ROYAL GLOBAL UNIVERSITY
GUWAHATI

ROYAL SCHOOL OF ENVIRONMENTAL & EARTH SCIENCES (RSEES)

DEPARTMENT OF GEOLOGY

COURSE STRUCTURE & SYLLABUS

FOR

M.Sc. GEOLOGY

W.E.F. ACADEMIC YEAR 2023-24

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1. Preamble

The role of higher education is very important in securing employment and/or providing further access to higher education comparable to the best available in the world class institutions. The improvement in the quality of higher education, therefore, deserves to be given highest priority to enable the young generation of students to acquire skill, training and knowledge in order to enhance their thinking, comprehension and application abilities and prepare them to compete, succeed and excel globally.

Sustained initiatives are required to reform the present higher education system for improving and upgrading the academic resources and learning environments by raising the quality of teaching and standards of achievements in learning outcomes across all undergraduate programs in science, humanities, commerce and professional streams of higher education.

The Assam Royal Global University is offering and continuously upgrading its postgraduate programmes in accordance with the Learning Outcomes-based Curriculum Framework (LOCF) which makes it student-centric, interactive and outcome-oriented with well-defined aims, objectives and goals to achieve. The LOCF has been formulated for the courses as far as the Qualification Descriptors, Program Outcomes (PO) and the Course Outcomes (CO) are concerned and the course structure and detailed contents of the courses regarding the various components like the class room teaching (theory), laboratory (experiments), tutorials, and industrial / field visits and projects are designed and planned to achieve the stated Learning Objectives (LO).

Outcome based learning is the principal end of pedagogical transactions in higher education in today's world in the light of exponential changes brought about in science and technology, and the prevalent utilitarian world view of the society. Geology as a discipline falls within the special category of science with a multidisciplinary approach.

2. Learning Outcomes-based Approach to Curricular Planning

Outcome based learning is the principal end of pedagogical transactions in higher education in today's world in the light of exponential changes brought about in science and technology, and the prevalent utilitarian world view of the society. Geology as a discipline falls within the special category of science with a multidisciplinary approach.

The basic premise of learning outcomes-based approach to curriculum planning and development is that higher education qualifications such as a Master's Degree programmes are earned and awarded on the basis of the following factors--(a) achievement of outcomes, demonstrated in terms of knowledge, understanding, skills, attitudes and values and (b) academic standards expected out of the graduates of a programme of study.

The expected learning outcomes are used as reference points to formulate graduate attributes, qualification descriptors, programme learning outcomes and course learning outcomes which in turn will help in curriculum planning and development, and in the design, delivery, and review of academic programmes.

In the Solar System amongst the terrestrial planet the Earth is the only living planet which has Lithosphere, oxygenated Atmosphere, Hydrosphere and the Biosphere. There is seamless interaction among these spheres. The Earth has hot interior and this very heat acts as the fuel to run the Earth engine. To understand how our planet works, at depth and at the surface, the ideas and principles of Biology, Chemistry, Physics, Mathematics and Geography are integrated in the exciting and stimulating studies which make up Earth Sciences. It is a fastmoving, diversifying, multidisciplinary field that ranges from understanding the Earths origin in the solar system, the evolution of hydrosphere and atmosphere as well as the earth's materials at the atomic level, through the geological processes that drive volcanoes and earthquakes, surface processes that shape landscapes and create the geological record, biological processes that build diversity and bring extinction, up to planetary-scale systems, such as plate tectonics, climate and the origins of life and ecosystems. The Earth

Science takes you very close to the nature as this is basically a filed Science. The geology program integrates field trips with classroom learning to give you the hands-on experience you need to succeed. These opportunities develop your technical skills using measuring instruments and laboratory equipment.

An outcome-based approach moves away from the emphasis on what is to be taught to what is actually learnt. This approach provides greater flexibility to the teachers to develop and the students to adopt different pedagogical strategies in an interactive and participatory ecosystem. The idea is to integrate social needs and teaching practices in a manner that is responsive to the need of the community. The Assam Royal Global University has addressed this aspect since its inception through the LOCF curricula adopted by the university in 2017. This approach is further consolidated through identifying further relevant and common outcomes beneficial to the student community and by developing such outcomes that not only match the specific needs of the students but also expands their outlook and values. Moreover, this curriculum keeps into perspective the fact that the focus is not just on domain knowledge or outcomes only but on processes and approaches to be employed in pedagogical transactions. This is important in order to ensure the efficacy of the curriculum adopted.

2.1. Nature and extent of PG program in Geology

The PG program in Geology builds on the basic Geosciences taught at the UG level in all the B.Sc. Geology programs in the country. Ideally, the undergraduate education should aim and achieve a sound grounding in understanding the basic concepts in Geosciences with sufficient content of topics from modern Geology and contemporary areas of exciting developments in geosciences to ignite the young minds. The curricula and syllabi are framed and implemented in such a way that the basic connection between theory and experiment and its importance in understanding Geology is apparent to the student. This is very critical in developing a scientific temperament and urge to innovate, create and discover in Geology. Unfortunately, the condition of our undergraduate education system in most parts of the country lacks the facilities to achieve the above goal and it is incumbent upon the university system to fill the gaps in the knowledge creation of our young minds created by the lack of infrastructural and academic resources of our undergraduate education system and strengthen their understanding in all the subjects through the PG programs specially in Geology.

The postgraduate program in Geology is presently being offered though the courses designed for granting M.Sc. Geology. The course is of two-year duration spread over four semesters after the B.Sc. Geology program.

Sl. No.	Semester	Mandatory Credits to be Secured for the Award
1	1st	21
2	2nd	23
3	3rd	30
4	4th	28
Total Credits		**102**

2.2. Aims of PG program in Geology

The aims and objectives of our PG educational program in Geology is structured to:

- Create the facilities and environment in all the educational institutions to introduce and consolidate the knowledge acquired at UG level and to motivate and inspire the students to create deep interest in Geology, to develop broad and balanced knowledge and understanding of geological concepts, principles and theories of stratigraphy, geological mapping, exploration of natural resources and understand Earth evolution.

- Learn, design and perform experiments in the labs to demonstrate the concepts, principles and theories learned in the classrooms.
- Develop the ability to apply the knowledge acquired in the classroom and laboratories to specific problems in theoretical and applied Geology.
- Expose the student to the vast scope of Geosciences as a theoretical and experimental science with applications in solving most of the geogenic problems in nature spanning from disaster management, watershed management, water pollution, oil exploration and mining, etc.
- Emphasize the need for integrating Geosciences as one of the most important branches of science for pursuing the interdisciplinary and multidisciplinary higher education and/or research in interdisciplinary and multidisciplinary areas.
- To emphasize the importance of Geology as the most important discipline for sustaining the existing industries and establishing new ones to create job opportunities at all levels of employment.

3. Graduate Attributes in Geology

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

GA 1: Disciplinary Knowledge:

a) Develop a systematic understanding of both core areas and advanced topics in the study of the Earth, its materials and structure, its history over 4600 million years, and the processes that have controlled its evolution as a planet by viewing Earth from new and challenging perspectives of time, space, process and pattern.
b) Stimulate students to see Geology as a vital component of our culture, where science develops as informed curiosity about the Earth and Society's environment, promoting human development and sustainability through the search for energy sources, raw materials, water supplies, sites for safe waste disposal, and the mitigation of natural hazards.
c) Develop skills in gathering and interpreting the geological and geophysical data used to gain this understanding and thereby equip students with the foundations for their professional careers or additional study.
d) Provide an excellent preparation for a career in professional practice in industrial or environmental Earth Sciences, research in Geosciences, and specialist areas of other physical and natural sciences.

GA 2: Communication Skills:

a) Skills to communicate in written, numerical, graphical and verbal forms, in ways that are appropriate to different audiences and indifferent situations, ranging from scientific and industry reports, to group and individual oral presentations, and from blogs and outreach articles, to news articles and essays.
b) Use group discussions and joint seminar presentations to research and present work collaboratively; and develop oral presentation and participation skills during seminars and group-work, and in written form through online e-learning tools, dissertations and essays.

GA 3: Critical Thinking:

a) Acquire an understanding of the concept in geology and related disciplines and an ability to understand, integrate, and extend it so that all fundamental geological concepts are accessible.
b) Acquire, digest and critically evaluate scholarly arguments, the assumptions behind them, and their theoretical and empirical components.

GA 4: Problem Solving:

a) Skills to recognise and articulate a problem and then apply appropriate conceptual frameworks and methods to solve it.
b) Emphasis is placed on larger, integrated problem-solving exercises, during which students are taught how to process complex data sets using a diverse range of skills and knowledge. This provides the foundation for student-led independent, but academically directed, project work.

GA 5: Analytical Reasoning:

a) Competency in both field and laboratory skills, and in data analysis, interpretation and presentation that permit the successful pursuit of pure or applied problems in geology.

GA 6: Research-Related Skills:

a) Develop a research design, which has an appropriate problem related to earth sciences but may incorporate some scientific methods, ability to plan and write a research paper.
b) Ability to process and interpret large, complex, datasets, to hypothesis set and test, and to function as a numerate, literate scientist able to prove insight and guidance related to real-world problems and issues.

GA 7: Digital Literacy:

a) ability of advanced Word skills and advanced GIS, statistics, databases, spreadsheets, digital drawing through online workbooks and workshops
b) ability to use digital resources for presentations

GA 8: Moral and Ethical Values:

a) The degree to which every student engages with these themes will vary but it is important that all think especially about ethical issues
b) Avoid unethical behaviour such as fabrication, falsification or misrepresentation of data or committing plagiarism, not adhering to intellectual property rights, and adopting objectives, unbiased and truthful actions in all aspects of work.

GA 9: Global Competency:

a) After completing course in Geology, the student is expected to be fully knowledgeable about the subject and not only from the point of view of examination.
b) He/she will be ready to accept challenges and stand in competition at a national and global level.

GA 10: Life-long Learning:

a) ability to blend academic and practical skills
b) ability to transfer such skills to other domains of one's life and work

4. Qualification descriptors for M. Sc. Geology

The qualification descriptors for a M.Sc. Geology Program may include the following. The graduates should be able to:

- Demonstrate a coherent and systematic knowledge and understanding of the field of Geology making intelligible Geoscientific research frontiers and theoretical developments in this field in the global context. This would also include the student's ability to collect, analyse, synthesise, summarise and inter-relate diverse processes and facts, to formulate and test hypotheses and reach conclusions.
- Demonstrate the ability to identify and differentiate rocks, minerals, fossils, other Earth materials and Earth structures in the field, as hand specimens and using laboratory techniques including microscopy and spectroscopic analysis. Skill to observe and record original field and laboratory data and then apply these to evaluate and resolve geological and geotechnical problems.
- Demonstrate skills in areas related to one's specialization area and current developments in the academic field of Geology, including a critical understanding of the latest developments in the area of specialization, and an ability to use modern established techniques of analyses and enquiry within the field of specialization.
- Demonstrate comprehensive knowledge about materials, including current research, scholarly, and/or professional literature, relating to essential and advanced learning areas pertaining to various subfields in Geology, and techniques and skills required for identifying problems and issues in their area of specialization.
- Demonstrate the ability to assemble and analyse incomplete and varied observational data and develop testable hypotheses, predictions or explanations from them. Skills to recognise associations between geological observations and then integrate them into their 3D and 4D (space-time) frameworks.

- Demonstrate the ability to share the results of academic and disciplinary learning through different forms of communication such as essays, dissertations, reports, findings, notes, etc. on different platforms of communication such as the classroom, conferences, seminars, workshops, the media and the internet.
- Address one's own learning needs relating to current and emerging areas of study in Geology, making use of research, development and professional materials as appropriate, including those related to new frontiers of knowledge in science.
- Ability to devise and carry out an independent field-based project, including the formulation and testing of hypotheses whilst in the process of carrying out the project. The integration of field-based, experimental and theoretical principles needed for the Earth Sciences.
- Demonstrate subject-related and transferable skills that are relevant to some of the Geology related jobs and employment opportunities in the public and private sector.

5. Program Outcomes in M.Sc. Geology

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

PO 1: Disciplinary Knowledge of Geology

- Ability to attain extensive and coherent knowledge and understanding of the academic field of Geology as a whole and its applications, and links to related disciplinary areas/subjects of study.

PO 2: Communication Skills

- Communicate the results of studies undertaken in the academic field of Geology accurately in a range of different contexts using the established and emerging concepts, constructs and techniques.

PO 3: Critical Thinking

- Develop skills in creative and critical thinking, analytical methods and integration of knowledge in multiple branches and will be able to formulate a scientific problem and strategies to solve it.

PO 4: Problem Solving

- Demonstrate the ability to use skills in Geology and its related areas of technology for formulating and tackling geosciences-related problems and identifying and applying appropriate geological principles and methodologies to solve a wide range of problems associated with geosciences.

PO 5: Analytical Reasoning

- Apply one's knowledge and understandings relating to Geology and skills to new/unfamiliar contexts and to identify and analyse problems and issues and seek solutions to real-life problems.

PO 6: Research-Related Skills

- Ability to identify research gaps, formulate research questions and ascertain relevant sources to find substantive explanations.

PO 7: Digital Literacy

- Ability to use digital sources for critical reading, data analysis, problem solving and presentations.

PO 8: Values: Moral, Ethical, Literary

- Ability to interrogate one's own ethical values, and to be aware of ethical issues.
- Ability to transfer such skills to other domains of one's life and work.

PO 9: Global Competency

- Demonstrate skills in identifying information needs, collection of relevant quantitative and/or qualitative geostatistical data drawing on a wide range of sources from the field and labs around the world, analyses and interpretation of data using methodologies as appropriate to the subject of Geology in the area of his/her specialization.

PO 10: Life-long Learning

- Graduate will acquire values and attitudes towards understanding complex environmental- economic-social challenges, and participating actively in solving current geological problems.

6. Program Specific Outcomes in M.Sc. Geology

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

PSO 1	**Academic competence:** (i) Study modern and advanced concepts, principles and processes underlying the field of Geology, its different subfields and its linkage with related disciplinary areas/subjects. (ii) Demonstrate an understanding of a wide range of geological processes (e.g., genesis of rocks and formation of geological structures, formation of minerals and their alteration, effects of human activities at meso-microscale.) (iii) Undertake field tour in any part of India with respect to lithology, structure and stratigraphy and produce geological maps.
PSO 2	**Personal and Professional Competence:** (i) Carry out field mapping in any part of India with respect to lithology, structure and stratigraphy and produce geological maps. (ii) Analyse geological data and samples procured during field work. (iii) Formulate ideas, execute scientific writing and authentic reporting, geological maps, effective presentation and communication skills.
PSO 3	**Research Competence:** (i) Apply skills developed towards comprehension of geological conditions to address issues and find solutions in case of ground water, mineral and fossil fuel exploration and geo hazards. (ii) Integrate informatics and statistical skills to explore and authenticate field and laboratory data for experimental and research purpose.
PSO 4	**Entrepreneurial and Social Competence:** (i) Employ Plan and conduct different geological services with demonstration of true values of leadership, cooperation and teamwork. (ii) Demonstrate awareness of ethical issues: Emphasizing on academic and research ethics, scientific misconduct, intellectual property rights and issues of plagiarism.

7. Teaching Learning Process

Teaching and learning in this programme involve a wide spectrum of activities. It includes-

- Lecture classes which are delivered through slideshow as well as video presentations.
- Tutorial classes where a closer interaction between the students and the teacher is present as each student gets individual attention.
- Mentor-Mentee
- Project-based learning (very small projects like 1-day field-based projects, so as to increase their practical skills and knowledge).
- Group discussion, Student presentations, Seminars
- Home assignments, Quizzes and class tests
- Interactive sessions with invited experts from various fields of Geology
- Industrial Tour and/or Field visit

8. Evaluation System

Methods	**Weightage**
Continuous Evaluation	30%
Semester End Examination	70%
Total	**100%**

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

- Class Participation (15%)
- Mid-Term Examination (10%)
- Attendance (5%)

Class Participation (15%): 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. 15% 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 30% to 40% 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 subject. 1-5 marks are given to students having more than 75% attendance. Attendance is awarded to a student as per the following connotation:

Percentage of Attendance (%)	Marks
More than 95%	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
More than 75% and up to 80%	1
Up to 75%	0

M.Sc. Geology

Programme Structure

Sl. No	Subject Code	Names of subjects	L	T	P	C	TCP
1st SEMESTER							
Sl. No	**Subject Code**	**Names of subjects**	**L**	**T**	**P**	**C**	**TCP**
		Core Courses					
1	GEOL164C101	Structural Geology	3	1	0	4	4
2	GEOL164C102	Geochemistry and Isotope Geology	3	1	0	4	4
3	GEOL164C103	Mineralogy and Crystal Chemistry	3	1	0	4	4
4	GEOL164C114	Practical – I	0	0	6	3	6
		Ability Enhancement Compulsory Courses (AECC)					
5	CEN984A101	Communicative English-I	1	0	0	1	1
6	BHS984A103	Behavioural Science-I	1	0	0	1	1
		Discipline Specific Elective (DSE): Any One To Be Selected					
7	GEOL164D141	Geomorphology	3	0	2	4	5
8	GEOL164D142	River Science	3	0	2	4	5
TOTAL CREDITS (C) = 21 AND TOTAL CONTACT PERIODS (TCP) = 24							
2nd SEMESTER							
Sl. No	**Subject Code**	**Names of subjects**	**L**	**T**	**P**	**C**	**TCP**
		Core Courses					
1	GEOL164C201	Igneous Petrology	3	1	0	4	4
2	GEOL164C202	Metamorphic Petrology	3	1	0	4	4
3	GEOL164C203	Stratigraphic Principles & Quaternary Geology	3	1	0	4	4
4	GEOL164C214	Practical – II	0	0	6	3	6
		Ability Enhancement Compulsory Courses (AECC)					
5	CEN984A201	Communicative English-II	1	0	0	1	1
6	BHS984A203	Behavioural Science-II	1	0	0	1	1
		Skill Enhancement Courses (SEC)					
7	GEOL164S211	Geological Mapping and Surveying	0	0	4	2	4
		Discipline Specific Elective (DSE): Any One To Be Selected					
8	GEOL164D241	GIS in Geology	3	0	2	4	5
9	GEOL164D242	Urban Geology	3	0	2	4	4
TOTAL CREDITS (C) = 23 AND TOTAL CONTACT PERIODS (TCP) = 26							
3rd SEMESTER							
Sl. No	**Subject Code**	**Names of subjects**	**L**	**T**	**P**	**C**	**TCP**
		Core Courses					
1	GEOL164C301	Indian Stratigraphy	4	0	0	4	4
2	GEOL164C302	Palaeontology	4	0	0	4	4
3	GEOL164C313	Practical – III	0	0	6	3	6
4	GEOL164C304	Sedimentology	4	0	0	4	4
		Ability Enhancement Compulsory Courses (AECC)					
5	CEN984A301	Communicative English-II	1	0	0	1	1
		Ability Enhancement Elective Courses (Any one)					
6		AEEC / SEC-2*	2	0	0	2	2
		Discipline Specific Elective (DSE): Any Three To Be Selected					
7	GEOL164D301	Earth & Climate	3	1	0	4	4
8	GEOL164D302	Analytical Geology	3	1	0	4	4
9	GEOL164D303	Geostatistics	3	1	0	4	4
10	GEOL164D304	Marine Geology	3	1	0	4	4
TOTAL CREDITS (C) = 30 AND TOTAL CONTACT PERIODS (TCP) = 33							

4th SEMESTER							
Sl. No	**Subject Code**	**Names of subjects**	**L**	**T**	**P**	**C**	**TCP**
		Core Courses					
1	GEOL164C401	Coal and Petroleum Geology	4	0	4	4	4
2	GEOL164C402	Economic Geology	3	0	2	4	5
3	GEOL164C413	Exploration and Mining Geology	4	0	4	4	4
4	GEOL164C424	Major Project	0	0	4	4	4
		Ability Enhancement Compulsory Courses (AECC)					
5	CEN984A401	Communicative English-II	1	0	0	1	1
		Discipline Specific Elective (DSE): Any Three To Be Selected					
6	GEOL164D441	Engineering Geology	3	0	2	4	5
7	GEOL164D402	Environmental Geology	4	0	0	4	4
8	GEOL164D403	Basin Analysis	4	0	0	4	4
9	GEOL164D444	Hydrogeology	3	0	2	4	5
TOTAL CREDITS (C) = 28 AND TOTAL CONTACT PERIODS (TCP) = 31							

Detailed Syllabus Of Semester 1

Paper I Core Course	STRUCTURAL GEOLOGY L-T-P-C: 4-0-0-4 Credit Units: 4 Scheme of Evaluation: (T)	Subject Code: GEOL164C101

Course Objectives: The course is a core component of the M.Sc. Geology program. It delves into the mechanical behaviour of rocks under stress, various types of deformation, and their geological implications. Students will explore rock mechanics, stress and strain analysis, deformation mechanisms, and the formation of structural features like folds, faults, and shear zones. The course covers both brittle and ductile deformation regimes and their significance in understanding Earth's geological history.

Course Outcome: By the end of this course the students will be able to:

1. Recall and explain fundamental principles of rock mechanics and stress and strain analysis in rocks.
2. Demonstrate their comprehension by interpreting geological phenomena, such as folds, faults, and shear zones, and explaining the geological significance of these features.
3. Apply their knowledge by conducting laboratory exercises to measure strain in rocks and by utilizing fieldwork to identify and document structural geological features.
4. Analyse geological structures critically, evaluating their implications for Earth's tectonic history and making informed interpretations based on structural geology principles.
5. Synthesize their knowledge of shear zones, including their geometry, kinematics, and geological importance, to create a comprehensive understanding of tectonic processes.

Detailed Syllabus:

Modules	Topics and Course Content	Hours
Unit 1	**Introduction to rock mechanics** Stress and Strain in rocks. Mohr stress circle; Determination of direction of shearing stress. Principal axes of strain, measurement of strain, Flinn’s diagram, Fry’s methods of strain measurement and other strain markers. Behaviour of rocks under stress: elastic, plastic, brittle, viscous and visco-elastic responses and their geological significance. Coulomb’s criteria of failure. Griffith’s Theory.	15
Unit 2	**Ductile deformation** Morphological classifications of fold following Ramsay (1967) and Fleuty’s classification (1964). Kinematics of folding. Buckle folds and shear folds. Determination of sense of shear from fold geometry; Superposition of folds. Boudinage: origin and its relationship to fold. Different types of planar and linear structures in deformed rocks; Mechanism of cleavage formation; Kinematic significance of foliation and lineation. Importance of cleavage bedding intersection in a folded terrain.	15
Unit 3	**Brittle deformation** Mechanics of faulting: Anderson's theory and its limitations. Complex geometry of normal, strike-slip and thrust faults with natural examples. Concept of fault zone weakening; fault reactivation and its significance. Geometric analyses of joints – Importance of Tectonic, Columnar and Release joints. Mechanical aspect of fracturing and joint formation. Joints with relation to folds and faults.	15
Unit 4	**Brittle ductile regime** Shear zones-geometry and kinematics: Analysis of strain in shear zones; Kinematic significance of different shear zone structures; Shear sense indicators; Flow behaviour of sheared rocks – ductile and brittle-ductile shear zones. Shear zones and their importance in evolution of continental crust. Fault/shear zone rocks: Cataclasite/Gouge/ Breccia, Mylonite, Pseudotachylyte.	15
	Total	**60**

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.

Paper II Core Course	GEOCHEMISTRY AND ISOTOPE GEOLOGY L-T-P-C: 3-1-0-4 Credit Units: 4 Scheme of Evaluation: (T)	Subject Code: GEOL164C102

Course Objectives:
The course explores the principles and applications of geochemistry and isotopic studies in understanding Earth's composition, evolution, and geochronology. Students will delve into the geochemical systems of the Earth, including the crust, mantle, ocean, and atmosphere, and examine the role of isotopes in dating geological events and processes.
Course Outcome: After the completion of course, the students will have ability to:

1. Recall and describe the fundamental principles of geochemical systems, including the composition of the Earth's crust, mantle, ocean, and atmosphere.
2. Demonstrate comprehension by explaining the interactions between Earth's geochemical systems and the concept of geochemical cycles, including biogeochemical cycles.
3. Apply their knowledge by utilizing element partitioning principles and the utility of trace and rare earth elements in petrogenesis to analyse geological scenarios.
4. Analyse radiogenic isotopes and their significance in geochronology, as well as the isotopic evolution of elements in geological contexts.
5. Synthesize their understanding of stable isotope geochemistry and its applications in geological research, including isotopic thermometry.

Detailed Syllabus:

Modules	Topics and Course Content	Hours
Unit 1	Crust and mantle as a geochemical system (composition of the crust, composition of mantle, interaction between crust and mantle). Ocean and atmosphere as a geochemical system (composition of ocean, composition of atmosphere, evolution of sea water and air, the rise of oxygen). Geochemical cycle. Concept of biogeochemical cycle.	15
Unit 2	Element partitioning and concept of distribution coefficient. Utility of trace and rare earth elements in petrogenesis of rocks. Principles and application of analytical instruments in geochemistry and isotope studies. Meteorites- classification, composition and origin. Type and composition of Martian and Lunar meteorites.	15
Unit 3	Stability and abundance of radionuclides, decay mechanism, radioactive decay and growth rate of radiogenic decay, decay series. Radiogenic isotopes: Radiogenic isotopes in geochronology (Rb-Sr, Sm-Nd, K-Ar, U-Th-Pb method of age dating). Extinct radionuclides in geochronological studies. Primordial ^{87}Sr – ^{86}Sr ratios. Isotopic evolution of Sr and Nd in the Earth.	15
Unit 4	Stable isotope geochemistry of carbon, oxygen, hydrogen: controls and their applications to geology; Oxygen isotope thermometry; Distribution of sulphur isotopes in nature and their application. Geochemistry of U and Th in rocks, minerals and sediments.	15
	Total	**60**

Text Books:

1) Geochemistry – W. M. White, (2013), Wiley-Blackwell Publishing.
2) Isotopes: Principles and Applications - Faure, Gunter and Teresa M. Mensing (2004), Wiley India Pvt. Ltd.

Reference Books:

1) Principles of Geochemistry - Mason, B., (3rd Edition, 1986), Wiley New York.
2) Introduction to Geochemistry: Principles and Applications - Kula C. Misra, (2012), Wiley-Blackwell Publishing.
3) Essentials of geochemistry - Walther, J. V. (2009), Jones & Bartlett Publishers.
4) Geochemistry: An Introduction - Albarède, F. (2003), Cambridge University Press.
5) Using Geochemical Data: Evaluation, Presentation, Interpretation - Hugh R. Rollinson (1993), John Wiley and Sons.
6) Levinson, A.A., 1974: Introduction to Exploration Geochemistry. Applied Publishers, Calgary.
7) Guntur Faur,1986(2nd edn.: Principles of Isotope Geology.
8) Claude Allegre, 2008: Isotope Geology.
9) Allan P. Dickin, 1995: Radiogenic Isotope Geology.

Paper III Core Course	MINERALOGY AND CRYSTAL CHEMISTRY L-T-P-C: 4-0-0-4 Credit Units: 4 Scheme of Evaluation: (T)	Subject Code: GEOL164C103

Course Objectives: The course explores the fundamental principles of mineralogy, crystal chemistry, and the structure of minerals. Students will learn about the periodicity and symmetry of crystals, chemical bonding, crystal defects, and the classification of minerals. Additionally, they will study the crystal structures of common rock-forming minerals, including silicates, and examine their properties and identification techniques.

Course Outcome: By the end of this course the students will be able to:

1. Recall and explain the fundamental principles of crystal symmetry, chemical bonding in crystals, and the crystal structures of minerals.
2. Demonstrate comprehension by interpreting the concepts of crystal defects, mineral classification, and structural transformations in minerals.
3. Apply their knowledge by identifying and describing the crystal structures of common rock-forming minerals and evaluating their chemical, physical, and optical properties.
4. Analyse crystallographic principles through X-ray crystallography and differentiate between various mineral groups based on their structural and chemical characteristics.
5. Synthesize their knowledge by applying advanced characterization techniques such as SEM, TEM, and EPMA in mineral analysis and identification.

Detailed Syllabus:

Modules	Topics and Course Content	Hours
Unit 1	Periodicity and symmetry-concept of space lattice. Chemical bonding in Crystal structures: Ionic, covalent and metallic bonding. Ionic radii, coordination number, Pauling's rule. Crystal structure of minerals- Hexagonal close-packing, cubic close-packing and body centred structure. Crystal Defects: Point Defects, Line defects and Planar defects.	15
Unit 2	Chemical classification of minerals; Composition of common rock-forming minerals. Crystals structure of silicate minerals: Silicates with isolated tetrahedra, Single chain silicates, Double chain silicates, the layered silicates, the framework silicates. Non-silicate structures. Mineralogy of clays.	15
Unit 3	Structural transformation: Isomorphism, Polymorphism pseudomorphism; Compositional classification, structural inversion, solid solution, rules governing solid solution behaviour, exsolution; examples from natural rocks: exsolution in pyroxenes and feldspars. Chemical, physical and optical properties of the following rock-forming silicate mineral groups: olivine, feldspar, pyroxene, amphibole, garnet and mica.	15
Unit 4	Principles of X-ray crystallography and Bragg's equation. Introduction to diffraction and imaging, X-ray diffraction: Single crystal method and powdered method; mineral identification by X- ray diffractometry, Reciprocal lattice, Crystal field theory. Application of SEM, TEM and EPMA in mineral characterization.	15
	Total	**60**

Text Books Suggested:

1) The Manual of Mineral Science (after James D. Dana) - Klein, C., Dutrow, B., Dwight, J., & Klein, C. The 23rd Edition (2007). J. Wiley & Sons.
2) Mineralogy - Dexter Perkins, 3rd edition (2015), Pearson Publication.
3) Introduction to Optical Mineralogy – William D. Nesse, 3rd edition (2004), Oxford University Press.

Reference books:

1) Bloss, F.D.: Crystallography and Crystal Chemistry.
2) Henrich, E.W.M.,1965: Microscopic Identification of Minerals; McGraw-Hill, New York.
3) Jones, M.P., 1987: Applied Mineralogy, A Quantitative Approach; Graham & Trotman.

Paper IV Core Course	PRACTICAL I L-T-P-C: 0-0-3-3 Credit Units: 3 Scheme of Evaluation: (P)	Subject Code: GEOL164C114

Course Objectives: The course focuses on practical applications and hands-on experience in geological analysis and interpretation. Students will learn to analyse geological maps, interpret stereographic structural data, create and interpret geochemical plots, and conduct optical mineral identification under a microscope.

Course Outcome: After the completion of course, the students will have ability to:

1) Recall and describe the fundamental principles of geological map analysis, stereographic projection, and geochemical plot interpretation.
2) Demonstrate comprehension by interpreting geological maps, profile sections, stereographic structural data, and geochemical plots. They will understand the principles behind these techniques.
3) Apply their knowledge by creating dip isogons in folds, solving structural problems related to borehole data, and conducting practical mineral identification under an optical microscope.
4) Analyse geological data, interpret contour diagrams, and critically assess geochemical variation diagrams, mineral formulas, and norm calculations for igneous rocks.
5) Synthesize their knowledge by preparing spider diagrams, REE plots, and interpreting these plots. They will develop the ability to synthesize complex geological data into meaningful interpretations.

Detailed Syllabus:

Modules	Topics and Course Content	Hours
Unit 1	Analysis and interpretation of geological maps, profile sections. Stereographic analysis of structural data: Stereographic projection of planar, linear and fold structures; use of specialized software. Interpretation of contour diagrams. Construction of dip isogons in folds. Structural problems related to borehole data.	22
Unit 2	Interpretation of common geochemical plots. Mineral formula (Stoichiometry) calculation from EPMA data of common silicate minerals. Geochemical variation diagrams and its interpretations (bivariate and trivariate plots): Harker variation diagram, AFM diagram, MgO diagram. Norm calculation of silica saturated igneous rocks. Preparation of spider diagrams and REE plots and their interpretation.	23
Unit 3	Study of the following silicate minerals under optical microscope: Olivine, Garnet, SilIimanite, Kyanite, Staurolite, Tourmaline, Enstatite, Diopside, Augite, Actinolite, Hypersthene, Hornblende, Serpentine, Muscovite, Biotite, Quartz, Orthoclase, Plagioclase, Microcline, Nepheline, Sodalite, Calcite.	25
Unit 4	Study of Becke line; Determination of refractive indices and birefringence; Pleochroic Scheme determination; Identification of Plagioclase Feldspars with the help of optical properties; Optic sign determination.	20
	Total	**90**

Text Books:

1) Structural Geology: an introduction to geometrical techniques - Ragan, D. M. (4th Ed., 2009)**,** Cambridge University Press
2) Mineralogy – Dexter Perkins, Pearson.
3) Geomorphology: A systematic analysis of late Cenozoic landforms - Arthur L Bloom, (3rd edition, 2004), Waveland Pr Inc.
4) Using Geochemical Data: Evaluation, Presentation, Interpretation - Hugh R. Rollinson (1993), John Wiley and Sons.

Reference Books:

1) A Textbook of Mineralogy – E.S. Dana (Revised by W.E. Ford); New Age International Publishers.
2) Mineral Science – K. Conelis; John Wiley & Sons, Inc.
3) Introduction to Optical Mineralogy – William D. Nesse, 3rd edition (2004), Oxford University Press.

Course: DSE 1	GEOMORPHOLOGY L-T-P-C: 3-0-2-4 Credit Units: 4 Scheme of Evaluation: (T+P)	Subject Code: GEOL164D141

Course Objectives: The course explores the processes and landforms that shape the Earth's surface. Students will study the forces of nature, such as endogenous and exogenous processes, that lead to the formation of various landforms. The course also covers topics related to mass wasting, fluvial geomorphic systems, coastal landforms, tectonic geomorphology, and Quaternary climate changes.

Course Outcome: By the end of this course the students will be able to:

1. Recall and describe the fundamental concepts of geomorphology, including the forces and processes that shape landforms.
2. Demonstrate comprehension by interpreting the mechanisms and classifications of mass wasting, hill slope morphology, and various landforms associated with aeolian, glacial, periglacial, and karst processes.
3. Apply their knowledge by analysing and explaining the processes of fluvial geomorphology, coastal geomorphology, and tectonic geomorphology. They will also calculate geomorphic indices and interpret topographical maps for different landforms.
4. Analyse landforms, such as erosional and depositional coastal features, and assess their formation processes. Students will also analyse the effects of tectonic and climatic factors on landform evolution.
5. Synthesize their knowledge by preparing longitudinal profiles of rivers, calculating stream length gradient indices, and using geomorphic indices to understand active tectonism.

Detailed Syllabus:

Modules	Topics and Course Content	Hours
Unit 1	Landforms, peneplanation, endogenous and exogenous forces, denudational processes. Mass wasting – mechanism and classification, hill slope morphology and processes. Major processes and associated landforms of aeolian, glacial and periglacial processes; Karst landscapes.	12
Unit 2	Fluvial geomorphic system: channel geometry and drainage patterns and their significance. Processes of transport, drainage basin evolution, structural control of fluvial erosion, fluvial erosional and depositional features. Drainage basin morphometry. Coastal geomorphology: shore zone processes, coastal landforms- erosional and depositional. Geomorphic features and zones of India.	12
Unit 3	Tectonic geomorphology: geomorphic markers, geomorphic indices of active tectonics, active tectonics and alluvial rivers; climatic and tectonic factors and rejuvenation of landforms. Endogenic – Exogenic processes of earth and their interactions, Rates of uplift and denudation, Tectonics and drainage development, Sea-level change.	12
Unit 4	Quaternary climate: the uplift-climate connection, glacial/interglacial cycles, Milankovitch hypothesis, Quaternary climate and sea level changes, climate records in sediments. Models of long-term landscape development. Overview of Indian Geomorphology.	12
List of Practicals	Topographical map interpretation for different landforms, Preparation of longitudinal profile of a river, Calculation of Stream length gradient index. Understanding active tectonism with the help of different geomorphic indices. Estimation of incision deficit, rate of sedimentation and erosion, sediment rating curve.	12
	Total	**60**

Text Books:

1) Fundamentals of Geomorphology - Richard John Huggett, (4th edition, 2016), Routledge.
2) Introduction to Geomorphology - Frank Ahnert, (1st edition, 29 May 1998), Routledge.
3) Geomorphology: A systematic analysis of late Cenozoic landforms - Arthur L Bloom, (3rd ed. 2004), Waveland Pr Inc.

Reference Books:

1) Charton, R.,2007: Fundamentals of Fluvial Geomorphology.
2) Grade, R.J.,2006: River Morphology.
3) Gaudie, A.,1990: Geomorphological Techniques.

Course: DSE 2	RIVER SCIENCE L-T-P-C: 3-0-2-4 Credit Units: 4 Scheme of Evaluation: (T+P)	Subject Code: GEOL162D142

Course Objectives: River Science is an interdisciplinary field of study that focuses on the physical, chemical, and biological processes that govern the behaviour of rivers and streams. This course will introduce students to the fundamental principles of River Science, including the study of water flow, sediment transport, river morphology, and ecology. Students will learn how to use field and laboratory techniques to collect and analyse data, and will gain an understanding of the role of rivers in shaping landscapes and ecosystems.

Course outcomes:

1. Remembering: Students will be able to recall and recognize the key concepts, principles, and facts related to River Science, including the properties of water, sediment, and river channels.
2. Understanding: Students will be able to explain the fundamental principles of River Science, including water flow, sediment transport, river morphology, and ecology.
3. Applying: Students will be able to apply River Science principles to analyse and interpret data from field and laboratory experiments, and to design and conduct their own research projects.
4. Analysing: Students will be able to analyse the interactions between physical, chemical, and biological processes in river ecosystems, and evaluate the impact of human activities on these processes.

Detailed Syllabus:

Modules	Topics and Course Content	Hours
Unit 1	**Stream hydrology** Basic stream hydrology, Physical properties of water, sediment and channel flow. River discharge, River hydrographs (UH, IUH, SUH, GIUH) and its application in hydrological analysis. Flood frequency analysis.	12
Unit 2	Sediment source and catchment erosion processes, Sediment load and sediment yield, Sediment transport processes in rivers, Erosion and sedimentation processes in channel. Drainage network, Quantitative analysis of network organization – morphometry.	12
Unit 3	Random Topology (RT) model and fractal analysis. Role of drainage network in flux transfer. Evolution of drainage network in geological time scale. Patterns of alluvial rivers - braided, meandering and anabranching channels.	12
Unit 4	Different classification approaches in fluvial geomorphology and its applications. River response to climate, tectonics and human disturbance Bedrock channel processes and evolution of fluvial landscapes. Fluvial hazards: Integrated approach to stream management, Introduction to river ecology.	12
List of Practicals	Stream sediment analysis. Determination of stream flow characteristics. Determination of channel cross-section. Determination of channel slope stability. Hydrograph analysis. Flood frequency analysis.	12
	Total	**60**

Text Books Suggested:

1) Davies, T. (2008) Fundamentals of hydrology. Routledge Publications.
2) Knighton, D. (1998) Fluvial forms and processes: A new perspective. Amold Pubs.
3) Richards. K. (2004) Rivers: Forms and processes in alluvial channels. Balckburn Press.

Reference Books:

1) Bryirely and Fryirs (2005) Geomorphology and river management. Blackwell Pub.,
2) Julien, P.Y. (2002) River Mechanics. Cambridge University Press.
3) Robert, A. (2003) River Processes: An introduction to fluvial dynamics. Arnold Publications.
4) Tinkler, K.J., Wohl, E.E. (eds.) 1998. Rivers over rock. American Geophyscial Union Monograph, Washington, DC.

Detailed Syllabus
Of Semester 2

Paper I Core Course	IGNEOUS PETROLOGY L-T-P-C: 4-0-0-4 Credit Units: 4 Scheme of Evaluation: (T)	Subject Code: GEOL164C201

Course Objectives: This course provides a comprehensive understanding of the origin, classification, and geochemical aspects of igneous rocks. Students will explore the processes involved in the formation of igneous rocks, their mineralogical and textural characteristics, and their significance in geological research, resource exploration, and tectonic settings.

Course Outcome:
After the completion of course, the students will be able to:
1. Understand the principles of igneous petrology.
2. Differentiate and classify igneous rocks based on their mineralogical and textural characteristics.
3. Analyse the geochemical composition of igneous rocks and their tectonic significance.
4. Interpret the geological history and magmatic evolution of an area using igneous rocks.
5. Evaluate the economic importance of igneous rocks and their associated mineral deposits.

Detailed Syllabus:

Modules	Topics and Course Content	Hours
Unit 1	Magmatic process- concept and models. Quantitative approach to partial melting, fractional crystallization and source characterization. Mantle melting, melt-mantle interaction and magmatic evolution in various geodynamic settings. Magmatism in the following tectonic settings: mid-ocean ridges, subduction zones and Continental and oceanic rift zone). Plume magmatism and hot spots. Concepts of mantle metasomatism. Mineralogy of upper mantle, phase transition in upper mantle.	15
Unit 2	Geochemical characteristics of igneous rocks: major, trace and isotopic composition of igneous rocks in the context of petrogenesis and palaeo-tectonic settings. Behaviour of trace element during equilibrium and fractional crystallization, equilibrium and fractional melting. Trace element modelling for igneous petrogenesis. Concept of activation energy and viscosity on melt equilibria. Trace element abundance of magmatic rocks (especially basalt and granite) from different tectonic setting.	15
Unit 3	Study of important two, three and four component systems at low and high pressures (wet and dry) and their application in describing textures and petrogenesis of various rock types. Petrogenetic processes involved in origin and evolution of different types of granitoids, Tectonic discrimination of granitoids on the basis of trace elements and isotopic abundances, brief idea about importance of granite in crust building process through time. Radiometric dating of igneous rocks.	15
Unit 4	Petrology and petrogenesis of major igneous rock types: Ultramafic rocks (Komatite, Kimberlite), Alkaline rocks, Ophiolites, Carbonatites, Flood basalts (Deccan Trap, Sylhet Trap), Anorthosites, Granitoids and Layered igneous complexes. Brief idea on physical volcanology, criteria for identification of several volcanic flows, distinct zones within a flow, common volcanic structures, pyroclasts.	15
	Total	**60**

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

Reference Books:
1) Vernom, R.H. & Clarke, G.L., 2008: Principles of Metamorphic Petrology; Cambridge.
2) Bucher, K. and Martin, F., 2002: Petrogenesis of Metamorphic Rocks; Springer-Verlag
3) Spears, F. 1993: Metamorphic Phase Equilibria and Pressure-Temperature-Time Paths. AGU Publication.

Paper II Core Course	METAMORPHIC PETROLOGY L-T-P-C: 4-0-0-4 Credit Units: 4 Scheme of Evaluation: (T)	Subject Code: GEOL164C202

Course Objectives:
This course provides an in-depth exploration of metamorphic rocks and processes, focusing on the mineralogical, textural, and structural changes that occur during metamorphism. Students will learn about the factors influencing metamorphism, the classification of metamorphic rocks, and their significance in understanding geological history and resource assessment.

Course Outcome:
After the completion of course, the students will be able to:
1. Understand the fundamental principles of metamorphic petrology.
2. Recognize and classify metamorphic rocks based on mineralogical and textural characteristics.
3. Interpret the P-T conditions of metamorphism and the metamorphic facies.
4. Analyse the relationship between metamorphism and tectonics.
5. Apply metamorphic petrology to geological mapping and resource assessment.

Detailed Syllabus:

Modules	Topics and Course Content	Hours
Unit 1	Metamorphism: Factors controlling metamorphism (T, P and fluids); Types of metamorphism: Regional, contact, dynamic, hydrothermal, impact, retrograde and ocean floor metamorphism. Sources of plate tectonic metamorphic heat for crustal metamorphism, geothermal gradient, crustal thickening processes and P-T-t path of metamorphism. Metamorphic zones; Metamorphic facies and facies series; Paired metamorphic belt; Metamorphic grades.	15
Unit 2	Textures of contact metamorphism and their petrogenetic significance. High strain metamorphic textures. Regional orogenic metamorphic textures: Tectonites, foliation, lineation; mechanism of tectonic development; Analyses of poly-deformed and poly-metamorphic rocks; other regional metamorphic textures; replacement textures and reaction rim and their role in reconstructing P-T-t history of metamorphism.	15
Unit 3	Mineral assemblages and their graphical representation: ACF, AKF and AFM and compositional phase diagrams. Chemical equilibrium in metamorphism. Metamorphic reactions. Cation exchange partitioning relationship among coexisting phases, application of geothermometry and geobarometry, and petrogenetic grid. Regional metamorphism of pelitic and basic metamorphic assemblages.	15
Unit 4	**Thermodynamics in Geology** Fundamental thermodynamic equation, Chemical potential, Gibbs Free Energy function; Enthalpy, entropy and activity, Free Energy change as a function of activity; variation of enthalpy, entropy and Gibbs Free Energy with temperature and pressure, Clausius-Clapeyron equation. Mixing components, Raoults Law and Henrys Law, standard state and activity, ideal and non-ideal solution behaviour and equilibrium constant.	15
	Total	**60**

Text Books Suggested:

1) Principles of igneous and metamorphic petrology – J. D. Winter (2014). Pearson.
2) Igneous and Metamorphic Petrology - Myron G. Best, 2013, John Wiley & Sons.

Reference Books:

1) Principles of igneous and metamorphic petrology – A. Philpotts & J. Ague. (2009). Cambridge University Press.
2) Petrogenesis of Metamorphic Rocks – H. G. F. Winkler, 2013, Springer Berlin Heidelberg.
3) Vernom, R.H. & Clarke, G.L., 2008: Principles of Metamorphic Petrology; Cambridge.
4) Bucher, K. and Martin, F., 2002: Petrogenesis of Metamorphic Rocks; Springer-Verlag
5) Spears, F. 1993: Metamorphic Phase Equilibria and Pressure-Temperature-Time Paths. AGU Publication.

Paper III Core Course	STRATIGRAPHIC PRINCIPLES AND QUATERNARY GEOLOGY			Subject Code:
	L-T-P-C: 4-0-0-4	Credit Units: 4	Scheme of Evaluation: (T)	GEOL164C203

Course Objectives: This course explores the principles and methods of stratigraphy, with a focus on the Quaternary period and geological history of India. Students will study stratigraphic units, correlation techniques, sequence stratigraphy, magnetostratigraphy, and the application of dating methods in Quaternary geology.

Course Outcome: After the completion of course, the students will have ability to:

1. Recall and describe the geological disposition of Indian stratigraphic sequences, the geological history of India, and the principles of stratigraphy.
2. Demonstrate comprehension by interpreting the concepts of sequence stratigraphy, magnetostratigraphy, and seismo-stratigraphy. They will understand the Quaternary period and its divisions, including the Neogene-Quaternary boundary.
3. Apply their knowledge by conducting Quaternary dating methods, such as cosmogenic radionuclides (C14, Be10, Al26), luminescence chronology, dendrochronology, and low-temperature thermochronology. They will also apply these methods to interpret the exhumation and denudation history of geological sequences.
4. Analyse the relationship between Quaternary climate and tectonics, including the Milankovitch theory, glacial-interglacial cycles, and the Little Ice Age. Students will evaluate Quaternary sea-level changes and climate proxies.
5. Synthesize their knowledge by studying Quaternary stratigraphy, oxygen isotope stratigraphy, magnetic stratigraphy, and event stratigraphy. They will examine Quaternary sedimentary records from various regions in India and understand their significance in geological research.

Detailed Syllabus:

Modules	Topics and Course Content	Hours
Unit 1	Geological disposition of the Indian stratigraphic sequences; geological history of India. Geological time scale. Stratigraphic units and International stratigraphic codes. Principles and methods of correlation of stratigraphic units, stratigraphic relationships - vertical and lateral. Concepts of Sequence stratigraphy, Magnetostratigraphy and Seismo-stratigraphy.	15
Unit 2	The Quaternary Period and its divisions, Neogene-Quaternary and Pleistocene-Holocene boundary, the Anthropocene, Quaternary dating methods-cosmogenic radionuclides- C^{14}, Be^{10}, Al^{26}, luminescence chronology, dendrochronology (principles, applications and limitations), low temperature thermochronology and exhumation/denudation history.	15
Unit 3	Quaternary climate and tectonics- the ice age, Milankovitch theory, glacial-interglacial cycles, LGM, Little Ice Age, Quaternary Sea level changes, uplift-climate connection, climate proxies and Quaternary paleoclimate, $^{87}Sr/^{86}Sr$ as proxy for silicate weathering, duricrusts-calcrete, ferricrete, alcrete and speleothems, application of stable isotopes in Quaternary climate.	15
Unit 4	Quaternary stratigraphy- oxygen isotope stratigraphy, magnetic stratigraphy – principles and application in Quaternary sequences (Indian examples), pedostratigraphy, soil profile and palaeosol, Quaternary records from marine and continental settings, event stratigraphy. Quaternary sedimentary records from India- Himalayan foreland, Son-Narmada valley, Gangetic plains, coastal plains, Brahmaputra plains of NE India.	15
	Total	**60**

Text Books:

1) Principles of Sedimentology and Stratigraphy, by Sam Boggs, Jr., 4th Edition, Pearson Prentice Hall, 2006.
2) Geomorphology: A systematic analysis of late Cenozoic landform, Arthur L Bloom., Pearson Ed.

Reference Books:

1) Stratigraphic Principles and Practices – J.M.Weller; Universal BookStall, Delhi.
2) Tectonic Geomorphology, Douglas W. Burbank and Robert S. Anderson, Blackwell Science.
3) Active tectonics, by Edward A. Keller and Nicholas Pinter, Prentice Hall.
4) Sequence Stratigraphy: Concepts and Applications – G. H. Fischer.

Paper IV Core Course	PRACTICAL II L-T-P-C: 0-0-6-3 Credit Units: 3 Scheme of Evaluation: (P)	Subject Code: GEOL164C214

Course Objectives: The course is designed to provide students with hands-on experience in the identification of igneous and metamorphic rocks, thin section preparation, mineral identification, and the application of geological concepts to practical problem-solving.

Course Outcome: After the completion of the course, the students will have ability to:

1. Recall and acquire knowledge of the identification and classification of hand specimens of igneous and metamorphic rocks. They will also understand the principles of thin section preparation and the study of igneous textures and minerals.
2. Demonstrate comprehension by interpreting the textures and minerals in thin sections of igneous and metamorphic rocks. They will understand the identification and genetic interpretation of common minerals.
3. Apply their knowledge by using phase diagrams to interpret magma crystallization and P-T conditions of metamorphism. They will utilize chemical analysis to determine the palaeotectonic settings of igneous rocks and perform geothermobarometry calculations using mineral assemblages and compositions.
4. Analyse and solve numerical and graphical problems related to solid-liquid equilibrium systems, magma viscosity, magma ascent rate, petrogenetic processes like fractional crystallization, partial melting, assimilation, and magma mixing. Students will also analyse textures to determine strain and deformation history.
5. Synthesize their knowledge by conducting petrofabric analysis of metamorphic rocks and measuring foliation and lineation orientations. They will apply fieldwork skills in an igneous and metamorphic terrain.

Detailed Syllabus:

Modules	Topics and Course Content	Hours
Unit 1	Identification of hand specimens of Igneous rocks. Thin section preparation and study of igneous textures and minerals. Identification of common minerals and their genetic interpretation.	23
Unit 2	Use of phase diagrams to interpret magma crystallization. Use of chemical analysis in determination of palaeotetonic settings of igneous rocks. Numerical/graphical problems on solid-liquid equilibrium system, magma viscosity, magma ascent rate. Numerical problems related to petrogenetic processes like fractional crystallization, partial melting, assimilation, magma mixing.	22
Unit 3	Identification of hand specimens of Metamorphic rocks. Study of metamorphic textures and minerals in thin section. Identification of index minerals for metamorphic grade determination. Petrofabric analysis of metamorphic rocks.	23
Unit 4	Use of phase diagrams to interpret P-T conditions of metamorphism. Geothermobarometry calculations using mineral assemblages and compositions. Determination of strain and deformation history from textures. Measurement of foliation and lineation orientations. Field work in an igneous and metamorphic terrain.	22
	Total	**90**

Text Books Suggested:

1) Petrography of Igneous and Metamorphic Rocks - Anthony R. Philpotts, Waveland Press Inc.
2) Using geochemical data: evaluation, presentation, interpretation - Rollinson, H. R. (2014), Routledge.

Reference Books:

1) Igneous and Metamorphic Petrology - Myron G. Best (2001)
2) Essentials of geochemistry - Walther, J. V. (2009), Jones & Bartlett Publishers.

Course: SEC	GEOLOGICAL MAPPING AND SURVEYING L-T-P-C: 0-0-4-2 Credit Units: 2 Scheme of Evaluation: (P)	Subject Code: GEOL164S211

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

Course Outcome: After the completion of course, the students will have ability to:

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

Detailed Syllabus:

Modules	Topics and Course Content	Hours
Unit 1	Introduction to Geological Mapping and Surveying: Definition and importance of geological mapping. Overview of geological surveying techniques and instruments. Fieldwork Preparation: Planning and organizing a geological field survey. Safety considerations and fieldwork logistics.	15
Unit 2	Topographic Mapping: Reading topographic maps and contour lines. Topographic map interpretation. Concept of Ratio scale. Large-scale and small-scale maps. Geological Field Techniques: Identification and classification of rocks and minerals in the field. Measuring various components of geological features like folds, faults, and joints.	15
Unit 3	Stratigraphic Mapping: Recording stratigraphic sequences and bedding orientations. Constructing geological cross-sections. Structural Mapping: Mapping and interpreting geological structures such as folds and faults. Analysis of structural deformation in the field.	15
Unit 4	Geological Mapping Project: Conducting a comprehensive geological survey and mapping project. Creating a detailed geological map and report based on field data.	15
	Total	**60**

Text Books suggested:

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

Reference Books:

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

Paper: DSE 1	GIS IN GEOLOGY L-T-P-C: 2-0-4-4 Credit Units: 4 Scheme of Evaluation: (T+P)	Subject Code: GEOL164D241

Course Objectives: The course is designed for M.Sc. Geology students to explore the use of Geographic Information Systems (GIS) in geological studies. Students will learn the fundamental concepts of GIS, its historical development, and its applications in geological research and industry. It covers GIS components, data types, spatial analysis, and geoprocessing techniques. Practical hands-on experience with GIS software and data collection using GPS devices will be provided.

Course Outcome: On completion of the course, the student will have the ability to:

1. Understand and acquire knowledge of the definition and scope of GIS in geological studies. They will understand the historical development of GIS technology and its key contributors in the field of geology.
2. Demonstrate comprehension by explaining the geological applications of GIS in both research and industry.
3. Apply their knowledge by working with spatial data types (vector and raster) commonly used in geology. Students will gain practical experience with GIS software, such as ArcGIS and QGIS.
4. Analyse spatial data through geoprocessing techniques, georeferencing, and attribute data management in GIS.
5. Synthesize their knowledge by mastering thematic mapping and symbology in geology.

Detailed Syllabus:

Modules	Topics and Course Content	Hours
Unit 1	Definition and scope of GIS in geological studies. Historical development and key contributors in GIS technology. GIS components and data structures. Data sources in GIS (e.g., GPS, remote sensing). Spatial data types (vector and raster) and their use in geology. Coordinate systems and map projections in geological mapping.	12
Unit 2	Introduction to GIS software (e.g., ArcGIS, QGIS). Data acquisition and management in GIS. Spatial analysis and geoprocessing techniques. Georeferencing. Geological data integration and attribute tables.	12
Unit 3	Creating geological maps using GIS software. Displaying geological features, contacts, and structures. Thematic mapping and symbology in geology. Image processing methods: Image restoration, image enhancement, False colour composite (FCC), Ratio images, multispectral classification - supervised and unsupervised, change detection images, accuracy assessment.	12
Unit 4	Concept of hyperspectral data and their importance. Planning needed to develop a GIS based project in earth science. Analysis of spatial and attribute data in GIS platform. 3D visualization and geological modelling.	12
List of Practicals	Familiarization with GIS software interface (e.g., ArcGIS, QGIS). Basic navigation, map creation, and data loading. Data collection using GPS devices for geological points of interest. Importing and organizing geological data (shapefiles, CSV files) into GIS. Attribute data management and database creation. Projecting geological data onto different coordinate systems. Creating geological maps with geological data layers. Symbolizing and labelling geological features (e.g., rock units, faults). Incorporating geological legends and scale bars.	12
	Total	**60**

Text Books:

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

Reference Books:

1. Curtis, H., 2000: The GPS Accuracy Improvement Initiative, GPS World, June, 2000.
2. Gonzalez, R. C., Woods, R. E., 2000: Digital Image Processing, Fifth Indian Reprint, Addison Wesley Longman, Delhi.
3. Miller, V. C.,1961: Photogeology; McGraw-Hill, New York.

Paper: DSE 2	URBAN GEOLOGY L-T-P-C: 3-0-2-4 Credit Units: 4 Scheme of Evaluation: (T+P)	Subject Code: GEOL164D242

Course Objectives: The course is designed for M.Sc. Geology students to explore the application of geological principles and practices in urban environments. Students will have a comprehensive understanding of the geological aspects of urban areas and their significance in urban planning, construction, and sustainability. They will gain practical skills in geological hazard assessment, mitigation, and reporting, as well as the ability to conduct independent or group research on urban geological issues.

Course Outcome: On completion of the course, the student will have the ability to:

1. Recall and acquire knowledge of the definition and scope of urban geology. They will understand the historical development of urban geology and key contributors to the field.
2. Demonstrate comprehension by explaining the geological factors influencing urbanization and sustainability.
3. Apply their knowledge by identifying and assessing geological hazards in urban environments, such as earthquakes, landslides, and sinkholes.
4. Analyse geological aspects of urban mineral resources, geothermal energy potential, and sustainable resource management along with groundwater resources, pollution sources, and contamination issues in urban areas.
5. Synthesize their knowledge by conducting independent or group research projects on specific urban geological issues. They will identify and document geological features, sketch geological maps, and report their findings and recommendations for construction projects.

Detailed Syllabus:

Modules	Topics and Course Content	Hours
Unit 1	Definition and scope of urban geology. Historical development and key contributors. Geological factors in urbanization and sustainability. Characterization of subsurface geology in urban areas.	12
Unit 2	Soil mechanics and foundation engineering. Identification and assessment of geological hazards: earthquakes, landslides, floods, sinkholes. Mitigation strategies and urban planning for hazard resilience.	12
Unit 3	Geothermal energy potential in cities. Urban mineral resources and their extraction. Groundwater resources and management. Sustainable resource management in urban areas.	12
Unit 4	Urban pollution sources and groundwater contamination. Environmental impact assessments and remediation strategies. Urban greenspace and geological aesthetics. Case studies of geological hazards in urban environments.	12
List of Practicals	**Independent or group research project on a specific urban geological issue** Identification and documentation of geological features (e.g., rock outcrops, soil types). Preparing geological maps of the study area. Reporting findings and recommendations for construction projects. Identification of potential geological hazards in urban areas (e.g., landslide-prone zones, etc) Preparation of research reports and presentations. Hazard assessment using GIS tools and geological data. Development of hazard mitigation plans for urban areas.	12
	Total	**60**

Text Books:

1. "Urban Geology: Process-Oriented Concepts for Adaptive and Integrated Resource Management" by Michael Gaupp and Axel-Michael Fiene.
2. "Engineering Geology for Society and Territory - Volume 8: Preservation of Cultural Heritage" edited by Giorgio Lollino, et al.

Reference Books:

1. "Urban Geology: An Emerging Geoscience" edited by Edward J. C. Stamos and David J. Sanderson.
2. "Geology in Urban Development: Case Histories in and around European Cities" edited by Rolf Brinkmann and Eberhard W. Brandes.

Detailed Syllabus Of Semester 3

Paper I Core Course	INDIAN STRATIGRAPHY L-T-P-C: 4-0-0-4 Credit Units: 4 Scheme of Evaluation: (T)	Subject Code: GEOL164C301

Course Objectives: This course is designed to provide an overview of the stratigraphic framework of India. It will cover the geological history of the Indian subcontinent, the different stratigraphic units, and their characteristics. The course will also discuss the tectonic and depositional history of India and its relationship with the surrounding regions.

Course Outcome: After the completion of course, the students will have ability to:

1. Remember: Identify and recall the different stratigraphic units in India and their characteristics.
2. Understand: Explain the geologic history of the Indian subcontinent and the tectonic and depositional history of India and its relationship with the surrounding regions.
3. Apply: Apply the principles of stratigraphy in the interpretation of the geological history of India.
4. Analyse: Analyse the economic significance of the different stratigraphic units and interpret the depositional environments of the different stratigraphic units.

Detailed Syllabus:

Modules	Topics and Course Content	Hours
Unit 1	Overview of the geological history of India. Geological time scale and major events in Indian geological history. Precambrian Formations of India: Dharwar Province, Eastern Ghats Province, Central Indian Province, Singhbhum-Orissa Province and Aravalli-Bundelkhand Province. Archaean-Proterozoic boundary.	15
Unit 2	Proterozoic Basins of Indian Peninsula: Cuddapah Supergroup, Vindhyan Supergroup, Kurnool Group. Precambrian-Cambrian boundary. Palaeozoic Formations of India: Himalayan Palaeozoics, marine Palaeozoics in Peninsular India.	15
Unit 3	Mesozoic Formations of India: Triassic of Spiti and Himalayan range; Jurassic of Kutch region, Cretaceous of Peninsular India. Deccan Traps and associated infra, inter and intra-trappean beds. Gondwana Sequence of India: Basin configuration, sedimentation and palaeoclimates, Gondwana deposits of Peninsular India, marine intercalations.	15
Unit 4	Stratigraphy of North-East India: Precambrians and all igneous activities of Shillong Plateau and Arunachal Himalayas. Gondwana and Paleozoic stratigraphy in the Northeastern region of India. Cretaceous deposits of the Northeast India, Cretaceous-Tertiary boundary, Sylhet traps and other Mesozoic intrusives of the Northeast India. Cenozoic stratigraphy of Assam-Arakan region. Introduction to Meghalayan Age.	15
	Total	**60**

Text Books:

1) The Making of India – K. S. Valdiya, Macmillan India Pvt. Ltd. (2010)
2) Cratons and Fold Belts of India – Ram. S. Sharma, Springer (2009)

Reference Books:

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

Paper II Core Course	PALAEONTOLOGY L-T-P-C: 4-0-0-4 Credit Units: 4 Scheme of Evaluation: (T)	Subject Code: GEOL164C302

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

Course Outcome: After the completion of course, the students will have ability to:

1. Remembering: Students will be able to recall and recognize the key concepts, principles, and facts related to the study of palaeontology.
2. Understanding: Students will be able to explain the principles of evolutionary biology and the methods used in palaeontological research.
3. Applying: Students will be able to apply palaeontological principles to identify, describe, and interpret the significance of fossils in the context of past life and environments.
4. Analysing: Students will be able to analyse the morphology, diversity, and distribution of fossil organisms and their significance in the evolutionary history of life.

Detailed Syllabus:

Modules	Topics and Course Content	Hours
Unit 1	**Key evolutionary events in Earth's history** Precambrian, Palaeozoic, Mesozoic and Cenozoic biota – brief idea, turnover pattern through time; controls of tectonics, geography and mass extinction. Major turning points in evolution of vertebrates – evolution of jaw, terrestrialization, ammonite evolution, evolution of dinosaurs, mammals.	15
Unit 2	**Vertebrate and Invertebrate Palaeontology** Vertebrate palaeontology: Evolution of man, equidae and proboscidae in the context of palaeoclimate and palaeoecology. Important invertebrate groups (e.g., Anthozoa, Brachiopoda, Echinoidea etc.) and their evolutionary palaeobiological significance.	15
Unit 3	**Micropalaeontology** Definition, types of microfossils and their importance. Nannofossils and their importance in geology; Trace fossils and their classification, Foraminifers - their evolution, geological distribution and their applications in palaeoecology, correlation, biostratigraphy and hydrocarbon exploration. Conodonts, ostracods and radiolaria – stratigraphic distribution and application.	15
Unit 4	**Palynology and its application; Gondwana Flora** Palynology and its stratigraphic and palaeoclimatic significance. Study of pollens and spores, diatoms, dianoflagellate. Palynological organic matters. Detail account of Gondwana flora in the World and in India in the context of palaeoclimate and palaeoecology.	15
	Total	**60**

Text Books:

1) Benton, M. (2009). Vertebrate paleontology. John Wiley & Sons. 4th Edition.
2) Armstrong, H.A., and Brasier, M.D. (2005) Microfossils. Blackwell Publishing.

Reference Books:

1) Invertebrate Paleontology, Shrock and Twenhoefells, CBS publishers
2) Introduction to Marine Palaeontology, Bilal U. Haq & Anne Boersma (Edited), Elsevier, 1998
3) Invertebrate Palaeontology and Evolution, E.N.K. Clarkson, 4th Edition, Blackwell Science
4) Earth System History, Stanley, S.M. and Luczaj, J.A. (2015). Freeman & Co. 4th edition.

Paper III Core Course	PRACTICAL - III L-T-P-C: 0-0-6-3 Credit Units: 3 Scheme of Evaluation: (P)	Subject Code: GEOL164C313

Course Objectives: The course aims to provide students with practical training in the study of rocks, fossils, and sedimentary structures from known Indian stratigraphic horizons, enabling them to develop proficiency in various techniques of geological analysis and interpretation.

Course Outcome: After the completion of course, the students will have ability to:

1. **Knowledge (BT1):** Students will acquire comprehensive knowledge of the lithostratigraphy, biostratigraphy, and sedimentology of Indian stratigraphic sequences, as well as the morphology and taxonomy of important fossil taxa found within these formations.
2. **Comprehension (BT2):** Students will develop a deep understanding of the principles and methods used in facies mapping, facies modelling, and paleogeographic reconstruction, allowing them to interpret ancient depositional environments and paleoenvironments from geological data.
3. **Application (BT3):** Through hands-on experience with rocks, fossils, and thin sections, students will learn to apply petrographic and microscopic techniques to the analysis of sedimentary rocks and their constituent minerals, as well as to conduct granulometric analysis and paleocurrent studies.
4. **Analysis (BT4):** Students will be able to analyze sedimentary structures, fossil assemblages, and lithological variations in vertical sections, identifying depositional environments, sedimentary facies, and paleoclimatic conditions, and interpreting the geological history recorded in the rock record.
5. **Synthesis (BT5):** By integrating data from field observations, laboratory analyses, and literature reviews, students will synthesize information to construct lithological profiles, biostratigraphic zonations, and paleocurrent maps, synthesizing diverse data sets to reconstruct past geological landscapes and sedimentary systems.
6. **Evaluation (BT6):** Students will critically evaluate the reliability and significance of their findings, assessing the accuracy of their interpretations and the uncertainties inherent in geological data, and considering alternative hypotheses and interpretations in light of available evidence.

Detailed Syllabus:

Modules	Topics and Course Content	Hours
Unit 1	Study of rocks in hand specimens and thin sections from known Indian stratigraphic horizons. Facies maps, Facies modeling, palaeogeographic reconstruction. Megascopic study of important fossil forms – lamellibranchs, cephalopods, gastropods, trilobites, brachiopods and echinoids.	15
Unit 2	Megascopic study of important fossils from Gondwana flora. Microscopic study of foraminifera, radiolaria, ostracods. Microscopic study of spores and pollens, dianoflagallete. Problems on biostratigraphic zonations.	15
Unit 3	Thin section petrography of sandstones and limestone. Separation of heavy mineral and their study under microscope. Granulometric analysis and their interpretation.	15
Unit 4	Study of hand specimens of different types of sedimentary structures. Preparation of lithology from vertical section. Paleocurrent analysis: field measurement procedures and laboratory techniques.	15
	Total	**60**

Text Books:

1) Principles of Sedimentology and Stratigraphy, by Sam Boggs, Jr., 4th Edition, Pearson Prentice Hall, 2006.
2) Benton, M. (2009). Vertebrate paleontology. John Wiley & Sons. 4th Edition.
3) Introduction to Sedimentology – S. M. Sengupta, (2018), CBS.

Reference Books:

1) Armstrong, H.A., and Brasier, M.D. (2005) Microfossils. Blackwell Publishing.
2) Principles of Sedimentary Basin Analysis, by A. D. Miall, 3rd Edition, Springer, 2000, 616pp.
3) Petrology of Sedimentary Rocks – Sam Boggs, (2nd edition, 2009), Cambridge University Press, New York.

Paper IV Core Course	SEDIMENTOLOGY L-T-P-C: 4-0-0-4 Credit Units: 4 Scheme of Evaluation: (T)	Subject Code: GEOL164C304

Course Objectives: The course aims to provide students with a comprehensive understanding of sedimentary processes, environments, and deposits, as well as the methods and techniques used in sedimentological analysis, enabling them to interpret sedimentary rocks and their depositional history.

Course Outcome: After the completion of course, the students will have ability to:

1. Knowledge (BT1): Acquire a thorough knowledge of sedimentary textures, structures, and environments, including the classification of sedimentary rocks, and the genesis of sedimentary structures.
2. Comprehension (BT2): Develop a deep comprehension of sedimentary processes and environments, including the interpretation of sedimentary facies and the classification of sedimentary basins based on tectonic settings.
3. Application (BT3): Apply sedimentological techniques, such as grain-size analysis, paleocurrent analysis, and heavy mineral analysis, to interpret sedimentary deposits and reconstruct past environments.
4. Analysis (BT4): Analyse sedimentary rocks and depositional sequences, identifying sedimentary structures, interpreting diagenetic processes, and assessing the provenance and tectonic history of sedimentary basins based on geochemical and mineralogical data.
5. Synthesis (BT5): By integrating data from sedimentological analyses, students will synthesize information to reconstruct past sedimentary environments, interpret depositional processes, and infer the tectonic and climatic conditions prevailing during sediment accumulation.

Detailed Syllabus:

Modules	Topics and Course Content	Hours
Unit 1	**Texture and structure of sediments** Texture of sedimentary rocks, textural elements- size, roundness, sphericity, fabric, form and surface textures, their measurement. Statistical treatment and interpretation of grain-size analysis data. Primary grain fabric: orientation of sand grains, pebbles. Structures of sedimentary rock - genesis and significance of sedimentary structures. Paleocurrent analysis.	15
Unit 2	**Sedimentary environments and Facies analysis** Sedimentary environments - classification of sedimentary environments, physical and chemical parameters of depositional environments, lithofacies assemblages from fluvial, deltaic, lacustrine, marine, glacial and arid environment. Genetic classification of sedimentary rocks; clastics (sandstone and shale), mineralogy of the clastic sediments. Diagenesis and lithification. Conglomerates: Composition, classification, origin and occurrence. Sedimentology of clay.	15
Unit 3	**Provenance, Sedimentary basins and tectonic control** Provenance determination using heavy minerals, quartz, feldspars and rock fragments. Origin, mineralogy, classification (Dunham and Folk) of limestone; Diagenesis and neomorphism of carbonate rocks. Sedimentary basins: classification of sedimentary basins, Sedimentation and tectonics (tectonic control of sedimentation, plate tectonics and sediment accumulations).	15
Unit 4	**Physico-chemical factors in sedimentation** Sedimentation as a geochemical process; Physico-chemical factors in sedimentation, Eh-pH diagrams, Geochemistry of natural water, geochemical analysis of sediments and their graphical plots to decipher their chemical maturity, weathering index of the source rocks, determination of provenance and tectonic settings, classification of sediments.	15
	Total	**60**

Text Books:

1. Petrology of Sedimentary Rocks – Sam Boggs, (2nd edition, 2009), Cambridge University Press, New York.
2. Sedimentology and Stratigraphy - Nichols, G. (2009), Second Edition. Wiley Blackwell.
3. Depositional Sedimentary Environments - Reineck and Singh, (1980), Springer – Verlag.

Reference Books:

1. Sedimentary Petrology – Tucker, M. E. (2006), Blackwell Publishing.
2. Introduction to Sedimentology – S. M. Sengupta, (2018), CBS.
3. Sedimentary Geology - Prothero, D. R., & Schwab, F. (2004), Macmillan.

Paper V DSE	EARTH AND CLIMATE L-T-P-C: 4-0-0-4 Credit Units: 4 Scheme of Evaluation: (T)	Subject Code: GEOL164D301

Course Objectives: This course aims to provide students with an understanding of the Earth's climate system, including its components, interactions, and variability over different time scales. The course will cover the basic principles of atmospheric science, oceanography, and paleoclimate, and their applications in climate modelling, climate change, and environmental issues.

Course Outcome: After the completion of course, the students will have ability to:

1. Remember: Students should be able to recall the basic concepts and terminology used in Earth and Climate science, including atmospheric and oceanic circulation, radiative forcing, greenhouse gases, and climate proxies.
2. Understand: Students should be able to explain the fundamental physical and chemical processes that govern the Earth's climate system, including energy balance, feedback mechanisms, and climate variability.
3. Apply: Students should be able to apply their knowledge of Earth and Climate science to analyse and interpret climate data, and to evaluate the scientific evidence for climate change and its impacts on natural and human systems.
4. Analyse: Students should be able to analyse the complexity and uncertainty of climate science, including the role of natural and anthropogenic factors in climate change, and the challenges of climate prediction and mitigation.

Detailed Syllabus:

Modules	Topics and Course Content	Hours
Unit 1	Definition of climate and climate system Historical perspectives on climate science Scientific methods and tools for climate research Components of climate system Basic concepts of Forcing and Response of Climate system	15
Unit 2	Incoming solar radiation and its variability Receipt and storage of heat. Heat transformation Earth’s heat budget. Interactions amongst various sources of earth’s heat. Land-ocean-atmosphere interactions and feedbacks	15
Unit 3	Atmospheric structure and composition, Greenhouse effect. Oceanic circulation and heat transport. El Niño-Southern Oscillation (ENSO) and other climate oscillations. Mechanism of monsoon; Monsoonal variation through time. Factors associated with monsoonal intensity; Effects of monsoon on Earth’s climate.	15
Unit 4	Milankovitch cycles and variability in the climate. Glacial-interglacial stages. The Last Glacial maximum (LGM); Pleistocene Glacial-Interglacial cycles. Younger Dryas. Paleoclimatology and proxy records. Evidence for past and present climate change. Impacts of climate change on natural and human systems.	15
	Total	**60**

Text Books:

1. Earth's Climate: Past and Future by William F. Rudd

Reference Books:

1. "Climate: A Very Short Introduction" by Mark Maslin
2. "The Earth System" by Lee R. Kump, James F. Kasting, and Robert G. Crane
3. "Global Physical Climatology" by Dennis L. Hartmann
4. "Paleoclimatology: Reconstructing Climates of the Quaternary" by Raymond S. Bradley

Paper VI DSE	ENVIRONMENTAL GEOLOGY L-T-P-C: 4-0-0-4 Credit Units: 4 Scheme of Evaluation: (T)	Subject Code: GEOL164D302

Course Objectives: This course provides an overview of the interactions between Earth's geologic processes and the environment, focusing on the recognition, evaluation, and mitigation of geological hazards and their impact on human societies. Topics include geological hazards such as earthquakes, landslides, floods, and volcanic eruptions, as well as issues related to groundwater contamination, soil degradation, and climate change. The course also explores methods for assessing and managing environmental risks and promoting sustainable development.

Course Outcome: After the completion of course, the students will have ability to:

1. BT1 (Remembering): Recall the fundamental concepts of environmental geology, including geological processes, hazards, and their impact on the environment.
2. BT2 (Understanding): Understand the significance of geological processes in shaping the environment and their role in influencing geological hazards.
3. BT3 (Applying): Apply geological principles to assess and quantify geological hazards, and propose mitigation strategies for environmental challenges.
4. BT4 (Analysing): Analyse case studies of major geological disasters to evaluate their impact on human societies and the environment, and identify factors contributing to environmental degradation.
5. BT5 (Evaluating): Evaluate the effectiveness of mitigation measures for geological hazards, and assess the impact of climate change on environmental systems.

Detailed Syllabus:

Modules	Topics and Course Content	Hours
Unit 1	Definition and scope of environmental geology Historical perspective and evolution of environmental geology Importance of geological processes in shaping the environment Overview of geological hazards: earthquakes, landslides, floods, volcanic eruptions	15
Unit 2	Factors influencing the occurrence and severity of geological hazards Methods for assessing and quantifying geological hazards Case studies of major geological disasters and their impact on human societies Introduction to anthropogenic environmental issues. Global Warming, Eutrophication.	15
Unit 3	Land use changes and their impact on geologic hazards Groundwater contamination: sources, transport mechanisms, and remediation strategies Soil erosion and degradation: causes, consequences, and mitigation measures Impact of climate change on geological hazards and environmental systems Mitigation and adaptation strategies for addressing climate change	15
Unit 4	Principles of sustainable development in the context of environmental geology Balancing economic development with environmental conservation Techniques for sustainable land use planning and natural resource management Landslide: types, causes, remedial measures, identification of susceptible areas. Case studies of successful sustainable development initiatives Environmental impact assessment (EIA) and environmental management systems (EMS)	15
	Total	**60**

Text Books:

1. "Environmental Geology" by Carla W. Montgomery
2. "Principles of Environmental Geology" by G. Tyler Miller Jr. and Scott Spoolman

Reference Books:

1. "Environmental Geology: Handbook of Field Methods and Case Studies" by Klaus Knödel and Gerhard Lange
2. "Geological Hazards: Their Assessment, Avoidance, and Mitigation" by Keith Turner and Roger Clark

Paper VII DSE	GEOSTATISTICS L-T-P-C: 4-0-0-4 Credit Units: 4 Scheme of Evaluation: (T)	Subject Code: GEOL164D303

Course Objectives: To provide students with a comprehensive understanding of geostatistical methods and their applications in analysing spatial data in geological and environmental contexts.

Course Outcome: After the completion of course, the students will have ability to:

1. BT1 (Remembering): Students will be able to recall the fundamental concepts of geostatistics, including spatial variability, random variables, and spatial dependence.
2. BT2 (Understanding): Students will demonstrate an understanding of variogram analysis, including the calculation, interpretation, and modeling of variograms.
3. BT3 (Applying): Students will apply kriging and spatial interpolation techniques to estimate values at unsampled locations and assess the uncertainty associated with these predictions.
4. BT4 (Analyzing): Students will analyze spatial datasets using geostatistical simulation techniques to generate multiple realizations of subsurface properties and assess their uncertainty.
5. BT5 (Evaluating): Students will evaluate the effectiveness of geostatistical methods in spatial decision-making processes, including their ability to incorporate uncertainty into decision support systems.

Detailed Syllabus:

Modules	Topics and Course Content	Hours
Unit 1	Definition and scope of geostatistics Historical development and key contributors Applications of geostatistics in geology, environmental science, mining, and other fields Basic concepts: spatial variability, random variables, and spatial dependence	15
Unit 2	Types of spatial data: point data, areal data, and volumetric data Data exploration and visualization techniques Descriptive statistics for spatial data: mean, variance, covariance, and correlation Spatial autocorrelation and Moran's I statistic	15
Unit 3	Concept of variogram and semivariogram Calculation of experimental variograms from spatial data Interpretation of variograms: nugget effect, sill, and range Modelling variograms: theoretical models and fitting Introduction to kriging: ordinary kriging, simple kriging, and universal kriging Kriging equations and estimation techniques Cross-validation and validation of kriging predictions Comparison with other interpolation methods: inverse distance weighting, spline interpolation	15
Unit 4	Introduction to geostatistical simulation techniques: sequential Gaussian simulation, conditional simulation Simulation algorithms: turning bands, sequential indicator simulation Applications of geostatistical simulation in reservoir modelling, mineral resource estimation, and groundwater modelling Spatial decision support systems Multi-criteria decision analysis using geostatistical methods Incorporating uncertainty into decision-making processes Case studies and practical applications of geostatistics in real-world scenarios	15
	Total	**60**

Text Books:

1. "An Introduction to Applied Geostatistics" by Edward H. Isaaks and R. Mohan Srivastava
2. "Geostatistics for Environmental Scientists" by Richard Webster and Margaret A. Oliver

Reference Books:

1. "Geostatistics: Modeling Spatial Uncertainty" by Jean-Paul Chilès and Pierre Delfiner
2. "Applied Geostatistics with SGeMS: A User's Guide" by Nicolas Remy, Alexandre Boucher, and Roland Froidevaux
3. "Geostatistics: Modeling Spatial Uncertainty" by Clayton V. Deutsch and André G. Journel

Paper VIII DSE	OCEANOGRAPHY AND MARINE GEOLOGY L-T-P-C: 4-0-0-4 Credit Units: 4 Scheme of Evaluation: (T)	Subject Code: GEOL164D304

Course Objectives: Oceanography and Marine geology explore the dynamic processes shaping Earth's oceans and the sediments and structures found on the ocean floor. This course provides an in-depth understanding of marine sediments, coastal processes, deep-sea geology, and the role of the oceans in Earth's climate system. Students will learn about methods for studying the ocean floor, palaeoceanographic reconstructions, marine resources, and environmental issues such as marine pollution.

Course Outcome: After the completion of course, the students will have ability to:

1. Remembering: Recall fundamental concepts in oceanography and marine geology.
2. Understanding: Explain the interdisciplinary nature of marine sciences and interpret oceanographic data.
3. Applying: Utilize analytical methods to interpret marine sedimentation patterns and their implications.
4. Analysing: Analyse marine stratigraphy data to understand palaeoceanographic reconstructions and assess marine mineral resources.
5. Evaluating: Assess the reliability of methods for interpreting marine pollution and evaluate legal frameworks for ocean governance.

Detailed Syllabus:

Modules	Topics and Course Content	Hours
Unit 1	**Introduction to Oceanography and Marine Geology** Definition and scope of oceanography and marine geology. Interdisciplinary nature of the field. Importance of oceans in Earth's systems. Types, sources, composition, and distribution of marine sediments. Coastal processes, sediment transport, and depositional environments.	15
Unit 2	**Exploring the Ocean Floor and Marine Stratigraphy** Methods and instruments for ocean floor exploration. Deep Sea Drilling Project (DSDP), Ocean Drilling Program (ODP), and International Ocean Discovery Program (IODP): objectives and major accomplishments. Sediment distribution in time and space in relation to tectonic models. Marine stratigraphy, correlation, and chronology. Causes and implications of deep-sea hiatuses.	15
Unit 3	**Palaeoceanography and Paleoclimatic Reconstructions** Multidisciplinary approaches to palaeoceanographic and paleoclimatic reconstructions. Impact of oceans on climate change throughout Earth's history. Ocean Anoxic Events (OAEs) and their palaeoceanographic significance. Evolution of oceans through geological time. Role of ocean gateways in global climate control.	15
Unit 4	**Mineral Resources, Marine Pollution, and Legal Frameworks** Mineral resources of the ocean, including polymetallic nodules and marine gas hydrates. Economic potential and environmental implications of marine mineral resources. Marine pollution and its interpretation using micropaleontological and geochemical tracers. Introduction to UNCLOS (United Nations Convention on the Law of the Sea). Exclusive Economic Zones (EEZs) and legal frameworks governing ocean resource management and conservation.	15
	Total	**60**

Text Books:

1. Arnold (2002): Quaternary Environmental Micropaleontology (Ed. Simon K. Haslett), Oxford Univ. Press, New York.
2. Seibold, E. and Berger, W.H. (1982): The Sea Floor, Springer-Verlag.

Reference Books:

1. Shepard, F.P. (1963). Submarine Geology, Harper Row.
2. Komar, P.D. (1976). Beach processes and sedimentation, Prentice Hall.
3. Kennett, J.P. (1982): Laboratory Exercises in Oceanography Marine Geology, Prentice Hall.

Detailed Syllabus Of Semester 4

Paper I Core Course	COAL AND PETROLEUM GEOLOGY L-T-P-C: 4-0-0-4 Credit Units: 4 Scheme of Evaluation: (T)	Subject Code: GEOL164C401

Course Objectives: The course aims to provide students with a comprehensive understanding of the geological processes involved in the formation of coal and petroleum, including their origin, distribution, and characteristics. It also aims to equip students with the necessary analytical skills to assess coal and petroleum resources and understand their environmental implications.

Course Outcome: After the completion of course, the students will have ability to:

1. Knowledge: By the end of the course, students will demonstrate a thorough understanding of the origin and evolution of coal and petroleum, including the geological, climatic, and tectonic factors influencing their formation.
2. Analysis: Students will be able to conduct comprehensive analyses of coal and petroleum samples, including petrographic examination, proximate and ultimate analysis, and characterization of coal macerals and petroleum components.
3. Application: Students will apply their knowledge of coal and petroleum geology to interpret geological features of coal seams and petroleum reservoirs, evaluate the environmental implications of coal usage, and assess the potential for hydrocarbon exploration and production in different geological settings.
4. Critical Thinking: Through case studies and practical exercises, students will develop critical thinking skills to evaluate the diagenetic processes involved in coalification, the migration and accumulation mechanisms of hydrocarbons, and the identification of structural and stratigraphic traps in oil and gas fields.
5. Problem Solving: Students will be able to solve geological problems related to coal and petroleum geology, such as interpreting coal and petroleum source rocks, assessing reservoir properties, and identifying exploration targets for hydrocarbon resources.

Detailed Syllabus:

Modules	Topics and Course Content	Hours
Unit 1	**Origin of coal** Evolutionary development of flora; climatic, paleogeographic and tectonic requirements for origin of peat swamps; sedimentation of coal and coal bearing sequence, geological features of coal seams; age and geographical distribution of coal; diagenesis of peat and coalification, physical and chemical changes of coal associated with progressing coalification; Causes of coalification.	15
Unit 2	**Coal analysis, petrography and distribution** Coal sampling; coal analysis, chemical properties of coal, proximate analysis and ultimate analysis; physical properties of coal; trace elements in coal; coal classification. Petrography of coal: Macroscropic description of coal; microscopic description of coal, macerals classification, properties, origin and application, microlithotypes. Coal as an oil prone source rock; coal and environment Geology of Indian coal deposits: Geological and geographical distribution of Indian coal deposits; geology of coal deposits of Northeast India	15
Unit 3	**Origin of petroleum, Source and reservoir rocks** Basic components of petroleum, Physical properties of oil, Origin of petroleum, theories of organic and inorganic origin. Source rock-definition, nature and type of source rock. Process of diagenesis, catagenesis and metagenesis in the formation of source rocks. Characteristics of reservoir rocks, Clastic reservoir rock, Carbonate reservoir rock, Fractured and miscellaneous reservoir rock, Marine and non-marine reservoir rock; Porosity and permeability of reservoir rocks	15
Unit 4	**Hydrocarbon migration, accumulation and distribution** Hydrocarbon migration from the source rock to the reservoir rock, short distance and long-distance migration, Primary and secondary migration; classification and types of traps: structural, stratigraphic and combination type of traps. Oil and gas fields of Assam, Arunachal Pradesh, Nagaland, Tripura, Mizoram, Cambay basins, Bombay Off-shore and Krishna-Godaveri basins.	15
	Total	**60**

Text Books:

1. Coal, its Formation and Compositions - By Francis, W. (1961), Edward Arnold Pub., London, 806p.
2. Textbook of Coal (Indian Context)- By Chandra D., Singh, R.M., Singh, M.P. (2000), Tara Printing Works, Varanasi.
3. Petroleum Geology (Developments in Petroleum Science), by R.E. Chapman

Reference Books:

1. Stach`s Textbook of Coal Petrology; 1982: Stach, E., Machowsky, Berlin, Stuttgart.
2. Larry Thomas, 2002: Coal Geology, John Wiley.
3. Ward, R.C.,1984: Coal Geology and Coal Technology.
4. Raja Rao, C. S., 1981: Coalfields of India. Bull. Series A, No. 45, volm. I, Coalfields of NE India; GSI.
5. A.I. Levorsen, 1985: Geology of Petroleum; CBS Publishers, New Delhi.

Paper II Core Course	ECONOMIC GEOLOGY L-T-P-C: 4-0-0-4 Credit Units: 4 Scheme of Evaluation: (T)	Subject Code: GEOL164C402

Course Objectives: The course aims to provide students with a comprehensive understanding of economic geology, focusing on the origin, distribution, and exploitation of mineral resources. It will cover various types of ore deposits, their genesis, and their significance in the context of crustal evolution and resource exploration.

Course Outcome: After the completion of course, the students will have ability to:

1. Recall the classification schemes and characteristic features of various ore deposits.
2. Explain the geological processes involved in ore formation and their relationship to crustal evolution.
3. Apply economic geology principles to assess the economic potential of mineral deposits.
4. Analyse the regional geology of India to understand the distribution and genesis of mineral deposits.
5. Evaluate the significance and sustainability of mining operations and resource utilization practices.

Detailed Syllabus:

Modules	Topics and Course Content	Hours
Unit 1	**Ore Genesis** Morphology of ore bodies, textural and structural features of ores, chemical composition of ore, classification of ore deposits. Metallogeny and its relation to crustal evolution. Genesis of ore deposits: Magmatic, Hydrothermal, Metasomatic, pegmatitic, submarine exhalation and volcanogenic.	15
Unit 2	Sedimentary type ore deposits: chemical sedimentary and detrital sedimentary ore deposits. Metamorphic type ore deposits. Metallogeny of Archaean greenstone belts and Proterozoic mobile belts Structural and chemical control of ore deposits.	15
Unit 3	**Indian deposits** Metallic mineral deposits of India, their distribution, mode of occurrence, mineralogy and genesis: iron, manganese, chromium, copper, lead and zinc, gold, silver, aluminium, nickel and molybdenum. Non- metallic mineral deposits: Diamond, limestone and dolomite, magnesite, phosphates, asbestos, gemstone, refractory minerals.	15
Unit 4	**Economic minerals of North-East India:** Clay mineral deposits. Critical, strategic and essential minerals. Radioactive minerals (Uranium and Thorium): their distribution, mode of occurrence, mineralogy and genesis. Uranium mineralization. Distribution of Rare Earth minerals, Ion-absorption REEs. Limestone, Vanadium and Graphite deposits.	15
	Total	**60**

Text Books:

1. Economic Mineral Deposits – M.L. Jensen & A.M.Bateman (3rd Edition); John Wiley and Sons, Inc.
2. An Introduction to Ore Geology, by A.M. Evans.
3. Economic Geology (Economic Mineral Deposits) – U.Prasad; CBS Publishers & Distributors.

Reference Books:

1. Ore Genesis: A Hollistic Approach, by Asoke Mookherjee
2. Hussain, A.M., 1985: The Economics and Economic Geology of the Mineral Industries; Allied Publishers Pvt. Ltd.
3. Ore Geology and Industrial Minerals: An Introduction, by A.M. Evans, 3rd Edition, Blackwell Science.
4. Ore Deposits of India – K.V.G.K. Gokhale & T.C. Rao; Affiliated East-West Press Pvt. Ltd
5. Mineral Resources of India – by D. K. Banerjee.

Paper III Core Course	PRACTICAL - IV L-T-P-C: 0-0-6-3 Credit Units: 3 Scheme of Evaluation: (P)	Subject Code: GEOL164C413

Course Objectives: To provide practical training in the identification, characterization, and analysis of coal, ores, and industrial minerals relevant to geological exploration and resource assessment.

Course Outcome: After the completion of course, the students will have ability to:

1. Apply basic principles of coal and ore identification to differentiate between different types of coal and lithotypes.
2. Perform proximate analysis of coal samples accurately, demonstrating understanding of the methods and their significance in coal characterization (BT Level 2).
3. Analyze coal samples using petrographic microscopy, interpreting internal structures and compositions to infer depositional environments and coal quality (BT Level 3).
4. Interpret structure contour, isopay, and isopach maps proficiently to estimate coal reserves and understand the geological setting of coal deposits (BT Level 3).
5. Demonstrate proficiency in recognizing and classifying various textures and structures in ore hand specimens, applying knowledge of ore genesis (BT Level 2).
6. Identify and describe the characteristics of opaque metallic minerals under an ore microscope, relating their mineralogy to industrial applications (BT Level 3).

Detailed Syllabus:

Modules	Topics and Course Content	Hours
Unit 1	Study of coal in hand specimen. Identification of different types of coal, lithotypes. Proximate analysis of coal- determination of moisture, ash and volatile matter.	15
Unit 2	Petrography of coal- polished block study under microscope. Structure contour, isopay and isopach maps. Interpretation of structure contour maps; Reserve estimation and calculation.	15
Unit 3	Study of common textures and structures in ore hand specimens. Identification of industrial minerals in hand specimen for cement, steel, refractory, glass and ceramic industry.	15
Unit 4	Identification of opaque metallic minerals under ore microscope - galena, sphalerite, pyrite, pyrrhotite, chalcopyrite, arsenopyrite, magnetite, haematite, ilmenite, goethite, chromite, cassiterite, covellite, cobaltite, niccolite.	15
	Total	**60**

Text Books:

1. Ore Geology and Industrial Minerals: An Introduction, by A.M. Evans, 3rd Edition, Blackwell Science.
2. Textbook of Coal (Indian Context)- By Chandra D., Singh, R.M., Singh, M.P. (2000), Tara Printing Works, Varanasi.

Reference Books:

1. An Introduction to Ore Geology, by A.M. Evans.
2. Coal and Organic Petrology - By Singh, M. P. (1998), 1st Ed., Hindustan Pub Corp (New Delhi).

Paper IV Core Course	MAJOR PROJECT L-T-P-C: 4-0-0-4 Credit Units: 4 Scheme of Evaluation: (P)	Subject Code: GEOL164C424

Course Objectives: To provide students with hands-on experience in conducting geological research projects, including fieldwork, sample collection, laboratory analysis, and interpretation, or in utilizing remote sensing and GIS techniques for environmental impact assessment (EIA) and natural disaster management.

Course Outcome: After the completion of course, the students will have ability to:

1. BT Level 1: Apply basic geological knowledge and fieldwork techniques to collect representative samples from a specific geological terrane or to gather remote sensing and GIS data for EIA and disaster management projects.
2. BT Level 2: Formulate research problems related to the collected samples or remote sensing data and develop appropriate models or methodologies to address them.
3. BT Level 3: Conduct laboratory analyses of collected samples or process remote sensing data using GIS techniques, demonstrating proficiency in data interpretation and analysis.
4. BT Level 4: Synthesize findings from fieldwork, laboratory analyses, or remote sensing/GIS data to draw meaningful conclusions and propose solutions or recommendations for geological or environmental challenges.
5. BT Level 5: Communicate research findings effectively through written reports, presentations, and discussions, demonstrating critical thinking skills and the ability to integrate theoretical knowledge with practical applications in geological research or environmental management.

Detailed Syllabus:

Modules	Topics and Course Content	Hours
Unit 1	Field Work in a specific geological terrane: collection of representative samples, Formulation of research problem and prepare a model to address it, carry out Lab analysis and interpretation to address the problem OR Carry out minor remote sensing and GIS based projects related to EIA and/or natural disaster management.	60
	Total	**60**

Paper V DSE	ENGINEERING GEOLOGY L-T-P-C: 3-0-2-4 Credit Units: 4 Scheme of Evaluation: (T+P)	Subject Code: GEOL164D441

Course Objectives: To provide students with a comprehensive understanding of the engineering properties of soil and rocks, including their classification, strength, deformation characteristics, and their relevance to construction and infrastructure projects such as dams, reservoirs, and tunnels.

Course Outcome: After the completion of course, the students will have ability to:

1. Recall engineering properties of soil and rock for construction applications.
2. Understand geological factors influencing dam, reservoir, and tunnel construction.
3. Apply soil and rock classification systems to assess site suitability and construction methods.
4. Analyse forces on dams, reservoirs, and tunnels to identify stability issues and propose solutions.
5. Develop strategies for treating weak zones in dam foundations and improving rock mass properties.

Detailed Syllabus:

Modules	Topics and Course Content	Hours
Unit 1	Soil: Engineering properties of soil, definition of unit weight, specific gravity, porosity and void ratio, water content, degree of saturation. Elementary knowledge of compressibility, consolidation, compaction and shear strength. Importance of clay mineralogy, Atterberg units and soil classification, soil and engineering structures.	11
Unit 2	Rocks: Strength of rocks, hardness, elasticity, porosity, specific gravity. Rock masses: discontinuity in rock masses, weathering of rock masses, rock mass deformation. Engineering classification of rocks, classification of rock masses in the field according to R.Q.D. (rock quality designation), Bieniswaki and Q-system. Quarrying with special reference to rock blasting. Rock as construction materials. Improvement of rock mass properties - grouting, bolting and anchoring.	11
Unit 3	Dams and Reservoirs: Classification and parts of dams; geological and geophysical investigation of dam sites, foundation and abutment problems, forces acting on them; Seepage, bearing strength and rebound problem; Treatment of weak zones - grouting. Investigation of reservoir area, control of leakage and silting.	11
Unit 4	Geotechnical investigation for tunnel construction: General geotechnical consideration for site locations, geology of the area, importance of structural discontinuities on tunnel and bridge alignment, groundwater conditions, rock stress condition. Methods of tunnel excavation.	12
List of Practical	Computation of reservoir area, catchment area, reservoir capacity and reservoir life. Merits, demerits & remedial measures based upon geological cross sections of project sites. Computation of Index properties of rocks. Computation of RQD, RSR, RMR and 'Q' Determine shear strength parameters of rocks and soils. Determine Poisson ration, modulus of elasticity and Point Load Index and uniaxial compressive strength of rocks. Carryout numerical and graphical analysis of stability problems.	30
	Total	**75**

Text Books:

1. Krynin, D.P. and Judd W.R. 1957. Principles of Engineering Geology and Geotechnique, McGraw Hill (CBS Publ).
2. Johnson, R.B. and De Graf, J.V. 1988. Principles of Engineering Geology, John Wiley.
3. Goodman, R.E., 1993. Engineering Geology: Rock in Engineering constructions. John Wiley & Sons, N.Y.

Reference Books:

1. Waltham, T., 2009. Foundations of Engineering Geology (3rd Edn.) Taylor & Francis.
2. Bell, F.G-, 2006. Basic Environmental and Engineering Geology Whittles Publishing.
3. Bell, F.G, 2007. Engineering Geology, Butterworth-Heineman
4. Singh, B. & Goel, R.K.: Rock Mass Classification; A Practical Approach in Civil Engineering; Elsevier.
5. Gokhale, K.V.G.K., 1999: Principles of Engineering Geology; B.S. Publications.

Paper VI DSE	EXPLORATION AND MINING GEOLOGY L-T-P-C: 4-0-0-4 Credit Units: 4 Scheme of Evaluation: (T)	Subject Code: GEOL164D402

Course Objectives: To provide students with a comprehensive understanding of exploration and mining geology principles, methods, and techniques essential for the discovery and extraction of mineral resources.

Course Outcome: After the completion of course, the students will have ability to:

1. Recall and explain the physical properties of rocks and their significance in exploration and mining activities.
2. Apply various drilling techniques and interpret well logs for subsurface characterization.
3. Analyse and evaluate different exploration methods, including geophysical techniques, for resource identification.
4. Assess the suitability of mineral prospecting and exploration methods for different geological settings.
5. Evaluate the environmental impact of mining activities and propose sustainable solutions.

Detailed Syllabus:

Modules	Topics and Course Content	Hours
Unit 1	**Physical Properties of Rocks and Drilling Techniques** Physical properties of rocks: density, susceptibility, resistivity, and elastic wave velocities. Factors influencing rock properties and their importance in exploration and mining. Overview of drilling techniques: parameters, types, and applications. Duties and responsibilities of well site geologists in exploration drilling operations.	15
Unit 2	**Well Logging and Exploration Methods** Basics of well logging techniques and their significance in exploration. Various types of well logs including SP, GR, resistivity, neutron, density, and sonic logs. Principles and interpretation of well logs for subsurface characterization. Introduction to geological, geochemical, and geophysical exploration methods for hydrocarbon and mineral resources.	15
Unit 3	**Geophysical Exploration Techniques** Principles of seismic survey methods: reflection and refraction techniques. Gravity and magnetic survey methods for subsurface mapping and interpretation. Electrical methods: resistivity and induced polarization surveys. Seismic, gravity, magnetic, and resistivity surveys for hydrocarbon and mineral exploration.	15
Unit 4	**Mineral Prospecting, Exploration, and Mining** Methods of mineral prospecting and exploration: surface and subsurface techniques. Overview of mining methods for metallic and non-metallic minerals, including coal and alluvial mining. Quarrying operations with a focus on rock blasting techniques. Sustainable practices and environmental considerations in mineral exploration and mining.	15
	Total	**60**

Text Books:

1. Geological Methods in Mineral Exploration and Mining – by Roger Marjoribanks; Springer, 2010.

Reference Books:

1. Introductory Mining Engineering, 2nd Edition – by Howard L. Hartman and Jan M. Mutmansky

Paper VII DSE	BASIN ANALYSIS L-T-P-C: 4-0-0-4 Credit Units: 4 Scheme of Evaluation: (T)	Subject Code: GEOL164D403

Course Objectives: To provide students with a comprehensive understanding of basin analysis, including the geodynamic processes shaping sedimentary basins, the tools and methods used in their analysis, and the significance of basin stratigraphy in petroleum exploration.

Course Outcome: After the completion of course, the students will have ability to:

1. Understand the concept of basin analysis and its relevance in the study of sedimentary basins within the framework of plate tectonics.
2. Identify and apply various tools and methods utilized in basin analysis, including surface and subsurface investigation techniques and the interpretation of petrophysical logs.
3. Analyse sedimentation processes and basin stratigraphy, including the recognition of stratigraphic cycles and their driving mechanisms.
4. Evaluate the principles and applications of sequence stratigraphy in understanding depositional systems and their relevance to petroleum exploration.
5. Apply the knowledge gained in basin analysis to assess the petroleum charge system, identify reservoirs, and evaluate trapping mechanisms in hydrocarbon exploration.

Detailed Syllabus:

Modules	Topics and Course Content	Hours
Unit 1	**Introduction** Basin analysis - the integrated study of sedimentary basins as geodynamic entities Plate tectonic framework and basin formation. Classification and characteristics of the sedimentary basins.	15
Unit 2	**Tools and methods of basin analysis** Surface and subsurface investigation methods. Petrophysical logs, preparation of structure contour, isopach, lithofacies, clastic ratio and paleocurrent maps. Petrographic and geochemical analysis. Geophysical techniques: seismic reflection, gravity, and magnetic surveys.	15
Unit 3	**Sedimentation and Basin stratigraphy** Terrestrial sediments and solute yields, measurements of erosion rates, functioning of sediment routing systems. Sedimentary environments and facies analysis. Stratigraphic sequences and cycles – definition and recognition, driving mechanism for stratigraphic pattern, depositional systems, relation of depositional style to basin setting. Sequence stratigraphy principles and applications. Basin subsidence, thermal history, and sedimentary basin evolution.	15
Unit 4	**Petroleum Exploration and Basin Analysis** Petroleum system components and their relationship to basin architecture. Play concept and hydrocarbon prospectivity assessment, the petroleum charge system, reservoir and trap. System tracts and sequences in siliciclastic and carbonate deposits, sequence stratigraphy and petroleum exploration.	15
	Total	**60**

Text Books:

1. Basin Analysis – Principles and Applications by Philip A. Allen and John R. Allen, Blackwell Publishing Ltd., 2nd Edition, 2005
2. Sequence Stratigraphy – By Dominic Emery and Keith Mayers, 1996, Blackwell Science, 269pp

Reference Books:

1. Paleocurrents and Basin Analysis, by Potter, P. E., and Pettijohn, E J., 1977. Springer-Verlag, Berlin. 425pp.
2. Principles of Sequence Startigraphy – by Octavian Catuneanu, ELSIVIER Publishers
3. Sedimentology and Stratigraphy - Nichols, G. (2009), Second Edition. Wiley Blackwell.

Paper VIII DSE	HYDROGEOLOGY L-T-P-C: 3-0-2-4 Credit Units: 4 Scheme of Evaluation: (T+P)	Subject Code: GEOL164D444

Course Objectives: The course aims to impart a comprehensive understanding of hydrogeological principles and practices. Students will learn about groundwater occurrence, movement, and quality assessment, applying concepts such as Darcy's law and aquifer properties to explore and manage groundwater resources effectively. They will gain proficiency in evaluating groundwater chemistry for diverse uses and recognizing its occurrence in different geological settings. Additionally, they will acquire skills in surface and subsurface investigation techniques for groundwater assessment and develop the ability to estimate safe yield and manage groundwater resources sustainably.

Course Outcome: After the completion of course, the students will have ability to:

1. Knowledge: Understand hydrogeological fundamentals, including the hydrologic cycle and groundwater properties.
2. Comprehension: Interpret hydrographs and groundwater levels, and grasp principles of well hydraulics.
3. Application: Apply Darcy's law and aquifer testing to assess groundwater resources.
4. Analysis: Analyse groundwater dynamics, including saltwater intrusion risks.
5. Synthesis: Develop groundwater management strategies considering sustainability.

Detailed Syllabus:

Modules	Topics and Course Content	Hours
Unit 1	Definition of hydrology and hydrogeology. Hydrologic cycle - precipitation and run-off. Analysis of hydrograph, base flow separation, factors governing shape of hydrograph. Occurrence of ground water: openings in rocks, types of openings. Porosity and void ratio. Definition of aquifers, aquiclude, aquitard and aquifuge. Subsurface distribution of water, vadose water and ground water. Specific yield and retention. Estimation of specific yield. Aquifers and their classification. Ground water recharging.	11
Unit 2	Ground water movement, Darcy's law - its range of validity and limitation. Hydraulic conductivity, permeability, effective stress, specific storage, transmissivity and storativity. Physical and chemical characteristics of ground water. Chemical classification of ground water. Quality criteria for drinking, irrigation, and industrial uses. Occurrence of ground water in different rock types- igneous, metamorphic, sedimentary and non-indurated sediments. Ground water provinces of India.	11
Unit 3	Ground water levels and fluctuations - secular, seasonal and diurnal variation. Factors governing ground water level fluctuation. Fresh and salt water relationship in coastal area. Ghyben-Herzberg principle. Prevention and control of sea water Intrusion. Basic principles of well hydraulics- drawdown and cone of depression. Steady state and nonsteady state flow. Equation for pumping tests. Step drawdown test and aquifer performance test. Analysis of pumping test data.	11
Unit 4	Surface and subsurface investigation of ground water. Hydrogeological mapping. Systematic and reappraisal survey by well inventory method. Geophysical methods of exploration - gravity, magnetic, electrical and seismic methods. S.P., resistivity, gamma and neutron gamma logging. Ground water exploration by test drilling. Ground water assessment, development and management. Concept of ground water reserve - static and dynamic reserve. Safe yield and overdraft. Factors governing safe yield. Equation of hydrologic equilibrium. Ground water budgeting.	12
List of Practical	Preparation and interpretation of water level contour maps and depth to water level maps. Study, preparation and analysis of hydrographs for differing groundwater conditions. Water potential zones of India (map study). Graphical representation of chemical quality data and water classification (C-S and Trilinear diagrams) Simple numerical problems related to: determination of permeability in field and laboratory, Groundwater flow, Well hydraulics etc.	30
	Total	**75**

Text Books:

1. Todd, D. K. 2006. Groundwater hydrology, 2nd Ed., John Wiley & Sons, N.Y.
2. Raghunath, H.M.,1983: Ground Water; Wiley Eastern Ltd., New Delhi.

Reference Books:

1. Davis, S. N. and De Weist, R.J.M. 1966. Hydrogeology, John Wiley & Sons Inc., N.Y.
2. Karanth K.R., 1987, Groundwater: Assessment, Development and management, Tata McGraw-Hill Pub. Co. Ltd.
3. Tolman, C. F.: Ground Water; McGraw-Hill Book Co., New York.
4. Walton, W. C.,1970: Ground Water Resource Evaluation; McGraw-Hill Inc.