Rationale:** Provide essential skills for harnessing geospatial technologies, enabling students to analyze and interpret spatial data crucial for applications in environmental monitoring, urban planning, and natural resource management.
e. **Course Learning Objective:**

CLOBJ 1	Gain remote sensing and GIS basics: electromagnetic principles, satellite sensors, spatial data, and GIS models.
CLOBJ 2	Acquire expertise in operating and calibrating remote sensing gear, spanning satellites, drones, and ground-based tools.
CLOBJ 3	Proficiency in interpreting remote sensing imagery for extracting key data, including land cover classification, change detection, and environmental feature identification.
CLOBJ 4	Show adeptness in gathering, organizing, and managing spatial data with GIS software, accounting for diverse data sources, formats, and metadata standards.

f. **Course Learning Outcomes:**

CLO 1	Understanding core remote sensing and GIS concepts, encompassing electromagnetic radiation principles, sensor technologies, spatial data models, and GIS functionalities.
CLO 2	Analyzing remote sensing imagery, employing advanced techniques such as land cover classification, change detection, and feature extraction.
CLO 3	Proficiency in applying spatial analysis techniques in GIS, utilizing methods like buffering, overlay analysis, proximity analysis, and suitability modeling to solve spatial problems.

CLO 4	Applying remote sensing and GIS tools for environmental monitoring and assessment, analyzing land use changes, deforestation, urbanization, and other ecological dynamics proficiently.

g. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
3	0	0	3	20	20	-	60	-	100

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

h. Course Content:

Sr. No.	Content	Weightage	Teaching Hours
1	**Unit 1:** Principles of Remote Sensing: General Idea, Aerial Photographs and their Geometry, Photogrammetry, Recent Advancements and Applications, Satellite Remote Sensing, Image Interpretation and Digital Processing Techniques	**35%**	**15**
2	**Unit 2:** Geological Studies: Image Characters and their relations with ground objects based on tone, texture and pattern	**30%**	**15**
3	**Unit 3:** Principles of terrain analysis, evaluation of ground water potential, rock type identification, interpretation of topographic and tectonic features	**35%**	**15**
Total		**100%**	**45**

i. Textbook and Reference Book:

1. "Remote Sensing and GIS for Ecologists: Using Open Source Software" by Martin Wegmann, Benjamin Leutner, and Stefan Dech

2. "Remote Sensing and GIS Integration: Theories, Methods, and Applications" by QihaoWeng
3. "Introduction to Geographic Information Systems" by Kang-Tsung Chang
4. "Remote Sensing of the Environment: An Earth Resource Perspective" by John R. Jensen
5. "GIS Fundamentals: A First Text on Geographic Information Systems" by Paul Bolstad
6. "Geographic Information Science and Systems" by Paul A. Longley, Michael F. Goodchild, David J. Maguire, and David W. Rhind
7. "GIS Tutorial 1: Basic Workbook" by Wilpen L. Gorr and Kristen S. Kurland
8. "Digital Image Processing" by Rafael C. Gonzalez and Richard E. Woods
9. "Spatial Analysis and GIS" by S. S. Yadav and R. K. Maikhuri

(6)

a. **Course Name:** Marine Geology
b. **Course Code:** 11211155
c. **Prerequisite: A** solid background in basic geology and oceanography, ensuring students have foundational knowledge in Earth processes and marine environments.
d. **Rationale:** Comprehensive understanding of Earth's dynamic processes in marine environments, investigating seafloor features, sedimentation patterns, and plate tectonics, providing essential insights for marine resource exploration and environmental management.
e. **Course Learning Objective:**

CLOBJ 1	Develop a thorough grasp of marine geology principles and processes, covering seafloor spreading, plate tectonics, sedimentation, and marine geological features.
CLOBJ 2	Analyze plate tectonics and seafloor spreading mechanisms, exploring their impacts on ocean basin formation, mid-ocean ridges, and subduction zones.
CLOBJ 3	Explore marine sedimentation processes, encompassing factors driving sediment transport, deposition, and diverse sediment type formation.
CLOBJ 4	Examine marine geological records for reconstructing past oceanographic conditions and climate changes, emphasizing sediment core interpretation and marine fossil analysis.
CLOBJ 5	Evaluate the role of marine geology in resource exploration, including the identification and assessment of marine mineral resources, hydrocarbons, and the potential environmental impact of resource extraction.

f. **Course Learning Outcomes:**

CLO 1	Describing the salient features and biological processes of marine ecosystems.
CLO 2	Explaining the types and divisions of various marine habitats.
CLO 3	Learn about the sedimentary processes within and on the boundaries of ocean basins.
CLO 4	Understand the formation of ocean basins, including the role of mid-ocean ridges in basin
CLO 5	Understand the past history and impact of sea level change.

g. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
3	0	0	3	20	20	-	60	-	100

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

h. Course Content:

Sr. No.	Topics	Weightage	Teaching Hours
1	**Unit 1:** History of Marine Geology, Scope and Applications of Marine Geological Investigations. Oceanic Expeditions: Challenger Expedition, Deep Sea Drilling Project, Ocean Drilling Programme, Joint Global Flux Studies (JGOFS), Integrated Ocean Drilling Programme (IODP). Marine Sediments, Sources and Composition, Sediment Types and Distribution.	**35%**	**15**
2	**Unit 2:** Ocean Floor topography-- Continental Margins: Continental Shelf and Slope, Its Origin, Continental Rise; Submarine Canyon and Their Origin, Oceanic Ridges: Ridges, Fracture Zones; Ocean Basins: Abyssal Plains, Abyssal Hills, Seamounts and Guyots, Marginal Trenches. Submarine Volcanism, Tsunamis – Causes and Effects. Coral Reefs – Their Nature and Theory Of Atoll Formation. Sea Level Changes, Causes and Types of Sea Level Changes, Methods of Study.	**35%**	**15**
3	**Unit 3:** Oceanic Circulation - Surface, Intermediate And Deep Ocean Circulation; Forces that Produce and Effects	**30%**	**15**

	Circulation Patterns in World Oceans; Important Phenomena Associated with Surface Circulation; Formation and Movement of Deep and Bottom Waters. Methods of Exploring the Ocean Floor: Sub Bottom Geological Sampling Equipment's – Snappers or Grabs, Corers: Gravity, Piston, Spade, Vibratory, Corers. Dredges, Underwater Photography and Diving.		
Total		**100%**	**45**

i. Textbook and Reference Books

1. Seibold, Eugen, and Wolfgang Berger. The sea floor: an introduction to marine geology. Springer, 2017.
2. Anderson, John B. Antarctic marine geology. Cambridge University Press, 1999.
3. Vacquier, V. (1972). Geomagnetism in marine geology. Elsevier.
4. Burk, Creighton A., and Charles L. Drake, eds. The geology of continental margins. Springer, 2013.
5. Cronan, David Spencer, ed. Handbook of marine mineral deposits. Vol. 18. CRC press, 1999.
6. Hampton, Lloyd. Physics of sound in marine sediments. Springer Science & Business Media, 2013.

(7)

a. **Course Name:** Engineering Geology
b. **Course Code:** 11211160
c. **Prerequisite:** A foundational understanding of core geological concepts, proficiency in mathematics and physics for analyzing geological hazards, slope stability, and foundation design in civil engineering projects.
d. **Rationale:** Provides a comprehensive understanding of the geological factors influencing site selection, foundation design, and slope stability. Mitigating geological risks associated with construction projects, ensuring the safety and stability of infrastructure.
e. **Course Learning Objective:**

CLOBJ 1	Develop proficiency in geological mapping techniques and map interpretation to identify and characterize subsurface features vital for engineering design and construction planning.
CLOBJ 2	Expertise in geotechnical analysis, encompassing soil and rock mechanics, to evaluate mechanical properties and behavior of earth materials.
CLOBJ 3	Gain a comprehensive understanding of hydrogeological processes, including groundwater flow, aquifer characteristics, and water-rock interactions.
CLOBJ 4	Develop the ability to assess geological hazards and risks, including seismic activity, landslides, and subsidence.
CLOBJ 5	Examine the environmental impacts of engineering endeavors, accounting for geological considerations. Grasp the ways human activities affect ecosystems and geologically delicate regions, and devise strategies for sustainable and environmentally conscious engineering practices.

f. **Course Learning Outcomes:**

CLO 1	Conducting comprehensive geological site assessments, employing appropriate techniques to characterize subsurface conditions and identify geological features relevant to engineering projects.

CLO 2	Applying geotechnical principles to analyze and design foundations, slopes, and other critical components of civil engineering projects, considering the mechanical properties and behaviours of earth materials.
CLO 3	Enhance skills to assess geological hazards such as landslides, earthquakes, and groundwater-related issues, and develop effective mitigation strategies to enhance the safety and stability of infrastructure projects.
CLO 4	Integrating geological considerations into the decision-making processes of engineering projects, ensuring that geological factors are appropriately addressed in site selection, design, and construction phases.
CLO 5	Assessing the environmental impact of engineering activities from a geological perspective, considering interactions between human activities, geological features, and ecosystems.

g. Teaching & Examination Scheme:

Teaching Scheme				**Evaluation Scheme**					
L	**T**	**P**	**C**	**Internal Evaluation**			**ESE**		**Total**
				MSE	**CE**	**P**	**Theory**	**P**	
3	**0**	**0**	**3**	**20**	**20**	**-**	**60**	**-**	**100**

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

h. Course Content:

Sr. No.	**Content**	**Weightage**	**Teaching Hours**
1	**Unit 1:** Role of engineering geology in civil construction and mining industry; Role of geology in planning, location, design, construction and performance of major civil engineering structures	**34%**	**15**
2	**Unit 2:** Engineering properties of rocks, Use of Soils and elements of Soil mechanics, soils and their classifications, weathering. Discontinuities in rock masses.	**33%**	**15**

3	**Unit 3:** Tunnels, Buildings: Site Exploration and Foundation, Bridges and Pavements; Dams and Reservoirs, Structures in earthquake prone regions.	**33%**	**15**
Total		**100%**	**45**

i. Textbook and Reference Book:

1. Anthony M. Knapp. Basic Soil Mechanics (2010), Taylor & Francis
2. Parbin Singh. Engineering and General Geology (2010). S. K. Kataria& Sons
3. Fred G. Bell. Engineering Geology (2007). Elsevier Science
4. George H. Davis, Stephen J. Reynolds, and Charles F. Kluth. Structural Geology of Rocks and Regions (2011). Wiley
5. John C. W. Cripps. Geotechnical Investigation Methods: A Field Guide for Geotechnical Engineers (2015). CRC Press

Semester 3

(1)

a. **Course Name:** Mining Geology and Mineral Economics

b. **Course Code:** 11211202

c. **Prerequisite:** Supplement your education with economic principles, financial analysis, and knowledge of mineral markets for a well-rounded foundation in mining geology and mineral economics.

d. **Rationale:** Mining geology is essential for identifying and characterizing mineral deposits, determining their economic viability, and optimizing extraction methods. It provides crucial insights into ensuring efficient resource utilization, minimizing environmental impact, and supporting sustainable mining practices.

e. **Course Learning Objective:**

CLOBJ 1	To understand basic terminologies related to mining.
CLOBJ 2	To learn mining methods including alluvial, open cast, underground and coal.
CLOBJ 3	To educate the concept of mineral resources and its estimation, economic consideration of mineral resources.
CLOBJ 4	To be aware of Mineral legislation of India and Mineral inventory.
CLOBJ 5	To be aware of internal and external trade, price, monopoly and stock pile.

f. **Course Learning Outcomes:**

CLO 1	Facilitates effective communication within the mining industry, ensuring precise and unambiguous exchange of information among professionals, researchers, and stakeholders.
CLO 2	Enables efficient and sustainable extraction of mineral resources by understanding and applying appropriate mining methods tailored to specific geological conditions.
CLO 3	Supports strategic project planning, risk assessment, and financial modeling, ensuring adherence to regulatory standards and optimizing mineral extraction methods.
CLO 4	Essential for legal compliance, efficient project planning, environmental and social responsibility, securing permits, risk mitigation, community engagement, attracting

	investors, positive government relations, promoting ethical practices, potential legal advocacy.
CLO 5	Crucial for aligning mineral practices with government policies, ensuring resource sustainability, optimizing production based on demand, and staying competitive in the dynamic mineral market.

g. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
4	0	0	4	20	20	-	60	-	100

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

h. Course Content:

Sr. No.	Content	Weightage	Teaching Hours
1	**Unit 1:** Mining Geology Terminology, Various types of mining methods (Alluvial, open cast, underground and coal).	25%	15
2	**Unit 2:** Meaning and specialities of mineral deposits. Mineral resource and its estimation. Mineral classification, Economic consideration of mineral resources. Infrastructure, production, processing, co product and by-product.	25%	15
3	**Unit 3:** Mineral legislation of India, Mineral inventory. Internal and external trade, price, monopoly and stockpile	25%	15
4	**Unit 4:** National mineral policy, Consumption and substitution, demand analysis and market survey	25%	15
Total		**100%**	**60**

i. Textbook and Reference Book:

1. Economic Geology: Principles and Practice" by Walter L. Pohl
2. Mineral Resource Estimation" by M. Bonham-Carter
3. Mineral Exploration: Principles and Applications- S.K. Haldar
4. Courses in Mining Geology- Arogyaswami
5. Mining Geology- D.N. Verma
6. Elements of Mining Technology - D.J. Deshmukh

(2)

a. **Course Name:** Geochemistry
b. **Course Code:** 11211203
c. **Prerequisite:** Foundation knowledge of Chemistry, Geology, Mathematics, and Statistics.
d. **Rationale:** Offers broad applications across geological, environmental, and planetary sciences, providing essential insights for resource management, environmental conservation, and a deeper understanding of Earth's dynamic processes.
e. **Course Learning Objective:**

CLOBJ 1	To know the Origin and abundance of elements in the solar system and composition of planets and meteorites.
CLOBJ 2	To be aware of periodic table, radioactive decay, low of radioactive decay, half-life period.
CLOBJ 3	To be familiar with geochemistry of Sm-Nd method, Rb-Sr method, U-Pb, Th-Pb, Pb-Pb method radioactive isotope.
CLOBJ 4	To recognize atomic structures and properties of elements in the Periodic Table, Special properties of transition and rare earth elements.
CLOBJ 5	To evaluate geochemistry of hydrosphere, biosphere and atmosphere

f. **Course Learning Outcomes:**

CLO 1	Understanding regarding origin, evolution, and composition of celestial bodies. It provides insights into the processes that shaped the formation of planets, stars, and other celestial objects.
CLO 2	Allows for accurate dating of rocks, fossils, and artifacts, providing insights into Earth's history
CLO 3	Helpful for dating geological formations to understanding environmental changes, natural hazards, and resource exploration. It plays a pivotal role in unraveling the Earth's complex geological history and processes.

CLO 4	Essential for addressing environmental issues, promoting sustainable practices, and advancing our understanding of Earth's interconnected systems.
CLO 5	It enables them to address real-world challenges related to marine ecosystems, climate change, and sustainable resource management.

g. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
4	0	0	4	20	20	-	60	-	100

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

h. Course Content:

Sr. No.	Content	Weightage	Teaching Hours
1	**Unit 1:** Origin and abundance of elements in the solar system and in the Earth and its constituents, Cosmic abundance of elements, composition of planets and meteorites.	**25%**	**15**
2	**Unit 2:** Concepts of geochemistry: Introduction to properties of elements: The periodic table, radioactive decay, low of radioactive decay, half-life period. Geochemistry of Radioactive Isotopes: Rb, Sr, K, Ar, Sm, Nd, U,Th, Pb; Radiogenic Isotope Geochronometers: Sm-Nd method, Rb-Sr method, U-Pb, Th-Pb, Pb-Pb method	**25%**	**15**
3	**Unit 3:** Atomic structures and properties of elements in the Periodic Table, Special properties of transition and rare earth elements, Geochemistry of hydrosphere, biosphere and atmosphere	**25%**	**15**

4	**Unit 4:** Chromatography, Aqueous geochemistry-basic concepts and speciation in solutions, Eh, pH relations Elements of marine chemistry	**25%**	**15**
Total		**100%**	**60**

i. Textbook and Reference Book:

1. Mason, B. Principles of Geochemistry, Wiley Eastern, 1982
2. Krauskopf, K.B. Introduction to Geochemistry, Mc Graw Hill, 1994
3. Faure, G. Inorganic Geochemistry, Prentice Hall, 1991.
4. Aswathnarayana, U. Principles of Nuclear Geology, Oxford Press, 1985.
5. Faul, H. (Ed.), Nuclear Geology, Wiley 1954.

(3)

a. **Course Name:** Exploration Geology
b. **Course Code:** 11211204
c. **Prerequisite:** Fundamental of Chemistry, Physics and Geology
d. **Rationale:** It contributes to resource discovery, economic development, and environmental stewardship.
e. **Course Learning Objective:**

CLOBJ 1	To gather geological data in search of valuable minerals, ultimately mapping surface geology.
CLOBJ 2	To deals with methods of drilling and recovering samples and sampling method
CLOBJ 3	To understand the subsurface of an Earth using geochemical methods.
CLOBJ 4	To understand the subsurface of an Earth using geophysical methods.
CLOBJ 5	To acquire subsurface data using Electrical, Gravity methods of exploration.

f. **Course Learning Outcomes:**

CLO 1	It aids in resource exploration, environmental management, hazard assessment, and infrastructure planning, contributing to informed decision-making and sustainable practices.
CLO 2	The benefits of various drilling methods include their adaptability to different geological conditions, cost-effectiveness, efficiency in obtaining samples, and suitability for specific applications such as mineral exploration, environmental investigations, water well drilling, and energy resource extraction.
CLO 3	The geochemical method offers valuable tools for unravelling the complexities of the subsurface, aiding in mineral exploration, environmental assessments, oil and gas exploration, and understanding geological processes beneath the Earth's surface.
CLO 4	These methods contribute valuable information for understanding the composition, structure, and properties of the Earth's subsurface.
CLO 5	Seismic data helps us by providing detailed images of the subsurface, aiding in reservoir characterization, hydrocarbon exploration, fault identification, and structural analysis. It is crucial for planning and optimizing drilling, monitoring

	reservoirs, and has applications in environmental studies, geothermal exploration, carbon capture and storage, mining exploration, and natural hazard assessments.

g. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
4	0	0	4	20	20	-	60	-	100

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

h. Course Content:

Sr. No.	Content	Weightage	Teaching Hours
1	**Unit 1:** Gathering and presenting geological data, Geological guides to mineral search, Designing a reconnaissance project, Mapping surface Geology	25%	15
2	**Unit 2:** Methods of drilling and recovering samples. Geological mapping in underground mines, Sampling methods.	25%	15
3	**Unit 3:** Exploration geochemistry-methods and applications, Basic Principles of geophysical exploration.	25%	15
4	**Unit 4:** Electrical, Gravity, Magnetic, Seismic and Radiometric prospecting	25%	15
Total		100%	60

i. Textbook and Reference Book:

1. Economic Geology: Principles and Practice" by Walter L. Pohl
2. Mineral Exploration: Principles and Applications- S.K. Haldar
3. Courses in Mining Geology- Arogyaswami

(4)

a. **Course Name:** Hydrogeology
b. **Course Code:** 11211205
c. **Prerequisite:** A solid foundation in basic geology, chemistry, physics, mathematics (especially algebra and calculus), environmental science, and fieldwork skills.
d. **Rationale:** Crucial for managing water resources, protecting the environment, planning land use, assessing climate change impacts, designing infrastructure, mitigating natural hazards, supporting ecosystems, managing water quality, promoting sustainable development, and advancing scientific knowledge of Earth's subsurface processes.
e. **Course Learning Objective:**

CLOBJ 1	To understand the origin and age of ground water along with cross section of soil and basic terms related to aquifer, porosity & vertical distribution of water.
CLOBJ 2	To acquire the types of aquifers, storage coefficient, specific retention and specific yield.
CLOBJ 3	To learn Darcy's Law, Permeability, Groundwater levels and fluctuations along with Fresh and saltwater relationship in coastal areas and Ghyben-Herzberg principle.
CLOBJ 4	To investigate the availability of water by Remote sensing.
CLOBJ 5	To examine the availability of water by Geophysical exploration specially Electrical resistivity method

f. **Course Learning Outcomes:**

CLO 1	Age of water is essential for a comprehensive understanding of hydrological processes, sustainable water management, climate change impact assessment, environmental protection, geological processes, paleoclimatology, carbon cycling, ecosystem health, and responsible infrastructure development.
CLO 2	Essential for sustainable groundwater management, well design, groundwater recharge and discharge assessments, environmental impact evaluations, infrastructure development, climate change adaptation, water resource planning, environmental protection, natural hazard assessment, and ecosystem support.

CLO 3	Ghyben-Herzberg principle provides a simple conceptual model for describing the equilibrium conditions between freshwater and saltwater in coastal aquifers.
CLO 4	Remote sensing is a valuable tool in hydrogeology for collecting information about the Earth's surface and subsurface without direct physical contact.
CLO 5	Geophysical methods provide students with valuable practical experience, enhances their understanding of subsurface processes, and prepares them for real-world applications in groundwater exploration, management, and environmental protection.

g. Teaching & Examination Scheme:

Teaching Scheme				**Evaluation Scheme**					
L	**T**	**P**	**C**	**Internal Evaluation**			**ESE**		**Total**
				MSE	**CE**	**P**	**Theory**	**P**	
4	**0**	**0**	**4**	**20**	**20**	**-**	**60**	**-**	**100**

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

h. Course Content:

Sr. No.	**Content**	**Weightage**	**Teaching Hours**
1	**Unit 1: Occurrence of Groundwater** Origin & age of groundwater, Rock properties affecting groundwater Aquifers, Porosity, Soil classification, Porosity and representative elementary volume, Specific surface Vertical distribution of groundwater Zone of Aeration Soil water zone, Intermediate vadose zone, Capillary zone, measurement of water content	**25%**	**15**
2	**Unit 2: Aquifer** Types of aquifers, Unconfined aquifer, Confined aquifers, Leaky aquifer, Idealized	**25%**	**15**

	aquifer Storage Coefficient Zone of Saturation Specific Retention, Specific Yield		
3	**Unit 3: Groundwater management** Darcy's Law, Permeability, Groundwater levels and fluctuations: Various causes of water level fluctuations. Fresh and saltwater relationship in coastal areas; Ghyben-Herzberg principle and its modification, prevention and control of sea water intrusion	**25%**	**15**
4	**Unit 4: Surface Investigation of groundwater** Geologic methods, Remote sensing, Geophysical exploration, Electrical resistivity method, Seismic refraction method, Gravity and Magnetic methods	**25%**	**15**
Total		**100%**	**60**

i. Textbook and Reference Book:

1. Davies, S.N. and De Wiest, R.J.M. (1966) Hydrology, John Wiley, N.Y.
2. Fetter, C.W. (1990) Applied Hydrology, Prentice Hall
3. Todd, D.K. (1980) Groundwater Hydrology. John Wiley& Sons, N.Y.
4. Raghunath H. M. – Hydrology

(5)

a. **Course Name:** Petroleum and Coal Geology
b. **Course Code:** 11211206
c. **Prerequisite**: Basics of Geology, Chemistry and physics**.**
d. **Rationale:** Provide understanding of global energy demands, contribute to economic development, explore and develop new hydrocarbon resources, mitigate exploration risks, advance technological capabilities, and address environmental considerations.
e. **Course Learning Objective:**

CLOBJ 1	To understand the Origin, Occurrence, migration and accumulation of hydrocarbons along with reservoir rocks.
CLOBJ 2	To learn Geological, geophysical and Geochemical methods of petroleum exploration
CLOBJ 3	To study Drilling rigs, Drill holes, different methods of drilling; coring; casing and cementation; drilling fluids.
CLOBJ 4	To know the Functions of petroleum geologist and to recognize different well logging methods
CLOBJ 5	To understand the Originpeat swamps, development of the coal facies, diagenesis of peat and coalification.

f. **Course Learning Outcomes:**

CLO 1	Understanding the processes, factors, and methods involved in the movement and accumulation of hydrocarbons within the Earth's subsurface.
CLO 2	One can be well-prepared to contribute to the multifaceted field of oil exploration and work collaboratively across disciplines to maximize the success of exploration efforts.
CLO 3	Hands-on exposure to drilling methods and drilling rigs is a crucial component of petroleum geology education. It provides students with practical skills, enhances their understanding of subsurface geology, and prepares them for careers in the exploration and production of oil and gas.

CLO 4	Multi-faceted role and involves a combination of fieldwork, data analysis, and decision-making to contribute to the successful exploration and production of hydrocarbon resources. Their expertise is essential for ensuring the sustainable and responsible development of oil and gas reserves.
CLO 5	A comprehensive understanding of the methods and processes involved in exploring and extracting methane from coal beds.

g. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
3	0	0	3	20	20	-	60	-	100

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

h. Course Content:

Sr. No.	Content	Weightage	Teaching Hours
1	**Unit 1:** Origin; Occurrence migration and accumulation of hydrocarbons. Petroleum traps. Reservoir rocks and Reservoir conditions. Geological geophysical and Geochemical methods of petroleum exploration	**35%**	**15**
2	**Unit 2:** Drilling rigs, Drill holes, different methods of drilling; coring; casing and cementation; drilling fluids. Functions of petroleum geologist. Formation evaluation – Geologging and well logs – Electric, Radioactive and Acoustic	**30%**	**15**
3	**Unit 3:** Origin of peat swamps, development of the coal facies, diagenesis of peat and coalification. Classification, Coal petrology. Coal bed methane. Coal exploration techniques	**35%**	**15**

Total	**100%**	**45**

i. Text Book and Reference Book:

1. Bhagwan Sahay. (1994) Petroleum exploration and exploitation practices. AlliedPub
2. Deshpande B. G. The world of petroleum.
3. Levorson A. I., Geology of Petroleum. CBS Pub.
4. North F. K. (1985) Petroleum Geology.
5. Selley R. C. (1985) Elements of Petroleum Geology, Academic Press, London

(6)

a. **Course:** Instrumentation Techniques in Geology
b. **Course code:** 11211208
c. **Prerequisite:** Basic understanding of mineralogy, petrology, structural geology, palaeontology, physics and chemistry
d. **Rationale:** Acquire knowledge about instrument techniques used in Geological sample analysis
e. **Course Learning Objective:**

CLOBJ 1	To develop a comprehensive understanding of the fundamental principles and operational mechanisms of advanced analytical instruments used in geological research.
CLOBJ 2	To equip students with the skills to utilize techniques such as X-ray diffraction (XRD), scanning electron microscopy (SEM), and inductively coupled plasma mass spectrometry (ICP-MS) for mineral and geochemical analysis.
CLOBJ 3	To train students in interpreting data obtained from instrumental analyses, enabling them to draw meaningful conclusions about geological processes and materials.
CLOBJ 4	To enable students to integrate field sampling techniques with laboratory instrumentation for a holistic approach to geological problem-solving.
CLOBJ 5	To develop critical thinking in assessing the accuracy, precision, and limitations of various instrumentation techniques and their suitability for specific geological applications.

f. **Course Learning Outcomes:**

CLO 1	Demonstrate a thorough understanding of the working principles, calibration, and operation of advanced instruments used in geological studies.
CLO 2	Apply instrumental techniques such as X-ray diffraction (XRD), scanning electron microscopy (SEM), and atomic absorption spectroscopy (AAS) to analyze minerals, rocks, and soils.

CLO 3	Analyze and interpret data generated from geological instrumentation to understand the physical, chemical, and structural characteristics of geological materials.
CLO 4	Evaluate the advantages, limitations, and appropriate applications of various analytical instruments in addressing geological and environmental research problems.
CLO 5	Evaluate the advantages, limitations, and appropriate applications of various analytical instruments in addressing geological and environmental research problems.

g. Teaching and Examination Scheme

Teaching Scheme				Examination Scheme					Total
Lecture Hrs / week	Tutorial Hrs / week	Lab Hrs / Week	Credit	Internal Marks			External Marks		
				T	P	CE	T	P	
3	0	0	3	20	-	20	60	-	100

Lect - Lecture, Tut - Tutorial, Lab - Lab, T - Theory, P - Practical, CE - CE, T - Theory, P – Practical

h. Course Content

Sr. No.	Topics	Weightage	Teaching Hours
1	**Unit 1:** Preparation of thin sections and polished sections involves processes such as cutting, grinding, and polishing, powder sample preparation involves crushing and pulverizing. Techniques for microfossils slide preparation. Remote sensing and GIS techniques encompass aerial photograph studies, image interpretation, and classification techniques.	**25%**	**10**
2	**Unit 2:** The principles, components, functioning, and uses of petrological microscopes, ore microscopes, scanning electron microscopes (SEMs), electron probe microanalyzers (EPMA), cathodoluminescence (CL) & thermoluminescence (TL) spectrometry. Methods in sedimentology encompass various techniques such as sieving and sieve shaking, as well as processes like sample etching and staining. Methods for	**25%**	**15**

	analyzing heavy minerals and clay minerals, as well as studying the size and shape of sediment particles.		
3	**Unit 3:** Preparation of rock powder for geochemical analysis. Rock digestion through acid treatment, rock digestion through fusion with alkali salts, basic concept, and working principles of atomic absorption spectrometer (AAS), X-Ray Diffraction (XRD), X-Ray Fluorescence (XRF), Inductively Coupled Plasma-Mass Spectrometer (ICP-MS), Inductively Coupled Plasma - Atomic Emission Spectrometer (ICP-AES), Laser Ablated-Inductively Coupled Plasma-Mass Spectrometer (LA-ICP-MS), Thermal Ionization Mass Spectrometer (TIMS) and isotope clean lab chemistry.	**25%**	**15**
4	**Unit 4:** Geophysical instruments: Geophones, gravimeters, ultrasonic testers (for P-wave and S-wave), resistivity measurements, and gamma-ray spectroscopy commonly used in geodynamic modelling and geophysical exploration. Various geophysical logging techniques.	**25%**	**5**
Total		**100%**	**45**

i) Textbook and Reference Book:

1. Principles and Applications of Geochemistry" by Gunter Faure
2. Modern Analytical Geochemistry: An Introduction to Quantitative Chemical Analysis Techniques for Earth, Environmental, and Materials Scientists" by Robin Gill
3. Fundamentals of X-Ray Crystallography" by Jenö S. Nag

(7)

a. **Course Name:** Ore Geology

b. **Course Code:** 11211210

c. **Prerequisite:** Ore geology is instrumental in supporting sustainable resource management, fostering economic development, and addressing the global demand for minerals and natural resources while considering environmental and economic factors.

d. **Rationale:** Studying ore geology is crucial for identifying and managing valuable natural resources, driving economic development, mitigating environmental impact, and advancing scientific understanding.

e. **Course Learning Objective:**

CLOBJ 1	To know about ore minerals in the form of physical and chemical properties along with its process of formation commonly known as ore-genesis.
CLOBJ 2	To learn difference in ore formed by magmatism, sedimentary processes, and metamorphism.
CLOBJ 3	To gain facts regarding formation of ore due to the hydrothermal activity, contact metasomatism and Sublimation
CLOBJ 4	To gather the knowledge of metallic minerals, Gold, Silver, Platinum and its process of formation.
CLOBJ 5	To collect information about Ferrous and allied metals such as Iron, Manganese, Chromium, Vanadium, Non- Ferrous and Allied Metals, Copper, Lead and Zinc, Tin, Antimony, Bismuth and Critical Minerals.

f. **Course Learning Outcomes:**

CLO 1	Ability to accurately identify ore minerals through comprehensive analysis of their physical and optical properties and ore genesis.
CLO 2	Help to understand the behaviour or exchange of elements during emplacement of magma, deposition of sediments and effect of stress and temperature on pre-existing rock or mineral.
CLO 3	Anyone can learn a role of volatiles produce subtle or drastic variation in mineral chemistry or grade of ore and the process of sublimation.

CLO 4	Understanding mode of occurrence regarding precious metal, Ferrous and Non-ferrous metal
CLO 5	Ability to recognize the abundance of radioactive elements and Gem stone

g. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
3	0	0	3	20	20	-	60	-	100

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

h. Course Content:

Sr. No.	Content	Weightage	Teaching Hours
1	**Unit 1:** Introduction: Essential factor in Mineral Deposition and ore-genesis; Geological Thermometers, Ore-genesis, Association of Ores with igneous rocks, Presence of Mineral deposits with gaseous emanations, Origin of Ore minerals from Residual Liquid of Magma.	**25%**	**11**
2	**Unit 2:** Process of Formation of Mineral Deposits: Magmatic Concentration, Sedimentation, Metamorphism, Contact metasomatism, Hydrothermal processes, Sublimation	**25%**	**12**
3	**Unit 3:** Metallic mineral deposits, precious metals- Gold, Silver, Platinum (mineralogy, uses, mode of occurrence & origin), Ferrous and Allied Metals- Iron, Manganese, Chromium, Vanadium, Non- Ferrous and Allied Metals, Copper, Lead and Zinc, Tin, Antimony, Bismuth	**25%**	**11**
4	**Unit 4:** Radioactive metals- Uranium and Thorium, Non-metallic Minerals, Mineral fuels, Gemstones	**25%**	**11**

Total	100%	45

i. Textbook and Reference Book:

1. Umeshwar Prasad, Economic Geology – Economic Mineral Deposits, CBS Publishers & Distributors
2. Economic Geology: Principles and Practice – Walter L. Pohl
3. Economic Mineral Deposits – Alan M. Bateman
4. An Introduction to Economic Geology and Its Environmental Impact- Anthony Evans
5. Ore Geology, Economic Minerals and Mineral – S.K. Tiwari

Semester 4

(1)

a. **Course Name:** Project work / Dissertation

b. **Course Code:** 11211250

c. **Prerequisite:** The prerequisites delineated for the Geology dissertation are formulated to ascertain that students commencing independent research endeavours exhibit a robust academic groundwork and possess the requisite skills for conducting substantial and ethically sound research.

d. **Rationale:** The fulfilment of foundational and advanced coursework equips students with a comprehensive grasp of the interdisciplinary facets inherent in Geology. Concurrently, incorporating research methodology and literature review skills guarantees their capacity to formulate and conduct a meticulous research project proficiently.

e. **Course Learning Objective:**

CLOBJ 1	Develop the ability to design and execute an independent, rigorous research project in Geology, showcasing proficiency in formulating research questions, hypotheses, and methodologies.
CLOBJ 2	Enhance skills in critically reviewing and synthesizing relevant scientific literature, demonstrating a comprehensive understanding of existing knowledge and identifying gaps for further investigation.
CLOBJ 3	Acquire hands-on experience in collecting geological data through fieldwork or laboratory methods and develop expertise in analysing data using appropriate techniques and tools.
CLOBJ 4	Cultivate effective scientific communication skills, including the preparation of clear and concise written reports and oral presentations, to disseminate research findings within the scientific community.

f. **Course Learning Outcomes:**

CLO 1	Attain a high level of specialized knowledge and expertise within a specific area of Geology, demonstrating mastery in the chosen research topic through the dissertation project.
CLO 2	Demonstrate advanced research skills, including the ability to independently design and conduct a comprehensive investigation, analyze data effectively, and draw scientifically sound conclusions.
CLO 3	Develop and apply advanced critical thinking skills to identify and address complex geological challenges, showcasing the ability to analyze and solve problems within the chosen research domain.
CLO 4	Make a significant contribution to the body of scientific knowledge in Geology by generating original research findings, thereby advancing the understanding of specific geological phenomena or processes.

g. Teaching & Examination Scheme:

Teaching Scheme				**Examination Scheme**				
				Theory Marks		**Practical Marks**		**Total**
L	**T**	**P**	**C**	**External Marks**	**Internal Marks**	**External Marks**	**Internal Marks**	
-	**-**	**22**	**15**	**-**	**-**	**200**	**-**	**200**

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

h. Course Content

Sr. No.	**Content**	**Weightage**	**Teaching Hours**
1	**Dissertation** **(Dissertation/ Project work/ Industrial Training Report Environmental Issue/Survey Project Report)**	**100**	**28**

	• The purpose of this exercise is to become familiar with research methods, computer application, literacy and the presentation skills. Moreover, to think about how to approach, communicate and assess geology and geological problems from various viewpoints. All viewpoints must be addressed in your outline and project. The student has the freedom to select any research problem related to geology; they can also work for their masters' thesis in the department or research institutes or industry with prior communication and approval from both the side. 1. Select any geological problem/ Research Problem in consultation with the faculty for proper guidance. 2. Learn what resources are available and how to access them 3. Collect references, secondary information on the topic and prepare bibliography 4. Set the methodology, approve it from faculty/supervisor and proceed for field and experimental work. 5. Collect findings Record Results (statistics/data tables) 6. Interpret and explain results (using charts) 7. Conclusion and preparation of detailed report/thesis 8. Use outline and related research for presentation of your work **The outline must include the following:** • For guidelines and format/ consult faculty. • Literature Review section should include citations and/or references from previous studies of the topic • References must be taken from a book, journal, newspaper and Internet. 1. Make certain that your cited sources are in APA Citation Style.		

(2)

a. **Course Name:** Comprehensive Viva-Voce
b. **Course Code:** 11211256
c. **Prerequisite:** Students must have acquired a solid foundation of theoretical knowledge and practical skills relevant to the course to effectively engage in the comprehensive Viva examination.
d. **Rationale: It** serves as a critical assessment tool, allowing faculty to evaluate students' depth of understanding, integration of knowledge, and oral communication skills across various aspects of the course.
e. **Course Learning Objective:**

CLOBJ 1	Develop effective oral communication skills by articulating complex concepts, demonstrating the ability to express ideas clearly and concisely.
CLOBJ 2	Showcase the capacity to integrate information from diverse course components, emphasizing a holistic understanding of the subject matter.
CLOBJ 3	Demonstrate advanced critical thinking skills by responding to spontaneous questions, evaluating scenarios, and offering well-reasoned analyses in real-time.
CLOBJ 4	Apply theoretical knowledge to practical scenarios, showcasing the ability to connect conceptual frameworks to real-world situations relevant to the course.

f. **Course Learning Outcomes:**

CLO 1	Attain an in-depth mastery of the course material, demonstrating a nuanced understanding that goes beyond surface-level knowledge through oral examination.
CLO 2	Display proficiency in communicating complex concepts, ensuring the ability to convey ideas clearly and succinctly during the viva-voce examination.
CLO 3	Develop advanced critical analysis skills, enabling the evaluation and synthesis of information on-the-fly in response to questions posed by examiners.
CLO 4	Showcase the practical application of acquired knowledge by responding to situational queries, illustrating the ability to transfer theoretical concepts to real-world scenarios.

g. **Teaching & Examination Scheme:**

Teaching Scheme				Examination Scheme				
				Theory Marks		Practical Marks		Total
L	T	P	C	External Marks	Internal Marks	External Marks	Internal Marks	
-	-	-	4	-	-	100	-	100

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**-Continuous Evaluation, **ESE-** End Semester Examination, **W-**Weightage, **T-**Teaching Hours

h. Course Content

Sr. No.	Content	W	T
1	**Viva voce** **(Dissertation/ Project work/ Industrial Training Report Environmental Issue/Survey Project Report)** ● The purpose of this exercise is to become familiar with research methods, computer application, literacy and the presentation skills. Moreover, to think about how to approach, communicate and assess geology and geological problems from various viewpoints. All viewpoints must be addressed in your outline and project. The student has the freedom to select any research problem related to geology; they can also work for their masters' thesis in the department or research institutes or industry with prior communication and approval from both the side. ● **A 15-minute formal oral presentation and viva-voce during the final examination.**	-	-

ANNEXURE-IV

Semester-I

(1)

a. **Course Name:** Lab 1 (Mineralogy and Crystallography)

b. **Course Code:** 11211106

c. **Prerequisite:** A foundational understanding of mineral identification, crystal structures, and basic geological principles, providing them with the necessary background to engage with the advanced laboratory exercises.

d. **Rationale:** Provide students with practical, hands-on experience in the identification and characterization of minerals, emphasizing the application of crystallographic principles.

e. **Course Learning Objective:**

CLOBJ 1	Develop the ability to identify various minerals through practical laboratory exercises, emphasizing hands-on experience with mineral specimens and analytical techniques.
CLOBJ 2	Gain a comprehensive understanding of crystallographic principles, including crystal systems, symmetry elements, and their application to mineral structures, enhancing the ability to interpret and describe crystal arrangements.
CLOBJ 3	Acquire skills in microscopic analysis of minerals, utilizing techniques such as thin-section petrography to explore mineral textures, associations, and structural characteristics.
CLOBJ 4	Develop proficiency in using laboratory tools and equipment for mineral characterization, including X-ray diffraction, optical microscopy, and other analytical methods employed in mineralogical investigations.

f. **Course Learning Outcomes:**

CLO 1	Demonstrate expertise in mineral identification, showcasing the ability to accurately recognize and classify a diverse range of minerals based on physical and optical properties.
CLO 2	Apply advanced knowledge of crystallographic principles to analyze and interpret the internal structures of minerals, demonstrating an understanding of crystal systems and symmetry elements.

CLO 3	Exhibit advanced skills in microscopic analysis of minerals, effectively utilizing thin-section petrography and other techniques to investigate mineral textures, associations, and crystallographic features.
CLO 4	Showcase competency in utilizing a variety of laboratory tools and techniques, including X-ray diffraction and optical microscopy, for precise mineral characterization and analysis.

g. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
0	-	4	2	-	-	40	-	60	100

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

Exp. No.	Name of the Experiment
1	Observation and documentation on symmetry of crystals
2	Study of physical properties of minerals in hand specimen
3	Microscopic study of rock forming minerals

h. Textbook and Reference Book:

1. Winter, J. D. (2010). Principles of Igneous and Metamorphic Petrology. Prentice Hall.
2. Philpotts, A. R., & Ague, J. J. (2009). Principles of Igneous Petrology. Cambridge University Press.
3. Best, M. G. (2002). Igneous and Metamorphic Petrology. Wiley-Blackwell.
4. Tilling, R. I., &Heliker, C. C. (Eds.). (2013). Igneous petrology and volcanology: Selected papers of Frank W. Clarke. Geological Society of America.

(2)

a. **Course Name:** Lab 2 (Igneous Petrology)
b. **Course Code:** 11211107
c. **Prerequisite:** A solid understanding of igneous rock formations, igneous textures, igneous rock classification, and mineralogical concepts. Additionally, a background in laboratory techniques and fieldwork may be beneficial for a comprehensive engagement with the course material.
d. **Rationale:** Provide students with hands-on experience in examining and analysing igneous rocks, fostering a practical understanding of the processes governing their formation and evolution.
e. **Course Learning Objective:**

CLOBJ 1	Develop proficiency in the identification of various igneous rocks through hands-on laboratory exercises, enabling students to recognize and classify different rock types based on mineral composition and texture.
CLOBJ 2	Acquire skills in microscopic petrography to examine thin sections of igneous rocks, enabling detailed observations of mineral assemblages, textures, and crystal structures for comprehensive geological interpretations.
CLOBJ 3	Learn and apply geochemical techniques to analyze the elemental composition of igneous rocks, fostering an understanding of the processes governing their formation, differentiation, and evolution.
CLOBJ 4	Develop fieldwork skills related to igneous petrology, including the identification of outcrops, recognition of field relationships, and the collection of relevant samples for subsequent laboratory analysis.

f. **Course Learning Outcomes:**

CLO 1	Demonstrate a mastery of igneous rock classification, showcasing the ability to identify and categorize rocks based on mineralogical composition, texture, and other pertinent characteristics.
CLO 2	Exhibit advanced proficiency in microscopic petrography, enabling the accurate analysis and interpretation of thin sections to unravel the intricate details of mineral assemblages and textures within igneous rocks.

CLO 3	Apply acquired geochemical analysis skills to interpret the elemental composition of igneous rocks, allowing for a deeper understanding of geological processes such as magma genesis, differentiation, and tectonic influences.
CLO 4	Apply learned fieldwork skills to effectively recognize and interpret igneous rock outcrops, establishing a connection between field observations and theoretical principles learned in the laboratory setting.

g. Teaching & Examination Scheme:

Teaching Scheme				**Evaluation Scheme**					
L	**T**	**P**	**C**	**Internal Evaluation**			**ESE**		**Total**
				MSE	**CE**	**P**	**Theory**	**P**	
0	**-**	**4**	**2**	**-**	**-**	**40**	**-**	**60**	**100**

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

Exp. No.	**Name of the Experiment**
1	Megascopic and microscopic studies of igneous rock
2	Norms calculation and rock classification

h. Textbook and Reference Book:

1. Winter, J. D. (2010). Principles of Igneous and Metamorphic Petrology. Prentice Hall.
2. Philpotts, A. R., & Ague, J. J. (2009). Principles of Igneous Petrology. Cambridge University Press.
3. Best, M. G. (2002). Igneous and Metamorphic Petrology. Wiley-Blackwell.
4. Tilling, R. I., &Heliker, C. C. (Eds.). (2013). Igneous petrology and volcanology: Selected papers of Frank W. Clarke. Geological Society of America.

(3)

a. **Course Name:** Lab 3 (Metamorphic Petrology)
b. **Course Code:** 11211108
c. **Prerequisite:** A basic understanding of metamorphic processes, rock classifications, and mineralogical transformations, providing them with the necessary background to engage effectively with the advanced laboratory exercises focused on the study of metamorphic rocks.
d. **Rationale:** Provide students with practical experience in examining and analysing metamorphic rocks, emphasizing the processes that transform rocks under varying pressure and temperature conditions.
e. **Course Learning Objective:**

CLOBJ 1	Develop proficiency in identifying and classifying metamorphic rocks through hands-on laboratory exercises, focusing on mineral assemblages, textures, and structural characteristics.
CLOBJ 2	Understand and interpret the mineralogical transformations associated with metamorphic processes, gaining insight into how changes in pressure and temperature influence mineral composition and texture.
CLOBJ 3	Acquire advanced skills in petrographic analysis, employing thin-section examination and microscopic techniques to investigate the microstructures and metamorphic features within rocks.
CLOBJ 4	Learn and apply geochemical analysis techniques to characterize metamorphic rocks, fostering an understanding of the chemical changes that occur during metamorphism and their geological implications.

f. **Course Learning Outcomes:**

CLO 1	Demonstrate expertise in the identification and classification of a wide range of metamorphic rocks, showcasing the ability to discern key mineralogical features and textures indicative of specific metamorphic conditions.
CLO 2	Exhibit advanced proficiency in mineralogical analysis through the application of petrographic techniques, enabling a detailed examination of metamorphic microstructures, mineral assemblages, and textures.

CLO 3	Showcase a thorough understanding of the geological forces and conditions responsible for metamorphic transformations, allowing for the interpretation of the evolutionary history of metamorphic rocks.
CLO 4	Apply acquired geochemical knowledge to interpret the chemical signatures of metamorphic rocks, demonstrating the ability to relate geochemical data to the metamorphic history and environmental conditions.

g. Teaching & Examination Scheme:

Teaching Scheme				**Evaluation Scheme**					
L	**T**	**P**	**C**	**Internal Evaluation**			**ESE**		**Total**
				MSE	**CE**	**P**	**Theory**	**P**	
0	**-**	**4**	**2**	**-**	**-**	**40**	**-**	**60**	**100**

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

Exp. No.	**Name of the Experiment**
1	Megascopic and microscopic studies of metamorphic rock

h. Textbook and Reference Book:

1. Winter, J. D. (2010). Principles of Igneous and Metamorphic Petrology. Prentice Hall.
2. Philpotts, A. R., & Ague, J. J. (2009). Principles of Igneous Petrology. Cambridge University Press.
3. Best, M. G. (2002). Igneous and Metamorphic Petrology. Wiley-Blackwell.

(4)

a. **Course Name:** Lab 4 (Sedimentary Petrology and Sedimentology)
b. **Course Code:** 11211109
c. **Prerequisite:** Foundational understanding of geological processes, sedimentary rock formations, sedimentary rock classification, and sedimentary texture and structures.
d. **Rationale:** Provide a comprehensive understanding of the processes involved in the formation, transportation, and deposition of sediments, as well as the subsequent lithification into sedimentary rocks.
e. **Course Learning Objective:**

CLOBJ 1	Develop proficiency in identifying and classifying sedimentary rocks through hands-on laboratory exercises, focusing on sedimentary structures, textures, and compositional variations.
CLOBJ 2	Acquire skills in stratigraphic analysis, including the interpretation of sedimentary sequences, bedforms, and depositional environments, fostering an understanding of the geological processes shaping sedimentary rock formations.
CLOBJ 3	Gain expertise in microscopic petrography techniques for the analysis of sedimentary thin sections, allowing for detailed examination of mineralogy, texture, and diagenetic alterations.
CLOBJ 4	Learn to interpret sedimentary rocks as archives of past environmental conditions, demonstrating the ability to reconstruct paleoenvironments based on sedimentary structures, fossil content, and lithological characteristics.

f. **Course Learning Outcomes:**

CLO 1	Demonstrate advanced proficiency in the analysis of sedimentary rocks, showcasing the ability to identify, classify, and interpret sedimentary structures, textures, and compositional variations.
CLO 2	Exhibit mastery in the interpretation of stratigraphic sequences, including the recognition of depositional environments, sedimentary facies, and diagenetic processes, demonstrating a comprehensive understanding of sedimentary rock formations.

CLO 3	Demonstrate expertise in microscopic petrography techniques for sedimentary thin sections, allowing for nuanced analyses of mineralogical and textural features critical for interpreting sedimentary rock histories.
CLO 4	Apply acquired skills to reconstruct paleoenvironments from sedimentary rocks, showcasing the ability to interpret sedimentary structures, fossil content, and lithological characteristics to infer past geological conditions.

g. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
0	-	4	2	-	-	40	-	60	100

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

Exp. No.	Name of the Experiment
1	Megascopic and microscopic identification of sedimentary rocks, Grain size analysis, sieving for sedimentary environment

h. Textbook and Reference Book:

1. Pettijohn, F. J., Potter, P. E., &Siever, R. (1987). Sand and Sandstone. Springer.
2. Boggs, S. (2009). Principles of Sedimentology and Stratigraphy. Pearson.
3. Tucker, M. E. (2001). Sedimentary Petrology: An Introduction to the Origin of Sedimentary Rocks. Wiley.
4. Reading, H. G. (1986). Sedimentary Environments: Processes, Facies, and Stratigraphy. Wiley-Blackwell.

Semester-II

(1)

a. **Course Name:** Lab 1 (Structural Geology and Tectonics)

b. **Course Code:** 11211157

c. **Prerequisite:** Understanding of fundamental geological concepts such as rock types, minerals, and basic geological processes. Proficiency in reading and interpreting geological maps. This skill is crucial for understanding the spatial distribution of geological features.

d. **Rationale:** Understanding and practical application. Structural Geology and Tectonics is designed to offer students a comprehensive and hands-on learning experience, aligning with the broader educational goals of fostering critical thinking, practical skills, and a deeper understanding of Earth's geological processes.

e. **Course Learning Objective:**

CLOBJ 1	Students will be able to identify and classify common geological structures, including folds, faults, joints, and cleavage, through hands-on observation of rock outcrops and outcrop analogs. This includes understanding the geometric characteristics and deformation mechanisms associated with each structure.
CLOBJ 2	Develop the ability to interpret geological maps and cross-sections to deduce the subsurface geometry of geological structures. Students will learn to recognize and analyze the spatial relationships of rock units, structures, and their tectonic significance.
CLOBJ 3	Apply fundamental concepts of stress and strain to explain the deformation of rocks and the development of geological structures. Students should be able to relate observed structural features to the forces and conditions that led to their formation.
CLOBJ 4	Acquire practical skills in conducting structural analysis, including the measurement of orientation, inclination, and relative ages of geological structures. Students will use compass clinometers and other tools to quantify structural parameters in the field.

f. **Course Learning Outcomes:**

CLO 1	Demonstrating the ability to identify and describe common geological structures, including folds, faults, joints, and cleavage, both in the field and through the examination of rock samples.

CLO 2	Developing competence in interpreting geological maps, recognizing and understanding the representation of geological structures, rock units, and tectonic features.
CLO 3	Acquiring quantitative skills in structural analysis, utilizing tools such as compass clinometers to measure the orientation, inclination, and relative ages of geological structures in various field settings.
CLO 4	Applying principles of stress and strain to explain the deformation of rocks and the development of geological structures, demonstrating an understanding of the forces and conditions involved in the Earth's crustal evolution.

g. Teaching & Examination Scheme:

Teaching Scheme				**Evaluation Scheme**					
L	**T**	**P**	**C**	**Internal Evaluation**			**ESE**		**Total**
				MSE	**CE**	**P**	**Theory**	**P**	
0	**-**	**4**	**2**	**-**	**-**	**40**	**-**	**60**	**100**

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

Exp. No.	**Name of the Experiment**
1	Petrofabric analysis: Streographic analysis of planes and lines. Analysis of folds, faults.
2	Interpretation of geological maps.
3	Map sections, structural problems.

h. Text Book and Reference Book:

1. Structural Geology: Fundamentals and Modern Developments" by S.K. Ghosh
2. An Introduction to Geological Structures and Maps by George M. Bennison.
3. Earth Structure: An Introduction to Structural Geology and Tectonics by Ben A. van der Pluijm and Stephen Marshak
4. Atlas of Structural Geology by Soumyajit Mukherjee
5. Tectonics by Eldridge M. Moores and Robert J. Twiss

(2)

a. **Course Name:** Lab 2 (Paleontology)
b. **Course Code:** 11211158
c. **Prerequisite:** Basic knowledge of geology and biology is recommended as a prerequisite for the Paleontology lab.
d. **Rationale:** Provides students with hands-on experience in fossil identification and interpretation, fostering an understanding of Earth's biological history and evolution.
e. **Course Learning Objective:**

CLOBJ 1	Develop the ability to accurately identify and classify fossils from various geological time periods, including invertebrates, vertebrates, and plant fossils, through hands-on examination and analysis.
CLOBJ 2	Understand the principles of stratigraphy and chronology to interpret the temporal and environmental context of fossils, including recognizing the significance of index fossils for dating rock layers.
CLOBJ 3	Gain skills in reconstructing past environments based on fossil assemblages, sedimentary structures, and geochemical indicators, enabling the interpretation of ancient ecosystems and climates.
CLOBJ 4	Apply principles of taphonomy to analyze the processes affecting the preservation and fossilization of organisms, enhancing the ability to infer post-mortem modifications and understand biases in the fossil record.

f. **Course Learning Outcomes:**

CLO 1	Demonstrating proficiency in the accurate identification and classification of diverse fossils, showcasing a comprehensive understanding of various taxa and their morphological characteristics.
CLO 2	Exhibiting competence in using fossils as stratigraphic markers, enabling the correlation of rock layers and the interpretation of the chronological sequence of events in Earth's history.
CLO 3	Developing the ability to reconstruct past environments by analyzing fossil assemblages, sedimentary structures, and geochemical indicators, providing insights into the ecological dynamics of ancient ecosystems.

CLO 4	Demonstrating the capability to apply taphonomic principles to analyze the preservation and alteration of fossils, allowing for a nuanced understanding of post-mortem processes and biases in the fossil record.

g. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
0	-	4	2	-	-	40	-	60	100

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

Exp. No.	Name of the Experiment
1	Morphological descriptions and illustrations of representative fossils belonging to some foraminiferal genera
2	Identification of species
3	Morphology of the important fossils
4	Distributions of fauna and flora through the Indian Paleozoic, Mesozoic and Cenozoic era

h. Textbook and Reference Book:

1. Introduction to Paleobiology and the Fossil Record by Michael J. Benton and David A. T. Harper.
2. Invertebrate Palaeontology and Evolution by Euan N. K. Clarkson
3. Vertebrate Paleontology by Michael J. Benton
4. Fossil Invertebrates" by Raymond C. Moore and Curt Teichert

(3)

a. **Course Name:** Lab 3 (Remote Sensing and GIS)
b. **Course Code:** 11211159
c. **Prerequisite:** Prior coursework in geospatial sciences and a fundamental understanding of remote sensing principles are prerequisites for the Remote Sensing and GIS Lab. Proficiency in GIS software and data interpretation skills is also recommended.
d. **Rationale:** The Remote Sensing and GIS Lab facilitates practical application of geospatial technologies, fostering expertise crucial for effective spatial analysis and problem-solving in fields like environmental science and urban planning.
e. **Course Learning Objective:**

CLOBJ 1	Develop proficiency in utilizing remote sensing technologies and GIS tools for spatial data acquisition, processing, and analysis.
CLOBJ 2	Enhance skills in interpreting and integrating diverse geospatial datasets to solve real-world problems in environmental monitoring and resource management.
CLOBJ 3	Apply advanced techniques for image classification, spatial modeling, and cartographic visualization in the context of remote sensing and GIS.
CLOBJ 4	Demonstrate the ability to design and execute independent geospatial projects, emphasizing critical thinking and problem-solving.

f. **Course Learning Outcomes:**

CLO 1	Proficiently apply remote sensing techniques and GIS tools to collect, process, and analyze spatial data, demonstrating a mastery of fundamental geospatial skills.
CLO 2	Successfully integrate and interpret diverse geospatial datasets to address real-world challenges, showcasing the ability to make informed decisions based on spatial information.
CLO 3	Execute advanced tasks such as image classification, spatial modelling, and cartographic visualization, showcasing expertise in utilizing sophisticated geospatial methodologies.
CLO 4	Independently design, implement, and present geospatial projects, reflecting critical thinking, problem-solving abilities, and effective communication of results.

g. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
0	-	4	2	-	-	40	-	60	100

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

Exp. No.	Name of the Experiment
1	Laboratory Exercise for remote sensing and photogeology: topographical map, aerial photo and satellite imagery interpretation for geological applications
2	Introduction to digital image processing

h. Textbook and Reference Book:

1. Remote Sensing and GIS Integration: Theories, Methods, and Applications by QihaoWeng
2. Digital Image Processing by Rafael C. Gonzalez and Richard E. Woods
3. Introduction to Geographic Information Systems" by Kang-Tsung Chang
4. GIS and Remote Sensing Applications in Biogeography and Ecology" by Andrew Skidmore and K. Praveen Karanth
5. GIS Tutorial 1: Basic Workbook" by Wilpen L. Gorr and Kristen S. Kurland
6. Remote Sensing and Image Interpretation" by Thomas Lillesand, Ralph W. Kiefer, and Jonathan Chipman

SEMESTER-III

(1)

a. **Course Name:** Hydrogeology (Lab 1)

b. **Course Code:** 11211207

c. **Prerequisite:** Basic knowledge of Geology, Mathematics, Statistics and GIS.

d. **Rationale:** In essence, hydrogeological practical work serves as a scientific exploration, providing the data and insights necessary to advance understanding, refine models, and make evidence-based decisions in the realm of groundwater science and management.

e. **Course Learning Objective:**

CLOBJ 1	Develop proficiency in fundamental hydrogeological field techniques, including well installation, groundwater sampling, and geophysical survey methods. Students should be able to execute these techniques with precision, considering safety protocols and environmental considerations.
CLOBJ 2	Enhance students' ability to collect, process, and interpret hydrogeological data. This includes measurements of groundwater levels, flow rates, aquifer properties, and the use of geospatial tools for mapping and analysis. Emphasize the importance of accuracy, precision, and quality control in data collection.
CLOBJ 3	Equip students with the skills to conduct laboratory analyses on groundwater samples. This involves understanding and performing tests for water quality parameters, chemical composition, and contaminants. Emphasize the importance of adherence to laboratory protocols and the interpretation of analytical results.
CLOBJ 4	Develop the ability to create and use hydrogeological models. This includes the application of software tools for groundwater flow modelling, aquifer parameter estimation, and the simulation of hydrological processes. Students should understand the limitations and uncertainties associated with modelling

f. **Course Learning Outcomes:**

CLO 1	Develop proficiency in the collection and analysis of hydrological field data. This includes measurements of river discharge, precipitation, soil moisture, and other relevant parameters. Students should be able to employ standard field instruments, record accurate measurements, and analyze the data using appropriate statistical techniques.

CLO 2	Acquire fundamental skills in hydrological modelling. Students should be able to understand and apply hydrological models to simulate and predict watershed behaviour. This includes using software tools for rainfall-runoff modelling, flood forecasting, and assessing the impact of land use changes on hydrological processes.
CLO 3	Develop competence in laboratory techniques for water quality analysis. This involves conducting tests for various water quality parameters such as pH, turbidity, dissolved oxygen, nutrients, and contaminants. Students should gain hands-on experience in using laboratory equipment and interpreting analytical results.
CLO 4	Comprehend the integration of remote sensing and Geographic Information System (GIS) methods in hydrological research. Students should utilize satellite imagery, aerial photos, and GIS tools to analyze land cover, delineate watersheds, and evaluate spatial hydrological feature patterns.

g. Teaching & Examination Scheme:

Teaching Scheme				**Evaluation Scheme**					
L	**T**	**P**	**C**	**Internal Evaluation**			**ESE**		**Total**
				MSE	**CE**	**P**	**Theory**	**P**	
0	**-**	**4**	**2**	**-**	**-**	**40**	**-**	**60**	**100**

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

Exp. No.	**Name of the Experiment**
1	Study of groundwater survey map
2	Interpretation of geological maps
3	Map sections, hydrogeological problems.

h. Textbook and Reference Book:

1. Davies, S.N. and De Wiest, R.J.M. (1966) Hydrology, John Wiley, N.Y.

2. Fetter, C.W. (1990) Applied Hydrology, Prentice Hall

3. Todd, D.K. (1980) Groundwater Hydrology. John Wiley& Sons, N.Y.

4. Raghunath, H.M. Hydrology

(2)

a. **Course:** Petroleum and Coal Geology (Lab 2)
b. **Course Code:** 11211209
c. **Prerequisite:** A related field with a focus on sedimentology, petrology, and strong laboratory skills.
d. **Rationale:** Hands-on experience essential for careers in hydrocarbon exploration, extraction, and environmental management.
e. **Course Learning Objective:**

CLOBJ 1	Develop proficiency in identifying physical and chemical properties, as well as lithological and textural characteristics of petroleum and coal.
CLOBJ 2	Analyze core samples, well logs, and seismic data to understand the geological conditions influencing hydrocarbon and coal deposits.
CLOBJ 3	Conduct laboratory analyses to determine properties such as porosity, permeability, thermal maturity, and rank of coal and petroleum resources.
CLOBJ 4	Utilize geological maps, cross-sections, and stratigraphic data to assess the distribution, quality, and economic viability of petroleum and coal reserves.

f. **Course Learning Outcomes:**

CLO 1	Differentiate samples by their physical, chemical, and petrological properties, and identify their depositional environments.
CLO 2	Analyze core samples, well logs, and stratigraphic data to determine reservoir characteristics and evaluate hydrocarbon and coal deposits.
CLO 3	Assess porosity, permeability, thermal maturity, and coal rank using industry-standard instruments and methodologies.
CLO 4	Synthesize geological, geochemical, and structural data to assess the quality, distribution, and economic viability of petroleum and coal reserves.

g. **Teaching and Examination Scheme**

Teaching Scheme					**Examination Scheme**					**Total**
Lecture Hrs / week	**Tutorial Hrs / week**	**Lab Hrs / Week**	**Credit**	**Internal Marks**			**External Marks**			
				T	**P**	**CE**	**T**		**P**	
-	-	4	2	-	-	40	-	-	60	100

Lect - Lecture, Tut - Tutorial, Lab - Lab, T - Theory, P - Practical, CE - CE, T - Theory, P – Practical

Exp. No.	Name of the Experiment
1	Macroscopic characterization of banded coals
2	Preparation of polished particulate mounts of coal.
3	Microscopic examination of polished mounts for identification of macerals.
4	Macroscopic and microscopic study of cores and well cuttings.
5	Study of geological maps and sections of important oilfields of India.
6	Calculation of coal reserve

h. Textbook and Reference Book:

1. Leverson, A.L. Geology of Petroleum. Freeman and co., 1970
2. Selley, R. C. Elements of Petroleum Geology, II Edition. Academic Press, 1998
3. Stach, E. et al. Stach's textbook of coal petrology. Berlin: Gebruder Borntraeger, 1975.
4. Taylor, G.H., Teichmüller, M.., Davis, C. Organic Petrology: A new handbook incorporating some revised parts of Stach's Textbook of Coal Petrology, 1998
5. Chandra, D., Singh, R.M., Singh, M.P. Text Book of Coal (Indian Context). Tara Printing Works, Varanasi, 2000