ROYAL GLOBAL UNIVERSITY
GUWAHATI

ROYAL SCHOOL OF ENVIRONMENTAL AND EARTH SCIENCES (RSEES)

DEPARTMENT OF GEOLOGY

COURSE STRUCTURE & SYLLABUS

(BASED ON NATIONAL EDUCATION POLICY 2020)

FOR

B.Sc. IN GEOLOGY

(4 YEARS SINGLE MAJOR)

W.E.F. ACADEMIC YEAR

2023-24

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1. Preamble

In pursuit of an elevated vision for higher education, The Assam Royal Global University (RGU) proudly embraces the essence of the National Education Policy (NEP) 2020. We recognize the profound role of higher education in fostering equity, human welfare, societal advancement, and the realization of India's constitutional aspirations. Within this transformative framework, the Department of Geology envisions cultivating exceptional, well-rounded individuals equipped to thrive in the 21st century.

Our mission is to empower students with the ability to delve deeply into specialized areas of geology while nurturing character, ethical values, and a commitment to the Constitution. At the heart of our curriculum lies an unwavering dedication to intellectual curiosity, scientific temper, creativity, and a spirit of service. Embracing multidisciplinarity, we aim to instil twenty-first-century capabilities that span across sciences, social sciences, arts, humanities, languages, as well as professional, technical, and vocational subjects.

Endeavouring to unlock the potential of each student, our flexible curricula are designed with credit-based courses and transformative projects, embracing community engagement, service, and environmental education. We proudly offer invaluable opportunities for internships, bridging the gap between theory and practice. Our students actively collaborate with local industries, businesses, and artisans, gaining practical insights to enhance their employability and readiness for the challenges of the real world.

In reverence to India's profound Knowledge System, we integrate courses that honour the nation's rich heritage, encompassing ancient disciplines like Vedic Mathematics, Vedangas, Indian Astronomy, Fine Arts, and Metallurgy. This holistic education instils an enlightened social consciousness, equipping our graduates to contribute meaningfully to society, unravelling innovative solutions for the greater good.

Embodying the core values of RGU, the Department of Geology aspires to be a catalyst for knowledge creation, fostering a vibrant, cooperative community. Our commitment to excellence in higher education seeks to nurture a harmonious, progressive, and prosperous nation, driven by informed, skilled, and compassionate citizens.

2. Introduction

Welcome to the Department of Geology at The Assam Royal Global University (RGU), where our curriculum is thoughtfully crafted in alignment with the transformative vision of the National Education Policy (NEP) 2020. Embodying the principles that higher education plays a pivotal role in promoting human and societal well-being, we are dedicated to nurturing individuals who are not only well-rounded but also creative thinkers and innovators of the 21st century.

In response to the NEP's call for a multidisciplinary approach, our curriculum seamlessly integrates the humanities and arts with Science, Technology, Engineering, and Mathematics (STEM). Through this harmonious blend, our students gain a comprehensive understanding of geology, fostering creativity, critical thinking, problem-solving prowess, and higher-order cognitive abilities. With an emphasis on conceptual understanding rather than rote learning, we foster an environment that encourages logical decision-making and innovation, all while upholding the values of ethics, human rights, and constitutional principles.

As staunch proponents of flexibility and individuality, we empower our learners to chart their unique learning trajectories and programs, choosing paths that align with their talents and passions. Our curriculum is designed to impart in-depth knowledge across various fields, fostering expertise and holistic development. Additionally, we place significant value on life skills such as effective communication, teamwork, leadership, and resilience, empowering our students to thrive both academically and in their future endeavours.

Technology stands at the core of our teaching and learning methodology, enhancing accessibility, and removing language barriers to ensure inclusivity for all students, including Divyang individuals. Rooted in respect for diversity, we take pride in contextualising our curriculum, pedagogy, and policies to celebrate the rich tapestry of India's cultures, knowledge systems, languages, and traditions.

Above all, we embrace the principles of equity and inclusion as the cornerstone of our educational decisions, ensuring a supportive and responsive institutional environment that enables all students to access high-quality education. With a deep-rooted appreciation for India's heritage, we infuse our curriculum with a sense of pride in its ancient and modern geology, nurturing a generation of geologists who can contribute meaningfully to the nation and the world.

As we embark on this journey of academic excellence, the Department of Geology at RGU is committed to fostering future geologists who not only unravel the mysteries of the Earth but also become compassionate, responsible, and socially conscious global citizens. Together, we pave the way for a vibrant and sustainable future, grounded in knowledge, innovation, and cultural understanding.

3. Approach to Curricular Planning

In the Department of Geology at The Royal Global University (RGU), our approach to curricular planning is deeply rooted in the visionary framework of the National Education Policy (NEP) 2020. As we shape our curriculum to meet the specific needs of geology students, we also draw inspiration from certain aspects of the Credit-Based Choice Based Credit System (CBCS) to enhance the learning experience. Our curriculum is thoughtfully designed with the following key elements:

1. Holistic Development: We prioritize the holistic development of our geology students. Beyond academic excellence, we aim to nurture their intellectual curiosity, critical thinking, and ethical values. Our curriculum fosters a deep appreciation for the natural world and instils a sense of environmental responsibility.

2. Learner-Centric Approach: Embracing the spirit of NEP 2020, our curricular planning adopts a learner-centric approach. We recognize the unique abilities and interests of each student, providing them with opportunities to tailor their academic journey and pursue specialized areas of geology.

3. Multidisciplinarity and Interdisciplinarity: Our geology curriculum integrates multidisciplinary knowledge, encompassing subjects like geography, physics, chemistry, and environmental studies. We encourage students to explore the interconnectedness of different disciplines, empowering them to become versatile professionals.

4. Flexibility and Choice: Drawing on certain inputs from CBCS, we offer geology students the flexibility to choose elective courses aligned with their interests and career goals. This freedom allows them to delve deeper into specific geology subfields and broaden their horizons.

5. Practical Experience and Research: Practical experiences and research play a pivotal role in our geology curriculum. Fieldwork, laboratory exercises, and research internships provide hands-on learning opportunities, honing students' field skills and analytical abilities.

6. Ethical and Environmental Values: We embed ethical values and environmental consciousness into our geology curriculum. Our students are encouraged to be responsible stewards of the Earth and to consider sustainability in their professional practice.

7. Continual Curriculum Review: Curricular planning in the Department of Geology is an ongoing process, subject to continuous review and improvement. We keep abreast of advancements in geology and consider industry feedback to ensure our curriculum remains cutting-edge and relevant.

8. Emphasis on Industry-Relevant Skills: Our geology curriculum places a strong emphasis on developing industry-relevant skills. Graduates are equipped with data analysis, GIS mapping, and geotechnical expertise, making them highly employable in various sectors.

9. International Perspectives: Embracing global awareness, we introduce international perspectives into our geology curriculum. Students explore geological phenomena worldwide, enriching their understanding of Earth's diverse geological processes.

In conclusion, the Department of Geology's approach to curricular planning at RGU seeks to create well-rounded geology professionals with a passion for exploration and environmental stewardship. Our dynamic and inclusive curriculum empowers students to become skilled geologists with a profound appreciation for the Earth's natural wonders and a commitment to contributing positively to society and the planet.

4. Award of Degree in B.Sc. Geology Programme

The structure and duration of undergraduate programmes of study offered by the University as per NEP 2020 include:

4.1. Undergraduate programmes of either 3 or 4-year duration with Single Major, with multiple entry and exit options, with appropriate certifications:

4.1.1. UG Certificate: Students who opt to exit after completion of the first year and have secured 40 credits will be awarded a UG certificate if, in addition, they complete one vocational course of 4 credits during the summer vacation of the first year. These students are allowed to re-enter the degree programme within three years and complete the degree programme within the stipulated maximum period of seven years.

4.1.2. UG Diploma: Students who opt to exit after completion of the second year and have secured 80 credits will be awarded the UG diploma if, in addition, they complete one vocational course of 4 credits during the summer vacation of the second year. These students are allowed to re-enter within a period of three years and complete the degree programme within the maximum period of seven years.

4.1.3. 3-year UG Degree: Students who will undergo a 3-year UG programme will be awarded UG Degree in the Major discipline after successful completion of three years, securing 120 credits and satisfying the minimum credit requirement.

4.1.4. 4-year UG Degree (Honours): A four-year UG Honours degree in the major discipline will be awarded to those who complete a four-year degree programme with 160 credits and have satisfied the credit requirements as given in the course structure.

4.1.5. 4-year UG Degree (Honours with Research): Students who secure 75% marks and above in the first six semesters and wish to undertake research at the undergraduate level can choose a research stream in the fourth year. They should do a research project or dissertation under the guidance of a Faculty Member of the University. The research project/dissertation will be in the major discipline. The students who secure 160 credits, including 12 credits from a research project/dissertation, will be awarded UG Degree (Honours with Research).

Award	Year	Credits to earn	Additional Credits	Re-entry allowed within (years)	Years to Complete
UG Certificate	1	40	4	3	7
UG Diploma	2	80	4	3	7

3-year UG Degree (Major)	3	120	x	x	x
4-year UG Degree (Honours)	4	160	x	x	x
4-year UG Degree (Honors with Research)	4	160	Students who secure cumulative 75% marks and above in the first six semesters.		

5. Graduate Attributes in Geology

Some of the characteristic attributes of a graduate in Geology are:

GA1: Disciplinary Knowledge: Upon completion of the B.Sc. Geology program, graduates will possess a comprehensive understanding of geological principles, theories, and methodologies. They will demonstrate proficiency in core geological concepts, including mineralogy, petrology, stratigraphy, and structural geology, enabling them to apply their knowledge to real-world geological challenges.

GA2: Complex Problem Solving: Graduates will be adept at tackling complex geological problems by employing a systematic and analytical approach. They will have honed their ability to analyse geological data, interpret geological phenomena, and propose viable solutions to address geological challenges and environmental issues.

GA3: Analytical & Critical Thinking: B.Sc. Geology graduates will be equipped with strong analytical and critical thinking skills, enabling them to evaluate geological data, identify patterns, and draw well-informed conclusions. They will apply critical thinking to assess the implications of geological findings and make informed decisions.

GA4: Creativity: Graduates will demonstrate creativity in approaching geological research and exploration. They will be capable of thinking innovatively to address geological challenges and propose novel solutions in geological exploration and resource management.

GA5: Communication Skills: B.Sc. Geology graduates will possess effective communication skills, both written and verbal, allowing them to articulate geological concepts, research findings, and exploration outcomes to diverse audiences. They will communicate complex geological information with clarity and precision.

GA6: Research-related Skills: Graduates will be equipped with research-related skills, including data collection, analysis, and interpretation. They will have experience in conducting geological research and utilizing various research methodologies to contribute to the advancement of geological knowledge.

GA7: Collaboration: Graduates will excel in collaborative settings, demonstrating an ability to work effectively as part of multidisciplinary teams. They will value diverse perspectives, fostering productive collaborations to address complex geological challenges.

GA8: Leadership Readiness/Qualities: B.Sc. Geology graduates will exhibit leadership readiness and qualities, taking initiative in geological projects and resource management. They will possess the skills to lead teams and guide geological initiatives with a sense of responsibility and vision.

GA9: Digital and Technological Skills: Graduates will be proficient in utilizing digital tools and technologies relevant to the field of geology. They will be adept at employing Geographic Information Systems (GIS), remote sensing, and other technological advancements in geological exploration and analysis.

GA10: Environmental Awareness and Action: Graduates will demonstrate a strong sense of environmental awareness and responsibility. They will consider the environmental impact of geological activities and strive to implement sustainable practices in geological exploration and resource management, contributing to environmental conservation and protection.

6. Program Learning Outcomes in B.Sc. Geology

Upon satisfactory completion of B.Sc. degree in Geology, the graduates will be able to achieve the following:

PLO1: Knowledge of Geology: Graduates will demonstrate a deep understanding of geological principles, theories, and concepts across various subfields of geology, including mineralogy, petrology, stratigraphy, and structural geology.

PLO2: Develop Complex Problem-Solving Skills in Geology: Graduates will be capable of analysing complex geological problems, synthesizing information from diverse sources, and proposing effective solutions to geological challenges and environmental issues.

PLO3: Develop Analytical & Critical Thinking Skills in Geology: Graduates will employ analytical and critical thinking skills to evaluate geological data, interpret geological phenomena, and make evidence-based judgments in geological research and exploration.

PLO4: Develop the ability to create: Graduates will exhibit creativity in geological research and exploration, demonstrating innovative thinking in addressing geological problems and proposing new approaches to geological investigations.

PLO5: Develop effective communication skills: Graduates will effectively communicate geological concepts and research findings to both specialized and non-specialized audiences through well-structured written reports, oral presentations, and visual representations.

PLO6: Develop Geological Research-related Skills: Graduates will demonstrate proficiency in conducting geological research, including data collection, analysis, and interpretation, and contribute to the advancement of geological knowledge through independent and collaborative research projects.

PLO7: Develop abilities to collaborate: Graduates will work effectively as part of multidisciplinary teams, valuing diverse perspectives and engaging in constructive collaborations to address geological challenges and explore research opportunities.

PLO8: Develop Leadership Qualities: Graduates will exhibit leadership readiness and qualities, displaying initiative in geological projects and resource management, and effectively leading teams towards achieving geological objectives.

PLO9: Develop Digital and Technological Skills in Geology: Graduates will utilize digital tools and technologies relevant to geology, including Geographic Information Systems (GIS), remote sensing, and geospatial analysis, to enhance geological exploration and analysis.

PLO10: Develop Environmental Awareness in geological activities: Graduates will demonstrate a strong sense of environmental awareness and responsibility in geological activities, striving to implement sustainable practices and contribute to environmental conservation and protection.

7. Program Specific Outcomes in B.Sc. Geology

Upon completion of this programme the student will be able to:

PSO 1	**Geological Knowledge and Understanding:** Upon completion of the B.Sc. Geology program, students will demonstrate a comprehensive knowledge and understanding of geological principles, concepts, and theories. They will be able to apply this knowledge to analyse geological phenomena and interpret geological data.
PSO 2	**Field Skills and Geological Surveys:** Students will develop proficiency in geological fieldwork, including mapping, sample collection, and data recording. They will be capable of conducting geological surveys and investigations in diverse terrains and geological settings.
PSO 3	**Environmental and Resource Assessment:** Students will understand the relationship between geology and the environment. They will acquire skills to assess the impact of geological activities on the environment and evaluate geological resources such as minerals, fossil fuels, and groundwater.

PSO 4	**Geotechnical Analysis and Hazard Assessment:** Students will be equipped with geotechnical analysis skills to evaluate the engineering properties of geological materials. They will also identify and assess geological hazards, such as earthquakes, landslides, and volcanic eruptions, contributing to disaster preparedness plans.

8. Teaching Learning Process

In the Department of Geology, our teaching-learning process for the B.Sc. Geology curriculum is designed to foster a dynamic and engaging educational experience, aligning with the transformative vision of the National Education Policy (NEP) 2020. The process encompasses the following key principles:

a) **Learner-Centric Approach:** We prioritize our students' needs and interests, adopting a learner-centric approach to education. Our faculty members create a supportive and inclusive learning environment, encouraging active participation and intellectual curiosity among students. Tutorial classes where a closer interaction between the students and the teacher is present as each student gets individual attention.

b) **Blended Teaching Methodologies:** We employ a blend of traditional and modern teaching methodologies, leveraging technology to enhance the learning process. Lectures, practical sessions, fieldwork, and virtual tools are integrated to provide a well-rounded understanding of geological concepts.

c) **Multidisciplinary Perspectives:** Recognizing the significance of multidisciplinary learning, we encourage students to explore diverse aspects of geology, including its intersections with environmental sciences, engineering, and geography. This approach broadens their perspectives and fosters interdisciplinary thinking.

d) **Experiential Learning:** Practical experiences and fieldwork form an integral part of our curriculum. Students actively engage in geological surveys, laboratory work, and research projects, honing their analytical and problem-solving skills. Very small projects like 1-day field-based projects are part of our curriculum so as to continuously boost their practical skills and knowledge.

e) **Research and Inquiry:** We emphasize research and inquiry-based learning, motivating students to undertake independent geological investigations. By delving into real-world geological challenges, students develop critical thinking abilities and contribute to the advancement of geological knowledge.

f) **Environmental Awareness:** Environmental consciousness is infused throughout the curriculum. Students are sensitized to the environmental impact of geological activities and explore sustainable practices to address geological challenges responsibly.

g) **Continuous Assessment:** Our teaching-learning process includes regular formative assessments to gauge student progress and offer constructive feedback. This approach enables personalized learning and promotes continuous improvement.

h) **Industry Collaboration:** We foster collaborations with industry experts and research organizations to provide students with exposure to the practical applications of geology. Guest lectures, workshops, and internships enhance their understanding of real-world geological scenarios.

i) **Communication and Presentation Skills:** We emphasize the development of effective communication and presentation skills. Students are encouraged to articulate their geological findings and research outcomes with clarity and precision. It includes Group discussions, Student presentations, Home assignments, Quizzes and class tests.

j) **Professional Ethics:** Professional ethics and integrity are instilled in our students' education. They are encouraged to uphold ethical standards in all aspects of geological practice, including research, exploration, and resource management.

k) **Mentor-Mentee Relationship:** The Mentor-Mentee relationship is an integral part of our teaching-learning process. Each B.Sc. Geology student is paired with a knowledgeable Mentor who provides individualized guidance, academic support, and career advice. The Mentor-Mentee relationship fosters a supportive and nurturing environment, empowering students to reach their full potential and excel in their academic and personal development.

9. Assessment Methods

Methods	Weightage
Continuous Evaluation	50%
Semester End Examination	50%
Total	**100%**

The Continuous Evaluation component is again re-divided as per the following connotation:

- Class Participation (35%)
- Mid-Term Examination (10%)
- Attendance (5%)

Class Participation (35%): Every student's progress and performance are continuously adjudged throughout the semester in different ways such as Class Tests, Viva, Assignments, Project Work, and Seminars etc. 35% marks are allotted under the head 'Class Participation'.

Mid-Term Examination (10%): This is a written test conducted in the middle of the semester after completion of 40% to 50% of the course. 10% marks are allotted for Mid-Term Examination.

Attendance (5%): Ideally, a student is expected to attend 100% of the classes, but considering various hindrances like illness, accident, etc. a relaxation of maximum 25% is given, which means a student has to maintain an attendance of minimum 75% in each course; failing to do so will lead to debarment of the student from the examination in the said course. 1-5 marks are given to students having 75% attendance or more. Attendance is awarded to a student as per the following connotation:

Percentage of Attendance (%)	Marks
95% and above	5
More than 90% and up to 95%	4
More than 85% and up to 90%	3
More than 80% and up to 85%	2
75% and up to 80%	1
Below 75%	0

Semester wise and component wise distribution of Courses
(Four Year UGP-Single Major)

Year	Semester	Major (Core)		Minor		Interdisciplinary	AEC-(English/MIL/Regional Language)	SEC/Internship/Apprenticeship/Dissertation	VAC	Total credits
		Course Level	No. of Courses	Course Level	No. of Course	No. of Courses	No. of Courses	No. of Courses	No. of Courses	
I	I	100	2	100	1	1	1	1	1	20
	II	100	2	100	1	1	1	1	1	20
	Exit -1: UG Certificate in the relevant discipline/Subject Total credit requirement : 40 credit (Additional 4 credit of work based vocational course/ internship/ apprenticeship on exit)									
2	III	200	2	(200 & above)	1	1	1	1	0	20
	IV	200	3	(200 & above)	2	0	1	0	0	20
Exit -2:UG Diploma in the relevant discipline/subject Total credit requirement: 80 credit (additional 4 credit of work based vocational course/internship/apprenticeship on exit) To undergo Summer Internship during Summer Break										
3	V	300	3	(200 & above)	1	0	0	1 (internship)	0	20
	VI	300	4	(200 & above)	1	0	0		0	20
For students who undertake 3 year UG Programme, UG Degree will be awarded in the relevant subject/discipline Total credit requirement: 120										
4	VII	400	4	(300 & above)	1	0	0	0	0	20
	VIII	400	2	(300 & above)	0	0	0	1 (Res. Proj/Dissertation)	0	20
									Total	**160**

Note:
After completion of Internship during Summer Term, students will have to submit a report with a completion certificate and comments from the internship supervisor/coordinator and make a presentation on his/her work relating the work to the overall learning objectives.

B. Sc. Geology

Programme Structure

1st SEMESTER				
Sl. No	**Course Code**	**Name of Courses**	**Course Level**	**Credits**
		Major Courses		
1	GEOL162M141	Physical Geology	100	3
2	GEOL162M142	Mineral Science	100	3
		Minor Course		
3	GEOL162N101	Physical Geology	100	3
		Interdisciplinary Courses		
4	IKS992K101	Indian Knowledge System 1	-	3
		Ability Enhancement Courses		
5	CEN982A101	Communicative English I	-	1
6	BHS982A104	Behavioural Science I	-	1
		Skill Enhancement Courses		
7	GEOL162S111	Geological Mapping and Surveying	-	3
		Value Added Courses		
8		VAC 1 (Basket Course)	-	3
9		**Course through SWAYAM portal** ***(to be selected by the department)***	-	3 or 4
			TOTAL	20 + (3 or 4)

2nd SEMESTER				
Sl. No	**Course Code**	**Name of Courses**	**Course Level**	**Credits**
		Major Courses		
1	GEOL162M241	Geochemistry	100	3
2	GEOL162M242	Igneous Petrology	100	3
		Minor Course		
3	GEOL162N201	Geology and Natural Hazards	100	3
		Interdisciplinary Courses		
4	IKS992K201	Indian Knowledge System 2	-	3
		Ability Enhancement Courses		
5	CEN982A201	Communicative English II	-	1
6	BHS982A202	Behavioural Science II	-	1
		Skill Enhancement Courses		
7	GEOL162S211	Geomorphology and Landform Analysis	-	3
		Value Added Courses		
8		VAC 2 (Basket Course)	-	3
9		**Course through SWAYAM portal** ***(to be selected by the department)***	-	3 or 4
			TOTAL	20 + (3 or 4)

3rd SEMESTER				
Sl. No	**Course Code**	**Name of Courses**	**Course Level**	**Credits**
		Major Courses		
1	GEOL162M341	Metamorphic Petrology	200	4
2	GEOL162M342	Sedimentology	200	4
		Minor Course		
3	GEOL162N341	Mineralogy	200	4
		Interdisciplinary Courses		
4	GEOL162I301	Physics and Chemistry of Earth (Basket Course)	-	3

		Ability Enhancement Courses		
5	CEN982A301	Communicative English III	-	1
6	BHS982A304	Behavioural Science III	-	1
		Skill Enhancement Courses		
7	GEOL162S311	Remote Sensing and GIS	-	3
8		**Course through SWAYAM portal** ***(to be selected by the department)***	-	3 or 4
			TOTAL	20 + (3 or 4)

4th SEMESTER

Sl. No	Course Code	Name of Courses	Course Level	Credits
		Major Courses		
1	GEOL162M441	Principles of Stratigraphy	200	4
2	GEOL162M442	Palaeontology	200	4
3	GEOL162M403	Earth Science in Ancient India (IKS)	200	4
		Minor Course		
3	GEOL162N441	Petrology	200	3
4	GEOL162N442	Structural Geology	200	3
		Ability Enhancement Courses		
5	CEN982A401	Communicative English IV	-	1
6	BHS982A404	Behavioural Science IV	-	1
7		**Course through SWAYAM portal** ***(to be selected by the department)***	-	3 or 4
			TOTAL	20 + (3 or 4)

5th SEMESTER

Sl. No	Course Code	Name of Courses	Course Level	Credits
		Major Courses		
1	GEOL162M541	Structural Geology	300	4
2	GEOL162M502	Indian Stratigraphy	300	4
3	GEOL162M543	Hydrogeology	300	4
4	GEOL162M524	Summer Internship	-	4
		Minor Course		
5	GEOL162N541	Fuel Geology	200	4
			TOTAL	20

6th SEMESTER

Sl. No	Course Code	Name of Courses	Course Level	Credits
		Major Courses		
1	GEOL162M601	Geostatistics	300	4
2	GEOL162M642	Economic Geology	300	4
3	GEOL162M643	Engineering and Environmental Geology	300	4
4	GEOL162M644	Fuel Geology	300	4
		Minor Course		
5	GEOL162N601	Environmental Geology	200	4
			TOTAL	20

7th SEMESTER

Sl. No	Course Code	Name of Courses	Course Level	Credits
		Major Courses		
1	GEOL162M741	Advanced Structural Geology and Tectonics	400	4
2	GEOL162M742	Advanced Igneous and Metamorphic Petrology	400	4

3	GEOL162M743	Advanced Sedimentology and Quaternary Geology	400	4
4	GEOL162M704	Climatology and Oceanography	400	4
		Minor Course		
5	GEOL162N701	Stratigraphy	300	4
			TOTAL	20

8th SEMESTER

Sl. No	Course Code	Name of Courses	Course Level	Credits
		Major Courses		
1	GEOL162M841	Geomorphology	400	4
2	GEOL162M802	Research Methodology	400	4
3	GEOL162M823	Dissertation	-	12
		Advanced Course in lieu of Dissertation		
4	GEOL162M804	Geology of North-East India	400	4
5	GEOL162M805	Planetary Geology	400	4
6	GEOL162M806	Urban Geology	400	4
			TOTAL	20

Preferred list of Value-Added Courses for the students of B.Sc. Geology

Sl. No.	Course Name	Semester	Credits = 3	
			Theory	Practical
1	Climate Change	1	2	1
2	Renewable Energy and Sustainable Technologies	1	2	1
3	Climate Writing	1	2	1
4	Disaster Management	2	2	1
5	Sustainable Development and Green Living	2	2	1
6	Community-Based Approaches to Environmental Conservation	2	2	1

Detailed Syllabus Of Semester 1

Type of Course: Major	**Physical Geology** **Course Level: 100** **Credit: 3** **L-T-P-C: 2-0-1-3** **Scheme of Evaluation: Theory + Practical**	**Course Code:** **GEOL162M141**

Course Objectives: Physical Geology is an introductory course that covers the fundamental principles of geology. It provides an understanding of the Earth's internal and external processes that shape the Earth's surface and subsurface features. This course covers a range of topics, including mineralogy, petrology, plate tectonics, structural geology, and geological time.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Remember the fundamental concepts of geology, including the rock cycle, plate tectonics, and geological time.	BT 1
CO 2	Explain the processes that form the Earth's surface features and analyze the geological structures and their influence on the formation of natural resources.	BT 2
CO 3	Apply the principles of mineralogy and petrology to identify and classify different types of rocks and minerals, interpret geological maps and cross-sections, and solve geological problems.	BT 3
CO 4	Analyse geomorphological processes and data to understand the various geomorphic activities and their impact on landscape evolution.	BT 4

Modules	Topics and Course Content	Hours
Unit 1	Earth Science & its branches. Origin and evolution of the Universe and Solar System, The standard model of planetary formation. General features of the components of the solar system. Distribution of elements in solar system and in Earth.	10
Unit 2	Mechanical layering of the Earth: lithosphere, asthenosphere, mantle and core. Formation of core, mantle, crust, hydrosphere, and atmosphere. Introduction to Rocks – its types and associated features. Introduction to the concept of Geological Time Scale.	10
Unit 3	Concept of continental drift, seafloor spreading and plate tectonics. Plate boundaries and their geological effects: origin of oceans, continents, mountains and rift valleys. Earthquake and earthquake belts. Volcanoes and its types, distribution and eruptions. Geothermal gradient and internal heat of the Earth. Earth's magnetic field; Convection in Earth's core and production of its magnetic field.	12
Unit 4	Geomorphological processes and their significance. concept of base level and datum. Concept of exogenic and endogenic processes. Weathering, erosion, mass-wasting and their types. Landforms produced by – glacial processes, fluvial processes, aeolian processes, coastal processes, igneous activities.	12
List of Practicals	Interpretation of geomorphic processes of the area with the help of geomorphic models. Preparation of topographic profile from given contour map. Preparation of longitudinal profile of a river. Calculation of Stream length gradient index. Understanding active tectonism with the help of different morphometric parameters.	30
Experiential Learning: Home Assignments – 8 hrs, Presentation – 4 hrs, Video Screening – 4 hrs		16
Total Notional Credit Hours		**90**

Text Books:

1) Introduction to Physical Geology – Thompson & Turk
2) Essentials of Geology - Stephen Marshak, 4th edition, W. W. Norton & Company

Reference Books:

1) Physical Geology – R. F. Flint and J Skinner, John Wiley and Sons, Inc.
2) Global Tectonics - Philip Kearey, Keith A. Klepeis, Frederick J. Vine, (3rd edition, 2009), Wiley-Blackwell.

Type of Course: Major	**Mineral Science** **Course Level: 100** **Credit: 3** **L-T-P-C: 2-0-1-3** **Scheme of Evaluation: Theory + Practical**	**Course Code:** **GEOL162M142**

Course Objectives: Mineral Science is an undergraduate-level course that focuses on the study of minerals and their properties, including crystallography, optical properties, chemical composition, and physical characteristics. The course provides an overview of the formation and classification of minerals, as well as the processes involved in their identification and analysis.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Remember and identify the properties of minerals, their classification, and crystallographic systems.	**BT 1**
CO 2	Explain the physical and chemical properties of minerals and their economic importance.	**BT 2**
CO 3	Apply mineralogical knowledge to identify minerals using optical microscopy and physical characteristics of the specimens.	**BT 3**
CO 4	Analyse various crystallographic and mineralogical data to identify and classify them into various classes.	**BT 4**

Modules	Topics and Course Content	Hours
Unit 1	Unit cell and Lattice structures, Bravais Lattices; Types of crystal structures (e.g., cubic, hexagonal); Symmetry elements and point groups; Crystallographic axes and planes; Overview of crystal systems (e.g., isometric, tetragonal, etc.); Crystallographic axes and symmetry elements for each system.	11
Unit 2	Interfacial angle, crystal parameters and indices. Stereograms and Hermann- Mauguin System. Relationship between crystallography and mineral properties. Concept of crystal, crystalline and amorphous substances. Minerals - definition, physical and chemical properties; Chemical classification of minerals.	11
Unit 3	Silicate and non-silicate structures of minerals. Study of physical properties of minerals of the following group of minerals: Olivine, Pyroxene, Amphibole, Mica, Silica and Feldspar.	11
Unit 4	Polarization of light, Polarisers. Functions of petrological microscope. Optical behaviour of minerals: Absorption, Transmission and Double-refraction of light. Theory of light propagation in minerals: Isotropy and Anisotropy; Optic axis. Optical properties of minerals in thin section. Introduction to X-Ray diffractometry in minerals.	11
List of Practicals	Exercises on stereographic projection of crystal faces. Study of the following silicate minerals in hand specimen and under optical microscope: Olivine, Garnet, Sillimanite, Kyanite, Staurolite, Tourmaline, Enstatite, Diopside, Augite, Actinolite, Hypersthene, Hornblende, Serpentine, Muscovite, Biotite, Quartz and its varieties, Orthoclase, Plagioclase, Microcline, Nepheline, Sodalite, Calcite, Beryl, Talc, Zeolite. Determination of Pleochroic Scheme of minerals. Identification of Plagioclase Feldspars by Michel-Levy method.	30
Experiential Learning: Home Assignments – 8 hrs, Presentation – 4 hrs, Video Screening – 4 hrs		16
Total Notional Credit Hours		**90**

Text Books Suggested:

1) Mineralogy - Dexter Perkins, 3rd edition (2015), Pearson Publication.

Reference books:

1) Introduction to Optical Mineralogy – William D. Nesse, 3rd edition (2004), Oxford University Press.
2) The Manual of Mineral Science (after James D. Dana) - Dutrow, B., Dwight, J., & Klein, C.; (2007) J. Wiley & Sons.
3) Introduction to Rock Forming Minerals – W. A. Deer, R. A. Howie, and J. Zussman, 3rd edition (2013), Prentice Hall.

Type of Course: Minor	**Physical Geology** **Course Level: 100** **Credit: 3** **L-T-P-C: 3-0-0-3** **Scheme of Evaluation: Theory**	**Course Code:** GEOL162N101

Course Objectives: This course provides an overview of the fundamental principles of physical geology, focusing on the study of Earth's processes, materials, and the dynamic forces that shape the planet.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Demonstrate a comprehensive understanding of Earth's structure, composition, and geological processes.	**BT 1**
CO 2	Comprehend the principles of plate tectonics and the processes that drive geological changes.	**BT 2**
CO 3	Apply geological concepts to explain natural phenomena, such as earthquakes, volcanoes, and mountain formation.	**BT 3**
CO 4	Analyze geological data to interpret Earth's history and the formation of various geological formations.	**BT 4**

Modules	Topics and Course Content	Hours
Unit 1	Definition and scope of physical geology Earth's structure, composition, and geologic time Study of minerals and their properties Classification and identification of rocks	17
Unit 2	Understanding plate movements and boundaries The role of plate tectonics in earthquakes, volcanoes, and mountain building Understanding seismicity and volcanic eruptions Impact of earthquakes and volcanoes on the Earth's surface	16
Unit 3	Study of weathering, erosion, mass-wasting and sedimentation Fluvial, glacial, marine and coastal processes and features. Epirogenic processes and movements.	17
Unit 4	Geological processes and their influence on the environment Human interaction with geological hazards such as landslides, earthquakes, volcanic eruptions, floods, mining activities and other civil engineering projects. Relationship between geology and climate change.	16
Experiential Learning: Home Assignments – 10 hrs, Presentation – 10 hrs, Video Screening – 4 hrs		24
Total Notional Credit Hours		**90**

Text Books:

1) Introduction to Physical Geology – Thompson & Turk
2) Essentials of Geology - Stephen Marshak, 4th edition, W. W. Norton & Company

Reference Books:

1) Physical Geology – R. F. Flint and J Skinner, John Wiley and Sons, Inc.
2) Global Tectonics - Philip Kearey, Keith A. Klepeis, Frederick J. Vine, (3rd edition, 2009), Wiley-Blackwell.

Type of Course: AEC	Behavioural Sciences -1 Credit: 1 L-T-P-C: 1-0-0-1 Scheme of Evaluation: Theory	Course Code: BHS982A104

Course Objectives: To increase one's ability to draw conclusions and develop inferences about attitudes and behaviour, when confronted with different situations that are common in modern organizations.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Understand self & process of self-exploration.	**BT 1**
CO 2	Learn about strategies for development of a healthy self-esteem.	**BT 2**
CO 3	Apply the concepts to build emotional competencies.	**BT 3**

Modules	Topics and Course Content	Hours
Unit 1	**Introduction to Behavioural Science** Definition and need of Behavioural Science, Self: Definition components, Importance of knowing self, Identity Crisis, Gender and Identity, Peer Pressure, Self-image: Self Esteem, Johari Window, Erikson's model.	4
Unit 2	**Foundations of individual behaviour** Personality- structure, determinants, types of personalities. Perception: Attribution, Errors in perception. Learning- Theories of learning: Classical, Operant and Social	4
Unit 3	**Behaviour and communication** Defining Communication, types of communication, barriers to communication, ways to overcome barriers to Communication, Importance of Non-Verbal Communication/Kinesics, Understanding Kinesics, Relation between behaviour and communication.	4
Unit 4	**Time and Stress Management** Time management: Introduction-the 80:20, sense of time management, Secrets of time management, Effective scheduling. Stress management: effects of stress, kinds of stress-sources of stress, Coping Mechanisms. Relation between Time and Stress.	4
Total Notional Credit Hours		**16**

Text Books:

1) J William Pfeiffer (ed.) Theories and Models in Applied Behavioural Science, Vol 3, Management; Pfeiffer & Company
2) Blair J. Kolasa, Introduction to Behavioural Science for Business, John Wiley & Sons Inc.
3) K. Alex, Soft skills; S. Chand.

Type of Course: SEC	Geological Mapping and Surveying Credit: 3 L-T-P-C: 0-0-3-3 Scheme of Evaluation: Practical	Course Code: GEOL162S111

Course Objectives: The course focuses on developing hands-on skills in collecting geological data, understanding geological formations, and creating geological maps.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Comprehend the various methods and instruments used in geological fieldwork.	**BT 1**
CO 2	Understand the significance of geological mapping and surveying in geological exploration and research.	**BT 2**
CO 3	Apply geological surveying techniques to measure and record geological features in the field.	**BT 3**
CO 4	Analyze and interpret geological field data to identify rock types, stratigraphic sequences, and structural elements.	**BT 4**
CO 5	Evaluate the reliability and accuracy of geological data collected during fieldwork.	**BT 5**
CO 6	Synthesize field data to create detailed geological maps and cross-sections.	**BT 6**

Modules	Topics and Course Content	Hours
Unit 1	Introduction to Geological Mapping and Surveying: Definition and importance of geological mapping. Overview of geological surveying techniques and instruments. Fieldwork Preparation: Planning and organizing a geological field survey. Safety considerations and fieldwork logistics.	17
Unit 2	Topographic Mapping: Understanding topographic maps and contour lines. Topographic map reading and interpretation. Concept of Toposheet indexing. Use of handheld GPS for geological surveying. Basics of Total Station Survey. Distance, height and pace approximation in geological traversing.	16
Unit 3	Geological Field Techniques: Identification and classification of rocks and minerals in the field. Measuring geological structures, including folds, faults, and joints. Structural Mapping: Mapping and interpreting geological structures such as folds and faults. Analysis of structural deformation in the field.	17
Unit 4	Geological Mapping Project: Conducting a comprehensive geological survey and mapping project. Creating a detailed geological map and report based on field data.	16
Experiential Learning: Field Trip		24
Total Notional Credit Hours		**90**

Text Books suggested:

1) Guide to Field Geology – S. M. Mathur, PHI Publications
2) Field Geology – F. H. Lahee, CBS Publishers and Distributors Pvt Ltd; Sixth Edition (2002)

Reference Books:

1) Manual of Field Geology – Robert R. Compton; John Wiley & Sons.
2) Basic Methods of Structural Geology – Stephen Marshak & Gautam Mitra; Pearson Publication.

Detailed Syllabus Of Semester 2

Type of Course: Major	Geochemistry Course Level: 100 Credit: 3 L-T-P-C: 2-0-1-3 Scheme of Evaluation: Theory + Practical	Course Code: GEOL162M241

Course Objectives: Geochemistry is the study of the chemical composition, structure, and processes of the Earth and other planets. This course covers the fundamentals of geochemistry, including the principles of thermodynamics, kinetics, isotope geochemistry, and major and trace element geochemistry.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Remember the basic concepts of geochemistry, including thermodynamics, kinetics, and isotope geochemistry.	BT 1
CO 2	Understand the principles of major and trace element geochemistry and their applications in geological systems.	BT 2
CO 3	Apply geochemical methods to investigate geological processes and solve geological problems.	BT 3
CO 4	Analyse geochemical data using appropriate statistical and graphical techniques.	BT 4

Modules	Topics and Course Content	Hours
Unit 1	Definition and scope of geochemistry in Earth sciences. Major geological reservoirs and elemental abundances in the Earth's crust. Introduction to properties of elements: The periodic table, atomic environment of elements. Geochemical classification of elements.	11
Unit 2	Types of chemical bonding in minerals and rocks. Crystal structures and their influence on mineral properties. Geochemical cycles of major elements (C, O, N, S) in the Earth's crust. Concepts of mass balance. Chemical reactions and equations. Conservation of mass, isotopic and elemental fractionation. Fractionation and partitioning of elements during geological processes.	11
Unit 3	Chemical differentiation and Composition of the Earth (Continental crust, Oceanic crust, depleted mantle, enriched mantle and core). Geology of Meteorites. Cosmic abundance of elements. Geochemical variability of magma and its products.	11
Unit 4	Basic concepts of Aqueous geochemistry, Eh-pH relations. Mineral reactions- diagenesis and hydrothermal reactions. Chemical changes during metamorphism and metasomatism. Stable and radiogenic isotope systems and their applications. Isotopic dating methods and their use in geochronology.	11
List of Practicals	Types of geochemical data analysis and interpretation of common geochemical plots. Geochemical variation diagrams and its interpretations (bivariate and trivariate plots): Harker variation diagram, AFM diagram. Norm calculation of silica saturated igneous rocks.	30
Experiential Learning: Home Assignments – 8 hrs, Presentation – 4 hrs, Video Screening – 4 hrs		16
Total Notional Credit Hours		**90**

Text books:

1) Geochemistry – W. M. White, (2013), Wiley-Blackwell Publishing.
2) Introduction to Geochemistry: Principles and Applications - Kula C. Misra, (2012), Wiley-Blackwell Publishing.

Reference books:

1) Principles of Geochemistry - Mason, B., (3rd Edition, 1986), Wiley New York.
2) Essentials of geochemistry - Walther, J. V. (2009), Jones & Bartlett Publishers.

Type of Course: Major	**Igneous Petrology** Course Level: 100 Credit: 3 L-T-P-C: 2-0-2-3 Scheme of Evaluation: Theory + Practical	Course Code: GEOL162M242

Course Objectives: Igneous Petrology is a course designed to provide an understanding of the origin, classification, textures, and mineralogy of igneous rocks. The course will cover the processes that lead to the formation of magmas, their emplacement and crystallization, and the resultant diversity of igneous rocks. The course will also explore the relationship between igneous processes and tectonic settings.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Classify igneous rocks based on their mineralogy and textures.	**BT 1**
CO 2	Describe the processes involved in the formation of magmas and their subsequent crystallization into igneous rocks. Explain the relationship between igneous processes and tectonic settings.	**BT 2**
CO 3	Analyse and interpret igneous rock suites using microscopic and macroscopic techniques.	**BT 3**
CO 4	Evaluate the applications of igneous petrology in geologic exploration and mineral resource identification.	**BT 4**

Modules	Topics and Course Content	Hours
Unit 1	Introduction: Heat flow, geothermal gradient, Physical and chemical properties of magmas. Classification and nomenclature of igneous rocks. Textures and structures of igneous rocks. Mode of occurrence of Igneous rocks.	11
Unit 2	Types of magma sources. Magma chambers. Melting processes in the Earth's mantle and crust. Magma ascent and eruption and their products. Nucleation and Crystallisation rates. Crystallisation of Magma, Reaction Principle, Mechanisms of Magmatic differentiation, Role of volatiles in magmatic differentiation.	12
Unit 3	Classification schemes for plutonic and volcanic rocks. Petrogenesis of Felsic and Mafic igneous rocks: Granitoids, Basalt, Gabbro, Alkaline rocks, peridotites and kimberlites. Continental rifting and flood basalts.	10
Unit 4	Plate tectonics and igneous rock formation. Igneous rocks as indicators of tectonic processes. Oceanic crust formation and composition. Volcanic eruptions and associated rocks. Volcanic hazards monitoring. Major igneous provinces of NE India. Barren Island Volcanics.	11
List of Practicals	Study of important igneous rocks in hand specimens and thin sections (textural and mineralogical): granite, granodiorite, diorite, gabbro, anorthosites, ultramafic rocks, basalts, andesites, trachyte, rhyolite, dacite.	30
Experiential Learning: Home Assignments – 8 hrs, Presentation – 4 hrs, Video Screening – 4 hrs		16
Total Notional Credit Hours		**90**

Text Books Suggested:

1) Principles of igneous and metamorphic petrology – A. Philpotts & J. Ague. (2009). Cambridge University Press.
2) Principles of igneous and metamorphic petrology – J. D. Winter (2014). Pearson

Reference Books:

1) Petrology: the study of igneous, sedimentary, and metamorphic rocks. L. A. Raymond, (2002). McGraw-Hill Science Engineering
2) Principles of Petrology – G. W. Tyrrell. (1926). Springer

Type of Course: Minor	Geology and Natural Hazards Course Level: 100 Credit: 3 L-T-P-C: 3-0-0-3 Scheme of Evaluation: Theory	Course Code: GEOL162N201

Course Objectives: The course explores the geological factors and interactions that lead to earthquakes, volcanic eruptions, landslides, floods, and other geological hazards. It also emphasizes the understanding of hazard assessment, mitigation, and their impact on society and the environment.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Remember and identify the geological and environmental impacts of different hazards.	**BT 1**
CO 2	Understand the geological processes responsible for natural hazards.	**BT 2**
CO 3	Apply geological and geophysical principles to hazard assessment and mapping.	**BT 3**
CO 4	Analyse case studies of past geological hazards and their societal implications.	**BT 4**
CO 5	Evaluate the role of geologists in assessing and mitigating natural hazards.	**BT 5**

Modules	Topics and Course Content	Hours
Unit 1	Definition and classification of natural hazards Overview of geological processes and their relation to hazards Plate tectonics and seismicity, Seismic waves and earthquake mechanisms Volcanic processes and types of eruptions Volcanic landforms and volcanic risk assessment	17
Unit 2	Causes and triggers of landslides Landslide types and susceptibility mapping Floods and its contributing factors, Concept of Flood cyclicity Floodplain and flood risk assessment	16
Unit 3	Tsunami generation and propagation Coastal erosion and impact on communities Cloud-burst and their environmental impact. Sink-holes – its causes and environmental impact. Radon emanation and its potential health hazards.	17
Unit 4	Development of hazard mitigation plans and policies Analysis of historic geological disasters and their impact Social and environmental justice in hazard response Ethical responsibilities of geologists in hazard assessment and communication	16
Experiential Learning: Home Assignments – 10 hrs, Presentation – 10 hrs, Video Screening – 4 hrs		24
Total Notional Credit Hours		**90**

Text Books Suggested:

1) Natural Hazards and Disasters: Donald Hyndman, David Hyndman, 5th Edition, 2020, Cengage Learning.
2) Earthquakes and Geological Hazards - The Next Generation: Timothy L. Hall, Michael L. Anderson, 2nd Edition, 2021, Wiley-Blackwell.

Reference Books:

1) Volcanoes – Global Perspectives: John P. Lockwood, Richard W. Hazlett, 3rd Edition, 2015, Wiley-Blackwell.

2) Landslides – Types, Mechanisms, and Modelling: Jean Hutchinson, 1st Edition, 2011, Cambridge University Press.
3) Atmosphere, Clouds, and Climate: David Randall, 1st Edition, 2012, Princeton University Press.

Type of Course: SEC	Geomorphology and Landform Analysis Credit: 3 L-T-P-C: 0-0-6-3 Scheme of Evaluation: Practical	Course Code: GEOL162S211

Course Objectives: This practical and field-based course focuses on developing students' practical skills in understanding and interpreting various landforms and their significance in geological studies.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Identify different landforms and understand their formation mechanisms.	**BT 1**
CO 2	Comprehend the relationship between tectonics, climate, and surface processes in shaping landforms.	**BT 2**
CO 3	Apply geomorphological principles to interpret landscape evolution during field studies.	**BT 3**
CO 4	Analyse the formation and significance of specific landforms through field investigations.	**BT 4**
CO 5	Evaluate the influence of human activities on landform evolution through practical case studies.	**BT 5**
CO 6	Integrate geomorphological knowledge with geological mapping during field exercises.	**BT 6**

Modules	Topics and Course Content	Hours
Unit 1	Introduction to field instruments and geospatial tools Field study of river systems and their dynamics Analysis of flow regimes, sediment transport, and channel morphology Field identification and interpretation of erosional features Exploration of valleys, gullies, and river terraces	20
Unit 2	Field investigations of depositional features Study of alluvial fans, floodplains, and meander belts Practical exercises on sediment characterization and analysis Understanding sedimentary structures and their significance	20
Unit 3	Field-based assessment of fluvial response to climate variations Identification of paleochannels and fluvial terraces Field-based study of anthropogenic influences on river dynamics Evaluation of river management and restoration practices	25
Unit 4	Practical application of GIS, remote sensing, and digital terrain models for fluvial mapping Study of fluvial landforms and sedimentary processes using geospatial tools	25
Total Notional Credit Hours		**90**

Text Books suggested:

1) Fluvial Geomorphology: Luna B. Leopold, M. Gordon Wolman, and John P. Miller, 1st Edition, 2014, W. H. Freeman and Company.
2) Geomorphology and Global Environmental Change: Olav Slaymaker and Thomas Spencer, 1st Edition, 2012, Cambridge University Press.

Reference Books:

1) Principles of Geomorphology: William D. Thornbury, 1st Edition, 2019, Wiley-Blackwell.
2) Applied Fluvial Geomorphology for River Engineering and Management: Philip J. Ashworth, Gary J. Brierley, and G. Mathias Kondolf, 2nd Edition, 2019, Wiley-Blackwell.

Detailed Syllabus Of Semester 3

Type of Course: Major	Metamorphic Petrology Course Level: 200 Credit: 4 L-T-P-C: 3-0-2-4 Scheme of Evaluation: Theory + Practical	Course Code: GEOL162M341

Course Objectives: This course provides an in-depth understanding of the origin, classification, and petrological properties of metamorphic rocks. Students will learn about the various metamorphic processes, including the role of fluids and deformation, and how these processes influence mineral assemblages and textures. The course also covers the use of metamorphic petrology in understanding the tectonic and thermal history of a region.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Describe the classification and nomenclature of metamorphic rocks.	**BT 1**
CO 2	Identify and interpret the mineral assemblages and textures of metamorphic rocks, and explain their significance.	**BT 2**
CO 3	Apply knowledge of metamorphic processes and petrographic techniques to identify and interpret metamorphic rocks and their evolution.	**BT 3**
CO 4	Analyse the factors that control the metamorphic process, including pressure, temperature, fluids, and deformation.	**BT 4**

Modules	Topics and Course Content	Hours
Unit 1	**Metamorphism:** Definition of metamorphism. Factors controlling metamorphism. Types of metamorphism - contact metamorphism, regional metamorphism, fault zone metamorphism, impact metamorphism.	9
Unit 2	**Metamorphic facies and grades** Mineralogical phase rule of closed and open system. Index minerals, Chemographic projections. Metamorphic zones and isogrades. Concept of metamorphic facies and grade.	9
Unit 3	**Metamorphism and Tectonism & Petrogenesis** Relationship between metamorphism and deformation. Structure and textures of metamorphic rocks. Metamorphic mineral reactions (prograde and retrograde).	9
Unit 4	**Petrogenesis** Migmatites and their origin. Metasomatism and role of fluids in metamorphism. Petrogenesis of metamorphic rock associations- schists, gneisses, khondalites, charnockites, blue schists and eclogites.	9
List of Practicals	Hand Specimen and Microscopic study of the following metamorphic rocks: Low grade metamorphic rocks: serpentinites, albite-epidote-chlorite quartz schist, slate, talc-tremolite, quartz-mica schist., quartzo-feldspathic gneiss Medium to high grade metamorphic rocks: amphibolite, hornfels, garnetiferous schists, sillimanite-kyanite-bearing rocks, Granulites, eclogite, diopside-forsterite marble. Graphical plots and their interpretation.	30
Experiential Learning: Home Assignments – 8 hrs, Presentation – 8 hrs, Video Screening – 8 hrs		24
Total Notional Credit Hours		**120**

Text books:

1) Principles of igneous and metamorphic petrology – A. Philpotts & J. Ague. (2009). Cambridge University Press.
2) Principles of igneous and metamorphic petrology – J. D. Winter (2014). Pearson

Reference books:

1) Petrology: the study of igneous, sedimentary, and metamorphic rocks. L. A. Raymond, (2002). McGraw-Hill Science Engineering
2) Igneous and Metamorphic Petrology - Myron G. Best (2001).

Type of Course: Major	**Sedimentology** **Course Level: 200** **Credit: 4** **L-T-P-C: 3-0-2-4** **Scheme of Evaluation: Theory + Practical**	**Course Code:** **GEOL162M342**

Course Objectives: This course will focus on the processes of sedimentation, the diagenesis of sediments, and the properties and classification of sedimentary rocks. Topics covered will include sedimentary environments, depositional processes, sedimentary structures, mineralogy, texture, and sedimentary rock classification. The course will also cover the interpretation of sedimentary rocks in terms of paleoenvironmental and paleoclimatic conditions.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Students will be able to recall and recognize the key concepts, principles, and facts related to sedimentary petrology.	**BT 1**
CO 2	Students will be able to explain the processes of sedimentation, diagenesis, and lithification that result in the formation of sedimentary rocks.	**BT 2**
CO 3	Students will be able to apply the principles and concepts of sedimentary petrology to analyze and interpret the origin, composition, and classification of sedimentary rocks.	**BT 3**
CO 4	Students will be able to analyse sedimentary rocks in terms of their texture, mineralogy, sedimentary structures, and depositional environments.	**BT 4**

Modules	Topics and Course Content	Hours
Unit 1	Weathering and Erosion: Physical, chemical and biological weathering. Sedimentary texture: size, shape, roundness, sphericity, fabric, packing. Concepts of diagenesis, Stages of diagenesis, Compaction and cementation.	9
Unit 2	Textural classification of sediments and sedimentary rocks. Sediment dynamics: Nature of fluid flow – Laminar vs. turbulent flow, concept of flow regime and sediment transport. Sedimentary structures – bedforms and internal stratification.	9
Unit 3	Concept of sedimentary facies. Depositional features associated with fluvial, marine, desert, glacial and lacustrine environments (textural properties and structures).	9
Unit 4	Concept of Paleocurrent analysis. Mineralogical classification of sediments and sedimentary rocks (clastics and non-clastics). Geochemical fence.	9
List of Practicals	Grain size analysis of sediments (sieve and pipette method) Determination of roundness and sphericity of sediment grains. Study of sedimentary structures in hand specimens/peel specimens. Paleocurrent analysis. Petrography of clastic and non-clastic rocks through hand specimens. Petrography of clastic and non-clastic rocks through thin sections. Heavy mineral study.	30
Experiential Learning: Home Assignments – 8 hrs, Presentation – 8 hrs, Video Screening – 8 hrs		24
Total Notional Credit Hours		**120**

Text Books Suggested:

1) Introduction to Sedimentology – S. M. Sengupta, (2018), CBS.
2) Depositional Sedimentary Environments - Reineck and Singh, (1980), Springer – Verlag.

Reference Books:

1) Sedimentology and Stratigraphy - Nichols, G. (2009), Second Edition. Wiley Blackwell.

2) Sedimentary Rocks – F. J. Pettijohn.
3) Sedimentary Petrology – Tucker, M. E. (2006), Blackwell Publishing.
4) Petrology of Sedimentary Rocks – Sam Boggs, (2nd edition, 2009), Cambridge University Press, New York.

Type of Course: Minor	**Mineralogy** **Course Level: 200** **Credit: 4** **L-T-P-C: 3-0-2-4** **Scheme of Evaluation: Theory + Practical**	**Course Code:** **GEOL162N341**

Course Objectives: Mineralogy is an undergraduate-level course that focuses on the study of minerals and their properties, including crystallography, optical properties, chemical composition, and physical characteristics. The course provides an overview of the formation and classification of minerals, as well as the processes involved in their identification and analysis.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Remember and identify the properties of minerals, their classification, and crystallographic systems.	**BT 1**
CO 2	Explain the physical and chemical properties of minerals and their economic importance.	**BT 2**
CO 3	Apply mineralogical knowledge to identify minerals using optical microscopy and physical characteristics of the specimens.	**BT 3**
CO 4	Analyse various crystallographic and mineralogical data to identify and classify them into various classes.	**BT 4**

Modules	Topics and Course Content	Hours
Unit 1	Unit cell and Lattice structures, Bravais Lattices; Types of crystal structures (e.g., cubic, hexagonal); Symmetry elements and point groups; Crystallographic axes and planes; Overview of crystal systems (e.g., isometric, tetragonal, etc.); Crystallographic axes and symmetry elements for each system.	9
Unit 2	Interfacial angle, crystal parameters and indices. Stereograms and Hermann- Mauguin System. Relationship between crystallography and mineral properties. Concept of crystal, crystalline and amorphous substances. Minerals - definition, physical and chemical properties; Chemical classification of minerals.	9
Unit 3	Silicate and non-silicate structures of minerals. Study of physical properties of minerals of the following group of minerals: Olivine, Pyroxene, Amphibole, Mica, Silica and Feldspar.	9
Unit 4	Polarization of light, Polarisers. Functions of petrological microscope. Optical behaviour of minerals: Absorption, Transmission and Double-refraction of light. Theory of light propagation in minerals: Isotropy and Anisotropy; Optic axis. Optical properties of minerals in thin section. Introduction to X-Ray diffractometry in minerals.	9
List of Practical	Exercises on stereographic projection of crystal faces. Study of the following silicate minerals in hand specimen and under optical microscope: Olivine, Garnet, Sillimanite, Kyanite, Staurolite, Tourmaline, Enstatite, Diopside, Augite, Actinolite, Hypersthene, Hornblende, Serpentine, Muscovite, Biotite, Quartz and its varieties, Orthoclase, Plagioclase, Microcline, Nepheline, Sodalite, Calcite, Beryl, Talc, Zeolite. Determination of Pleochroic Scheme of minerals. Identification of Plagioclase Feldspars by Michel-Levy method.	30
Experiential Learning: Home Assignments – 8 hrs, Presentation – 8 hrs, Video Screening – 8 hrs		24
Total Notional Credit Hours		**120**

Text Books Suggested:

1) Mineralogy - Dexter Perkins, 3rd edition (2015), Pearson Publication.

Reference Books:

1) Introduction to Optical Mineralogy – William D. Nesse, 3rd edition (2004), Oxford University Press.
2) The Manual of Mineral Science (after James D. Dana) - Dutrow, B., Dwight, J., & Klein, C.; (2007) J. Wiley & Sons.
3) Introduction to Rock Forming Minerals – W. A. Deer, R. A. Howie, and J. Zussman, 3rd edition (2013), Prentice Hall

Type of Course: IDC	**PHYSICS AND CHEMISTRY OF EARTH** **Credit: 3** **L-T-P-C: 3-0-0-3** **Scheme of Evaluation: Theory**	**Course Code: GEOL162I301**

Course Objectives: The course provides an integrated understanding of Earth's physical features, interior structure, and magnetism. It covers the geochemical processes that determine the origin and abundance of elements, as well as isotope applications in geological processes. Additionally, the course explores mantle convection and phase transitions, equipping students with the knowledge to analyse and model the interplay between these geological and geophysical phenomena.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	List and describe the Earth's major surface features and internal structure, including key sub-divisions and discontinuities.	**BT 1**
CO 2	Explain the principles of Earth's magnetism and the processes driving magnetic field production and secular variation.	**BT 2**
CO 3	Apply geochemical classification principles to classify elements based on their abundance and characteristics within the Earth and the solar system.	**BT 3**
CO 4	Analyse isotopic data to interpret geological processes and the history of Earth's formation and differentiation.	**BT 4**

Modules	Topics and Course Content	Hours
Unit 1	**Earth's Physical Features and Interior** Earth's surface features: continents, continental margins, oceans. Earth's interior: variation of physical quantities and seismic wave velocity inside the Earth. Major sub-divisions and discontinuities of the Earth's interior. Core: seismological and other geophysical constraints. Convection in the mantle.	15
Unit 2	**Earth's Magnetism and Core Dynamics** Elements of Earth's magnetism. Convections in the Earth's core and production of magnetic field. Secular variation and westward drift. Solar activity and magnetic disturbance.	10
Unit 3	**Geochemistry and Elemental Composition** Elements: origin of elements/nucleosynthesis. Abundance of elements in the solar system/planet Earth. Geochemical classification of elements. Earth accretion and early differentiation.	10
Unit 4	**Isotope Geochemistry and Mantle Dynamics** Isotopes and their applications in understanding Earth processes. Stable isotopes: stable isotope fractionation and oxygen isotopes. Sub-lithospheric mantle: mineralogy/phase transitions.	10
Experiential Learning: Home Assignments – 15 hrs, Presentation – 15 hrs, Video Screening – 15 hrs		45
Total Notional Credit Hours		**90**

Text Books Suggested:
1) Essentials of Geology - Stephen Marshak, 4th edition, W. W. Norton & Company
2) Introduction to Geochemistry: Principles and Applications - Kula C. Misra, (2012), Wiley-Blackwell Publishing.

Reference Books:

1) Essentials of geochemistry - Walther, J. V. (2009), Jones & Bartlett Publishers.
2) Introduction to Physical Geology – Thompson & Turk

Type of Course: SEC	Remote Sensing and GIS Credit: 3 L-T-P-C: 2-0-2-3 Scheme of Evaluation: Theory + Practical	Course Code: GEOL162S341

Course Objectives: This course introduces the fundamental principles of remote sensing and Geographic Information Systems (GIS) and their applications in Earth Sciences. The course covers the principles of electromagnetic radiation, remote sensing sensors, and image interpretation techniques. Students will also learn the basic concepts of GIS and spatial analysis.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Recall basic concepts and facts related to remote sensing and GIS.	**BT 1**
CO 2	Explain the principles and theories behind remote sensing and GIS techniques.	**BT 2**
CO 3	Apply remote sensing and GIS techniques to analyse and interpret spatial data.	**BT 3**
CO 4	Analyse and interpret remotely sensed data to derive meaningful information.	**BT 4**
CO 5	Synthesize their knowledge by mastering thematic mapping and symbology in geology.	**BT 5**

Modules	Topics and Course Content	Hours
Unit 1	Concepts in Remote Sensing, History of Remote Sensing. Sensors, scanners and platforms. Satellites and types. Characteristics of a few Indian Satellites. Indian space missions. Drone surveys of mapping (introduction).	9
Unit 2	Types and acquisition of aerial photographs; Scale and resolution; Principles of stereoscopy, relief displacement, vertical exaggeration and distortion. Elements of aerial photo interpretation; Identification of sedimentary, igneous and metamorphic rocks and various aeolian, glacial, fluvial and marine landforms.	9
Unit 3	Digital Image Processing, Image Errors, Rectification and Restoration. FCC, Image Enhancement, Filtering, Image Rationing. Image classification and accuracy assessment.	9
Unit 4	GIS, Datum, Coordinate systems and Projection systems, Introduction to DEM analysis. GPS: Concepts of GPS; Integrating GPS data with GIS. Applications of GPS in earth system sciences.	9
List of Practical	Aerial Photo interpretation Identification of sedimentary, igneous and metamorphic rocks Identification of various aeolian, glacial, fluvial and marine landforms. Registration of satellite data with a toposheet of the area. Image Processing (analog and digital data) Creation of stereo images from UAV data Determination of elevation from UAV data	30
Experiential Learning: Home Assignments – 8 hrs, Presentation – 8 hrs, Video Screening – 8 hrs		24
Total Notional Credit Hours		**90**

Text Books suggested:

1) De Mars, M. N., 1999: Fundamentals of Geographic Information Systems, John Wiley & Sons Inc., New York.
2) Gopi, S., 2005: Global Positioning System Principles and Applications, Ta McGraw Hill, New Delhi.

Reference Books:

1) Curtis, H., 2000: The GPS Accuracy Improvement Initiative, GPS World, June, 2000.

2) Gonzalez, R. C., Woods, R. E., 2000: Digital Image Processing, Fifth Indian Reprint, Addison Wesley Longman, Delhi.
3) Miller, V. C.,1961: Photogeology; McGraw-Hill, New York.

Detailed Syllabus Of Semester 4

Type of Course: Major	**Principles of Stratigraphy** **Credit: 4** **L-T-P-C: 3-0-1-4** **Scheme of Evaluation: Theory + Practical**	**Course Code:** **GEOL162M441**

Course Objectives: This course provides an introduction to the fundamental principles and concepts of stratigraphy. Students will learn about the methods and techniques used to study and interpret the layers of rocks that make up Earth's crust, including the principles of relative and absolute dating, correlation, and stratigraphic nomenclature. The course will also cover the major events and processes that have shaped Earth's geologic history, as recorded in the rock record.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Students will be able to recall and recognize the basic concepts, principles, and terminology of stratigraphy.	**BT 1**
CO 2	Students will be able to explain the fundamental processes and phenomena that shape the rock record, and the principles and methods used to study and interpret stratigraphic data.	**BT 2**
CO 3	Students will be able to apply stratigraphic principles and techniques to analyse and interpret geologic data and to reconstruct the geologic history of a region.	**BT 3**
CO 4	Students will be able to analyse the spatial and temporal relationships between rock units, and to evaluate the relative ages and depositional environments of these units.	**BT 4**

Modules	Topics and Course Content	Hours
Unit 1	The scope and objectives of stratigraphy The major events and processes that have shaped Earth's geologic history The evolution of life on Earth and its relation to geologic events. The geologic time scale and its subdivisions.	9
Unit 2	Concepts of Lithostratigraphy, Chrono-stratigraphy and Bio-stratigraphy. The principles and guidelines for stratigraphic nomenclature (ICS code of nomenclature). Introductory concepts of sequence stratigraphy, chemo- stratigraphy and magneto-stratigraphy. Global Mass extinction events.	9
Unit 3	Concepts and methods of stratigraphic correlation. The use of biostratigraphy and chemo-stratigraphy in stratigraphic correlation. The Quaternary Period and its divisions, Neogene-Quaternary and Pleistocene- Holocene boundary, the Meghalayan Age.	9
Unit 4	Quaternary stratigraphy- principles and application in Quaternary sequences (Indian examples), soil profile and palaeosol, Quaternary records from marine and continental settings, event stratigraphy. Idea of Quaternary climate changes (glaciation and sea level changes).	9
List of Practicals	Construction of geologic sections and interpretation of stratigraphy. Study of reconstruction of different Proterozoic supercontinents with time. Preparation of fence diagrams from stratigraphic logs. Preparation of stratigraphic columns and their paleo-environment reconstruction.	30
Experiential Learning: Home Assignments – 8 hrs, Presentation – 8 hrs, Video Screening – 8 hrs		24
Total Notional Credit Hours		**90**

Text Books suggested:

1) Stratigraphic Principles and Practices – J. M. Weller; Universal Book Stall, Delhi.
2) Principles of Sedimentology and Stratigraphy, by Sam Boggs, Jr., 4th Edition, Pearson Prentice Hall, 2006.

Reference Books:

1) Stratigraphy: Principles and Methods by Stanley, Steven M.
2) Stratigraphy: A Modern Synthesis by Sloss, L. L.
3) The Geologic Time Scale 2020 by Gradstein, Felix M.
4) Sedimentary Geology: An Introduction to Sedimentary Rocks and Stratigraphy by Prothero, Donald R.

5) Basic Concepts in Sedimentology and Stratigraphy by Nichols, Gary.

Type of Course: Major	**Palaeontology** **Credit: 4** **L-T-P-C: 3-0-1-4** **Scheme of Evaluation: Theory + Practical**	**Course Code: GEOL162M442**

Course Objectives: Palaeontology is the study of ancient life, focusing on the evolution, diversity, and extinction of organisms over geological time. This course will cover the history and methods of palaeontological research, the principles of evolutionary biology, and the study of fossils as evidence of past life. Topics covered will include the origin and evolution of life, major extinction events, the use of fossils in stratigraphy, and the interpretation of the ecological and biogeographic contexts of ancient ecosystems.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Students will be able to recall and recognize the key concepts, principles, and facts related to the study of palaeontology	**BT 1**
CO 2	Students will be able to explain the principles of evolutionary biology and the methods used in palaeontological research.	**BT 2**
CO 3	Students will be able to apply palaeontological principles to identify, describe, and interpret the significance of fossils in the context of past life and environments.	**BT 3**
CO 4	Students will be able to analyse the morphology, diversity, and distribution of fossil organisms and their significance in the evolutionary history of life.	**BT 4**

Modules	Topics and Course Content	Hours
Unit 1	Nature and importance of fossil record; Fossilization processes and modes of preservation. Types of fossils (body fossils, trace fossils, leaked fossils, etc.). Importance of Index fossils. Theory of organic evolution as interpreted from fossil record. Speciation, Taxonomic hierarchy. Introduction to Palae-botany and Ichnology.	7
Unit 2	Morphology and stratigraphic significance of the following important invertebrate groups: a. Brachiopoda b. Lamellibranchia (Bivalvia) c. Cephalopoda d. Gastropoda e. Echinoidia f. Trilobites.	12
Unit 3	Origin of vertebrates and major steps in vertebrate evolution. Brief introduction to vertebrate palaeontology (Hominidae, Equidae, Proboscidae). Mesozoic reptiles with special reference to origin, diversity and extinction of dinosaurs.	9
Unit 4	Microfossils and its application. Introduction to palynology. Detailed account of Gondwana Flora in India in the context of Palaeoclimate and Palaeoecology. Role of fossils in sequence stratigraphy, hydrocarbon exploration and palaeoclimatic studies. Fossils and biogeographic provinces, dispersals and barriers.	8
List of Practicals	Identification of fossils in hand specimens. Derivation of evolutionary trend in a given set of fossils. Identification of fossil assemblages and their stratigraphic horizon. Identification of micro-fossils with the help of microscope. Exercises related to fossil spores and pollens.	30
Experiential Learning: Home Assignments – 8 hrs, Presentation – 8 hrs, Video Screening – 8 hrs		24
Total Notional Credit Hours		**90**

Text Books suggested:

1) An Introduction to Palaeontology – Amal Dasgupta, The World Press Private Limited.
2) Palaeontology: (Palaeobiology) Evolution and Animal Distribution – P.C. Jain, M.S. Anantharaman, Vishal Publishing.

Reference Books:

1) Introduction to Paleobiology and the Fossil Record – Michael J. Benton, David A. T. Harper, and Robert L. Carroll, 2nd edition, 2013 by Wiley-Blackwell.
2) Principles of Paleontology - D. M. Raup & S. M. Stanley. W. H. Freeman (1971).

3) Fossils in Earth Sciences – Anis Ray.

Type of Course: Major	**Earth Science in Ancient India** **Credit: 4** **L-T-P-C: 4-0-0-4** **Scheme of Evaluation: Theory**	**Course Code:** **GEOL162M403**

Course Objectives: This course aims to explore the rich heritage of earth science in ancient India, delving into the cosmological, geological, and environmental knowledge embedded in Vedic and other ancient Indian texts. By examining the ancient Indian perspectives on the Earth, the solar system, and natural phenomena, students will develop a deeper understanding of the interconnectedness between ancient wisdom and modern scientific principles.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Students will acquire knowledge of Vedic cosmology and ancient Indian astronomical theories, including the concepts of Lokas, Nakshatras, and the contributions of ancient Indian astronomers to celestial mechanics.	**BT 1**
CO 2	Students will comprehend the geological significance of minerals, metals, and landforms described in ancient Indian texts, as well as the hydrological and geomorphic features of the Sapta Sindhu region.	**BT 2**
CO 3	Students will apply their understanding of ancient Indian tectonic theories and geomantic concepts to interpret the formation of mountains, earthquakes, and architectural principles in Vastu Shastra.	**BT 3**
CO 4	Through the analysis of ancient water management systems and environmental ethics embedded in ancient Indian texts, students will critically evaluate the sustainability and conservation practices advocated by ancient Indian civilization.	**BT 4**

Modules	Topics and Course Content	Hours
Unit 1	**The Earth and the Solar System**: Vedic texts for references to cosmology, celestial bodies, and their significance. Understand the concept of Loka (worlds or realms) and the role of the Sun, Moon, and stars. Nakshatras (lunar mansions) and their connection to timekeeping. Works of ancient Indian astronomers such as Aryabhata, Varahamihira, and Brahmagupta: their contributions to understanding planetary motion, eclipses, and celestial coordinates. Siddhantas (astronomical treatises) and their mathematical models.	20
Unit 2	**Earth Materials, Surface Features, and Processes**: Examine ancient Indian texts for references to minerals, metals, and their uses. Significance of minerals like gold, copper, and iron in ancient trade and economy. Ancient mining techniques and sites of India. Descriptions of landforms in ancient texts. Investigate the Brahmaputra Valley and its geological features. Role of rivers (e.g., Sarasvati, Ganga, Brahmaputra, etc) in shaping the landscape.	20
Unit 3	**Interior of the Earth, Deformation, and Tectonics**: Investigate ancient Indian theories on the formation of mountains and earthquakes. Concept of Meru and its geological symbolism. Study ancient texts for accounts of earthquakes. Introduction to Geo-archaeology.	25
Unit 4	**Natural resource management and sustainable livelihood**: Ancient water management systems (e.g., stepwells, irrigation tanks, aqueducts). Importance of water conservation and sustainable practices. References to rainfall patterns and flood control. Description of Sea-level change in ancient texts. Ancient urban planning, sustainable housing, etc.	25
Experiential Learning: Home Assignments – 8 hrs, Presentation – 8 hrs, Video Screening – 8 hrs		24
Total Notional Credit Hours		**90**

Reference Books:

1) "The Lost River: On The Trail of the Sarasvati" by Michel Danino
2) "Vedic Cosmology: Mysteries of the Sacred Universe" by Richard L. Thompson
3) "Astronomy in India: A Historical Perspective" by Mani Bhaumik
4) "Ancient India as Described by Megasthenes and Arrian: Being a Translation of the Fragments of the Indika of Megasthenes" by J. W. McCrindle
5) "Ancient mining techniques and sites of India" By A. K. Grover, Retd. DDG GSI.

Type of Course: Minor	**Petrology** **Credit: 3** **L-T-P-C: 2-0-1-3** **Scheme of Evaluation: Theory + Practical**	**Course Code:** **GEOL162N442**

Course Objectives: To provide students with a comprehensive understanding of the formation, classification, and characteristics of igneous, metamorphic, and sedimentary rocks, enabling them to interpret petrological processes and their implications for Earth's geological history and tectonic evolution.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Students will be able to demonstrate a thorough understanding of the classification, textures, and structures of igneous, metamorphic, and sedimentary rocks, as well as the geological processes responsible for their formation.	**BT 1**
CO 2	Students will be able to interpret and explain the physical and chemical properties of magmas, the factors controlling metamorphism, and the processes involved in weathering and sedimentary flux, demonstrating a deeper comprehension of petrological concepts.	**BT 2**
CO 3	Students will be able to apply their knowledge of petrology to identify and interpret various types of igneous, metamorphic, and sedimentary rocks in hand specimen and thin section, and to relate these observations to geological environments and tectonic settings.	**BT 3**
CO 4	Students will develop the ability to analyse petrological data, including mineral assemblages, textures, and structures, to infer past geological conditions, such as temperature, pressure, and deformation regimes, and to evaluate the processes involved in rock formation and modification.	**BT 4**

Modules	Topics and Course Content	Hours
Unit 1	**Igneous Petrology:** Introduction: Heat flow, geothermal gradient, Physical and chemical properties of magmas. Classification of igneous rocks. Textures and structures of igneous rocks. Mode of occurrence of Igneous rocks. Crystallisation of Magma, Reaction Principle, Magmatic differentiation. Plate tectonics and igneous rock formation.	9
Unit 2	**Metamorphic Petrology:** Definition of metamorphism and Metasomatism. Factors controlling metamorphism. Types of metamorphism - contact metamorphism, regional metamorphism, fault zone metamorphism, impact metamorphism. Index minerals, Metamorphic zones and isogrades. Concept of metamorphic facies and grade. Structure and textures of metamorphic rocks. and role of fluids in metamorphism.	9
Unit 3	**Sedimentology:** Weathering and sedimentary flux: Physical and chemical weathering. Sedimentary texture: size, shape, roundness, sphericity, fabric, packing. Concepts of diagenesis, Stages of diagenesis, Compaction and cementation. Textural classification of sediments and sedimentary rocks.	9
Unit 4	Sediment dynamics: Nature of fluid flow – Laminar vs. turbulent flow, concept of flow regime and sediment transport. Sedimentary structures – bedforms and internal stratification. Concept of sedimentary environment and facies.	9
List of Practical	Study of important igneous rocks in hand specimens and thin sections: granite, granodiorite, diorite, gabbro, anorthosites, ultramafic rocks, basalts, andesites, trachyte, rhyolite, dacite. Hand Specimen and Microscopic study of the following metamorphic rocks: a) Serpentinites, albite-epidote-chlorite-quartz schist, slate, talc-tremolite, calcite-quartz schist.	30

	b) Gneisses, amphibolite, hornfels, garnetiferous schists, sillimanite-kyanite-bearing rocks, Granulites, eclogite, diopside-forsterite marble. Grain size analysis of sediments (sieve and pipette method). Study of sedimentary structures in hand specimens. Petrography of clastic and non-clastic rocks through hand specimens and thin sections.	
Experiential Learning: Home Assignments – 8 hrs, Presentation – 8 hrs, Video Screening – 8 hrs		24
Total Notional Credit Hours		**90**

Text Books suggested:

1) Principles of Petrology – G. W. Tyrrell. (1926). Springer
2) Principles of igneous and metamorphic petrology – J. D. Winter (2014). Pearson
3) Introduction to Sedimentology – S. M. Sengupta, (2018), CBS.

Reference Books:

1) Principles of igneous and metamorphic petrology – A. Philpotts & J. Ague. (2009). Cambridge University Press.
2) Principles of igneous and metamorphic petrology – A. Philpotts & J. Ague. (2009). Cambridge University Press.
3) Sedimentary Rocks – F. J. Pettijohn.

Type of Course: Minor	Structural Geology Credit: 3 L-T-P-C: 2-0-1-3 Scheme of Evaluation: Theory + Practical	Course Code: GEOL162N443

Course Objectives: Structural geology is a sub-discipline of geology that deals with the study of deformation and deformation-related structures of rocks at various scales. This course aims to provide a fundamental understanding of structural geology, including the analysis of structural data and the interpretation of deformation processes that occur in the Earth's crust.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Students will be able to recall the basic concepts, terminology, and principles of structural geology.	BT 1
CO 2	Students will be able to comprehend the various types of rock deformation and deformation related structures, including folds, faults, and joints.	BT 2
CO 3	Students will be able to apply their knowledge of structural geology to analyze and interpret geological maps and cross-sections.	BT 3
CO 4	Students will be able to analyse structural data, including the measurement and plotting of various structural elements, such as strike, dip, and plunge.	BT 4

Modules	Topics and Course Content	Hours
Unit 1	Diastrophic and non-diastrophic structures. Structural elements: planar and linear structures, concept of strike and dip, trend and plunge, rake/pitch. Outcrop patterns of different structures.	9
Unit 2	Concept of rock deformation: Stress – normal and shear stress, stress at a point, Stress ellipsoid and principal stress axes, Mohr's stress circle and various stress types. Strain in rocks, types of strain, Principal strain axes and Strain ellipses. Flinn's diagram.	9
Unit 3	Concept of brittle and ductile deformation. Fold morphology; Geometric and genetic classification of folds; Introduction to the mechanics of folding: Buckling, Bending, Flexural slip and flow folding. Description and origin of foliations and lineations.	9
Unit 4	Geometry of pinch and swell and boudin structure. Basic idea of shear zone, faults and joints. Geometric and genetic classification of fractures and faults. Geologic/geomorphic criteria for recognition of faults.	9
List of Practical	Preparation of a topographic profile Drawing profile sections and interpretation of geological maps of different complexities. Structural contouring and 3-point (bore hole) problems of dip and strike. Determination of true thickness of strata from a given exposure. Exercises of stereographic projections of mesoscopic structural data (planar, linear, folded) Exercises on plotting and analysis of linear data in Rose diagram.	30
Experiential Learning: Home Assignments – 8 hrs, Presentation – 8 hrs, Video Screening – 8 hrs		24
Total Notional Credit Hours		**90**

Text Books suggested:

1) Structural Geology - Robert J. Twiss & Eldridge M. Moores, (2nd edition, 2007), W. H. Freeman & Co Ltd.
2) Structural Geology - M. P. Billings, 4th edition, Prentice-Hall.

Reference Books:

1) Foundations of Structural Geology - Park, R. G. (2005), Routledge.
2) Structural Geology – Fundamentals and Modern Developments - S. K. Ghosh, (2013), Elsevier Science.
3) Structural Geology of Rocks and Region - G. R. Davis, (1984), John Wiley.
4) Structural Geology – Haakon Fossen, (2010), Cambridge University Press, New York.

Detailed Syllabus
Of Semester 5

Type of Course: Major	**Structural Geology** Credit: 4 L-T-P-C: 3-0-1-4 Scheme of Evaluation: Theory + Practical	Course Code: GEOL162M541

Course Objectives: The course aims to provide students with a fundamental understanding of rock deformation processes, structural analysis techniques, and their applications in tectonics, resource exploration, and geohazard assessment.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Recall fundamental concepts of structural geology, including types of rock deformation, stress-strain relationships, and structural elements.	**BT 1**
CO 2	Explain the fundamental concepts of rock deformation, stress, and strain, and their role in shaping Earth's crust.	**BT 2**
CO 3	Identify and classify various structural features such as folds, faults, joints, foliations, and lineations based on their geometry, genesis, and mechanics.	**BT 3**
CO 4	Analyse the mechanics of brittle and ductile deformation, including fault kinematics, shear zones, and superposed deformation.	**BT 4**
CO 5	Interpret structural data using stereographic projections, rose diagrams, and cross-section construction for geological mapping and resource exploration.	**BT 5**

Modules	Topics and Course Content	Hours
Unit 1	**Fundamentals of Structural Geology** Introduction to Structural Geology: Importance in geosciences and resource exploration. Structural Elements: Planar and linear features, strike and dip, trend and plunge, rake/pitch. Rock Deformation Concepts: Brittle vs. ductile deformation, types of deformation (elastic, plastic, and rupture). Stress and Strain: • Types of stress (normal, shear, hydrostatic, differential). • Stress ellipsoid, principal stress axes, Mohr's stress circle. • Strain ellipsoid, principal strain axes, types of strain, Flinn's diagram.	9
Unit 2	**Brittle Structures** Fractures and Joints: Classification, formation mechanisms, tectonic significance. Faults: • Classification (dip-slip, strike-slip, oblique-slip, listric, growth faults). • Mechanics of faulting and fault plane characteristics. • Fault zone structures: gouge, breccia, mylonites. • Criteria for fault recognition in the field.	9
Unit 3	**Ductile Deformation & Folding** Folds: • Geometry and classification (geometric and genetic). • Fold mechanisms: buckling, bending, flexural slip, flexural flow, passive folding. • Interference patterns of folds. Foliation & Lineation: • Types, formation processes, relation to stress fields. • Shear fabrics (S-C structures, mineral lineations). Boudinage: Types, formation processes, tectonic significance.	9
Unit 4	**Structural Analysis and Applications** Geometric Analysis of Structures: • Principles of structural analysis and representation in maps. • Outcrop patterns of folded, faulted, and unconformable sequences. • Importance of cross-section construction in structural interpretation.	9

	Superposed Deformation: • Concept of polyphase deformation. • Types of fold interference patterns and their recognition. Tectonic Controls on Rock Structures: • Relationship between structural geology and regional tectonics. • Structural control on mineralisation, hydrocarbon reservoirs, and groundwater flow. Introduction to Digital Structural Mapping: • Use of GIS and remote sensing for structural interpretation. • Role of digital elevation models (DEMs) in structural geology.	
Practical	Topographic Profiles & Structural Contour Maps Geological Map Interpretation (including fold and faulted terrains) Thickness Calculations (true and apparent thickness from exposures) Stereographic Projections (plotting and analysis of mesoscopic structures) Rose Diagram Analysis (linear structure orientations) 3-Point Borehole Problems (dip and strike calculations) Digital Structural Mapping (introduction to GIS-based structural analysis) Field Exercises – Identification and documentation of folds, faults, and joints in local outcrops.	30
Experiential Learning: Home Assignments – 8 hrs, Presentation – 8 hrs, Video Screening – 8 hrs		24
Total Notional Credit Hours		**90**

Text Books suggested:

1) Fossen, H. (2016). Structural Geology. Cambridge University Press.
2) Twiss, R. J., & Moores, E. M. (2007). Structural Geology. W. H. Freeman.

Reference Books:

1) Davis, G. H., Reynolds, S. J., & Kluth, C. (2011). Structural Geology of Rocks and Regions. Wiley.
2) Van der Pluijm, B. A., & Marshak, S. (2004). Earth Structure: An Introduction to Structural Geology and Tectonics. W. W. Norton.
3) Ramsay, J. G. (1967). Folding and Fracturing of Rocks. McGraw-Hill.
4) Lisle, R. J., Brabham, P. J., & Barnes, J. W. (2011). Basic Geological Mapping. Wiley-Blackwell.

Type of Course: Major	Indian Stratigraphy Credit: 4 L-T-P-C: 3-1-0-4 Scheme of Evaluation: Theory	Course Code: GEOL162M502

Course Objectives: To develop a fundamental understanding of the stratigraphic framework of India, including its cratonic provinces, sedimentary basins, and volcanic provinces, while also exploring the major stratigraphic boundaries and their significance in paleoenvironmental and climate change studies.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Recall the physiographic divisions of India and their relation to major geological provinces.	BT 1
CO 2	Explain the geological and tectonic history of India, including major cratons, mobile belts, and sedimentary basins.	BT 2
CO 3	Apply fundamental stratigraphic principles to analyse and correlate Proterozoic, Phanerozoic, and Quaternary successions in India.	BT 3
CO 4	Distinguish between various volcanic provinces and stratigraphic boundaries in India and assess their economic and geodynamic significance.	BT 4
CO 5	Evaluate the role of Quaternary stratigraphy in reconstructing past climatic conditions and predicting future climate change trends.	BT 5

Modules	Topics and Course Content	Hours
Unit 1	Brief introduction to the physiographic subdivisions of India. Introduction to Indian Shield and mobile belts. Geological and tectonic history of India.	14
Unit 2	Introduction to Proterozoic basins of India. Brief geology of Dharwar, Bastar, Singhbhum and Aravalli.	18
Unit 3	**Palaeozoic stratigraphy** of Kashmir and its correlatives from Spiti and Zanskar. **Mesozoic stratigraphy of India:** Cretaceous successions of Cauvery basin. **Cenozoic stratigraphy of India:** Siwalik successions **Volcanic provinces of India:** Deccan Trap, Rajmahal Trap, Sylhet Trap, Abor Volcanics.	16
Unit 4	**Important Stratigraphic boundaries in India:** a. Precambrian-Cambrian boundary b. Permian-Triassic boundary c. Cretaceous-Tertiary boundary **Introduction to Quaternary Stratigraphy:** Glacial and interglacial deposits in Himalayas, Fluvial and Aeolian sediments of Thar Desert, and Indo-Gangetic-Brahmaputra Plain. Significance of Quaternary stratigraphy in climate change studies.	18
Experiential Learning: Home Assignments – 8 hrs, Presentation – 8 hrs, Video Screening – 8 hrs		24
Total Notional Credit Hours		**90**

Text Books suggested:

1) Valdiya, K. S. (2010). The Making of India: Geodynamic Evolution. Springer.
2) Krishnan, M. S. (2009). Geology of India and Burma (6th Edition). CBS Publishers & Distributors.

Reference Books:

1) Indian Stratigraphy by Srikant Das, Birbal Sahni Institute of Paleobotany (2018)
2) Indian Geology: An Introduction by D. N. Wadia, Tata McGraw-Hill Education (2007)
3) Geology of India: A Review by N. C. Pant and B. P. Radhakrishna, Springer (2014)
4) Geology of India by V. P. Dimri, Springer (2020)
5) Geology of India (Vol. 1 & 2) – M. Ramakrishnan & R. Vaidyanadhan, Geological Society of India, Bangalore (2008).

Type of Course: Major	Hydrogeology Credit: 4 L-T-P-C: 3-0-1-4 Scheme of Evaluation: Theory + Practical	Course Code: GEOL162M543

Course Objectives: To provide students with a comprehensive understanding of groundwater occurrence, movement, exploration, chemistry, and management, enabling them to apply hydrogeological concepts for sustainable groundwater resource utilization.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Recall fundamental concepts of hydrogeology, including the hydrologic cycle, types of aquifers, and groundwater movement.	**BT 1**
CO 2	Explain the fundamental concepts of the hydrologic cycle, groundwater occurrence, and aquifer systems.	**BT 2**
CO 3	Apply Darcy's law and well hydraulics principles to analyse groundwater flow and aquifer properties.	**BT 3**
CO 4	Analyse different groundwater exploration techniques and their applications in hydrogeological studies.	**BT 4**
CO 5	Evaluate groundwater quality by interpreting hydrochemical parameters and contamination risks.	**BT 5**

Modules	Topics and Course Content	Hours
Unit 1	**Introduction** Scope of hydrogeology and its societal relevance. Hydrologic cycle: precipitation, evapo-transpiration, run-off, infiltration and subsurface movement of water. Rock properties affecting groundwater, Vertical distribution of subsurface water. Types of aquifers, aquifer parameters.	9
Unit 2	**Groundwater flow and Well hydraulics** Darcy's law and its validity; Intrinsic permeability and hydraulic conductivity. Groundwater flow rates and flow direction; Laminar and turbulent groundwater flow. Basic Concepts of Well hydraulics (drawdown; specific capacity etc).	9
Unit 3	**Groundwater exploration and Hydrochemistry** Surface-based groundwater exploration methods. Introduction to subsurface borehole logging methods. Physical and chemical properties of water and water quality.	9
Unit 4	**Groundwater management** Groundwater recharge and conservation strategies (rainwater harvesting and artificial recharge). Seawater intrusion in coastal aquifers and mitigation strategies. Surface and subsurface water interaction. Groundwater pollution: sources, effects, and remediation. Climate change and its impact on groundwater resources.	9
Practical	Preparation and interpretation of water level contour maps and depth to water level maps. Study, preparation and analysis of hydrographs for differing groundwater conditions. Identification of groundwater potential zones in India (map-based study). Graphical representation of hydrochemical data (Piper, Stiff, and Wilcox diagrams). Simple numerical problems related to permeability, groundwater flow, and well hydraulics. Case studies on groundwater contamination and management.	30
Experiential Learning: Home Assignments – 8 hrs, Presentation – 8 hrs, Video Screening – 8 hrs		24
Total Notional Credit Hours		**90**

Text Books suggested:

1) Todd, D.K. & Mays, L.W. (2005). Groundwater Hydrology (3rd Edition). Wiley.
2) Raghunath, H.M. (2007). Groundwater (3rd Edition). New Age International Publishers.

Reference Books:

1) Fetter, C.W. (2001). Applied Hydrogeology (4th Edition). Prentice Hall.
2) Karanth, K.R. (1987). Groundwater Assessment, Development and Management. Tata McGraw-Hill.
3) Domenico, P.A. & Schwartz, F.W. (1998). Physical and Chemical Hydrogeology (2nd Edition). Wiley.

Type of Course: Major	Summer Internship Credit: 4 L-T-P-C: 0-0-0-4 Scheme of Evaluation: Project	Course Code: GEOL162M524

Course Objectives: To provide students with hands-on experience in geological fieldwork, laboratory techniques, and industry applications, bridging academic knowledge with real-world geological practices.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Explain the practical applications of geological concepts in real-world scenarios through hands-on fieldwork, laboratory analysis, or industrial training.	**BT 2**
CO 2	Demonstrate technical skills in geological mapping, exploration techniques, hydrogeological assessments, and geotechnical investigations in professional settings.	**BT 3**
CO 3	Develop professional communication skills by preparing structured reports, maintaining field diaries, and delivering presentations based on internship experiences.	**BT 3**
CO 4	Assess geological data, interpret field observations, and evaluate resource potential, environmental impacts, or structural stability in diverse geological terrains.	**BT 4**
CO 5	Critically examine the relevance of geological methods and tools used in industry and research, applying problem-solving skills to tackle real-world challenges.	**BT 5**

Internship Structure & Guidelines	
1	**Internship Duration & Timeline:** • **Total Duration:** 45 Days • **Internship Period:** After completion of 4th semester examinations and before the commencement of the 5th semester.
2	**Internship Venues:** • **Government Organisations:** GSI, AMD, CGWB, ONGC, NHPC, ISRO, NGRI, IMD, etc. • **Mining & Exploration Companies:** Coal India, MECL, HZL, Vedanta, Oil India, etc. • **Geotechnical & Environmental Firms:** CBRI, WAPCOS, NEERI, IITs, and other consultancies. • **Academic & Research Institutions:** Universities, IITs, CSIR labs, and NGOs working in earth sciences and disaster management.
3	**Nature of Work:** • **Geological Mapping & Fieldwork:** Lithological mapping, core logging, structural analysis. • **Mineral & Petroleum Exploration:** Ore reserve estimation, petrography, hydrocarbon exploration techniques. • **Hydrogeology & Environmental Studies:** Water resource assessments, groundwater quality analysis, remote sensing applications. • **Geotechnical & Engineering Geology:** Slope stability studies, site investigations, tunnelling, and construction material testing. • **GIS & Remote Sensing:** Digital mapping, satellite image interpretation, DEM analysis.
4	**Assessment & Evaluation (100 Marks)**

Component	Weightage (%)
Internship Diary (Daily work record)	15%
Mid-Term Report (Progress update)	20%
Final Internship Report (Comprehensive documentation)	30%
Presentation & Viva-Voce (Evaluation by faculty panel)	35%

	• **Internship Diary:** Daily record of observations, tasks, and learnings. • **Mid-Term Report:** A brief progress report submitted midway through the internship. • **Final Report:** Detailed documentation of the work carried out, including methodologies, results, and conclusions. • **Presentation & Viva-Voce:** Oral presentation of findings before a faculty panel, followed by a Q&A session.

Type of Course: Minor	**Fuel Geology** **Credit: 4** **L-T-P-C: 3-0-1-4** **Scheme of Evaluation: Theory + Practical**	**Course Code: GEOL162N541**

Course Objectives: To provide fundamental knowledge of the origin, occurrence, exploration, and economic significance of coal, petroleum, gas hydrates, and nuclear fuels, with a focus on their geological characteristics and global/Indian distribution.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Recall the fundamental concepts of coal, petroleum, gas hydrates, and nuclear fuels, including their origin, classification, and occurrence.	**BT 1**
CO 2	Understand the formation processes, geological settings, and economic significance of various fuel resources.	**BT 2**
CO 3	Apply knowledge of fuel geology in resource exploration and extraction techniques.	**BT 3**
CO 4	Analyse different types of hydrocarbon traps, reservoir characteristics, and the impact of plate tectonics on fuel distribution.	**BT 4**
CO 5	Evaluate the sustainability, environmental impact, and future prospects of conventional and unconventional fuel resources.	**BT 5**

Modules	Topics and Course Content	Hours
Unit 1	**Coal Geology** Definition and origin of coal; Process of coal formation (peatification, coalification). Basic classification of coal (Rank, Type, and Grade). Fundamentals of Coal Petrology: Lithotypes, Microlithotypes, and Macerals. Proximate and Ultimate analysis of coal. **Unconventional Coal Resources:** • Coal Bed Methane (CBM) – Formation, exploration, and global/Indian scenario. • Underground coal gasification and coal liquefaction processes.	9
Unit 2	**Petroleum Geology** Chemical composition and physical properties of crude oil. Origin and formation of petroleum: Organic matter transformation, maturation of kerogen. Migration of petroleum: Primary and secondary migration mechanisms. Reservoir rocks: General attributes, classification (clastic and chemical), and petrophysical properties. **Petroleum reservoirs and traps:** • Definition and significance of hydrocarbon traps. • Anticlinal theory vs. trap theory. • Classification of hydrocarbon traps – Structural, stratigraphic, and combination traps. • Cap rocks: Definition and properties. • Time of trap formation and hydrocarbon accumulation. • Plate tectonics and global distribution of hydrocarbon reserves.	9
Unit 3	**Gas Hydrates** • Occurrence, origin, and geological settings. • Structure and types of gas hydrates. • Stability conditions and factors controlling gas hydrate formation. • Gas hydrate reservoirs and estimation of gas volumes. • Gas hydrate extraction techniques and inhibitors.	9

Unit 4	**Nuclear Fuels** **Uranium and Thorium Geology:** • Mineralogy and geochemistry of U and Th-bearing economic minerals. • Distribution of uranium and thorium in ore bodies through geologic time. • U and Th metallogenic provinces of India. **Exploration and Detection of Nuclear Fuels:** • Radioactivity detectors: Geiger-Müller counter, proportional and scintillation counters, and gamma-ray spectrometers. • Geological and geophysical methods for uranium-thorium exploration.	9
Practical	Megascopic identification of coal types (peat, lignite, bituminous, anthracite). Proximate analysis of coal (moisture, volatile matter, ash content, and fixed carbon determination). Study of physical properties of crude oil samples (density, viscosity, API gravity). Interpretation of well-log data for hydrocarbon exploration. Identification and classification of reservoir rocks (clastic vs. chemical). Construction and analysis of porosity and permeability graphs for reservoir characterisation. Study of different types of hydrocarbon traps using block diagrams. Identification of geological settings favourable for gas hydrate formation.	30
Experiential Learning: Home Assignments – 8 hrs, Presentation – 8 hrs, Video Screening – 8 hrs		24
Total Notional Credit Hours		**90**

Text Books suggested:

1) Chandra, D. Singh, R.M. & Singh, M.P. – Textbook of Coal (Indian Context) (Tata McGraw Hill)
2) Levorsen, A.I. – Geology of Petroleum (CBS Publishers)

Reference Books:

1) Tissot, B.P. & Welte, D.H. – Petroleum Formation and Occurrence (Springer)
2) Selley, R.C. – Elements of Petroleum Geology (Academic Press)
3) Durrance, E.M. – Radioactivity in Geology: Principles and Applications (Ellis Horwood Ltd.)
4) Dadhich, R.K. & Sharma, N.L. – Nuclear Fuel Cycle (Narosa Publishing House)
5) Bachu, S. – Gas Hydrates: Energy Resource and Environmental Challenges (Elsevier)

Detailed Syllabus Of Semester 6

Type of Course: Major	Geostatistics Credit: 4 L-T-P-C: 3-1-0-4 Scheme of Evaluation: Theory	Course Code: GEOL162M601

Course Objectives: The course aims to provide students with a fundamental understanding of geostatistical methods for spatial data analysis, focusing on their applications in geology, mining, hydrogeology, and environmental sciences. It introduces key concepts such as spatial variability, variogram analysis, interpolation techniques, and decision-making tools to enable students to analyse and model geological data effectively.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Recall fundamental concepts of statistics and geostatistics, including spatial data types and variability.	**BT 1**
CO 2	Understand the principles of spatial data analysis, correlation, regression, and hypothesis testing in geostatistics.	**BT 2**
CO 3	Apply geostatistical techniques such as variogram analysis, spatial autocorrelation, and interpolation methods to geological datasets.	**BT 3**
CO 4	Analyse geostatistical models for resource estimation, hydrogeology, and environmental applications using real-world case studies.	**BT 4**
CO 5	Evaluate and compare different geostatistical methods, including Kriging, inverse distance weighting, and machine learning-based approaches, for decision-making in geological studies.	**BT 5**

Modules	Topics and Course Content	Hours
Unit 1	**Fundamentals of Geostatistics** Definition, scope, and significance of geostatistics. Historical development and key contributors. Applications in geology, environmental science, mining, hydrogeology, and petroleum exploration. Basic concepts: spatial variability, random variables, stationarity, and spatial dependence. Types of spatial data: point data, areal data, volumetric data. Data exploration and visualization techniques (e.g., histograms, scatter plots, box plots).	16
Unit 2	**Statistical Methods in Geostatistics** Descriptive statistics: mean, median, mode, standard deviation, skewness, kurtosis, variance, and covariance. Correlation and regression analysis in spatial datasets. Probability distributions and their geological applications. Hypothesis testing: Null and Alternative hypothesis, Students' t-test, and Chi-square test. Spatial autocorrelation and Moran's I statistic.	17
Unit 3	**Spatial Interpolation and Variogram Analysis** Concept of variogram and semivariogram. Calculation of experimental variograms from spatial data. Interpretation of variograms: nugget effect, sill, and range. Structural analysis of spatial datasets: anisotropy and spatial continuity. Introduction to spatial interpolation techniques: inverse distance weighting (IDW), spline interpolation. Kriging techniques: ordinary kriging, universal kriging, and indicator kriging.	17
Unit 4	**Advanced Applications and Decision-Making in Geostatistics** Geostatistical simulation techniques in reservoir modelling, mineral resource exploration, and mining modelling. Application of machine learning and AI in geostatistical analysis. Multi-criteria decision analysis using geostatistical methods. Introduction to modern geostatistical software tools (e.g., R, Python, QGIS, ArcGIS).	16

	Case studies on geostatistical applications in natural resource exploration and environmental management.	
Experiential Learning: Home Assignments – 8 hrs, Presentation – 8 hrs, Video Screening – 8 hrs		24
Total Notional Credit Hours		**90**

Text Books suggested:

1) Davis, J.C. (2002). Statistics and Data Analysis in Geology. Wiley.
2) Chilès, J.P., & Delfiner, P. (2012). Geostatistics: Modeling Spatial Uncertainty. Wiley.

Reference Books:

1) Goovaerts, P. (1997). Geostatistics for Natural Resources Evaluation. Oxford University Press.
2) Kitanidis, P.K. (1997). Introduction to Geostatistics: Applications in Hydrogeology. Cambridge University Press.
3) Armstrong, M. (1998). Basic Linear Geostatistics. Springer.

Type of Course: Major	Economic Geology Credit: 4 L-T-P-C: 3-0-1-4 Scheme of Evaluation: Theory + Practical	Course Code: GEOL162M642

Course Objectives: The objective of this course is to provide a comprehensive understanding of ore deposits, their formation processes, exploration techniques, resource estimation, and sustainable mineral resource management.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Define key concepts of economic geology, such as ores, gangue minerals, tenor, grade, and mineral resources.	**BT 1**
CO 2	Understand the classification of ore deposits based on their mode of formation and describe various ore-forming processes.	**BT 2**
CO 3	Apply geological, geochemical, and geophysical exploration methods for mineral resource assessment.	**BT 3**
CO 4	Analyse mineral deposit models, metallogenic provinces, and global as well as Indian mineral resource distribution.	**BT 4**
CO 5	Evaluate ore grade, reserve estimation methods, and the environmental and economic impacts of resource utilization and mining.	**BT 5**

Modules	Topics and Course Content	Hours
Unit 1	**Introduction to Economic Geology** Ores, gangue minerals, tenor, grade, and lodes. Definitions of mineral occurrence, mineral deposit, and ore deposit. Economic and academic classification of mineral resources and reserves. Classification of ore deposits based on mode of formation (concordant and discordant ore bodies).	9
Unit 2	**Processes of Ore Formation and Deposit Types** Endogenous processes: Magmatic concentration, skarns, greisens, hydrothermal deposits. Exogenous processes: Weathering products and residual deposits, oxidation and supergene enrichment, placer deposits. Metallogenic provinces and epochs (Global and Indian perspective).	9
Unit 3	**Mineral Exploration and Resource Estimation** Exploration techniques: Remote sensing, GIS, geophysical, and geochemical methods. Recent advancements: AI and machine learning in mineral exploration. Ore grade assessment and reserve estimation. Economic and environmental considerations in mineral resource utilization.	9
Unit 4	**Important Economic Minerals of India** Metallic mineral deposits: Iron, copper, manganese, lead, zinc, aluminium, chromium. Non-metallic and industrial minerals: Limestone, phosphate, graphite, bauxite, and rare earth elements (REE). Atomic minerals: Uranium, thorium, and rare metals. Gemstones: Occurrence and economic significance. Sustainable mining practices and environmental impact assessment.	9
Practical	Study of physical properties (colour, streak, hardness, specific gravity, etc.) of: • **Metallic ores**: Iron (Hematite, Magnetite, Limonite), Copper (Chalcopyrite, Malachite), Manganese (Pyrolusite, Psilomelane), Lead and Zinc (Galena, Sphalerite), Aluminium (Bauxite), Chromium (Chromite). • **Industrial minerals**: Limestone, Fluorite, Graphite, Phosphate, Bauxite, and REE-bearing minerals. Microscopic study of ore-forming minerals (Under Reflected Light): Oxides and Sulphides. Assessment of ore grade and reserve estimation using Geometrical and Geostatistical methods. Preparation of mineral distribution maps of India. Understanding satellite imagery and spectral signatures of ore deposits.	30

Experiential Learning: Home Assignments – 8 hrs, Presentation – 8 hrs, Video Screening – 8 hrs	24
Total Notional Credit Hours	**90**

Text Books suggested:

1) Evans, A. M. (1993). Ore Geology and Industrial Minerals: An Introduction. Blackwell Science.
2) Guilbert, J. M., & Park, C. F. (2007). The Geology of Ore Deposits. Waveland Press.
3) Banerjee, D. K. (2014). Mineral Resources of India. Narosa Publishing.

Reference Books:

1) Robb, L. J. (2005). Introduction to Ore-Forming Processes. Wiley-Blackwell.
2) Craig, J. R., Vaughan, D. J., & Skinner, B. J. (2011). Resources of the Earth: Origin, Use, and Environmental Impact. Prentice Hall.
3) Moon, C. J., Whateley, M. K. G., & Evans, A. M. (2006). Introduction to Mineral Exploration. Blackwell Publishing.
4) Klemm, L., & Heinrich, C. (2019). Economic Geology: Principles and Practice. Wiley-Blackwell.
5) Ridley, J. (2013). Ore Deposit Geology. Cambridge University Press.
6) Mookherjee, A. (2000). Ore Genesis: A Holistic Approach. Allied Publishers.

Type of Course: Major	Engineering and Environmental Geology Credit: 4 L-T-P-C: 3-0-1-4 Scheme of Evaluation: Theory + Practical	Course Code: GEOL162M643

Course Objectives: To provide students with fundamental knowledge of engineering and environmental geology, focusing on the geological factors influencing construction projects, natural hazards, environmental impact assessment, and sustainable resource management.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Recall fundamental concepts of engineering geology, rock and soil properties, and environmental geology.	**BT 1**
CO 2	Explain geological considerations in civil engineering projects, such as dams, tunnels, and foundations.	**BT 2**
CO 3	Apply geotechnical classification systems (RQD, RMR, Q-System) for site evaluation in construction projects.	**BT 3**
CO 4	Analyse the causes, impacts, and mitigation strategies for landslides, floods, earthquakes, and water pollution.	**BT 4**
CO 5	Evaluate engineering and environmental geological data for sustainable planning and environmental impact assessment.	**BT 5**

Modules	Topics and Course Content	Hours
Unit 1	**Fundamentals of Engineering and Environmental Geology** Scope and significance of Engineering and Environmental Geology. Role of geologists in construction, urban planning, and environmental management. Engineering properties of rocks and soils: Atterberg limits, shear strength, consolidation. Clay minerals and their significance in geotechnical studies.	9
Unit 2	**Geological and Geotechnical Investigations for Engineering Projects** Rock Mass Classification: Rock Quality Designation (RQD), Rock Mass Rating (RMR), Tunnelling Quality Index (Q-System). Geological, geotechnical, and environmental considerations for dams, reservoirs, tunnels, and bridges. Foundation and abutment treatment techniques: Grouting, rock bolting, and other stabilization measures.	9
Unit 3	**Environmental Geology and Natural Hazards** Definition, scope, and principles of environmental geology. Pollution due to mining activities, industrial operations, and radioactive mineral extraction. Soil erosion and degradation: Causes and preventive measures. Floods: Causes, impacts, flood frequency analysis, management strategies, and case studies (including Assam). Water pollution: Sources, types, impact on ecosystems, pollution parameters, and potable water standards (Indian and WHO). Landslides: Causes, factors, hazard zonation, and mitigation measures. Earthquakes: Causes, seismic hazard assessment, and engineering solutions.	9
Unit 4	**Environmental Management and Impact Assessment** Introduction to Environmental Impact Assessment (EIA) and Environmental Management Systems (EMS). Geological considerations in EIA for large-scale urban and industrial projects. Sustainable resource management and environmental protection strategies.	9
Practical	Computation of reservoir area, catchment area, reservoir capacity, and reservoir life. Interpretation of geological cross-sections for engineering projects. Computation of index properties of rocks. Calculation and interpretation of RQD, RMR, RSR, and 'Q-system' ratings. Case studies on flood management and landslide hazard zonation.	30

	Water quality assessment based on pollution parameters and comparison with potable water standards.	
Experiential Learning: Home Assignments – 8 hrs, Presentation – 8 hrs, Video Screening – 8 hrs		24
Total Notional Credit Hours		**90**

Text Books suggested:

1) Krynine & Judd (2005) – Principles of Engineering Geology and Geotechnics, CBS Publishers.
2) Bell, F.G. (2007) – Fundamentals of Engineering Geology, Butterworth-Heinemann.

Reference Books:

1) Reddy, D.V. (2010) – Engineering Geology for Civil Engineers, Oxford University Press.
2) Gokhale, K.V.G.K. & Rao, D.M. (2018) – Experiments in Engineering Geology, CBS Publishers.
3) Keller, E.A. (2011) – Environmental Geology, Pearson Education.
4) Montgomery, C. (2016) – Environmental Geology, McGraw-Hill.
5) Blyth, F.G.H. & de Freitas, M.H. (1984) – A Geology for Engineers, Butterworth-Heinemann.

Type of Course: Major	Fuel Geology Credit: 4 L-T-P-C: 3-0-1-4 Scheme of Evaluation: Theory + Practical	Course Code: GEOL162M644

Course Objectives: To provide an in-depth understanding of the geological, geochemical, and economic aspects of conventional and unconventional fuels, including coal, petroleum, natural gas, gas hydrates, and nuclear energy resources, along with their exploration, exploitation, and environmental implications.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Define and explain the origin, classification, and fundamental properties of coal, petroleum, and nuclear fuels.	**BT 1**
CO 2	Describe the processes of petroleum generation, migration, and accumulation, as well as the role of kerogen maturation in hydrocarbon formation.	**BT 2**
CO 3	Identify and classify hydrocarbon traps, reservoir rocks, and cap rocks using geological and petrophysical parameters.	**BT 3**
CO 4	Evaluate the feasibility of coal bed methane, gas hydrates, and shale gas as alternative energy resources based on geological and geochemical conditions.	**BT 4**
CO 5	Assess the environmental impact of fuel extraction and suggest sustainable mitigation strategies in the context of modern energy demands.	**BT 5**

Modules	Topics and Course Content	Hours
Unit 1	**Coal Geology** Definition, origin, and formation of coal. Coal classification based on rank, type, and grade (Indian and International systems). Fundamentals of Coal Petrology – Lithotypes, microlithotypes, and macerals. Proximate and Ultimate analysis of coal. Coal Bed Methane (CBM): Global and Indian scenario, exploration and production. Underground coal gasification and Coal liquefaction: Principles, techniques, and applications. Environmental impact of coal mining and its mitigation strategies.	9
Unit 2	**Petroleum Geology** Composition and physical properties of crude oil and natural gas. Origin and formation of petroleum – Biogenic and thermal transformation of organic matter. Migration and accumulation of petroleum. Kerogen maturation and classification. Reservoir rocks – Petrophysical properties and classification (clastic vs. chemical). Cap rocks: Definition, properties, and types.	9
Unit 3	**Petroleum Reservoirs and Traps** Hydrocarbon traps: Definition and theories (Anticlinal theory, modern trap theory). Classification of traps – Structural, Stratigraphic, and Combination traps. Time of trap formation and hydrocarbon accumulation. Plate tectonics and global distribution of hydrocarbon reserves. Unconventional hydrocarbons – Oil sands, Oil shale, and Shale gas.	9
Unit 4	**Alternative and Nuclear Fuels** Gas Hydrates: Occurrence, structure, geological settings, stability, and economic significance. Shale Gas and Tight Oil: Exploration, production techniques, and challenges. Nuclear Fuels: • Uranium and Thorium-bearing minerals. • Geochemistry of U and Th. • Metallogenic provinces of India. • Methods of radioactive mineral exploration. • Detectors of radioactivity: Geiger-Müller counter, proportional counter, scintillation counters, and spectrometers. Environmental impact of fuel extraction and sustainable energy alternatives.	9

Practical	Megascopic identification of coal types (Peat, Lignite, Bituminous, Anthracite). Study of coal lithotypes and macerals under a reflected light microscope. Proximate analysis of coal: Moisture content, Volatile matter, Ash content, and Fixed carbon determination, rank and grade determination. Estimation of calorific value of coal using the Dulong formula. Study of physical properties of crude oil (viscosity, density, API gravity). Petrophysical properties of reservoir rocks (porosity, permeability, fluid saturation). Identification and classification of hydrocarbon traps using geological cross-sections. Preparation of isopach and structure contour maps for petroleum exploration.	30
Experiential Learning: Home Assignments – 8 hrs, Presentation – 8 hrs, Video Screening – 8 hrs		24
Total Notional Credit Hours		**90**

Text Books suggested:

1) Thomas, L. (2002). Coal Geology. Wiley-Blackwell.
2) Bjorlykke, K. (2010). Petroleum Geoscience: From Sedimentary Environments to Rock Physics. Springer.
3) IAEA Publications on nuclear fuel exploration and processing.

Reference Books:

1) Gluyas, J., & Swarbrick, R. (2004). Petroleum Geoscience. Blackwell.
2) Tissot, B. P., & Welte, D. H. (1984). Petroleum Formation and Occurrence. Springer.
3) North, F. K. (1985). Petroleum Geology. Springer.
4) Boggs, S. (2006). Principles of Sedimentology and Stratigraphy. Pearson.
5) Merrill, R. K. (1991). Sourcebook for Petroleum Geology. AAPG.
6) Sharma, S. (2017). Environmental Impact of Mining and Mineral Processing. Elsevier.

Type of Course: Minor	Environmental Geology Credit: 4 L-T-P-C: 3-1-0-4 Scheme of Evaluation: Theory	Course Code: GEOL162N601

Course Objectives: To introduce students to the interactions between geological processes and the environment, focusing on natural hazards, resource management, pollution control, and sustainable development.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Recall fundamental concepts of environmental geology and natural hazards.	**BT 1**
CO 2	Explain the impact of geological processes on the environment and human activities.	**BT 2**
CO 3	Apply geoscientific methods to assess environmental pollution and resource management.	**BT 3**
CO 4	Evaluate case studies on environmental degradation and mitigation strategies.	**BT 4**
CO 5	Critically assess environmental policies and propose sustainable solutions.	**BT 5**

Modules	Topics and Course Content	Hours
Unit 1	**Introduction to Environmental Geology** Definition, scope, and significance of environmental geology. Earth systems and human interactions: lithosphere, hydrosphere, atmosphere, and biosphere. Human impact on geological processes and vice versa.	9
Unit 2	**Environmental Pollution and Geology** Water Pollution: Sources (natural and anthropogenic), groundwater contamination, and mitigation. Soil Pollution: Causes (mining, industrial waste), impact, and remediation techniques. Air Pollution and Climate Change: Role of geological processes in atmospheric changes. Radioactive Pollution: Sources (nuclear waste, uranium mining), impacts, and control measures.	9
Unit 3	**Environmental Management and Impact Assessment** Introduction to Environmental Impact Assessment (EIA) and Environmental Management Systems (EMS). Geological considerations in EIA for large-scale urban and industrial projects. Sustainable resource management and environmental protection strategies.	9
Unit 4	**Resource Management and Sustainability** Water Resource Management: Groundwater recharge, rainwater harvesting, and conservation. Soil and Land Use Planning: Soil degradation, erosion control, and sustainable agriculture. Mining and Environmental Impact: Environmental effects of mining, EIA, and mine reclamation. Waste Management: Geology in waste disposal, landfills, and recycling. Sustainable Development Goals (SDGs) and geological perspectives.	9
Experiential Learning: Home Assignments – 8 hrs, Presentation – 8 hrs, Video Screening – 8 hrs		24
Total Notional Credit Hours		**90**

Text Books suggested:

1) Montgomery, C.W. (2020). Environmental Geology. McGraw-Hill.
2) Valdiya, K.S. (2013). Environmental Geology: Indian Context. McGraw-Hill.

Reference Books:

1) Bell, F.G. (2021). Environmental and Engineering Geology. CRC Press.
2) Singh, A.K. & Rajamani, V. (2016). Water Resources and Environmental Geology. Springer.
3) Keller, E.A. (2019). Environmental Geology. Pearson.

Detailed Syllabus Of Semester 7

Type of Course: Major	Advanced Structural Geology and Tectonics Credit: 4 L-T-P-C: 3-0-1-4 Scheme of Evaluation: Theory + Practical	Course Code: GEOL162M741

Course Objectives: To provide an advanced understanding of deformation processes in the Earth's crust, integrating structural geology principles with plate tectonic mechanisms while developing analytical and field-based skills for geological interpretation.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Define and recall fundamental concepts of stress, strain, rock deformation, and tectonic structures.	**BT 1**
CO 2	Understand the mechanics of rock deformation and classify different types of folds, faults, joints, and shear zones.	**BT 2**
CO 3	Apply strain analysis techniques and stereographic projections to interpret structural data.	**BT 3**
CO 4	Analyse deformation patterns to differentiate between brittle and ductile processes and their geological significance.	**BT 4**
CO 5	Evaluate the role of structural geology in tectonics, seismic activity, and resource exploration using field and remote sensing data.	**BT 5**

Modules	Topics and Course Content	Hours
Unit 1	**Fundamentals of Structural Geology** Introduction to rock mechanics: Stress and strain in rocks, stress tensor, strain tensor, finite and infinitesimal strain. Mohr stress circle and determination of the direction of shear stress. Principal axes of strain; measurement of strain using Flinn's diagram, Fry's method, and other strain markers. Behaviour of rocks under stress: elastic, plastic, brittle, viscous, and visco-elastic responses and their geological significance. Failure criteria: Coulomb's failure criterion, Griffith's theory of fracture. Planar and linear structures in deformed rocks: Cleavage, lineation, foliation and their kinematic significance.	9
Unit 2	**Folding, Faulting, and Jointing** Classification of folds: Ramsay's (1967) and Fleuty's (1964) classifications. Kinematics of folding: buckle folds, shear folds, and flexural slip folds. Determination of shear sense from fold geometry; superposed folding and interference patterns. Boudinage: Morphology, origin, and relationship to folding. Mechanics of faulting: Anderson's theory of faulting and its limitations. Geometry and kinematics of normal, strike-slip, and thrust faults with natural examples. Concept of fault zone weakening, fault reactivation, and seismotectonics. Geometric analysis of joints: Tectonic, columnar, and release joints.	9
Unit 3	**Shear Zones and Lithospheric Deformation** Shear zones: Geometry, kinematics, and classification. Strain analysis in shear zones: Shear sense indicators. Flow behaviour of sheared rocks: Ductile and brittle-ductile shear zones. Shear zone rocks: Cataclasite, gouge, breccia, mylonite, pseudotachylyte. Role of shear zones in the evolution of the continental crust.	9
Unit 4	**Tectonics and Structural Applications** Lithospheric plates, plate boundaries, and associated deformation. Orogeny and mountain-building processes: Himalayan tectonics, Andean-type orogeny. Subduction zones, mid-ocean ridges, and transform faults. Tectonic significance of structural geology in earthquake generation, magmatism, and basin evolution.	9

	Applications of structural geology in petroleum geology, mineral exploration, and engineering geology. Integration of remote sensing and GIS in structural geology.	
Practical	Measurement of structural elements in the field using a Brunton compass. Stereographic and equal-area projections for structural data analysis. Strain analysis using Flinn's diagram and Fry's method. Microstructural analysis of deformed rocks using thin sections. Construction of dip isogons and classification of folds. Interpretation of tectonic structures using Google Earth, GIS, and remote sensing.	30
Experiential Learning: Home Assignments – 8 hrs, Presentation – 8 hrs, Video Screening – 8 hrs		24
Total Notional Credit Hours		**90**

Text Books:

1) Structural Geology - Robert J. Twiss & Eldridge M. Moores, (2nd edition, 2007), W. H. Freeman & Co Ltd.
2) Structural Geology – Haakon Fossen, (2010), Cambridge University Press, New York.
3) Structural Geology- Fundamentals & Modern Developments (1993) - S K Ghosh, Pergamon Press.

Reference Books:

1) Pluijim, B.A.V.D. and Marshak, S., 2003: Earth Structure; 2nd edn., W.W. Norton & Co.
2) Pollard, D.D.,2005: Fundamentals of Structural Geology; Cambridge Univ. Press.

Type of Course: Major	Advanced Igneous and Metamorphic Petrology Credit: 4 L-T-P-C: 3-0-1-4 Scheme of Evaluation: Theory + Practical	Course Code: GEOL162M742

Course Objectives: To provide an in-depth understanding of the genesis, evolution, and geodynamic implications of igneous and metamorphic rocks using petrographic, geochemical, and thermodynamic approaches.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Recall fundamental igneous and metamorphic processes, including magma generation, crystallisation, and metamorphic transformations.	**BT 1**
CO 2	Understand the geochemical, mineralogical, and textural characteristics of igneous and metamorphic rocks in different tectonic settings.	**BT 2**
CO 3	Application of phase diagrams, geochemical data, and petrological concepts to determine the petrogenesis of igneous and metamorphic rocks.	**BT 3**
CO 4	Analyse various igneous and metamorphic processes by evaluating mineral assemblages, textures, and geochemical trends.	**BT 4**
CO 5	Evaluate the tectonic and thermal evolution of the lithosphere using petrological and geochemical evidence from natural rock samples.	**BT 5**

Modules	Topics and Course Content	Hours
Unit 1	**Igneous Processes and Geochemical Characterisation** Partial melting, magma differentiation, and source characterisation. Mantle melting and melt-mantle interaction in different geodynamic settings. Magmatism in mid-ocean ridges, subduction zones, continental and oceanic rift zones, and plume-related settings (hotspots). Major, trace, and isotopic geochemistry in petrogenetic interpretations. Trace element partitioning during equilibrium and fractional crystallisation/melting. Modelling trace element distribution in igneous petrogenesis.	9
Unit 2	**Petrology and Petrogenesis of Igneous Rocks** **Petrology and tectonic significance of major igneous rock types:** Ultramafic rocks (Komatiite, Kimberlite) Ophiolites and layered mafic-ultramafic complexes Alkaline rocks and carbonatites Flood basalts (Deccan Traps, Sylhet Traps) Granitoids and anorthosites – Tectonic discrimination of granitoids, their role in crustal evolution. **Experimental petrology and phase equilibria:** Two-, three-, and four-component phase systems at different pressures and temperatures. **Radiometric dating of igneous rocks and crustal evolution.**	9
Unit 3	**Metamorphic Processes, Reactions, and Textures** Crustal thickening, geothermal gradient, and P-T-t paths. Metasomatism and fluid-rock interactions. Paired metamorphic belts and their plate tectonic significance. Metamorphic zones, metamorphic grade. Thermodynamic basis of metamorphic facies. Mineral assemblages and phase diagrams (ACF, AKF, AFM). Cation exchange reactions and geothermobarometry. **Metamorphic textures and microstructures:** High-strain textures, deformation fabrics, reaction rims, and replacement textures. Analysis of poly-metamorphic and poly-deformed rocks.	9

Unit 4	**Thermodynamics and Advanced Metamorphic Petrology** **Thermodynamics in metamorphism:** Fundamental thermodynamic equations, enthalpy, entropy, and activity, Gibbs Free Energy. Application of the Clausius-Clapeyron equation in metamorphic reactions. Chemical potential and equilibrium in metamorphic systems. **Solution behaviour in metamorphic minerals:** Mixing components, ideal and non-ideal solutions. Raoult's Law and Henry's Law. **Geothermobarometry and petrogenetic grids:** P-T estimates using exchange and net-transfer reactions. Application of mineral chemistry in deciphering metamorphic conditions. **Role of fluids in metamorphism:** Fluid inclusions and their significance in metamorphic petrology. Retrograde metamorphism and re-equilibration.	9
Practical	**Igneous Petrology Practicals** 1. Use of phase diagrams (binary and ternary systems) to interpret magma crystallisation trends. 2. Geochemical analysis for petrogenetic interpretation – Use of major and trace element data to determine palaeotectonic settings of igneous rocks. 3. Numerical and graphical problems on magma dynamics: o Solid-liquid equilibrium system. o Magma viscosity and ascent rate. o Fractional crystallisation, partial melting, assimilation, and magma mixing (petrogenetic modelling). **Metamorphic Petrology Practicals** 4. Recognition of reaction textures, porphyroblastic growth, and deformation features through microscopic study of metamorphic rocks. 5. Identification of index minerals and determination of metamorphic grade. 6. Use of phase diagrams to interpret P-T conditions of metamorphism (ACF, AKF, AFM diagrams). 7. Geothermobarometry calculations using mineral assemblages – Estimation of pressure-temperature conditions of metamorphic reactions. 8. Petrofabric analysis of metamorphic rocks – Measurement of preferred orientation of minerals. 9. Determination of strain and deformation history – Study of deformation textures and structural evolution. 10. Measurement of foliation and lineation orientations – Use of stereographic projections. **Fieldwork** 11. Field study in an igneous and metamorphic terrain – • Identification of primary and secondary igneous structures. • Recognition of metamorphic facies, field textures, and structural fabrics. • Sample collection for petrographic and geochemical analysis.	30
Experiential Learning: Home Assignments – 8 hrs, Presentation – 8 hrs, Video Screening – 8 hrs		24
Total Notional Credit Hours		**90**

Text Books:

1) Best, M.G. – Igneous and Metamorphic Petrology
2) Philpotts & Ague – Principles of Igneous and Metamorphic Petrology

Reference Books:

1) Winter, J.D. – Principles of Igneous and Metamorphic Petrology
2) Turner, F.J. – Metamorphic Petrology
3) Yardley, B.W.D. – Introduction to Metamorphic Petrology
4) Rollinson, H. – Using Geochemical Data: Evaluation, Presentation, Interpretation

Type of Course: Major	Advanced Sedimentology and Quaternary Geology Credit: 4 L-T-P-C: 3-0-1-4 Scheme of Evaluation: Theory + Practical	Course Code: GEOL162M743

Course Objectives: To equip students with an in-depth understanding of sedimentary processes, depositional environments, and Quaternary geological changes, enabling them to reconstruct past climates, sea-level fluctuations, and human-environment interactions through applied geoscientific methods.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Define sedimentary textures, structures, and classification schemes.	BT 1
CO 2	Explain sedimentary rock classification, textures, and structures and their significance in reconstructing depositional environments.	BT 2
CO 3	Identify and differentiate various depositional environments using sedimentological and stratigraphic principles.	BT 3
CO 4	Analyse sedimentary basins using sequence stratigraphy and facies models.	BT 4
CO 5	Evaluate Quaternary geological changes, including glacial-interglacial cycles, climate proxies, and sea-level fluctuations.	BT 5

Modules	Topics and Course Content	Hours
Unit 1	**Sedimentary Basins** Sedimentary Basins in their plate tectonic environment. Classification of the sedimentary basins and their characteristics. Effects of mantle dynamics. Terrestrial sediments and solute yields. Measurements of erosion rates. Functioning of sediment routing systems.	9
Unit 2	**Depositional Environments & Sequence Stratigraphy** Depositional systems: Continental (fluvial, lacustrine, aeolian), transitional (deltaic, estuarine, coastal), and marine environments. Facies concept & facies models: Walther's Law of Facies Succession. Sequence Stratigraphy: Key concepts, systems tracts, parasequences, and sequence boundaries.	9
Unit 3	**Quaternary Geology & Climate Change** Introduction to Quaternary Period: Time scale and major climate events. Quaternary climates – Milankovitch cycles and climate forcing, eustatic changes. Proxy indicators of paleoclimatic changes - land, ocean and cryosphere (ice core studies). Sea-level fluctuations: Causes, methods of reconstruction, and impact on sedimentation. Palaeosols, loess deposits, and desertification: Indicators of past climate change. Quaternary Stratigraphy – Oxygen Isotope stratigraphy, biostratigraphy and magnetostratigraphy.	9
Unit 4	**Applied Quaternary Geology & Geoarchaeology** Dating methods: Radiocarbon dating, U-series, OSL, Cosmogenic nuclides, Amino acid. Quaternary geomorphology: Responses of geomorphic systems to climate, sea level and tectonics on variable time scales in the Quaternary. Human evolution and environmental changes: Archaeological evidence and climate-human interactions. Geoarchaeology case studies from Indian Sub-continent. Quaternary stratigraphy of India– continental records (fluvial, glacial, aeolian, palaeosols and duricrust); marine records; continental-marine correlation of Quaternary record.	9
Practical	1. **Heavy Mineral Separation and Microscopic Study** • Separation techniques (gravity separation, bromoform method, etc.). • Identification of common heavy minerals and their provenance significance. 2. **Paleocurrent Analysis** • Field measurement procedures for paleocurrent indicators. • Laboratory techniques: plotting and interpretation of rose diagrams and vector mean calculations.	30

	3. Preparation of Lithologs and Facies Analysis • Construction of lithologs from vertical sedimentary sections. • Interpretation of facies variations and depositional sequences.	
Experiential Learning: Home Assignments – 8 hrs, Presentation – 8 hrs, Video Screening – 8 hrs		24
Total Notional Credit Hours		**90**

Text Books:

1) Principles of Sedimentology and Stratigraphy – Sam Boggs Jr.
2) Sedimentology and Stratigraphy – Gary Nichols
3) Sedimentary Rocks – F.J. Pettijohn

Reference Books:

1) Introduction to Sedimentology – S. Sengupta
2) Sedimentary Petrology – Maurice E. Tucker
3) Depositional Sedimentary Environments - Reineck and Singh, (1980), Springer – Verlag.
4) Basin Analysis: Principles and Application to Petroleum Play Assessment – Philip A. Allen & John R. Allen

Type of Course: Major	Climatology and Oceanography Credit: 4 L-T-P-C: 3-1-0-4 Scheme of Evaluation: Theory	Course Code: GEOL162M704

Course Objectives: To provide an understanding of the Earth's climate system, atmospheric dynamics, oceanic circulation, and their interactions, with a focus on their geological significance and relevance to climate change.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Define key atmospheric and oceanographic concepts, terminologies, and classification systems.	BT 1
CO 2	Understand the interactions between the atmosphere, hydrosphere, and lithosphere in climate regulation.	BT 2
CO 3	Apply climatic and oceanographic data to interpret weather patterns, ocean circulation, and climate variability.	BT 3
CO 4	Analyse the causes and consequences of climate change using historical and modern datasets.	BT 4
CO 5	Evaluate the impact of human activities on climate and oceanic systems and propose sustainable solutions.	BT 5

Modules	Topics and Course Content	Hours
Unit 1	**Fundamentals of Climatology** Structure and chemical composition of the atmosphere, lapse rate and stability Solar radiation and Earth's energy budget Atmospheric temperature, pressure, and humidity distribution Cloud formation and precipitation processes Winds and general circulation patterns Jet streams and monsoonal systems w.r.t. to Indian Sub-continent Western disturbances and severe local convective systems Climatic zones and classification (Köppen & Thornthwaite)	9
Unit 2	**Atmospheric Dynamics and Climate Change** Atmospheric turbulence and boundary layer. Atmospheric stability and weather disturbances (cyclones, anticyclones, tornadoes) El Niño, La Niña, and Southern Oscillation (ENSO), Indian Ocean Dipole. Greenhouse effect and global warming Climatic and sea level changes on different time scales. Ice ages and Milankovitch cycles Climate modelling and prediction	9
Unit 3	**Oceanography and Ocean Circulation** Origin and evolution of oceans Physical and chemical properties of seawater (temperature, salinity, density) Residence times of elements in sea water. Oceanic circulation: Surface currents, thermohaline circulation, Coriolis effect and Ekman spiral, convergence, divergence and upwelling. Ocean waves and tides: Formation, classification, and effects Ocean-atmosphere interaction and its role in climate regulation Marine sediments and their significance in paleoceanography	9
Unit 4	**Marine Resources and Oceanic Processes** Oceanic productivity and biological zonation Coral reefs and their geological significance Hydrothermal vents and deep-sea ecosystems Marine pollution and its impact on climate Ocean exploration techniques (Remote Sensing, SONAR, Argo floats) Impact of climate change on oceans (sea-level rise, acidification) Opening and closing of ocean gateways and their effect on circulation and climate during the Cenozoic.	9

Experiential Learning: Home Assignments – 8 hrs, Presentation – 8 hrs, Video Screening – 8 hrs	24
Total Notional Credit Hours	**90**

Text Books:

1) Barry & Chorley – "Atmosphere, Weather and Climate"
2) Pinet – "Invitation to Oceanography"

Reference Books:

1) Critchfield – "General Climatology"
2) Lutgens & Tarbuck – "The Atmosphere: An Introduction to Meteorology"
3) Garrison – "Oceanography: An Invitation to Marine Science"
4) Trenberth – "Climate System Modeling"
5) Glenn & Turekian – "Oceans"
6) IPCC Reports – "Climate Change Assessments"

Type of Course: Minor	Stratigraphy Credit: 4 L-T-P-C: 3-1-0-4 Scheme of Evaluation: Theory	Course Code: GEOL162N701

Course Objectives: To introduce fundamental principles of stratigraphy, correlation techniques, depositional environments, and the geological history of Earth, with an emphasis on Indian stratigraphy.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Recall fundamental principles of stratigraphy and stratigraphic units.	BT 1
CO 2	Explain stratigraphic correlation techniques and depositional environments.	BT 2
CO 3	Apply knowledge of stratigraphy to interpret geological history.	BT 3
CO 4	Evaluate the impact of sea-level changes, plate tectonics, and extinction events on stratigraphy.	BT 4
CO 5	Assess the economic significance of stratigraphic units for resource exploration.	BT 5

Modules	Topics and Course Content	Hours
Unit 1	**Fundamentals of Stratigraphy** Definition, scope, and significance of stratigraphy. Fundamental principles of stratigraphy. Lithostratigraphy, Biostratigraphy, Chronostratigraphy, and Sequence Stratigraphy. Concept of facies and facies models. Unconformities and their significance in geological history.	9
Unit 2	**Stratigraphic Classification and Correlation** Lithostratigraphic units: Formation, Member, and Group. Biostratigraphy and biozones: Index fossils and their significance. Chronostratigraphy and Geochronology: Eons, Eras, Periods, and Epochs. Methods of stratigraphic correlation: Lithological, palaeontological, and geochronological approaches. Sea-level changes and their impact on stratigraphic records.	9
Unit 3	**Global Stratigraphy and Major Geological Events** Precambrian and Phanerozoic stratigraphy: Evolutionary trends and fossil records. Plate tectonics and its impact on stratigraphic sequences. Major extinction events in Earth's history. Sequence stratigraphy: Systems tracts, Sequence boundaries, and Parasequences. International Stratigraphic Code and Nomenclature.	9
Unit 4	**Indian Stratigraphy and Economic Significance** Precambrian Stratigraphy of India: Dharwar, Aravalli, Singhbhum, and Bundelkhand cratons. Palaeozoic Stratigraphy of India: Fossiliferous sequences of the Himalayas. Mesozoic Stratigraphy of India: Gondwana formations and their economic importance. Cenozoic Stratigraphy of India: Siwaliks, Deccan Traps, and Quaternary deposits.	9
Experiential Learning: Home Assignments – 8 hrs, Presentation – 8 hrs, Video Screening – 8 hrs		24
Total Notional Credit Hours		**90**

Text Books suggested:

1) Boggs, S. (2020). Principles of Sedimentology and Stratigraphy. Pearson.
2) The Making of India – K. S. Valdiya, Macmillan India Pvt. Ltd. (2010)

Reference Books:

1) Brenchley, P.J. & Harper, D.A.T. (1998). Palaeoecology: Ecosystems, Environments and Evolution. Springer.
2) Krishnan, M.S. (2009). Geology of India and Burma. CBS Publishers.
3) Ramakrishnan, M. & Vaidyanadhan, R. (2008). Geology of India (Vol. I & II). Geological Society of India.

Detailed Syllabus Of Semester 8

Type of Course: Major	Geomorphology Credit: 4 L-T-P-C: 3-0-1-4 Scheme of Evaluation: Theory + Practical	Course Code: GEOL162M841

Course Objectives: To develop an advanced understanding of geomorphic processes, with a focus on fluvial systems, tectonic influences, and GIS-based spatial analysis for landform evolution and environmental assessment.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Recall and describe fundamental geomorphic processes, landform development, and associated geological factors.	**BT 1**
CO 2	Describe the fundamental geomorphic processes and their role in landform development.	**BT 2**
CO 3	Apply morphometric techniques to analyse drainage basins and river systems.	**BT 3**
CO 4	Analyse and interpret spatial data using GIS and remote sensing for geomorphological studies.	**BT 4**
CO 5	Evaluate the impact of climate and tectonics on landscape evolution using geomorphic indices.	**BT 5**

Modules	Topics and Course Content	Hours
Unit 1	**Advanced Concepts in Geomorphology** Tectonic and climatic controls on landscape evolution. Rates of uplift and denudation; interaction between endogenic and exogenic processes. Models of long-term landscape development. Quaternary climate change: glacial/interglacial cycles, Milankovitch hypothesis, climate records in sediments. Sea-level changes and landscape evolution.	9
Unit 2	**Fluvial and Coastal Geomorphology** Channel geometry and drainage patterns; structural control on fluvial systems. River hydrodynamics: processes of erosion, transportation, and deposition. Drainage basin evolution and morphometry; role of lithology and tectonics. GIS and remote sensing applications in fluvial geomorphology: DEM-based watershed analysis, channel migration studies, and floodplain mapping. Coastal geomorphology: shore zone processes, erosional and depositional landforms. Coastal vulnerability assessment using GIS.	9
Unit 3	**Tectonic Geomorphology** Geomorphic markers of active tectonics (e.g., fault scarps, river anomalies). Geomorphic indices of active tectonics (e.g., stream gradient index, hypsometric integral). River response to climate change and tectonics; river terraces and knickpoints. Relationship between tectonics and drainage evolution.	9
Unit 4	**Applied Geomorphology and Modern Techniques** Mass wasting: classification, triggering mechanisms, and hazard assessment. Application of GIS in landform mapping and change detection. Role of geomorphology in natural hazard assessment (landslides, floods). Remote sensing and terrain analysis for landform studies. Application of geomorphic principles in environmental and engineering projects.	9
Practical	**Topographic and Remote Sensing Analysis** Interpretation of landforms using topographical maps, satellite images, and DEMs. Extraction and analysis of watersheds and drainage networks using GIS and remote sensing. Digital Elevation Model (DEM) processing for terrain analysis and slope mapping. **Fluvial Geomorphology Exercises** Preparation of longitudinal river profiles using GIS. Calculation of stream length-gradient index, hypsometric integral, and bifurcation ratio. Automated drainage basin delineation using GIS. Mapping and analysing river meandering, channel migration, and floodplain changes using time-	30

	series satellite images. Sediment yield estimation and flood hazard zonation using GIS-based models. **Tectonic Geomorphology** Application of geomorphic indices (e.g., mountain-front sinuosity, valley floor width-to-height ratio) using GIS. Mapping and quantifying active faulting and neotectonic deformation using remote sensing techniques. **Coastal Geomorphology** Coastal landform mapping and shoreline change analysis using multi-temporal satellite data. **Applied Geomorphology** Landslide susceptibility mapping using GIS-based models (e.g., AHP, Frequency Ratio). Soil erosion modelling using GIS-based RUSLE (Revised Universal Soil Loss Equation). Geomorphological hazard zonation integrating remote sensing and field-based data.	
Experiential Learning: Home Assignments – 8 hrs, Presentation – 8 hrs, Video Screening – 8 hrs		24
Total Notional Credit Hours		**90**

Text Books:

1) Bloom, A.L. – Geomorphology: A Systematic Analysis of Late Cenozoic Landforms (Prentice Hall)
2) Huggett, R.J. – Fundamentals of Geomorphology (Routledge)
3) Obrien, P. & Pike, R. – Geomorphometry: Concepts, Software, Applications (Elsevier)

Reference Books:

1) Summerfield, M.A. – Global Geomorphology (Longman)
2) Thornbury, W.D. – Principles of Geomorphology (Wiley)
3) Kale, V.S., & Gupta, A. – Introduction to Geomorphology (Universities Press)
4) Schumm, S.A. – River Variability and Complexity (Cambridge University Press)
5) Burbank, D.W. & Anderson, R.S. – Tectonic Geomorphology (Blackwell)
6) Bishop, M.P. & Shroder, J.F. – Remote Sensing and GIS for Natural Hazards Assessment (Taylor & Francis)
7) Montgomery, D.R. & Dietrich, W.E. – Topographic Controls on Watershed-Scale Erosion and Deposition

Type of Course: Major	Research Methodology Credit: 4 L-T-P-C: 3-1-0-4 Scheme of Evaluation: Theory	Course Code: GEOL162M802

Course Objectives: To equip students with the fundamental principles of research, methodologies for data collection and analysis, scientific writing skills, and ethical considerations in research.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Define key research concepts and methodologies.	BT 1
CO 2	Explain different research designs and data collection techniques.	BT 2
CO 3	Apply statistical and analytical tools to interpret research data.	BT 3
CO 4	Evaluate research findings for accuracy, reliability, and significance.	BT 4
CO 5	Develop well-structured research reports, proposals, and presentations.	BT 5

Modules	Topics and Course Content	Hours
Unit 1	**Introduction to Research** Definition, characteristics, and objectives of research. Types of research: Basic vs. Applied, Qualitative vs. Quantitative. Research process: Identifying a research problem, formulating hypotheses, and setting objectives. Literature review: Sources, referencing styles, and plagiarism detection tools. Research ethics and integrity: Ethical considerations, avoiding bias, and responsible authorship.	9
Unit 2	**Research Design and Methodology** Research design: Experimental, Descriptive, and Analytical approaches. Sampling techniques: Probability and Non-Probability sampling methods. Data collection methods: Field surveys, laboratory experiments, remote sensing, and archival research. Questionnaire design and interviews: Structure, reliability, and validity. Introduction to case study methodology and mixed-methods research.	9
Unit 3	**Data Analysis and Interpretation** Basics of statistical analysis: Measures of central tendency, dispersion, and correlation. Hypothesis testing: Parametric and non-parametric tests, p-values, and confidence intervals. Introduction to software tools: Excel, SPSS, R, and GIS for research. Data visualization: Graphs, charts, and mapping techniques. Errors in research: Accuracy, precision, and reproducibility of results.	9
Unit 4	**Scientific Writing and Presentation** Structure of a research paper: Abstract, Introduction, Methodology, Results, Discussion, and Conclusion. Writing a thesis or dissertation: Formatting, citation styles (APA, MLA, Chicago), and bibliography management. Writing research proposals and funding applications. Presentation skills: Creating effective slides and posters. Publication process: Peer review, impact factor, indexing, and open-access journals.	9
Experiential Learning: Home Assignments – 8 hrs, Presentation – 8 hrs, Video Screening – 8 hrs		24
Total Notional Credit Hours		**90**

Text Books suggested:

1) Kothari, C.R. & Garg, G. (2019). Research Methodology: Methods and Techniques. New Age International.
2) Creswell, J.W. & Creswell, J.D. (2018). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. Sage Publications.

Reference Books:

1) Krishnaswamy, K.N., Sivakumar, A.I. & Mathirajan, M. (2009). Management Research Methodology: Integration of Principles, Methods, and Techniques. Pearson.
2) Walliman, N. (2017). Research Methods: The Basics. Routledge.
3) Zikmund, W.G., Babin, B.J., Carr, J.C., & Griffin, M. (2016). Business Research Methods. Cengage Learning.

Type of Course: Major	**Dissertation** Credit: 12 L-T-P-C: 0-0-12-12 Scheme of Evaluation: Practical	Course Code: GEOL162M823

Course Objective: To develop advanced research skills in geological sciences by conducting independent research, applying analytical tools, and effectively communicating scientific findings.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Prepare a scientific research problem and design a feasible methodology.	BT 2
CO 2	Conduct advanced field investigations, data collection, and laboratory analyses.	BT 3
CO 3	Apply geospatial, statistical, and computational methods to interpret geological datasets.	BT 4
CO 4	Critically evaluate results and draw meaningful geological conclusions.	BT 5
CO 5	Write a scientific dissertation, including literature review, methodology, results, and discussion.	BT 6

Sl. No.	Research Outline	Timeline
1	**Advanced Research Planning & Proposal Writing** • Selection of research topic and problem formulation. • Review of scientific literature, gap analysis, and research hypothesis formation. • Research proposal writing: Objectives, methodology, data requirements. • Ethical considerations in research (plagiarism, data integrity, authorship).	2 Weeks
2	**Data Collection, Processing & Methodology** • Field investigations: Geological mapping, sampling, geophysical/geochemical surveys. • Data collection techniques: Borehole logging, GIS, remote sensing, petrography, geostatistics. • Experimental methods: XRD, XRF, SEM-EDS, thin section petrography, sediment analysis. • Computational techniques: Python/R for geosciences, RockWorks, ArcGIS/QGIS applications.	4 Weeks
3	**Analysis, Interpretation & Discussion** • Data processing & interpretation: Statistical and spatial analysis, cross-validation. • Conceptual geological models: Structural, hydrogeological, or mineral deposit models. • Comparison with previous studies & existing theories. • Scientific discussions: Uncertainty assessment, limitations of findings.	5 Weeks
4	**Report Writing, Publication & Presentation** • Scientific report structure: Abstract, introduction, methodology, results, discussion, conclusion. • Formatting as per journal/conference standards. • Graphical representation: Maps, cross-sections, geospatial models. • Preparation for oral defence & viva-voce.	4 Weeks
Total		**15 weeks**

Assessment Criteria:

Component	Marks (%)	Evaluation Criteria
Proposal Presentation	10%	Clarity, feasibility, scientific value
Mid-Term Review & Progress Report	20%	Quality of research progress

Component	Marks (%)	Evaluation Criteria
Dissertation Report	40%	Depth, originality, scientific rigour
Oral Defence & Viva	20%	Presentation skills, depth of understanding
Research Ethics & Engagement	10%	Effort, interactions, adherence to research norms

Reference Books:

1) Kothari, C. R. (2004). Research Methodology: Methods and Techniques.
2) Davis, J. C. (2002). Statistics and Data Analysis in Geology.
3) Bonham-Carter, G. (1994). Geographic Information Systems for Geoscientists: Modelling with GIS.
4) Telford, W. M., Geldart, L. P., & Sheriff, R. E. (1990). Applied Geophysics.
5) Montello, D. R., & Sutton, P. C. (2012). An Introduction to Scientific Research Methods in Geography and Environmental Studies.
6) Academic papers & journal articles related to the research topic.

Type of Course: Major	**Geology of North-East India** **Credit: 4** **L-T-P-C: 3-1-0-4** **Scheme of Evaluation: Theory**	**Course Code:** **GEOL162M804**

Course Objectives: To provide a detailed understanding of the geological framework, tectonics, stratigraphy, structural geology, mineral resources, and natural hazards of Northeast India, integrating recent research and advancements.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Recall the major lithostratigraphic units, structural features, and mineral resources of Northeast India.	**BT 1**
CO 2	Understand the tectonic evolution and stratigraphic framework of the region in relation to plate tectonics and basin development.	**BT 2**
CO 3	Interpret geological maps, seismic data, and remote sensing information to assess geological hazards and resource potential.	**BT 3**
CO 4	Analyse the impact of tectonics, climate, and human activities on the geological processes of Northeast India.	**BT 4**
CO 5	Assess the economic potential of mineral and hydrocarbon resources and their sustainable utilization.	**BT 5**

Modules	Topics and Course Content	Hours
Unit 1	**Tectonic and Structural Framework** Geographical and geological setting of Northeast India Tectonic domains: Shillong Plateau, Indo-Myanmar Orogenic Belt, Eastern Himalayan Syntaxis, Bengal Basin Evolution of the Indian Plate and its interaction with the Eurasian and Burmese plates Seismicity and active tectonics: fault systems, earthquake zones, and paleoseismic studies Geodynamic evolution of the Himalayas, Indo-Burma Ranges, and Assam-Arakan Basin	9
Unit 2	**Stratigraphy and Palaeontology** Precambrian formations: Shillong Group, Gneissic Complex, and associated lithounits Gondwana formations of Northeast India: stratigraphy, sedimentation, and palaeoclimate Mesozoic sequences: Cretaceous-Tertiary boundary and associated intrusions (Sylhet Traps, Rajmahal Traps) Cenozoic stratigraphy of the Assam-Arakan Basin. Palaeontology of Northeast India: Characteristic Flora, Fauna and Microfossils (including spores and pollens).	9
Unit 3	**Economic Geology and Hydrocarbon Resources** Mineral resources: coal, limestone, petroleum, uranium, and rare earth elements Oil and gas fields of NE India Coal deposits of NE India Uranium occurrences in Meghalaya and associated radioactive mineralization Hot springs and their geothermal Potential in Northeast India	9
Unit 4	**Geomorphology, Environmental Geology, and Hazards** Geomorphology of the Brahmaputra Valley Drainage characteristics of Brahmaputra, Barak, Subansiri, Lohit River systems Geohazards: seismic hazards, Floods and landslides in Northeast India Soil erosion in Northeast India Environmental impact of mining and hydroelectric projects in the region	9
Experiential Learning: Home Assignments – 8 hrs, Presentation – 8 hrs, Video Screening – 8 hrs		24
Total Notional Credit Hours		**90**

Text Books:

1) Krishnan, M.S. (2017) – Geology of India and Burma, CBS Publishers.
2) Valdiya, K.S. (2016) – Himalayan Geology, Springer.

3) Banerjee, A. (2015) – Tectonics of the Eastern Himalayas and Indo-Myanmar Orogenic Belt, Cambridge Scholars Publishing.

Reference Materials:

1) Geological Survey of India (GSI) Memoirs and Publications on Northeast India, Various editions. (Reports & Books)
2) Jain, A.K. & Manickavasagam, R.M. (2018) – Geology of the Himalayas and Northeast India, Elsevier. (Book)
3) Acharyya, S.K. (2007) – Tectonic Framework and Evolution of the Eastern Himalayas and Indo-Burma Orogen, Journal of Asian Earth Sciences, 29(2), 219–233. (Research Paper)
4) Murthy, K.S.R. et al. (2012) – Petroleum Geology of the Assam-Arakan Basin, Journal of Petroleum Geology, 35(4), 321–340. (Research Paper)
5) Rai, S. et al. (2020) – Seismotectonics of Northeast India: Recent Advances, Tectonophysics, 796, 228–245. (Research Paper)

Type of Course: Major	**Planetary Geology** Credit: 4 L-T-P-C: 3-1-0-4 Scheme of Evaluation: Theory	Course Code: GEOL162M805

Course Objective: To develop an understanding of the geological processes shaping planetary bodies, the evolution of the Solar System, and the application of remote sensing and astrobiology in planetary exploration.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Recall key concepts related to planetary formation, surface processes, and geological evolution of Solar System bodies.	**BT 1**
CO 2	Explain the geological features and atmospheric evolution of terrestrial planets, moons, and asteroids.	**BT 2**
CO 3	Apply remote sensing and crater dating methods to interpret planetary surface processes.	**BT 3**
CO 4	Compare planetary environments to assess habitability and geological activity.	**BT 4**
CO 5	Evaluate the feasibility of space resource utilisation and human exploration strategies.	**BT 5**

Modules	Topics and Course Content	Hours
Unit 1	**Origin and Evolution of the Solar System** The formation and differentiation of planetary bodies. Origin of elements, planetary accretion, and core formation. Methods of Solar System exploration: space missions, remote sensing, sample return missions. Meteorites, asteroids, and comets as records of early Solar System processes. Giant impacts and planetary evolution (e.g., Earth-Moon system formation). Dating planetary surfaces using crater analysis and radiometric methods.	9
Unit 2	**Comparative Planetary Geology** Thermal evolution of planets and moons: influence of planetary size and composition. Planetary atmospheres: evolution, retention, and climate history. Surface and internal geology of terrestrial planets: **Mercury:** Tectonics, volcanism, and magnetic field. **Venus:** Surface weathering, volcanism, and atmospheric dynamics. **Moon:** Regolith formation, impact cratering, and volcanic plains. **Mars:** Volcanism (Tharsis region), fluvial and glacial geomorphology, dust storms. Geological and geophysical properties of major moons (e.g., Europa, Titan, Ganymede). Giant planets and their satellites: structure, atmospheres, and magnetospheres.	9
Unit 3	**Planetary Surface Processes & Remote Sensing Applications** Impact cratering: formation stages, ejecta distribution, and shock metamorphism. Volcanism on terrestrial planets and icy moons (e.g., cryovolcanism on Enceladus). Aeolian, fluvial, and glacial processes on Mars and Titan. Remote sensing techniques in planetary geology: multispectral imaging, radar, LIDAR. Data analysis from space missions (Lunar Reconnaissance Orbiter, Mangalyaan, Perseverance) Applications of GIS and machine learning in planetary surface mapping.	9
Unit 4	**Astrobiology and Planetary Exploration** Habitability criteria in the Solar System: liquid water, energy sources, and organic molecules. Biosignatures and life-detection strategies on Mars, Europa, and Enceladus. Exoplanetary geology: Earth-like planets and their geological potential. Terraforming Mars: scientific feasibility and challenges. Future planetary exploration missions and their scientific objectives (e.g., Artemis, Dragonfly, Mars Sample Return). Space resources: mining asteroids and lunar regolith for sustainable space exploration.	9
Experiential Learning: Home Assignments – 8 hrs, Presentation – 8 hrs, Video Screening – 8 hrs		24
Total Notional Credit Hours		**90**

Text Books:

1) The New Solar System – Beatty, Petersen, Chaikin (5th Ed., 1999)
2) Planetary Geology – Greeley & Batson (1990)
3) Comparative Planetology, Geological Perspectives – Ronald Greeley (1985)

Reference Materials:

1) Meteorites and Their Parent Planets – Harry Y. McSween (2nd Ed., 1999, Book)
2) Solar System Evolution: A New Perspective – Stuart Ross Taylor (2nd Ed., 2001, Book)
3) Astrobiology: A Very Short Introduction – David Catling (2013, Book)
4) Evidence for Water on Mars – Malin & Edgett (Science, 2000, Paper)
5) Impact Cratering as a Geological Process – Melosh (1989, Paper)
6) Planetary Science: The Science of Planets Around Stars – de Pater & Lissauer (2015, Book)
7) NASA Technical Reports on Planetary Geology and Remote Sensing (Various Years, Reports)

Type of Course: Major	**Urban Geology** Credit: 4 L-T-P-C: 3-1-0-4 Scheme of Evaluation: Theory	Course Code: GEOL162M806

Course Objective: To develop an understanding of geological processes in urban environments and equip students with the knowledge and skills to assess geological hazards, manage urban resources, and apply geotechnical and GIS-based solutions for sustainable urban development.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Define and explain fundamental concepts of urban geology, including geological factors influencing urbanisation and sustainability.	**BT 1**
CO 2	Describe and analyse various geohazards such as earthquakes, landslides, and subsidence, and assess their impact on urban areas.	**BT 2**
CO 3	Apply geological principles in geotechnical investigations, land-use planning, and hazard mitigation strategies.	**BT 3**
CO 4	Analyse groundwater resources, urban mineral resources, and environmental concerns to develop sustainable management strategies.	**BT 4**
CO 5	Evaluate geological risks using GIS and remote sensing techniques for hazard assessment and urban planning.	**BT 5**

Modules	Topics and Course Content	Hours
Unit 1	**Fundamentals of Urban Geology** Definition, scope, and significance of Urban Geology Geological factors influencing urban development and sustainability Subsurface geological characterisation in urban areas Soil mechanics and foundation engineering for construction Geological materials in urban infrastructure development	9
Unit 2	**Geohazards and Risk Assessment in Urban Areas** Geological hazards: Earthquakes, landslides, floods, subsidence, sinkholes Urban flood risk assessment and mitigation strategies Engineering solutions for urban landslides and slope stability Seismic microzonation and earthquake-resistant design principles Role of remote sensing and GIS in urban hazard mapping	9
Unit 3	**Urban Resources and Environmental Management** Groundwater resources, aquifer characterisation, and management Urban mineral resources: Quarrying, excavation, and impacts Geothermal energy in cities: Potential, challenges, and applications Urban pollution: Sources, groundwater contamination, and remediation Sustainable urban planning: Environmental impact assessments (EIA)	9
Unit 4	**Applied Urban Geology and GIS Applications** Geology-based urban planning and land-use zoning Geological aesthetics and urban greenspace development Use of GIS and remote sensing in urban geology studies Case studies of geological hazards in urban environments Policies and regulations for urban geological sustainability	9
Experiential Learning: Home Assignments – 8 hrs, Presentation – 8 hrs, Video Screening – 8 hrs		24
Total Notional Credit Hours		**90**

Text Books:

1) Bell, F. G. (2004). Engineering Geology and Construction. CRC Press.
2) McCall, G. J. H., Marker, B. R. & Laming, D. J. C. (2004). Urban Geology in Land Use Planning. Geological Society of London.

Reference Materials:

1) Keller, E. A. & DeVecchio, D. E. (2019). Natural Hazards: Earth's Processes as Hazards, Disasters, and Catastrophes. Routledge.
2) Goudie, A. (2018). Human Impact on the Natural Environment: Past, Present, and Future. Wiley-Blackwell.
3) Yan, J. & Edwards, P. (2019). GIS and Geostatistical Techniques for Groundwater Science. Elsevier.
4) Rivas, V. & Horacio, D. (2014). Urban Geology in Latin America. Springer.
5) van Westen, C. J. (2000). GIS in Natural Hazard Assessment. ITC Journal, 2(3), 45-58. [Paper]
6) Brunsden, D. (1993). The Role of Geomorphology in Urban Planning and Hazard Assessment. Geological Society Special Publications, 14, 63-75. [Paper]