ROYAL GLOBAL UNIVERSITY
GUWAHATI

ROYAL SCHOOL OF ENVIRONMENTAL & EARTH SCIENCES (RSEES)

DEPARTMENT OF GEOLOGY

COURSE STRUCTURE & SYLLABUS

FOR

M.Sc. GEOLOGY

W.E.F.
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(Based on National Education Policy 2020)

Table of Contents

1. Preamble

India is one of the fastest-growing economies globally, with knowledge creation and research playing a pivotal role in sustaining this momentum. As the nation aspires to establish itself as a leading knowledge society and one of the largest economies, there is an urgent need to expand research capabilities and outputs across disciplines.

At Royal Global University, we align ourselves with this national vision by fostering a robust ecosystem of research and innovation, nurturing a vast talent pool that is critical for achieving these ambitious goals.

The National Education Policy (NEP) 2020 emphasizes the transformation of higher education to support India's transition to a knowledge-driven economy. Key initiatives such as multidisciplinary education with multiple entry and exit options, undergraduate research opportunities, and a learning outcomes-based curriculum are at the forefront of this transformation.

The postgraduate (PG) programmes at Royal Global University are designed to advance students' expertise in their chosen fields and equip them for higher research pursuits. These programmes provide the advanced knowledge and specialized skills necessary for students to evolve from learners to innovators, contributing meaningfully to the nation's knowledge economy.

In line with NEP 2020, Royal Global University offers restructured degree programmes to provide flexible and holistic education. The policy envisions undergraduate programmes with various certification options, including:

- A UG certificate after completing 1 year of study,
- A UG diploma after 2 years,
- A Bachelor's degree after a 3-year programme, or
- A preferred 4-year multidisciplinary Bachelor's degree, offering students the opportunity to explore holistic and multidisciplinary education alongside their chosen major and minors.

Similarly, postgraduate programmes at Royal Global University are designed with flexibility to cater to diverse academic and professional aspirations, fostering a new generation of knowledge creators who will shape India's future as a global leader.

Royal Global University remains committed to empowering students and creating an educational environment that embodies the principles of NEP 2020, driving innovation and excellence in higher education.

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. Recommendations of NEP 2020 Pertinent to Postgraduate Education

- A **2-year PG programme** may be offered, with the second year exclusively dedicated to research for students who have completed a 3-year Bachelor's programme.
- For students who have completed a **4-year Bachelor's programme with Honours or Honours with Research**, a **1-year PG programme** could be introduced.
- An **integrated 5-year Bachelor's/Master's programme** may also be offered.
- Universities are encouraged to provide PG programmes in core areas such as **Machine Learning**, multidisciplinary fields like **AI + X**, and professional domains such as **healthcare**, **agriculture**, and **law**.
- A **National Higher Education Qualifications Framework (NHEQF)** will define higher education qualifications in terms of learning outcomes. The PG programme levels will correspond to **Levels 6, 6.5, and 7** under the NHEQF.
- The PG framework must align with the **National Credit Framework (NCrF)** to facilitate the creditization of learning, including the assignment, accumulation, storage, transfer, and redemption of credits, subject to appropriate assessment.

4. Key Features of the Postgraduate Curriculum Framework

- **Interdisciplinary Flexibility**: Students can transition between different disciplines of study.

- **Choice of Specialization**: Students with a UG qualification, including a major and minor(s), have the flexibility to pursue their PG programme in their major, minor(s), or any other subject, provided they demonstrate the required competence.

- **Learner-Centric Options**: Opportunities are provided for students to select courses aligned with their interests.

- **Diverse Learning Modes**: Flexibility to adopt alternative learning methods, including offline, Open and Distance Learning (ODL), online, and hybrid modes.

- **Mobility and Credit Flexibility**: In line with the UGC (Establishment and Operation of Academic Bank of Credits in Higher Education) Regulations, 2021, and the UGC Guidelines for Multiple Entry and Exit in Academic Programmes, students benefit from greater academic mobility. These frameworks support the implementation of the proposed **"Curriculum and Credit Framework for Postgraduate Programmes"**.

5. Credit Requirements and Eligibility Criteria for PG Programmes

- A 1-year (2-semester) PG programme at level 6.5 on the NHEQF requires a Bachelor's degree with Honours or Honours with Research and a minimum of 160 credits.

- A 2-year (4-semester) PG programme at level 6.5 on the NHEQF requires a 3-year (6-semester) Bachelor's degree with a minimum of 120 credits.

- For professional PG programmes such as M.E., M.Tech., etc., a 2-year (4-semester) PG programme at level 7 of the NHEQF requires a 4-year Bachelor's degree (e.g., B.E., B.Tech.) with a minimum of 160 credits.

- A student is eligible for a PG programme in a discipline corresponding to either their major or minor(s) from their UG programme. Admission may be granted based on performance in the UG programme.

- Regardless of the major or minor disciplines pursued during UG, a student can seek admission to any discipline of a PG programme if they qualify through a National level entrance examination in the relevant discipline.

6. Generic Learning Outcomes at the Postgraduate Level

Under the **National Higher Education Qualifications Framework (NHEQF)**, higher education qualifications are classified across levels ranging from **Level 4.5 to Level 8**. These levels represent sequential stages of learning, defined through a set of learning outcomes that outline what learners are expected to **know, understand, and demonstrate** upon successfully completing a programme of study at a specific level. Learning outcomes are articulated as measurable graduate attributes, which students must achieve and demonstrate upon completing their programme. For postgraduate studies, these outcomes ensure students are equipped with advanced knowledge, skills, and competencies essential for their academic and professional growth.

- **NHEQF Level 4.5** corresponds to the learning outcomes expected in the first year (first two semesters) of an undergraduate programme.

- **NHEQF Level 8** corresponds to the outcomes appropriate for a doctoral-level programme.

Postgraduate programmes fall between **Level 6.5 and Level 7**, as outlined in the NHEQF. The framework ensures that PG students acquire both depth in their subject knowledge and the ability to apply their learning to complex, real-world challenges.

For a comprehensive understanding of the detailed learning outcomes for PG programmes, refer to the National Higher Education Qualifications Framework (NHEQF).

6.1. Graduate Attributes & Learning outcomes descriptors for a higher education qualification at level 6.5 on the NHEQF

Qualifications that signify completion of the postgraduate degree are awarded to students who:

GA1: have demonstrated knowledge and understanding that is founded upon and extends and/or enhances that typically associated with the first cycle, and that provides a basis or opportunity for originality in developing and/or applying ideas, often within research context.

GA2: can apply their knowledge and understanding, and problem-solving abilities in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their field of study.

GA3: have the ability to integrate knowledge and handle complexity, and formulate judgments with incomplete or limited information, but that include reflecting on social and ethical responsibilities linked to the application of their knowledge and judgments.

GA4: can communicate their conclusions, and the knowledge and rationale underpinning these, to specialist and non-specialist audiences clearly and unambiguously.

GA5: have the learning skills to allow them to continue to study in a manner that may be largely self-directed or autonomous.

The PG degree (M.Sc. Geology) will be awarded to students who have demonstrated the achievement of the outcomes located at level 6.5 on the NHEQF. Refer Table 6.1.1

Table 6.1.1

Element of the descriptor	**NHEQF level descriptors** *The graduates should be able to demonstrate the acquisition of:*
Knowledge and understanding	• advanced knowledge about a specialized field of enquiry with acritical understanding of the emerging developments and issues relating to one or more fields of learning, • advanced knowledge and understanding of the research principles, methods, and techniques applicable to the chosen field(s) of learning or professional practice, • procedural knowledge required for performing and accomplishing complex and specialized and professional tasks relating to teaching, and research and development.
General, technical and professional skills required to perform and accomplish tasks	• advanced cognitive and technical skills required for performing and accomplishing complex tasks related to the chosen fields of learning. • advanced cognitive and technical skills required for evaluating research findings and designing and conducting relevant research that contributes to the generation of new knowledge. • specialized cognitive and technical skills relating to a body of knowledge and practice to analyse and synthesize complex information and problems.

Application of knowledge and skills	• apply the acquired advanced theoretical and/or technical knowledge about a specialized field of enquiry or professional practice and a range of cognitive and practical skills to identify and analyse problems and issues, including real-life problems, associated with the chosen fields of learning. • apply advanced knowledge relating to research methods to carryout research and investigations to formulate evidence-based solutions to complex and unpredictable problems.
Generic learning outcomes	**Effective Communication and Presentation** • Listen attentively, analyse texts and research papers, and present complex information clearly to diverse audiences. • Communicate technical information, research findings, and explanations in a structured manner. • Concisely discuss the relevance and applications of research findings in the context of emerging developments and issues. **Critical Thinking and Analytical Skills** • Evaluate evidence reliability, identify logical flaws, and synthesize data from multiple sources to draw valid conclusions. • Support arguments with evidence, address opposing view points, and critique the reasoning of others. **Self-Directed Learning and Professional Development** • Address personal learning needs in chosen fields of study, work, or professional practice. • Pursue self-paced learning to enhance knowledge and skills, particularly for advanced education and research. **Research Design and Methodology** • Define and articulate research problems, formulate hypotheses, and design relevant research questions. • Develop appropriate tools and techniques for data collection and analysis. • Use statistical and analytical methods to interpret data and establish cause-and-effect relationships. **Research Execution and Ethics** • Plan, conduct, and report investigations while adhering to ethical standards in research and practice. • Apply research ethics rigorously in fieldwork and personal research activities. **Problem-Solving and Decision-Making** • Make informed judgments and decisions based on empirical evidence and analysis to solve real-world problems. • Take responsibility for individual and group actions in generating solutions within specific fields of study or professional practice.
Constitutional, humanistic, ethical, and moral values	• embrace and practice constitutional, humanistic, ethical, and moral values in one's life, • adopt objective and unbiased actions in all aspects of work related to the chosen fields/subfields of study and professional practice, • participate in actions to address environmental protection and sustainable development issues, • support relevant ethical and moral issues by formulating and presenting coherent arguments, • follow ethical principles and practices in all aspects of research and development, including inducements for enrolling participants, avoiding unethical practices such as fabrication, falsification or misrepresentation of data or committing plagiarism.

Employability & job ready skills, entrepreneurship skills and capabilities/qualities and mindset	• adapting to the future of work and responding to the demands of the fast pace of technological developments and innovations that drive the shift in employers' demands for skills, particularly with respect to the transition towards more technology-assisted work involving the creation of new forms of work and rapidly changing work and production processes. • exercising full personal responsibility for the output of own work as well as for group/team outputs and for managing work that is complex and unpredictable requiring new strategic approaches.

The levels of PG programmes as per the NHEQF are summarized in Table 6.1.2

Level	Credits	Qualification	Credit Requirement Per year	Credit Points	Total Notional Learning hours
6	160	1 – yr P.G. Diploma	40	240	1200
6.5	160	1-Year PG after a 4-year UG	40	260	1200
6.5	120	2-Year PG after a 3-year UG	40	260	1200
7	160	2-Year PG after a 4-year UG such as B.E., B. Tech. etc	40	280	1200

7. Curricular Components

2-year PG: Students entering 2-year PG after a 3-year UG programme can choose to do:

- only course work in the third and fourth semester or
- course work in the third semester and research in the fourth semester or
- only research in the third and fourth semester.

1-year PG: Students entering 1-year PG after a 4-year UG programme can choose to do

- only coursework or
- research or
- coursework and research.

8. Credit Distribution

8.1 For 1-year PG

Table: 8.1.1

Curricular Components	PG Programme (one year) after 4-yr UG (Hons./Hons. with Research) Minimum Credits			
	Course Level	Coursework	Research thesis/project/Patent	Total Credits
Coursework + Research	500	20	20	40
Coursework	500	40	--	40
Research		--	40	40

8.2 For 2-year PG

Table: 8.1.2

Curricular Components		PG Programme (one year) for 4-yr UG (Hons./Hons. with Research) Minimum Credits			
		Course Level	**Coursework**	**Research thesis/project /Patent**	**Total Credits**
PG Diploma		400	40	--	40
1st Year (1st & 2nd Semester)		400 500	24 16	--	40
Students who exit at the end of 1st year shall be awarded a Postgraduate Diploma					
2nd Year (3rd & 4th Semester)	Coursework & Research	500	20	20	40
	Coursework (or)	500	40	--	40
	Research	40	40		

Exit Point:

For those who join 2-year PG programmes, there shall only be one exit point. Students who exit at the end of 1st year shall be awarded a Postgraduate Diploma.

9. Course Levels

400-499: Advanced courses which would include lecture courses with practicum, seminar-based course, term papers, research methodology, advanced laboratory experiments/software training, research projects, hands-on-training, internship/apprenticeship projects at the undergraduate level or First year Postgraduate theoretical and practical courses.

500-599: For students who have graduated with a 4-year bachelor's degree. It provides an opportunity for original study or investigation in the major or field of specialization, on an individual and more autonomous basis at the postgraduate level.

10. Switching Subjects in Postgraduate Programme

The first degree often inspires students to explore alternative career paths that may require a shift in their field of study. While transitioning to a different discipline through a postgraduate degree can be challenging, the **National Education Policy (NEP)** provides the necessary flexibility to make it achievable. Postgraduate programmes offer students the opportunity to change their field and pursue their aspirations through the following pathways:

- Students are eligible for admission to a PG programme in either the **major or minor discipline** studied during their undergraduate programme.
- Irrespective of the major or minor disciplines pursued in the undergraduate programme, students may seek admission to **any discipline** of PG programmes by qualifying the relevant National or University-level entrance examination.

Furthermore, candidates who have completed:

- A **4-year UG programme**,
- A **3-year UG + 2-year PG programme**, are eligible for admission to **M.E. or M. Tech. programmes** in related fields.

This framework enables students to redefine their academic trajectory and achieve their professional goals in a new discipline.

11. 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.

12. 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. 0-5 marks are given to students having 75% attendance or more.

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

M. Sc. Geology

Two-Year Programme Structure

1st SEMESTER

Sl. No	Course Code	Name of Courses	Course Scheme	Course Level	Credits
1	GEOL164C141	Structural Geology and Tectonics	T + P	500	4
2	GEOL164C142	Mineralogy and Crystal Chemistry	T + P	400	4
3	GEOL164C143	Igneous and Metamorphic Petrology	T + P	500	4
4	GEOL164C144	Sedimentology and Quaternary Geology	T + P	500	4
5	GEOL164C105	Climatology and Oceanography	T	400	4
6		**Course through SWAYAM portal** *(to be selected by the department)*	T		3 or 4
				TOTAL	20 + (3 or 4)

2nd SEMESTER

Sl. No	Course Code	Name of Courses	Course Scheme	Course Level	Credits
1	GEOL164C241	Indian Stratigraphy and Applied Palaeontology	T + P	400	4
2	GEOL164C242	Geomorphology	T + P	500	4
3	GEOL164C203	Geology of NE India	T	400	4
4	GEOL164C204	Planetary Geology	T	400	4
5	GEOL164C205	Urban Geology	T	400	4
6		**Course through SWAYAM portal** *(to be selected by the department)*	T		3 or 4
				TOTAL	20 + (3 or 4)

Students who exit at the end of 1st year shall be awarded a Postgraduate Diploma

3rd SEMESTER

Sl. No	Course Code	Name of Courses	Course Scheme	Course Level	Credits
1	GEOL164C341	Engineering Geology	T + P	500	4
2	GEOL164C342	Economic Geology	T + P	500	4
3	GEOL164C343	Fuel Geology	T + P	500	4
4	GEOL164C304	Exploration Geology	T	500	4
5	GEOL164C305	Mining Geology	T	500	4
				TOTAL	20

4th SEMESTER

Sl. No	Course Code	Name of Courses	Course Scheme	Course Level	Credits
1	GEOL164C421	Dissertation	P	-	20
				TOTAL	20

M. Sc. Geology

One-Year Programme Structure

1st SEMESTER					
Sl. No	**Course Code**	**Name of Courses**	**Course Scheme**	**Course Level**	**Credits**
1	GEOL164C341	Engineering Geology	T + P	500	4
2	GEOL164C342	Economic Geology	T + P	500	4
3	GEOL164C343	Fuel Geology	T + P	500	4
4	GEOL164C304	Exploration Geology	T	500	4
5	GEOL164C305	Mining Geology	T	500	4
				TOTAL	20
2nd SEMESTER					
Sl. No	**Course Code**	**Name of Courses**	**Course Scheme**	**Course Level**	**Credits**
1	GEOL164C421	Dissertation	P	-	20
				TOTAL	20

Detailed Syllabus
Two-Year M.Sc. Programme
Semester 1

Course Level: 500	STRUCTURAL GEOLOGY AND TECTONICS L-T-P-C: 3-0-1-4 Credits: 4 Scheme of Evaluation: (T + P)	Course Code: GEOL164C141

Course Objective: 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.	12
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.	12
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.	10
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.	11

	Tectonic significance of structural geology in earthquake generation, magmatism, and basin evolution. 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
	Total	**75**

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.

Course Level: 400	MINERALOGY AND CRYSTAL CHEMISTRY L-T-P-C: 3-0-1-4 Credits: 4 Scheme of Evaluation: (T + P)	Course Code: GEOL164C142

Course Objective: To provide a comprehensive understanding of mineral structures, crystal chemistry, and mineralogical analysis techniques, integrating theoretical concepts with practical applications in geology.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Recall fundamental concepts of crystallography, crystal chemistry, and mineral classification.	**BT 1**
CO 2	Understanding the principles of crystal structures, bonding, structural transformations, and mineral properties.	**BT 2**
CO 3	Apply X-ray diffraction and optical techniques for mineral identification and characterization.	**BT 3**
CO 4	Analyse the relationship between mineral structures, composition, and their physical and optical properties.	**BT 4**
CO 5	Evaluate mineral stability, solid solution behaviour, and the role of advanced analytical techniques (SEM, TEM, EPMA) in mineralogical studies.	**BT 5**

Modules	Topics and Course Content	Hours
Unit 1	Periodicity and symmetry-concept of space lattice, unit cell, and crystal systems. Chemical bonding in Crystal structures: Ionic, covalent and metallic bonding. Ionic radii, coordination number, Pauling's rule for crystal stability. Crystal structure of minerals- Hexagonal close-packing, cubic close-packing and body centred structure. Crystal Defects: Point Defects, Line defects and Planar defects.	12
Unit 2	Chemical classification of minerals; Composition of common rock-forming minerals. Silicate minerals and their structures: Isolated tetrahedra (nesosilicates), Single-chain silicates (inosilicates), Double-chain silicates (amphiboles), Layered silicates (phyllosilicates), Framework silicates (tectosilicates). Non-silicate mineral structures and mineralogy of clays.	12
Unit 3	Structural transformation in minerals: Isomorphism, Polymorphism, and Pseudomorphism. Compositional classification and structural inversion in minerals. Solid solution and exsolution mechanisms: Rules governing solid solution behaviour; examples from pyroxenes and feldspars. Chemical, physical, and optical properties of major silicate mineral groups: olivine, feldspar, pyroxene, amphibole, garnet, and mica.	10
Unit 4	Principles of X-ray crystallography and Bragg's equation. Introduction to diffraction and imaging techniques. X-ray diffraction (XRD): Single-crystal and powder diffraction methods for mineral identification. Reciprocal lattice and Crystal field theory. Application of SEM, TEM and EPMA in mineral characterization.	11

Practical	Study of crystallographic symmetry using models. Identification of minerals through optical properties in thin sections under a petrological microscope. Pleochroic Scheme determination. Identification of Plagioclase Feldspars with the help of optical properties. Optic sign determination. X-ray diffraction analysis for mineral identification. Interpretation of mineral chemistry using EPMA data.	30
	Total	**75**

Text Books:

1) Deer, Howie & Zussman – Introduction to the Rock-Forming Minerals
2) Klein & Dutrow – Manual of Mineral Science

Reference Books:

1) Putnis – Introduction to Mineral Sciences
2) Nesse – Introduction to Optical Mineralogy
3) Azaroff – Elements of X-ray Crystallography

Course Level: 500	IGNEOUS AND METAMORPHIC PETROLOGY L-T-P-C: 3-0-1-4 Credits: 4 Scheme of Evaluation: (T + P)	Course Code: GEOL164C143

Course Objective: 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.	12
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.**	12
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.	10

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.	11
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
	Total	**75**

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

Course Level: 500	SEDIMENTOLOGY AND QUATERNARY GEOLOGY L-T-P-C: 3-0-1-4 Credits: 4 Scheme of Evaluation: (T + P)	Course Code: GEOL164C144

Course Objective: 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.	12
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.	12
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.	10
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.	11

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. **3. Preparation of Lithologs and Facies Analysis** • Construction of lithologs from vertical sedimentary sections. • Interpretation of facies variations and depositional sequences.	30
	Total	**75**

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

Course Level: 400	CLIMATOLOGY AND OCEANOGRAPHY L-T-P-C: 3-1-0-4 Credits: 4 Scheme of Evaluation: (T)	Course Code: GEOL164C105

Course Objective: 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)	15
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	15
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	15
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	15

	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.	
	Total	**60**

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"

Detailed Syllabus
Two-Year M.Sc. Programme
Semester 2

Course Level: 400	INDIAN STRATIGRAPHY AND APPLIED PALAEONTOLOGY L-T-P-C: 3-0-1-4 Credits: 4 Scheme of Evaluation: (T + P)	Course Code: GEOL164C241

Course Objective: To develop an understanding of the fossil record, evolutionary trends, and the stratigraphic framework of India, integrating palaeontological and stratigraphic data for geological interpretations.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Describe key evolutionary events, mass extinctions, and major fossil groups in Earth's history.	**BT 1**
CO 2	Understand the evolutionary trends of vertebrates, invertebrates, and microfossils and their applications in palaeoenvironmental and biostratigraphic studies.	**BT 2**
CO 3	Apply palaeontological and stratigraphic principles to analyse fossil records and interpret sedimentary sequences in the Indian geological framework.	**BT 3**
CO 4	Analyse lithostratigraphic, biostratigraphic, and palaeontological data to reconstruct past environments and correlate geological formations.	**BT 4**
CO 5	Evaluate the significance of major geological events (e.g., Precambrian-Proterozoic boundary, Cretaceous-Tertiary transition) using palaeontological and stratigraphic evidence.	**BT 5**

Modules	Topics and Course Content	Hours
Unit 1	Definition and scope of Applied Palaeontology. Fossils as tools for stratigraphic correlation: Biostratigraphy (zones, index fossils, biochronology). Fossils and palaeoenvironmental reconstructions: Palaeoclimatology and palaeoecology. Introduction to Micropalaeontology: Types of microfossils (foraminifera, ostracods, nannofossils, conodonts, radiolaria). Applications in petroleum exploration: palaeobathymetry, age dating, reservoir characterisation.	12
Unit 2	Spores, pollen, dinoflagellates: Stratigraphic and palaeoclimatic significance. Use of palynofossils in coal, petroleum, and groundwater studies. Trace fossils: Types, ichnofacies, and their use in environmental interpretation and sedimentary basin analysis. Gondwana Flora: Stratigraphic correlation, palaeoclimatic implications, economic relevance. Recent advances: Fossil data in climate change studies and basin modelling.	12
Unit 3	**Stratigraphic Framework of India** **Tectonic Framework:** Cratons, mobile belts, and inter-cratonic shear zones of India. **Precambrian Geology:** Proterozoic basins (Cuddapah, Vindhyan, Kurnool), Archaean-Proterozoic boundary, and Precambrian-Cambrian transition. **Phanerozoic Stratigraphy:** Palaeozoic sequences of the Himalayas and marine Palaeozoics in Peninsular India. **Mesozoic Sequences:** Triassic of Spiti, Jurassic of Kutch, Cretaceous formations of Peninsular India. **Cenozoic Stratigraphy:** Deccan Traps and associated infra/intertrappean sequences.	10
Unit 4	**Applied Stratigraphy and Field Applications** **Gondwana Sequence of India**: Basin configuration, sedimentation, palaeoclimates, and marine intercalations. Recent trends in classification of Gondwana strata in India. **Cretaceous-Tertiary Boundary**: Significant events and fossil records. **Stratigraphic Correlation**: Use of fossils in biostratigraphic correlation, and palaeoenvironmental reconstructions. **Applied Palaeontology in Exploration**: Fossil-based interpretations for hydrocarbon and mineral exploration.	11

Practical	Study of major invertebrate and vertebrate fossils (hand specimens and thin sections). Identification and classification of foraminifera, ostracods, radiolaria under a microscope. Palynological sample preparation and analysis. Biostratigraphic correlation using fossil records. Preparation and interpretation of lithostratigraphic and biostratigraphic columns. Field-based stratigraphic section measurement and fossil sampling (if feasible).	30
	Total	**75**

Text Books:

1) Raup & Stanley – "Principles of Paleontology"
2) The Making of India – K. S. Valdiya, Macmillan India Pvt. Ltd. (2010)
3) Cratons and Fold Belts of India – Ram. S. Sharma, Springer (2009)

Reference Books:

1) Clarkson – "Invertebrate Palaeontology and Evolution"
2) Invertebrate Paleontology, Shrock and Twenhoefells, CBS publishers
3) Benton & Harper – "Introduction to Paleobiology and the Fossil Record"
4) Geology of India: A Review by N. C. Pant and B. P. Radhakrishna, Springer (2014)
5) Indian Stratigraphy by Srikant Das, Birbal Sahni Institute of Paleobotany (2018)
6) Geology of India by V. P. Dimri, Springer (2020)
7) Geology of India (Vol. 1 & 2) – M. Ramakrishnan & R. Vaidyanadhan, Geological Society of India, Bangalore (2008).
8) Bose, Mazumdar & Sarkar – "Indian Stratigraphy"

Course Level: 500	GEOMORPHOLOGY L-T-P-C: 3-0-1-4 Credits: 4 Scheme of Evaluation: (T + P)	Course Code: GEOL164C242

Course Objective: 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.	12
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.	12
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.	10
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.	11

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-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.	30
	Total	**75**

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

Course Level: 400	GEOLOGY OF NORTHEAST INDIA L-T-P-C: 3-1-0-4 Credits: 4 Scheme of Evaluation: (T)	Course Code: GEOL164C203

Course Objective: 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	15
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).	15
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	15
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	15
	Total	**60**

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)

Course Level: 400	PLANETARY GEOLOGY L-T-P-C: 3-1-0-4 Credits: 4 Scheme of Evaluation: (T)	Course Code: GEOL164C204

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.	15
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.	15
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.	15
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). Space resources: mining asteroids and lunar regolith for sustainable space exploration.	15
	Total	**60**

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)

Course Level: 400	URBAN GEOLOGY L-T-P-C: 3-1-0-4 Credits: 4 Scheme of Evaluation: (T)	Course Code: GEOL164C205

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	15
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	15
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)	15
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	15
	Total	**60**

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]

Detailed Syllabus
Two-Year M.Sc. Programme
Semester 3

Course Level: 500	ENGINEERING GEOLOGY L-T-P-C: 3-0-1-4 Credits: 4 Scheme of Evaluation: (T + P)	Course Code: GEOL164C341

Course Objective: To equip students with the principles of engineering geology and geotechnical investigation, focusing on soil and rock mechanics, slope stability, and the geological considerations essential for infrastructure development.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Recall fundamental concepts of soil mechanics, rock properties, and geological factors influencing engineering projects.	**BT 1**
CO 2	Understand the fundamental concepts of soil and rock mechanics and their applications in geotechnical engineering.	**BT 2**
CO 3	Apply geological principles in site selection, foundation analysis, and stability assessment of dams, tunnels, and slopes.	**BT 3**
CO 4	Analyse the impact of geological structures and material properties on infrastructure stability and hazard mitigation.	**BT 4**
CO 5	Evaluate engineering problems related to slope stability, tunnel construction, and dam safety using geotechnical investigation methods and GIS-based tools.	**BT 5**

Modules	Topics and Course Content	Hours
Unit 1	**Fundamentals of Soil and Rock Mechanics** Soil: Engineering properties, unit weight, specific gravity, porosity, void ratio, water content, and degree of saturation. Compressibility, consolidation, compaction, and shear strength of soils. Clay mineralogy and its significance in soil behaviour, Atterberg limits, and soil classification. Engineering properties of rocks: Strength, hardness, elasticity, porosity, and specific gravity. Rock masses: Discontinuities, weathering, and deformation. Engineering classification of rocks and rock masses (RQD, Bieniawski's RMR, Q-system).	12
Unit 2	**Ground Improvement Techniques** Rock mass improvement techniques: Grouting, bolting, anchoring, and shotcreting. Quarrying and rock blasting techniques. Use of rocks as construction materials. Geotechnical properties of aggregates used in construction.	12
Unit 3	**Dams and Reservoirs** Types of engineering geological investigations: Preliminary and Detailed Types and classification of dams. Geological and geophysical investigations for dam foundations and abutments. Foundation and abutment problems: Seepage, bearing strength, and rebound problems. Treatment of weak zones: Grouting, anchoring and rock bolting. Reservoir area investigations, leakage control, and sedimentation issues. Problems associated with earth dams and embankments.	11
Unit 4	**Tunnels, Bridges, and Slope Stability** Geotechnical investigations for tunnel construction: Site selection, geological considerations, groundwater influence, and rock stress conditions. Tunnel excavation methods and support systems. Role of geological discontinuities in tunnel and bridge alignment. Landslide hazard zonation and slope stability analysis. Engineering solutions for slope stability problems using GIS and remote sensing.	10

Practical	Computation of reservoir area, catchment area, reservoir capacity, and reservoir life. Analysis of geological cross-sections for infrastructure projects. Computation of index properties of soils. Determination of RQD, RMR, and Q-values. Shear strength analysis of rocks and soils. Determination of strength of rock mass by GSI (Geological Strength Index) method and uniaxial compressive strength of rocks. GIS-based analysis of slope stability and landslide hazard zonation. Numerical and graphical analysis of geotechnical stability problems (Markland's Test)	30
	Total	**75**

Text Books:

1) Bell, F.G. (2007). Engineering Geology. Elsevier.
2) Krynine, D.P., & Judd, W.R. (2005). Principles of Engineering Geology and Geotechnics. CBS Publishers.

Reference Books:

1) Hobbs, W.R., & Waltham, T. (2002). Foundations of Engineering Geology. Routledge.
2) West, T.R. (2004). Geology Applied to Engineering. Waveland Press.
3) Das, B.M. (2011). Principles of Geotechnical Engineering. Cengage Learning.
4) Goodman, R.E. (1993). Engineering Geology: Rock in Engineering Construction. John Wiley & Sons.

Course Level: 500	ECONOMIC GEOLOGY L-T-P-C: 3-0-1-4 Credits: 4 Scheme of Evaluation: (T + P)	Course Code: GEOL164C342

Course Objective: To provide a comprehensive understanding of the genesis, classification, and economic significance of ore deposits, along with modern mineral exploration techniques and sustainable resource management.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Recall the fundamental concepts of ore genesis, classification, and economic significance of mineral deposits using basic scientific principles.	**BT 1**
CO 2	Understand the fundamental processes of ore formation and classification of ore deposits.	**BT 2**
CO 3	Apply geophysical, geochemical, and remote sensing techniques for mineral exploration.	**BT 3**
CO 4	Analyse the structural and geochemical controls governing ore deposition.	**BT 4**
CO 5	Evaluate the distribution, mineralogy, and genesis of major mineral resources in India, including those in North-East India.	**BT 5**

Modules	Topics and Course Content	Hours
Unit 1	**Fundamentals of Ore Genesis and Ore Deposits** Morphology, textural and structural features of ore bodies. Classification of ore deposits: Genetic and descriptive classification. Ore-forming processes: Magmatic, hydrothermal, sedimentary, metamorphic, contact metasomatic, pegmatitic, oxidation and supergene enrichment. SEDEX and VMS deposits, Placer deposits, Laterites. Role of tectonics in ore deposit formation: Metallogeny and crustal evolution. Metallogeny of Archaean greenstone belts and Proterozoic mobile belts.	12
Unit 2	**Structural and Chemical Controls on Ore Formation** Structural controls: Faults, folds, shear zones, unconformities, intrusions. Chemical controls: pH, redox potential, ligand complexing in ore formation. Geochemistry of ore-forming fluids: Stable and radiogenic isotopes in mineral exploration. Application of fluid inclusion studies in ore genesis.	12
Unit 3	**Mineral Resources of India** Distribution, mode of occurrence, mineralogy, and genesis of major mineral deposits in India: • **Critical Minerals**: Nickel, titanium, vanadium, tungsten, chromium, PGE, copper, graphite, manganese, molybdenum, lithium, and REE. • **Strategic Minerals**: Sulphur, lead, petroleum, zinc, mercury, platinum, nickel, graphite, tin, ferro-tungsten. • **Essential Minerals**: Iron ore, manganese, chromite, copper, gold, bauxite, coal, limestone, mica, gypsum, natural gas, thorium, uranium. Introduction to industrial minerals and their economic importance. Gemstones: Occurrence, economic value, and processing techniques.	11
Unit 4	**Applied Economic Geology** Strategic importance of minerals and resource security. Environmental and social impact of mineral extraction and mining sustainability. Role of GIS in mineral resource mapping and exploration. Economic minerals of **North-East India**: Critical, strategic, and essential minerals, with emphasis on petroleum, coal, bauxite, limestone, REE, and uranium.	10

Practical	Study of common textures and structures in ore hand-specimens. Identification of industrial minerals for cement, steel, refractory, glass, and ceramic industries. Optical and ore microscopy studies: Identification of opaque minerals (galena, sphalerite, pyrite, pyrrhotite, chalcopyrite, arsenopyrite, magnetite, haematite, ilmenite, goethite, chromite, cassiterite, covellite, cobaltite, niccolite). Fluid inclusion study of selected ore samples. Interpretation of geochemical data for mineral exploration. GIS-based mineral resource mapping exercises.	30
	Total	**75**

Text Books:

1) Evans, A. M. (1993) – Ore Geology and Industrial Minerals, Blackwell Science.
2) Mookherjee, A. (2000) – Ore Genesis: A Holistic Approach, Allied Publishers.

Reference Books:

1) Guilbert, J. M., & Park, C. F. Jr. (1986) – The Geology of Ore Deposits, Freeman.
2) Dutta, S. (2014) – Economic Geology: Economic Mineral Deposits, CBS Publishers.
3) Craig, J. R., Vaughan, D. J., & Skinner, B. J. (2011) – Resources of the Earth: Origin, Use, and Environmental Impact, Pearson.
4) Robb, L. J. (2005) – Introduction to Ore-Forming Processes, Wiley-Blackwell.
5) Deb, M. & Goodfellow, W. D. (2004) – Sediment-Hosted Lead-Zinc Sulphide Deposits: Attributes and Models of Some Major Deposits in India and Canada, Elsevier.
6) Geological Survey of India (GSI) Publications – Reports on Mineral Deposits in India.

Course Level: 500	FUEL GEOLOGY L-T-P-C: 3-0-1-4 Credits: 4 Scheme of Evaluation: (T + P)	Course Code: GEOL164C343

Course Objective: To provide students with a comprehensive understanding of the origin, classification, exploration, and economic significance of coal, petroleum, and natural gas, with a focus on their geological characteristics, distribution, and environmental considerations.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Recall and define the fundamental concepts related to the origin, classification, and properties of coal and petroleum.	**BT 1**
CO 2	Understand the processes of coalification, petroleum formation, migration, accumulation, and trapping mechanisms.	**BT 2**
CO 3	Apply coal and petroleum classification systems, analytical techniques, and petrographic methods to assess fuel resources.	**BT 3**
CO 4	Analyse geological, geochemical, and structural factors influencing the occurrence and distribution of coal and petroleum reserves.	**BT 4**
CO 5	Evaluate the economic significance, industrial applications, and environmental impact of fossil fuel exploration and extraction.	**BT 5**

Modules	Topics and Course Content	Hours
Unit 1	**Origin and Formation of Coal** Coal forming processes. Climatic, paleogeographic, and tectonic conditions for peat swamp development. Sedimentation of coal-bearing sequences and geological features of coal seams. Diagenesis of peat, coalification processes, and changes in coal properties. Causes of coalification and classification of coal ranks.	12
Unit 2	**Coal Analysis, Petrography, and Indian Coal Deposits** Coal sampling and analysis: proximate and ultimate analysis. Physical and chemical properties of coal, trace elements, and environmental concerns. Coal petrography: macroscopic and microscopic properties, maceral classification, microlithotypes. Classification and industrial applications of coal. Geological and geographical distribution of Indian coal deposits, with a focus on NE India.	12
Unit 3	**Origin and Characteristics of Petroleum** Basic components of petroleum and its physical properties. Theories of petroleum origin: organic and inorganic theories. Source rock definition, types, and transformation processes (diagenesis, catagenesis, metagenesis). Characteristics of source rocks, reservoir rocks, and cap rocks. Types of reservoir rocks: clastic, carbonate, fractured, marine, and non-marine reservoirs.	11
Unit 4	**Hydrocarbon Migration, Accumulation, and Indian Oil and Gas Fields** Hydrocarbon migration: primary and secondary migration mechanisms. Classification of hydrocarbon traps: structural, stratigraphic, and combination types. Classification of petroliferous basins of India. Major oil and gas fields of India: Assam, Arunachal Pradesh, Nagaland, Tripura, Mizoram, Cambay Basin, Bombay Offshore, Krishna-Godavari Basin. Environmental impact of hydrocarbon exploration and extraction.	10

Practical	Identification of different types of coal in hand specimens. Study of coal lithotypes and petrography under a microscope (polished block study). Proximate analysis of coal: determination of moisture, ash, and volatile matter. Interpretation of structure contour maps and isopach maps. Reserve estimation and calculation for coal and petroleum deposits.	30
	Total	**75**

Text Books:

1) Thomas, L. (2020). Coal Geology (3rd Edition). Wiley-Blackwell.
2) Tissot, B. P., & Welte, D. H. (1984). Petroleum Formation and Occurrence. Springer.

Reference Books:

1) Singh, R. M. (1997). Coal and Organic Petrology. Hindustan Publishing Corporation.
2) Stach, E., Taylor, G. H., Mackowsky, M. T., Teichmüller, M., & Chandra, D. (1982). Stach's Textbook of Coal Petrology. Gebrüder Borntraeger.
3) Diessel, C. F. K. (1992). Coal-bearing Depositional Systems. Springer.
4) North, F. K. (1985). Petroleum Geology. Allen & Unwin.
5) Doust, H., & Chapman, M. (2018). Hydrocarbon Exploration & Production. Elsevier.
6) Allen, P. A., & Allen, J. R. (2013). Basin Analysis: Principles and Application to Petroleum Play Assessment. Wiley-Blackwell.

Course Level: 500	EXPLORATION GEOLOGY L-T-P-C: 3-1-0-4 Credits: 4 Scheme of Evaluation: (T)	Course Code: GEOL164C304

Course Objective: To provide a comprehensive understanding of geological, geochemical, geophysical, and remote sensing methods used in mineral and hydrocarbon exploration, while integrating modern techniques, sustainability, and planning stages relevant to contemporary exploration programmes.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Identify and recall fundamental concepts, terminologies, and techniques used in geological, geophysical, and geochemical exploration.	**BT 1**
CO 2	Explain the principles behind different exploration methods and interpret the role of rock properties and surface features in resource identification.	**BT 2**
CO 3	Demonstrate the application of various exploration tools such as geochemical pathfinders, geophysical instruments, and remote sensing data in field or simulated exploration tasks.	**BT 3**
CO 4	Critically analyse subsurface data (e.g., seismic, resistivity, logging) to delineate potential mineral or hydrocarbon-bearing zones.	**BT 4**
CO 5	Assess the effectiveness and limitations of exploration techniques in different geological terrains and evaluate exploration data for feasibility reporting.	**BT 5**

Modules	Topics and Course Content	Hours
Unit 1	**Fundamentals and Planning of Exploration** Scope and importance of exploration geology in mineral and hydrocarbon industries Physical properties of rocks: density, magnetic susceptibility, resistivity, elastic wave velocities Factors influencing rock properties and their relevance to exploration Exploration planning stages: reconnaissance, detailed investigation, feasibility studies Environmental and sustainability concerns during exploration activities	15
Unit 2	**Geological, Geochemical, and Geobotanical Methods** Geological mapping and litho-structural interpretation in exploration Geochemical exploration: surface and subsurface sampling methods, pathfinder elements, data interpretation Geobotanical prospecting: principles, indicator plant species, and practical applications Introduction to geostatistics: sampling strategies, resource/reserve estimation basics	15
Unit 3	**Geophysical Exploration Techniques** Seismic methods: principles of reflection and refraction, seismic tomography Gravity and magnetic methods: instrumentation, survey techniques, data interpretation Electrical methods: resistivity surveys, induced polarisation (IP), self-potential (SP) Remote Sensing & GIS in mineral exploration: multispectral/hyperspectral imaging, spectral analysis for mineral targeting, integration with GIS	15
Unit 4	**Drilling, Logging, and Subsurface Investigations** Drilling techniques: core drilling, rotary drilling, directional drilling – applications and limitations Well logging techniques: SP, GR, resistivity, neutron, density, and sonic logs – interpretation and applications Role of well-site geologists in exploration drilling Surface and subsurface methods of mineral prospecting	15
	Total	**60**

Text Books:

1) Moon, C.J., Whateley, M.K.G., & Evans, A.M. (2006) - Introduction to Mineral Exploration (Wiley).
2) Robb, L. (2005) - Introduction to Ore-Forming Processes (Wiley-Blackwell).

Reference Books:

1) Dobrin, M.B. & Savit, C.H. (1988) - Introduction to Geophysical Prospecting (McGraw-Hill).
2) Telford, W.M., Geldart, L.P., & Sheriff, R.E. (1990) - Applied Geophysics (Cambridge University Press).
3) Kearey, P., Brooks, M., & Hill, I. (2002) - An Introduction to Geophysical Exploration (Wiley).
4) Craig, J.R., Vaughan, D.J., & Skinner, B.J. (2011) - Resources of the Earth: Origin, Use, and Environmental Impact (Pearson).
5) Gates, A.E. (2003) - Mining and Its Impact on the Environment (Taylor & Francis).

Course Level: 500	MINING GEOLOGY L-T-P-C: 3-1-0-4 Credits: 4 Scheme of Evaluation: (T)	Course Code: GEOL164C305

Course Objective: This course aims to equip students with comprehensive knowledge and practical understanding of the principles, methods, and applications of mining geology, including ore exploration, sampling, reserve estimation, mining techniques, and environmental and legal considerations associated with mining operations.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Recall and define fundamental concepts and terminologies related to mining geology, including mining methods, ore sampling, and reserve estimation.	**BT 1**
CO 2	Explain the processes of ore exploration, evaluation, and different mining techniques along with their geological implications.	**BT 2**
CO 3	Apply geological knowledge to identify suitable mining methods and perform basic calculations related to ore reserve estimation.	**BT 3**
CO 4	Analyse geological, structural, and economic factors that influence the selection of mining sites and techniques.	**BT 4**
CO 5	Evaluate the feasibility, efficiency, and environmental implications of various mining operations and plans.	**BT 5**

Modules	Topics and Course Content	Hours
Unit 1	**Basic Concepts in Mining Geology** Scope of mining geology: Role of a geologist in mining industry. Life cycle of a mining project: Exploration, feasibility, development, production, and closure. Classification of mineral deposits based on mining methods. Geological, economic, and technological factors influencing mine-development. Drilling techniques: Core and non-core drilling, planning of drilling programmes.	15
Unit 2	**Sampling and Ore Reserve Estimation** Principles and methods of sampling: Channel, chip, grab, bulk sampling. Sampling techniques for different types of deposits (vein, bedded, disseminated, etc.). Calculation of ore reserves: Tonnage factor, cut-off grade, classification of reserves. Methods of reserve estimation: Cross-sectional, longitudinal, triangular, polygonal, and geostatistical methods (basic concepts).	15
Unit 3	**Mining Methods and Geological Considerations** Overview of mining methods: Surface (open-cast, strip mining, placer mining) and underground (room and pillar, longwall mining, cut and fill, block caving). Quarrying operations & rock blasting techniques. Geological factors influencing selection of mining methods. Rock mechanics in mining: Stability of rock slopes and underground openings. Geotechnical investigations for mine-planning.	15
Unit 4	**Mineral Beneficiation, Mineral Economics and Sustainable Mining** Introduction to mineral beneficiation: Comminution, concentration, dewatering. Environmental impact of mining and mitigation measures: Acid mine drainage, land degradation, rehabilitation practices, Waste disposal and tailing management. Mine reclamation, sustainable mineral development. Overview of Indian mining legislation: Mines and Minerals (Development and Regulation) Act, 1957 and amendments. National Mineral Policy. Concept of mineral economics: resource classification, mineral pricing, impact of market trends on exploration.	15
	Total	**60**

Text Books:

1) Arogyaswamy, R.N.P. (1996). Courses in Mining Geology. Oxford & IBH.
2) Marjoribanks, R. (2010). Geological Methods in Mineral Exploration and Mining. Springer.

Reference Books:

1) Evans, A.M. (1993). Ore Geology and Industrial Minerals. Blackwell.
2) Bell, F.G. (1992). Environmental Geology: Principles and Practice. Blackwell.
3) Indian Bureau of Mines publications and reports.

Detailed Syllabus
Two-Year M.Sc. Programme
Semester 4

Course Level: Research	DISSERTATION L-T-P-C: 0-0-0-20 Credits: 20 Scheme of Evaluation: (P)	Course Code: GEOL164C421

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
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.

Detailed Syllabus
One-Year M.Sc. Programme
Semester 1

Course Level: 500	ENGINEERING GEOLOGY L-T-P-C: 3-0-1-4 Credits: 4 Scheme of Evaluation: (T + P)	Course Code: GEOL164C341

Course Objective: To equip students with the principles of engineering geology and geotechnical investigation, focusing on soil and rock mechanics, slope stability, and the geological considerations essential for infrastructure development.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Recall fundamental concepts of soil mechanics, rock properties, and geological factors influencing engineering projects.	**BT 1**
CO 2	Understand the fundamental concepts of soil and rock mechanics and their applications in geotechnical engineering.	**BT 2**
CO 3	Apply geological principles in site selection, foundation analysis, and stability assessment of dams, tunnels, and slopes.	**BT 3**
CO 4	Analyse the impact of geological structures and material properties on infrastructure stability and hazard mitigation.	**BT 4**
CO 5	Evaluate engineering problems related to slope stability, tunnel construction, and dam safety using geotechnical investigation methods and GIS-based tools.	**BT 5**

Modules	Topics and Course Content	Hours
Unit 1	**Fundamentals of Soil and Rock Mechanics** Soil: Engineering properties, unit weight, specific gravity, porosity, void ratio, water content, and degree of saturation. Compressibility, consolidation, compaction, and shear strength of soils. Clay mineralogy and its significance in soil behaviour, Atterberg limits, and soil classification. Engineering properties of rocks: Strength, hardness, elasticity, porosity, and specific gravity. Rock masses: Discontinuities, weathering, and deformation. Engineering classification of rocks and rock masses (RQD, Bieniawski's RMR, Q-system).	12
Unit 2	**Ground Improvement Techniques** Rock mass improvement techniques: Grouting, bolting, anchoring, and shotcreting. Quarrying and rock blasting techniques. Use of rocks as construction materials. Geotechnical properties of aggregates used in construction.	12
Unit 3	**Dams and Reservoirs** Types of engineering geological investigations: Preliminary and Detailed Types and classification of dams. Geological and geophysical investigations for dam foundations and abutments. Foundation and abutment problems: Seepage, bearing strength, and rebound problems. Treatment of weak zones: Grouting, anchoring and rock bolting. Reservoir area investigations, leakage control, and sedimentation issues. Problems associated with earth dams and embankments.	11
Unit 4	**Tunnels, Bridges, and Slope Stability** Geotechnical investigations for tunnel construction: Site selection, geological considerations, groundwater influence, and rock stress conditions. Tunnel excavation methods and support systems. Role of geological discontinuities in tunnel and bridge alignment. Landslide hazard zonation and slope stability analysis. Engineering solutions for slope stability problems using GIS and remote sensing.	10

Practical	Computation of reservoir area, catchment area, reservoir capacity, and reservoir life. Analysis of geological cross-sections for infrastructure projects. Computation of index properties of soils. Determination of RQD, RMR, and Q-values. Shear strength analysis of rocks and soils. Determination of strength of rock mass by GSI (Geological Strength Index) method and uniaxial compressive strength of rocks. GIS-based analysis of slope stability and landslide hazard zonation. Numerical and graphical analysis of geotechnical stability problems (Markland's Test)	30
	Total	**75**

Text Books:

3) Bell, F.G. (2007). Engineering Geology. Elsevier.
4) Krynine, D.P., & Judd, W.R. (2005). Principles of Engineering Geology and Geotechnics. CBS Publishers.

Reference Books:

5) Hobbs, W.R., & Waltham, T. (2002). Foundations of Engineering Geology. Routledge.
6) West, T.R. (2004). Geology Applied to Engineering. Waveland Press.
7) Das, B.M. (2011). Principles of Geotechnical Engineering. Cengage Learning.
8) Goodman, R.E. (1993). Engineering Geology: Rock in Engineering Construction. John Wiley & Sons.

Course Level: 500	ECONOMIC GEOLOGY L-T-P-C: 3-0-1-4 Credits: 4 Scheme of Evaluation: (T + P)	Course Code: GEOL164C342

Course Objective: To provide a comprehensive understanding of the genesis, classification, and economic significance of ore deposits, along with modern mineral exploration techniques and sustainable resource management.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Recall the fundamental concepts of ore genesis, classification, and economic significance of mineral deposits using basic scientific principles.	**BT 1**
CO 2	Understand the fundamental processes of ore formation and classification of ore deposits.	**BT 2**
CO 3	Apply geophysical, geochemical, and remote sensing techniques for mineral exploration.	**BT 3**
CO 4	Analyse the structural and geochemical controls governing ore deposition.	**BT 4**
CO 5	Evaluate the distribution, mineralogy, and genesis of major mineral resources in India, including those in North-East India.	**BT 5**

Modules	Topics and Course Content	Hours
Unit 1	**Fundamentals of Ore Genesis and Ore Deposits** Morphology, textural and structural features of ore bodies. Classification of ore deposits: Genetic and descriptive classification. Ore-forming processes: Magmatic, hydrothermal, sedimentary, metamorphic, contact metasomatic, pegmatitic, oxidation and supergene enrichment. SEDEX and VMS deposits, Placer deposits, Laterites. Role of tectonics in ore deposit formation: Metallogeny and crustal evolution. Metallogeny of Archaean greenstone belts and Proterozoic mobile belts.	12
Unit 2	**Structural and Chemical Controls on Ore Formation** Structural controls: Faults, folds, shear zones, unconformities, intrusions. Chemical controls: pH, redox potential, ligand complexing in ore formation. Geochemistry of ore-forming fluids: Stable and radiogenic isotopes in mineral exploration. Application of fluid inclusion studies in ore genesis.	12
Unit 3	**Mineral Resources of India** Distribution, mode of occurrence, mineralogy, and genesis of major mineral deposits in India: • **Critical Minerals**: Nickel, titanium, vanadium, tungsten, chromium, PGE, copper, graphite, manganese, molybdenum, lithium, and REE. • **Strategic Minerals**: Sulphur, lead, petroleum, zinc, mercury, platinum, nickel, graphite, tin, ferro-tungsten. • **Essential Minerals**: Iron ore, manganese, chromite, copper, gold, bauxite, coal, limestone, mica, gypsum, natural gas, thorium, uranium. Introduction to industrial minerals and their economic importance. Gemstones: Occurrence, economic value, and processing techniques.	11
Unit 4	**Applied Economic Geology** Strategic importance of minerals and resource security. Environmental and social impact of mineral extraction and mining sustainability. Role of GIS in mineral resource mapping and exploration. Economic minerals of **North-East India**: Critical, strategic, and essential minerals, with emphasis on petroleum, coal, bauxite, limestone, REE, and uranium.	10

Practical	Study of common textures and structures in ore hand-specimens. Identification of industrial minerals for cement, steel, refractory, glass, and ceramic industries. Optical and ore microscopy studies: Identification of opaque minerals (galena, sphalerite, pyrite, pyrrhotite, chalcopyrite, arsenopyrite, magnetite, haematite, ilmenite, goethite, chromite, cassiterite, covellite, cobaltite, niccolite). Fluid inclusion study of selected ore samples. Interpretation of geochemical data for mineral exploration. GIS-based mineral resource mapping exercises.	30
	Total	**75**

Text Books:

3) Evans, A. M. (1993) – Ore Geology and Industrial Minerals, Blackwell Science.
4) Mookherjee, A. (2000) – Ore Genesis: A Holistic Approach, Allied Publishers.

Reference Books:

7) Guilbert, J. M., & Park, C. F. Jr. (1986) – The Geology of Ore Deposits, Freeman.
8) Dutta, S. (2014) – Economic Geology: Economic Mineral Deposits, CBS Publishers.
9) Craig, J. R., Vaughan, D. J., & Skinner, B. J. (2011) – Resources of the Earth: Origin, Use, and Environmental Impact, Pearson.
10) Robb, L. J. (2005) – Introduction to Ore-Forming Processes, Wiley-Blackwell.
11) Deb, M. & Goodfellow, W. D. (2004) – Sediment-Hosted Lead-Zinc Sulphide Deposits: Attributes and Models of Some Major Deposits in India and Canada, Elsevier.
12) Geological Survey of India (GSI) Publications – Reports on Mineral Deposits in India.

Course Level: 500	FUEL GEOLOGY L-T-P-C: 3-0-1-4 Credits: 4 Scheme of Evaluation: (T + P)	Course Code: GEOL164C343

Course Objective: To provide students with a comprehensive understanding of the origin, classification, exploration, and economic significance of coal, petroleum, and natural gas, with a focus on their geological characteristics, distribution, and environmental considerations.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Recall and define the fundamental concepts related to the origin, classification, and properties of coal and petroleum.	**BT 1**
CO 2	Understand the processes of coalification, petroleum formation, migration, accumulation, and trapping mechanisms.	**BT 2**
CO 3	Apply coal and petroleum classification systems, analytical techniques, and petrographic methods to assess fuel resources.	**BT 3**
CO 4	Analyse geological, geochemical, and structural factors influencing the occurrence and distribution of coal and petroleum reserves.	**BT 4**
CO 5	Evaluate the economic significance, industrial applications, and environmental impact of fossil fuel exploration and extraction.	**BT 5**

Modules	Topics and Course Content	Hours
Unit 1	**Origin and Formation of Coal** Coal forming processes. Climatic, paleogeographic, and tectonic conditions for peat swamp development. Sedimentation of coal-bearing sequences and geological features of coal seams. Diagenesis of peat, coalification processes, and changes in coal properties. Causes of coalification and classification of coal ranks.	12
Unit 2	**Coal Analysis, Petrography, and Indian Coal Deposits** Coal sampling and analysis: proximate and ultimate analysis. Physical and chemical properties of coal, trace elements, and environmental concerns. Coal petrography: macroscopic and microscopic properties, maceral classification, microlithotypes. Classification and industrial applications of coal. Geological and geographical distribution of Indian coal deposits, with a focus on NE India.	12
Unit 3	**Origin and Characteristics of Petroleum** Basic components of petroleum and its physical properties. Theories of petroleum origin: organic and inorganic theories. Source rock definition, types, and transformation processes (diagenesis, catagenesis, metagenesis). Characteristics of source rocks, reservoir rocks, and cap rocks. Types of reservoir rocks: clastic, carbonate, fractured, marine, and non-marine reservoirs.	11
Unit 4	**Hydrocarbon Migration, Accumulation, and Indian Oil and Gas Fields** Hydrocarbon migration: primary and secondary migration mechanisms. Classification of hydrocarbon traps: structural, stratigraphic, and combination types. Classification of petroliferous basins of India. Major oil and gas fields of India: Assam, Arunachal Pradesh, Nagaland, Tripura, Mizoram, Cambay Basin, Bombay Offshore, Krishna-Godavari Basin. Environmental impact of hydrocarbon exploration and extraction.	10

Practical	Identification of different types of coal in hand specimens. Study of coal lithotypes and petrography under a microscope (polished block study). Proximate analysis of coal: determination of moisture, ash, and volatile matter. Interpretation of structure contour maps and isopach maps. Reserve estimation and calculation for coal and petroleum deposits.	30
	Total	**75**

Text Books:

3) Thomas, L. (2020). Coal Geology (3rd Edition). Wiley-Blackwell.
4) Tissot, B. P., & Welte, D. H. (1984). Petroleum Formation and Occurrence. Springer.

Reference Books:

7) Singh, R. M. (1997). Coal and Organic Petrology. Hindustan Publishing Corporation.
8) Stach, E., Taylor, G. H., Mackowsky, M. T., Teichmüller, M., & Chandra, D. (1982). Stach's Textbook of Coal Petrology. Gebrüder Borntraeger.
9) Diessel, C. F. K. (1992). Coal-bearing Depositional Systems. Springer.
10) North, F. K. (1985). Petroleum Geology. Allen & Unwin.
11) Doust, H., & Chapman, M. (2018). Hydrocarbon Exploration & Production. Elsevier.
12) Allen, P. A., & Allen, J. R. (2013). Basin Analysis: Principles and Application to Petroleum Play Assessment. Wiley-Blackwell.

Course Level: 500	EXPLORATION GEOLOGY L-T-P-C: 3-1-0-4 Credits: 4 Scheme of Evaluation: (T)	Course Code: GEOL164C304

Course Objective: To provide a comprehensive understanding of geological, geochemical, geophysical, and remote sensing methods used in mineral and hydrocarbon exploration, while integrating modern techniques, sustainability, and planning stages relevant to contemporary exploration programmes.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Identify and recall fundamental concepts, terminologies, and techniques used in geological, geophysical, and geochemical exploration.	**BT 1**
CO 2	Explain the principles behind different exploration methods and interpret the role of rock properties and surface features in resource identification.	**BT 2**
CO 3	Demonstrate the application of various exploration tools such as geochemical pathfinders, geophysical instruments, and remote sensing data in field or simulated exploration tasks.	**BT 3**
CO 4	Critically analyse subsurface data (e.g., seismic, resistivity, logging) to delineate potential mineral or hydrocarbon-bearing zones.	**BT 4**
CO 5	Assess the effectiveness and limitations of exploration techniques in different geological terrains and evaluate exploration data for feasibility reporting.	**BT 5**

Modules	Topics and Course Content	Hours
Unit 1	**Fundamentals and Planning of Exploration** Scope and importance of exploration geology in mineral and hydrocarbon industries Physical properties of rocks: density, magnetic susceptibility, resistivity, elastic wave velocities Factors influencing rock properties and their relevance to exploration Exploration planning stages: reconnaissance, detailed investigation, feasibility studies Environmental and sustainability concerns during exploration activities	15
Unit 2	**Geological, Geochemical, and Geobotanical Methods** Geological mapping and litho-structural interpretation in exploration Geochemical exploration: surface and subsurface sampling methods, pathfinder elements, data interpretation Geobotanical prospecting: principles, indicator plant species, and practical applications Introduction to geostatistics: sampling strategies, resource/reserve estimation basics	15
Unit 3	**Geophysical Exploration Techniques** Seismic methods: principles of reflection and refraction, seismic tomography Gravity and magnetic methods: instrumentation, survey techniques, data interpretation Electrical methods: resistivity surveys, induced polarisation (IP), self-potential (SP) Remote Sensing & GIS in mineral exploration: multispectral/hyperspectral imaging, spectral analysis for mineral targeting, integration with GIS	15
Unit 4	**Drilling, Logging, and Subsurface Investigations** Drilling techniques: core drilling, rotary drilling, directional drilling – applications and limitations Well logging techniques: SP, GR, resistivity, neutron, density, and sonic logs – interpretation and applications Role of well-site geologists in exploration drilling Surface and subsurface methods of mineral prospecting	15
	Total	**60**

Text Books:

3) Moon, C.J., Whateley, M.K.G., & Evans, A.M. (2006) - Introduction to Mineral Exploration (Wiley).
4) Robb, L. (2005) - Introduction to Ore-Forming Processes (Wiley-Blackwell).

Reference Books:

6) Dobrin, M.B. & Savit, C.H. (1988) - Introduction to Geophysical Prospecting (McGraw-Hill).
7) Telford, W.M., Geldart, L.P., & Sheriff, R.E. (1990) - Applied Geophysics (Cambridge University Press).
8) Kearey, P., Brooks, M., & Hill, I. (2002) - An Introduction to Geophysical Exploration (Wiley).
9) Craig, J.R., Vaughan, D.J., & Skinner, B.J. (2011) - Resources of the Earth: Origin, Use, and Environmental Impact (Pearson).
10) Gates, A.E. (2003) - Mining and Its Impact on the Environment (Taylor & Francis).

Course Level: 500	MINING GEOLOGY L-T-P-C: 3-1-0-4 Credits: 4 Scheme of Evaluation: (T)	Course Code: GEOL164C305

Course Objective: This course aims to equip students with comprehensive knowledge and practical understanding of the principles, methods, and applications of mining geology, including ore exploration, sampling, reserve estimation, mining techniques, and environmental and legal considerations associated with mining operations.

Course Outcomes	Description	Bloom's Taxonomy
CO 1	Recall and define fundamental concepts and terminologies related to mining geology, including mining methods, ore sampling, and reserve estimation.	**BT 1**
CO 2	Explain the processes of ore exploration, evaluation, and different mining techniques along with their geological implications.	**BT 2**
CO 3	Apply geological knowledge to identify suitable mining methods and perform basic calculations related to ore reserve estimation.	**BT 3**
CO 4	Analyse geological, structural, and economic factors that influence the selection of mining sites and techniques.	**BT 4**
CO 5	Evaluate the feasibility, efficiency, and environmental implications of various mining operations and plans.	**BT 5**

Modules	Topics and Course Content	Hours
Unit 1	**Basic Concepts in Mining Geology** Scope of mining geology: Role of a geologist in mining industry. Life cycle of a mining project: Exploration, feasibility, development, production, and closure. Classification of mineral deposits based on mining methods. Geological, economic, and technological factors influencing mine-development. Drilling techniques: Core and non-core drilling, planning of drilling programmes.	15
Unit 2	**Sampling and Ore Reserve Estimation** Principles and methods of sampling: Channel, chip, grab, bulk sampling. Sampling techniques for different types of deposits (vein, bedded, disseminated, etc.). Calculation of ore reserves: Tonnage factor, cut-off grade, classification of reserves. Methods of reserve estimation: Cross-sectional, longitudinal, triangular, polygonal, and geostatistical methods (basic concepts).	15
Unit 3	**Mining Methods and Geological Considerations** Overview of mining methods: Surface (open-cast, strip mining, placer mining) and underground (room and pillar, longwall mining, cut and fill, block caving). Quarrying operations & rock blasting techniques. Geological factors influencing selection of mining methods. Rock mechanics in mining: Stability of rock slopes and underground openings. Geotechnical investigations for mine-planning.	15
Unit 4	**Mineral Beneficiation, Mineral Economics and Sustainable Mining** Introduction to mineral beneficiation: Comminution, concentration, dewatering. Environmental impact of mining and mitigation measures: Acid mine drainage, land degradation, rehabilitation practices, Waste disposal and tailing management. Mine reclamation, sustainable mineral development. Overview of Indian mining legislation: Mines and Minerals (Development and Regulation) Act, 1957 and amendments. National Mineral Policy. Concept of mineral economics: resource classification, mineral pricing, impact of market trends on exploration.	15
	Total	**60**

Text Books:

3) Arogyaswamy, R.N.P. (1996). Courses in Mining Geology. Oxford & IBH.
4) Marjoribanks, R. (2010). Geological Methods in Mineral Exploration and Mining. Springer.

Reference Books:

4) Evans, A.M. (1993). Ore Geology and Industrial Minerals. Blackwell.
5) Bell, F.G. (1992). Environmental Geology: Principles and Practice. Blackwell.
6) Indian Bureau of Mines publications and reports.

Detailed Syllabus
One-Year M.Sc. Programme
Semester 2

Course Level: Research	DISSERTATION L-T-P-C: 0-0-0-20 Credits: 20 Scheme of Evaluation: (P)	Course Code: GEOL164C421

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
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:

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