ROYAL GLOBAL UNIVERSITY
GUWAHATI

ROYAL SCHOOL OF ENVIROMENTAL & EARTH SCIENCES (RSEES)

DEPARTMENT OF GEOLOGY

COURSE STRUCTURE & SYLLABUS

M.Sc. Geology

w.e.f.-2021-22

Table of Contents

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

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	Geomorphology	3	1	0	4	4
3	GEOL164C103	Mineralogy & 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	GEOL164D101	Climatology and Oceanography	3	1	0	4	4
8	GEOL164D102	Evolution of life through time	3	1	0	4	4
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 & Metamorphic Petrology	3	1	0	4	4
2	GEOL164C202	Sedimentology	3	1	0	4	4
3	GEOL164C203	Geochemistry And Isotope 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
		Ability Enhancement Elective Courses (Any one)					
7		AEEC / SEC-1*	2	0	0	2	2
		Discipline Specific Elective (DSE): Any One To Be Selected					
8	GEOL164D201	Earth and Climate	3	1	0	4	4
9	GEOL164D202	Quaternary Geology	3	1	0	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	Principles of Stratigraphy & Indian Stratigraphy	3	1	0	4	4
2	GEOL164C302	Palaeontology	3	1	0	4	4
3	GEOL164C313	Practical – III	0	0	6	3	6
4	GEOL164C324	Minor Project	0	0	4	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	Hydrogeology	3	1	0	4	4
8	GEOL164D302	Remote Sensing and GIS	3	1	0	4	4
9	GEOL164D303	Research Methodology & 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	Fuel Geology	3	1	0	4	4
2	GEOL164C402	Economic & Exploration Geology	3	1	0	4	4
3	GEOL164C413	Practical – IV	0	0	6	3	6
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	GEOL164D401	Engineering Geology	3	1	0	4	4
7	GEOL164D402	Environmental Geology, Mapping & Surveying	3	1	0	4	4
8	GEOL164D403	Basin Analysis	3	1	0	4	4
9	GEOL164D404	Geophysical Exploration and Seismology	3	1	0	4	4
TOTAL CREDITS (C) = 28 AND TOTAL CONTACT PERIODS (TCP) = 31							

M. Sc. Course in Geology: Semester-I

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

Course Objectives: The main objectives of this programme are to understand the lithological and structural mapping of a terrain and correlate with available deformation sequence and also to identify basic structural elements and to interpret the complex geometry in crustal terrain as well as investigate the deformation structures within rocks from mesoscopic to microscopic scale.

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

1. Describe the behaviour of rocks under different stress and strain regimes.
2. Explain various processes involved in the formation of the topographical features and classify the structures on the basis of different parameters.
3. Compare between micro-, meso- and macro-structures.

Detailed Syllabus:

Modules	Topics and Course Content	Periods
Unit 1	**Introduction to rock mechanics** Definition of stress. Types of stress (hydrostatic, uniaxial, compressional, tensional, triaxial, deviatoric, differential and effective stress). Sign convention of shear stress; Mohr stress circle; Determination of direction of shearing stress. Definition of strain. Types of strain; 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.	12
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.	12
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.	12
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.	12
	Total	**48**

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) Ramsay, J.G., 1967: Folding and Fracturing of Rocks; McGraw-Hill, New York.
3) Ramsay, J.G. & Huber, M.I., 1983: The Techniques of Modern Structural Geology, Vol. I, Strain Analysis; Academic Press; pp1-308.
4) Pollard, D.D.,2005: Fundamentals of Structural Geology; Cambridge Univ. Press.

Paper II Core Course	GEOMORPHOLOGY			Subject Code:
	L-T-P-C: 4-0-0-4	Credit Units: 4	Scheme of Evaluation: (T)	GEOL164C102

Course Objectives: The objective of this course is to study the landforms and landform evolution. This course would help in understanding the basic concept of time scales of landscape analysis, to know the various parameters on geomorphic systems, and also to understand the applicability of Fluvial geomorphic system and Tectonic geomorphology.

Course Outcome: By the end of this course the students will be able to:
1. Understand the landforms as the unit of systematic analysis.
2. Explain the relationship between geometric perspective and its dimensions in Geology with the physical surrounding.
3. Illustrate and explain geomorphology of India at different timescales with respect to tectonic geomorphology.

Detailed Syllabus:

Modules	Topics and Course Content	Periods
Unit 1	**Geomorphic processes and landscape analysis** Geomorphic concepts; Landforms: Role of lithology, peneplanation, endogenous and exogenous forces, denudational processes. Time scales of landscape analysis, landform as the unit of systematic analysis, energy flow in geomorphic systems; models of landform evolution, consideration of structure, process and time. Mass wasting – mechanism and classification, hill slope morphology and processes.	12
Unit 2	**Geomorphic systems and associated landforms** 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, wind generated waves and tsunamis, coastal landforms- erosional and depositional.	12
Unit 3	**Landform development and Tectonic geomorphology** Major processes and associated landforms of aeolian, glacial and periglacial processes; Karst landscapes. Tectonic geomorphology: geomorphic markers, geomorphic indices of active tectonics, active tectonics and alluvial rivers; climatic and tectonic factors and rejuvenation of landforms.	12
Unit 4	**Geomorphology at different timescales and geomorphology of India** Holocene deformation and landscape; Deformation and Geomorphology at intermediate timescale; Pliocene-Pleistocene and Pleistocene-Holocene boundary problems. Tectonic geomorphology at Late Cenozoic time scales. Quaternary climate: the uplift-climate connection, glacial/interglacial cycles, Milankovitch hypothesis, Quaternary climate and sea level changes, climate records in sediments. Geomorphic features and zones of India. Extra-terrestrial landforms.	12
	Total	**48**

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.
4) Spark, B.W.,1986: Geomorphology; Longman Scientific & Technical

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

Course Objectives:
Mineral's identification is necessary to study and understand about the rocks as well as different structures, textures, associations and origins. As the minerals are crystalline in nature, so it is also important to have in-depth knowledge of crystallography.

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

1. Describe the basic chemistry involved in mineral formation and structures.
2. Identify and classify common rock forming minerals.
3. Identify the most common elements in Earth's crust and their order of abundance.

Detailed Syllabus:

Modules	Topics and Course Content	Periods
Unit 1	**Crystallography** Periodicity and symmetry-concept of space lattice. 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.	12
Unit 2	**Chemical classification of minerals and structure** 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.	12
Unit 3	**Transformation processes and optical properties of minerals** 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.	12
Unit 4	**X-ray crystallography and mineral characterization** Principles of X-ray crystallography and Bragg's equation. Introduction to diffraction and imaging, X-ray diffraction, mineral identification by X- ray diffractometry, Reciprocal lattice, Crystal field theory. Impact of X-ray crystallography. Defect in minerals: Point Defects, Line defects and Planar defects. Application of SEM, TEM and EPMA in mineral characterization.	12
	Total	**48**

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			Subject Code:
	L-T-P-C: 0-0-3-3	Credit Units: 3	Scheme of Evaluation: (P)	GEOL164C114

Course Objectives: The objective of this course is to develop skills on plotting the structural data on stereographic projections, Reading and interpretation of topographical maps, weather maps, Drawing and interpretation of graphs and preparation of qualitative and quantitative thematic maps, understand the mineral science, its formation and characteristics.

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

- Construct profile sections and interpret geological maps of different complexities
- Plot mesoscopic structural data on stereographic net and interpret topographic maps for different landforms.
- Identify the silicate minerals under microscope and determine the different physical as well as the optical properties.

Detailed Syllabus:

Modules	Topics and Course Content	Periods
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, if necessary. Significance of contour diagrams. Construction of dip isogons in folds. Structural problems related to borehole data.	12
Unit 2	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
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.	12
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.	12
	Total	**48**

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.

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.

Paper: DSE 1 Discipline Specific Elective	CLIMATOLOGY AND OCEANOGRAPHY			Subject Code:
	L-T-P-C: 4-0-0-4	Credit Units: 4	Scheme of Evaluation: (T)	GEOL164D101

Course Objectives:

The primary goal of this paper is to provide information regarding the atmospheric conditions, resultant weather and climates and its evolution with time and it's impacts on the planet earth. Morever, it deals with the ocean's ancient history, its current condition and the future, ocean floor topography and the available marine resources.

Course Outcome:

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

1. Understand the various weather and climatic conditions and its impact on a global scale.
2. Classify the important climatic aspects and unravel the mysteries of the past and the myth of the future.
3. Understand and analyse the oceanic processes and the availability of marine resources.

Detailed Syllabus:

Modules	Topics and Course Content	Periods
Unit 1	**Fundamentals of Climatology** The field of Climatology and its subdivisions; The structure and composition of Earth's atmosphere; Elements of weather and climate; Factors affecting the distribution of temperature, Vertical and horizontal and seasonal distribution of temperature; Insolation and heat budget; Temperature inversion; Pressure systems, Air circulation and Coriolis effect.	12
Unit 2	**Elements and factors of Weather and Climate** Cyclones: Tropical Cyclones, Temperate Cyclones; Anticyclones; Monsoon - Origin and Mechanism; Jet Streams; Atmospheric Moisture: Evaporation, Humidity, Condensation, Fog and Clouds, Precipitation Types, Stability and Instability; Climatic Regions, Climate change and global warming.	12
Unit 3	**Fundamentals of Oceanography** Definition and scope of oceanography; branches of Oceanography. Age and origin of oceans; Ocean floor profile- continental shelf, slope, submarine canyons, continental rise, abyssal plains; Approaches to paleooceanographic reconstructions. Distribution of temperature, salinity and density of oceans. Hypsometry and Bathymetry. Coral reefs-origin and distribution.	12
Unit 4	**Ocean circulation, Sediments and resources of Ocean** Oceanic water movements: Waves, Tsunamis and Tides. Surface ocean currents of Atlantic, Pacific and Indian Oceans; Thermohaline circulation; effects of ocean currents on global climate; El nino and La nina. Concept of Eustasy. Marine sediments; food and mineral resources of the sea.	12
	Total	**48**

Text Books:

1) Meteorology Today: An Introduction to Weather, Climate and the Environment – C. Donald Ahrens (13th Ed. 2020).
2) Essentials of Oceanography: Alan P. Trujillo & Harold V. Thurman (12th Edition, 2016).
3) Critchfield, H.J., 1987: General Climatology, Prentice-Hall of India, New Delhi

Reference Books:

1) Atmosphere, Weather and Climate - Roger G. Barry and Richard J. Chorley, (19th edition 2010) by Routledge, Taylor & Francis Group
2) Introduction to physical oceanography - Robert H Stewart (2006 edition)
3) Oceanography - A view of the earth by M. G. Gross (1977).
4) Thurman H.V.,1996: Essentials of Oceanography, Prentice-Hall, New Jersey

Paper: DSE 2 Discipline Specific Elective	EVOLUTION OF LIFE THROUGH TIME			Subject Code:
	L-T-P-C: 4-0-0-4	Credit Units: 4	Scheme of Evaluation: (T)	GEOL164D102

Course Objectives: The objective of this programme is to understand the various factors responsible for the origin of life and its sustenance and the evolutionary trend of organisms and the controlling factors for the evolution throughout the Geological history.

Course Outcome:

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

1. Describe the various factors responsible for the beginning of life on earth and different processes of fossilisation.
2. Illustrate the changes in the parameters of climate through time and its effect on organic evolution.
3. Explain the various geodynamic processes and their effect on distribution and evolution of organisms.

Detailed Syllabus:

Modules	Topics and Course Content	Periods
Unit 1	**Life through ages and Geobiology** Fossils and chemical remain of ancient life. Geological Time Scale with emphasis on major bio-events. Fossilization processes and modes of fossil preservation. Exceptional preservation sites- age and fauna Biosphere as a system, processes and products Biogeochemical cycles. Abundance and diversity of microbes, extremophiles. Microbes-mineral interactions, microbial mats	12
Unit 2	**Origin of life** Possible life sustaining sites in the solar system, life sustaining elements and isotope records Archean life: Earth's oldest life, Transition from Archean to Proterozoic, the oxygen revolution and radiation of life. Precambrian macrofossils – The garden of Ediacara. The Snow Ball Earth Hypothesis.	12
Unit 3	**Paleozoic and Mesozoic Life** The Cambrian Explosion. Biomineralization and skeletalization, Origin of vertebrates and radiation of fishes, Origin of tetrapods - Life out of water, Early land plants and impact of land vegetation. Life after the largest (P/T) mass extinction, life in the Jurassic seas Origin of mammals, Rise and fall of dinosaurs, Origin of birds; and spread of flowering plants.	12
Unit 4	**Cenozoic Life** Aftermath of end Cretaceous mass extinction – radiation of placental mammals. Evolution of modern grasslands and co-evolution of hoofed grazers. Rise of modern plants and vegetation. Back to water – Evolution of Whales. The age of humans: Hominid dispersals and climate setting, Climate Change during the Phanerozoic - continental break-ups and collisions. Plate tectonics and its effects on climate and life, Effects of life on climate and geology	12
	Total	**48**

Text Books:

1) Stanley, S.M., 2008 Earth System History
2) Jonathan I. Lumine W.H.Freeman Earth-Evolution of a Habitable World, Cambridge University Press.

Reference Books:

1) Canfield, D.E. & Konhauser, K.O., 2012 Fundamentals of Geobiology Blackwell
2) Cowen, R., 2000 History of Life, Blackwell
3) Jain, P.C., Ananthraman; M.S.: Palaeontology (Palaeobiology), Evolution and Animal Distribution.

M. Sc. Course in Geology: Semester-II

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

Course Objectives:
The central goal of this paper is to provide understandings on the compositional diversity of magma, magmatic rocks and its relation with the origin of the Earth and its global tectonics. It also furnishes information on the metamorphic processes, textures and structures and its response to changing physical conditions.

Course Outcome:
After the completion of course, the students will be able to:

1. Identify spatial mineral reactions in reconstructing PTt path of metamorphism.
2. Understand the various mineral reactions and their application in geothermobarometry and petrogenetic grid.
3. Apply the principles of phase equilibria in studying igneous systems.
4. Analyse different rocks on the basis of chemical characteristics and comment on their origin.

Detailed Syllabus:

Modules	Topics and Course Content	Periods
Unit 1	**Magma generation, mantle melting, geochemical characteristics** Magma, their generation in the crust and mantle. Present day magmatism and global tectonic processes. Magmatic process- concept and models. Quantitative approach to partial melting, fractional crystallization and source characterization. Geochemical characteristics of igneous rocks: chemical analyses, major, trace and isotopic composition of igneous rocks in the context of petrogenesis. Compatible and incompatible elements. Geochemical criteria for the identification of palaeo-tectonic settings of igneous rocks.	12
Unit 2	**Crystal-melt equilibria, classification, petrotectonic associations** Phase equilibria study in igneous system: binary, ternary and quaternary silicate system with reference to petrogenesis. Role of volatile H_2O and CO_2 in petrogenesis. IUGS Classification schemes of Igneous rocks. Plume magmatism and hot spots. Concepts of mantle metasomatism. 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 rocks.	12
Unit 3	**Fundamentals of metamorphism** Metamorphism: Nature and scope; Factors controlling metamorphism (T, P and fluids); Types of metamorphism: Regional, contact, dynamic, hydrothermal, impact, retrograde and ocean floor metamorphism. Regional orogenic metamorphic textures; other regional metamorphic textures; replacement textures and reaction rim and their role in reconstructing P-T-t history of metamorphism. Sources of plate tectonic metamorphic heat for crustal metamorphism, geothermal gradient, crustal thickening processes and P-T-t path of metamorphism.	12
Unit 4	**Facies assemblages, metamorphic reactions, Geothermobarometry** Facies, mineral assemblages and their graphical representation: ACF, AKF and AFM and compositional phase diagrams. Chemical equilibrium in metamorphism, solid-solid reaction, continuous and discontinuous metamorphic reaction. Cation exchange partitioning relationship among coexisting phases, application of geothermometry and geobarometry, and petrogenetic grid. Regional metamorphism of pelitic and basic metamorphic assemblages.	12
	Total	**48**

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.
4) Frost, B.R., Frost, C.D., 2014. Essentials of Igneous and Metamorphic Petrology. Cambridge University Press.

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

Course Objectives: The objective of the course is to interpret textures and structures of sedimentary rocks; critically analyse the physical and chemical parameters of sedimentary environments and classify them and interpret provenance, sedimentary basins and tectonic control.

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

1. Understand diagenetic environments and classify the sedimentary rocks genetically.
2. Analyse the processes of deposition of various types of sedimentary rocks.
3. Correlate sedimentation with tectonics and classify sedimentary basins.

Detailed Syllabus:

Modules	Topics and Course Content	Periods
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.	12
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.	12
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).	12
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.	12
	Total	**48**

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.
4) Selley, R. C. ,2000: Applied Sedimentology, 2nd edn., Academic Press.
5) Reading, H.G.(Edt.), 1996: Sedimentary Environments and Facies; Blackwell Science.
6) Carver, R.C.(Edt.),1971: Procedures in Sedimentary Petrology.

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

Course Objectives:
The course aims to give an introduction in how chemical principles are used to explain the mechanisms that control the large geological systems such as the Earth's mantle, crust, ocean and atmosphere, and the formation of the solar system. It also will give an overview of theory and applications of stable and radiogenic isotope geochemistry including the use of isotopes.

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

- Understand the behaviour of elements in a geochemical context, relate this knowledge to how elements redistribute within Earth and learn to interpret and explain interactions between Earth Reservoirs.
- Understand and interpret the major processes that form and modify the Earth's crust and mantle.
- Use isotopes to trace geological processes and age date specific events.

Detailed Syllabus:

Modules	Topics and Course Content	Periods
Unit 1	**Introduction to Geochemical System of Earth** Origin, abundance, geochemical classification and distribution of elements. Chemical differentiation of earth. 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).	12
Unit 2	**Geochemical cycle, Geochemical instruments, Meteorite study** Geochemical cycle; Concept of biogeochemical cycle; 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.	12
Unit 3	**Principles and application of radionuclides** 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.	12
Unit 4	**Stable isotope geochemistry** 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.	12
	Total	**48**

Text Books:

1) Geochemistry – W. M. White, (2013), Wiley-Blackwell Publishing.
2) Introduction to Geochemistry: Principles and Applications - Kula C. Misra, (2012), Wiley-Blackwell Publishing.
3) 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) Essentials of geochemistry - Walther, J. V. (2009), Jones & Bartlett Publishers.
3) Geochemistry: An Introduction - Albarède, F. (2003), Cambridge University Press.
4) Hawkes, H.E. & Webb, J.S.: Geochemistry in Mineral Exploration.
5) Levinson, A.A., 1974: Introduction to Exploration Geochemistry. Applied Publishers, Calgary.
6) Guntur Faur,1986(2nd edn.: Principles of Isotope Geology.
7) Claude Allegre, 2008: Isotope Geology.
8) Allan P. Dickin, 1995: Radiogenic Isotope Geology.

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

Course Objectives:
This paper will enable the students to identify the igneous, metamorphic rocks and sedimentary rocks in thin sections and hand specimens and interpret the petrogenesis of these rocks through their textures and structures.

Course Outcome: After the completion of the course, the students will have ability to:
1. Identify and differentiate between igneous, metamorphic rocks and sedimentary rocks and their textures.
2. Interpret class and origin of the rocks by solving CIPW norms and variation diagrams.
3. Apply and perform mineral formula calculations
4. Solve and evaluate numerical exercises related to X-ray crystallography.

Detailed Syllabus:

Modules	Topics and Course Content	Periods
Unit 1	Hand specimen study for determination of physical characteristics of Igneous rocks. Thin section study for determination of mineralogy and texture of Igneous rocks. Variation diagrams. Use of chemical analysis in determination of palaeotetonic settings of igneous rocks.	12
Unit 2	Hand specimen and thin section study of major Indian metamorphic rocks. Plots of mineral and rock composition in ACF, AKF and AFM diagram. Study of metamorphic texture.	12
Unit 3	Thin section petrography of sandstones and limestone. Separation of heavy mineral and their study under microscope. Granulometric analysis and their interpretation. Study of hand specimens of different types of sedimentary structures. Preparation of litholog from vertical section. Paleocurrent analysis: field measurement procedures and laboratory techniques.	12
Unit 4	Mineral formula calculations. Preparation of spider diagrams and REE plots and their interpretation. Study of rock-forming minerals in hand specimen and under microscope. Numerical exercises related to X-ray crystallography.	12
	Total	**48**

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.
3) Introduction to Sedimentology – S. M. Sengupta, (2018), CBS.

Reference Books:

1) Igneous and Metamorphic Petrology - Myron G. Best (2001)
2) Essentials of geochemistry - Walther, J. V. (2009), Jones & Bartlett Publishers.
3) Geochemistry – W. M. White, (2013), Wiley-Blackwell Publishing.
4) Petrology of Sedimentary Rocks – Sam Boggs, (2^{nd} edition, 2009), Cambridge University Press, New York.

Paper: DSE 3 Discipline Specific Elective	EARTH AND CLIMATE			Subject Code:
	L-T-P-C: 4-0-0-4	Credit Units: 4	Scheme of Evaluation: (T)	GEOL164D201

Course Objectives: The objective of the course is to understand the operation of Earth's climate system, interpret role of atmosphere and oceans in Earth's climate and response of biosphere and to get acquainted with orbital cyclicity and variability in climate.

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

1. Describe Forcing and Response Components of climate system and
2. Explain the heat transfer in ocean and its influence on climate.
3. Analyse and application on the role of stable isotopes in Paleoclimatology.

Detailed Syllabus:

Modules	Topics and Course Content	Periods
Unit 1	**Climate system and Earth's heat** Forcing and Response Components of climate system. Climate forcing, Climate controlling factors; Climate system response, response rates and interactions within the climate system; Feedbacks in climate system. Incoming solar radiation, receipt and storage of heat; Heat transformation; Earth's heat budget. Interactions amongst various sources of earth's heat.	12
Unit 2	**Role of atmosphere and oceans in Earth's climate** Heat transfer in ocean. Global oceanic conveyor belt and its control on earth's climate. Atmosphere and ocean interaction and its effect on climate. Sea ice and glacial ice. Mechanism of monsoon; Monsoonal variation through time; Factors associated with monsoonal intensity; Effects of monsoon on Earth's climate.	12
Unit 3	**Response of Biosphere to Earth's climate** Evolution of Earth's climate. Climate Change: natural vs. anthropogenic effects. Global Warming; Humans and climate change; Future perspectives. Brief introduction to archives of climate change. Archive based climate change data from the Indian subcontinent.	12
Unit 4	**Orbital cyclicity and climate** Milankovitch cycles and variability in the climate. Glacial-interglacial stages. The Last Glacial maximum (LGM); Pleistocene Glacial-Interglacial cycles. Younger Dryas. Marine isotope stages. Application of stable isotopes (Oxygen and Carbon) in Paleoclimatology. Paleoclimatic reconstructions from ice cores.	12
	Total	**48**

Text Books:

1) Rudiman, W.F., 2001. Earth's climate: past and future. Edition 2, Freeman Publisher.
2) Rohli, R.V., and Vega, A.J., 2007. Climatology. Jones and Barlatt

Reference Books:

1) Lutgens, F., Tarbuck, E., and Tasa, D., 2009. The Atmosphere: An Introduction to Meteorology, Pearson Publisher
2) Aguado, E., and Burt, J., 2009. Understanding weather

Paper: DSE 4 Discipline Specific Elective	QUATERNARY GEOLOGY			Subject Code:
	L-T-P-C: 4-0-0-4	Credit Units: 4	Scheme of Evaluation: (T)	GEOL164D202

Course Objectives: The objective of the course is to learn about the earth's surface process and the Quaternary geological history and associated issues of concern like climate change, active tectonics. The course also focuses on various tectonic forcing on climate and the consequent responses, imparts knowledge on the thick repository of Quaternary sediments and their stratigraphic framework in NE India.

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

1. Describe and explain the various types of chronological methods and data relevant to Quaternary period.
2. Relate and illustrate various forcing agents of the glacial-interglacial cycles and their impact on Quaternary climate.
3. Apply and interpret various techniques to reveal and understand the Quaternary stratigraphy.

Detailed Syllabus:

Modules	Topics and Course Content	Periods
Unit 1	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.	12
Unit 2	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, fericrete, alcrete and spleothems, application of stable isotopes in Quaternary climate.	12
Unit 3	Quaternary geomorphology- the earth as a system, energy flow in the geomorphic system, spatial and temporal scales of landscape analysis, role of structure, tectonics and climate in landform development, neotectonics and active tectonics and landscape response.	12
Unit 4	Quaternary stratigraphy- oxygen isotope stratigraphy, magnetic stratigraphy – principles and application in Quaternary sequences (Indian examples), pedostratigraphy, soil profile and paleosol, 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.	12
	Total	**48**

Text Books:

1) Geomorphology: A systematic analysis of late Cenozoic landform, Arthur L Bloom., Pearson Ed.

Reference Books:

1) Tectonic Geomorphology, Douglas W. Burbank and Robert S. Anderson, Blackwell Science.
2) Active tectonics, by Edward A. Keller and Nicholas Pinter, Prentice Hall.

M. Sc. Course in Geology: Semester-III

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

Course Objectives: The main objectives of this programme are to understand the basic concepts of stratigraphy and importance of stratigraphic correlation with paleogeographic reconstruction and also on the structure, lithology and stratigraphy of Precambrian, Palaeozoic and Mesozoic Formations of India and detailed stratigraphy of NE India.

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

1. Describe the concepts, techniques, and methodology appropriate for classification and correlation of stratigraphic units.
2. Explain the sedimentary basins of India and analyse basin configurations, sedimentation history and paleoclimate therein.
3. Illustrate and explain the tectono-sedimentary framework and evolution of the sedimentary basins of the Northeast India and classification and correlation of the sedimentary sequences.

Detailed Syllabus:

Modules	Topics and Course Content	Periods
Unit 1	**Basic concepts and principles of stratigraphy** Stratigraphy and its relation with sedimentation. Components of stratigraphy. Geological disposition of the Indian stratigraphic sequences; geological history of India. Geological time scale. Stratigraphic units –International and Indian stratigraphic codes.	10
Unit 2	**Stratigraphic correlation and application of stratigraphy** Principles and methods of correlation of stratigraphic units, stratigraphic relationships - vertical and lateral. Concepts of Sequence stratigraphy, Magnetostratigraphy and Seismo-stratigraphy. Sedimentary facies – concept of facies, lateral and vertical facies variation, facies modeling, palaeogeographic reconstruction.	10
Unit 3	**Indian Stratigraphy: Precambrian, Paleozoic and Mesozoic Formations** Precambrian Formations of India: Dharwar Province, Eastern Ghats Province, Central Indian Province, Singhbhum-Orissa Province and Aravalli-Bundelkhand Province. Archaean-Proterozoic boundary. Proterozoic formations of Indian Peninsula: Cuddapah Supergroup, Vindhyan Supergroup, Kurnool Group. Palaeozoic Formations of India: Himalayan Palaeozoics, marine Palaeozoics in Peninsular India, Precambrian-Cambrian boundary.	12
Unit 4	Mesozoic Formations of India: Triassic of Spiti and Himalayan range; Jurrasic 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. 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.	16
	Total	**48**

Text Books Suggested:

1) Stratigraphic Principles and Practices – J.M.Weller; Universal BookStall, Delhi.
2) Principles of Sedimentology and Stratigraphy, by Sam Boggs, Jr., 4th Edition, Pearson Prentice Hall, 2006.
3) The Making of India: Geodynamic Evolution- K.S. Valdiya, 2nd edition, Springer, 2016.

Reference Books:

1) Principles of Sequence Startigraphy, by Octavian Catuneanu, ELSIVIER Publishers.
2) Principles of Sedimentary Basin Analysis, by A. D. Miall, 3rd Edition, Springer, 2000, 616pp.
3) Precambrian Geology of India – S.M. Naqvi & J.J.W. Rogers; Oxford University Press.
4) Stratigraphy and Sedimentation, by W.C. Krumbein and L.L. Sloss, W.H. Freeman and Company.

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

Course Objectives: The main objective of the programme is to understand the evolution of life through geological time with respect to climate and tectonic changes. This programme also wants to introduce some major groups of macro and microfossils and their important uses and the study of Gondwana flora of the World and India in context of palaeoclimate and palaeoecology.

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

1. Describe major evolutionary breakthroughs in the evolution of life, major causes of mass-extinction events and some vertebrates based on fossil records in the context of changing pattern of paleoclimate and paleoecology.
2. Explain major invertebrate including microfossil groups and their application in palaeobiological interpretation, hydrocarbon explorations.
3. Explain the process of collecting and analysing fossils, application and significance of palynological studies and analysing the application of Gondwana flora in deciphering paleoclimate of the Permian Period.

Detailed Syllabus:

Modules	Topics and Course Content	Periods
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.	10
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.	14
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.	14
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.	10
	Total	**48**

Text Books Suggested:

1) Benton, M. (2009). Vertebrate paleontology. John Wiley & Sons. 4th Edition.
2) Armstrong, H.A., and Brasier, M.D. (2005) Microfossils. Blackwell Publishing.
3) Saraswati, P.K., and Srinivasan, M.S. (2016) Micropaleontology Principles and Applications. Springer International Publishing.

Reference Books:

1) Shrock and Twenhoefells, Invertebrate Paleontology, 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) Stanley, S.M. and Luczaj, J.A. (2015). Earth System History. Freeman & Co. 4th edition.
5) Foote, M. and Miller, I.A. (2007). Principles of Paleontology. Freeman & Co. 3rd edition.

Paper III Core Course	PRACTICAL III			Subject Code:
	L-T-P-C: 0-0-3-3	Credit Units: 3	Scheme of Evaluation: (P)	GEOL164C314

Course Objectives: The main objective of this practical programme is to identify the different rocks in hand specimens and thin sections from known Indian stratigraphic horizons and to establish the relationships between various facies maps and derive an understanding of paleogeographic reconstruction. This programme also focuses on the identification of different fossils and prepare and interpretation of various hydrogeological maps and sections using remote sensing and GIS.

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

1. Identify rocks of different stratigraphic horizons of India and locate them in geological maps as well as Prepare and interpret facies maps and perform facies modelling.
2. Identify different invertebrate and plant fossils fossil forms and microscopic study various microfossil groups and analyse biostratigraphic zonation based on foraminiferal fossil assemblages.
3. Prepare and interpret the various hydrogeological maps and sections using remote sensing and GIS and analysis of rainfall data and well hydrographs.

Detailed Syllabus:

Modules	Topics and Course Content	Periods
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.	12
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.	12
Unit 3	Analysis of rainfall data and well hydrograph. Estimation of average annual rainfall. Interpretation of topographic map, geologic map, aerial photograph and satellite imagery for ground water prospect evaluation. Preparation and interpretation of depth to water map, water table map, piezometric surface map, isolith map, chemical quality map and diagrams, hydrogeological sections.	12
Unit 4	Stereo vision test, use of pocket stereoscope and mirror stereoscope. Determination of height from aerial photographs using parallax bars. Study of satellite imagery. Visual interpretation of satellite imagery for lineament analysis, demarcation of litho-units and structures, delineation of landforms and land use. Digital image processing – image enhancement, on-screen digitization, ratio image and image classification. Hands on exercise on GIS - Preparation of geological map of a given terrain in GIS.	12
	Total	**48**

Text Books Suggested:

1) Principles of Sedimentology and Stratigraphy, by Sam Boggs, Jr., 4th Edition, Pearson Prentice Hall, 2006.
2) The Geology of Stratigraphic Sequences, by A. D. Miall, 2nd Edition, Springer, 2010.
3) Benton, M. (2009). Vertebrate paleontology. John Wiley & Sons. 4th Edition.
4) Armstrong, H.A., and Brasier, M.D. (2005) Microfossils. Blackwell Publishing.

Reference Books:

1) Principles of Sedimentary Basin Analysis, by A. D. Miall, 3rd Edition, Springer, 2000, 616pp.
2) Stratigraphy and Sedimentation, by W.C. Krumbein and L.L. Sloss, W.H. Freeman and Company.
3) Shrock and Twenhoefells, Invertebrate Paleontology, CBS publishers
4) Invertebrate Palaeontology and Evolution, E.N.K. Clarkson, 4th Edition, Blackwell Science
5) Stanley, S.M. and Luczaj, J.A. (2015). Earth System History. Freeman & Co. 4th edition.

Paper IV **Core Course**	**MINOR PROJECT**			**Subject Code:**
	L-T-P-C: 0-0-4-4	**Credit Units: 4**	**Scheme of Evaluation:** (P)	**GEOL164C324**

Course Objectives: The main objective to include minor project is to generate a pragmatic and research attitude in the students and to make students acquainted with technique of field survey, geological mapping.

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

1. Carry out field survey and geological mapping in an unknown geological terrain.
2. Work in various industrial sites as part of future career prospects
3. Carry out minor remote sensing and GIS based projects related to EIA and/or natural disaster management.

Detailed Syllabus:

Module	Topics and Course Content	Periods
Unit 1	Field Work in a specific geological terrane: identification of lithology, structure, fossil content along with collection of representative samples etc. followed by geological mapping and report writing **OR** Industrial training at mine site/mud logging/construction site/river site/OIL/ONGC followed by preparation of detailed report **OR** Internship in Remote sensing and GIS institutes or firms with hands on training in RS and GIS tools and their application.	48

Paper: DSE 1 Discipline Specific Elective	HYDROGEOLOGY			Subject Code:
	L-T-P-C: 4-0-0-4	Credit Units: 4	Scheme of Evaluation: (T)	GEOL164D301

Course Objectives: The main objective of this programme is to understand the origin and occurrence of ground water, chemical quality, importance and the factors governing the flow pattern of ground water. This programme also focusses on the relationship between fresh and salt water, performance of aquifer and application of various surface and subsurface investigation for ground water exploration.

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

1. Describe the occurrences of groundwater in various geological formations groundwater dynamics, physico-chemical factors governing its quality, its levels and fluctuations.
2. Explain the fluctuations of ground water levels, relate fresh and salt water in the coastal areas, analyse and application of rainfall data and aquifer pumping test data.
3. Illustrate and explain the hydrogeological concepts, exploration, exploitation and recharge of groundwater and also the importance of ground water assessment, development, management and budgeting.

Detailed Syllabus:

Modules	Topics and Course Content	Periods
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.	12
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.	12
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 non-steady state flow. Equation for pumping tests. Step drawdown test and aquifer performance test. Analysis of pumping test data.	12
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
	Total	**48**

Text Books:

1. Todd, D. K. 2006. Groundwater hydrology, 2nd Ed., John Wiley & Sons, N.Y.
2. Davis, S. N. and De Weist, R.J.M. 1966. Hydrogeology, John Wiley & Sons Inc., N.Y.
3. Karanth K.R., 1987, Groundwater: Assessment, Development and management, Tata McGraw-Hill Pub. Co. Ltd.
4. Tolman, C. F.: Ground Water; McGraw-Hill Book Co., New York.
5. Walton, W. C.,1970: Ground Water Resource Evaluation; McGraw-Hill Inc.
6. Raghunath, H.M.,1983: Ground Water; Wiley Eastern Ltd., New Delhi.

Paper: DSE 2 Discipline Specific Elective	REMOTE SENSING AND GIS			Subject Code:
	L-T-P-C: 4-0-0-4	Credit Units: 4	Scheme of Evaluation: (T)	GEOL164D302

Course Objectives: The ability to collect information over large spatial areas; to characterize natural features or physical objects on the ground; to observe surface areas and objects on a systematic basis and monitor their changes over time; and the ability to integrate this data with other information to aid decision-making.

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

1. Explain concepts, methodologies and applications of Remote Sensing technology.
2. Apply spatial data analysis to solve natural, environmental and societal problems and challenges
3. Ability to write and present a substantial technical report/document and publish international level research articles.

Detailed Syllabus:

Modules	Topics and Course Content	Periods
Unit 1	Concepts in Remote Sensing, History of Remote Sensing. Types and acquisition of aerial photographs; Scale and resolution. Spectral response curve. Sensors. Resolution properties of sensors. Resolution properties of Indian remote sensing satellites and sensors. Elements of photo and image interpretation. Remote sensing and geology.	12
Unit 2	Stereoscopy and vertical exaggeration. Basic elements of photogrammetric measurements of aerial photographs / digital stereo image. Digital photogrammetry: Concept of digital elevation model (DEM) and digital terrain model (DTM) and their uses. Advantages of digital photogrammetry over traditional optical photogrammetry. Orthophoto.	12
Unit 3	Thermal remote sensing; Thermal properties of materials; Characteristics of thermal images; thermal image processing and interpretation. Concept of LiDAR remote sensing. Microwave remote sensing; SLAR system; Spatial resolution of SLAR systems; Synthetic Aperture Radar (SAR); microwave remote sensing satellites; microwave image characteristics; Processing of microwave digital data; Geologic interpretation of radar image.	12
Unit 4	Image processing methods: Image restoration, image enhancement, False colour composite (FCC). Ratio images, multispectral classification - supervised and unsupervised, change detection images, accuracy assessment. Concept of hyperspectral data and their importance. Introduction to GIS and its components, vector and raster data, georeferencing, planning needed to develop a GIS based project in earth science, analysis of spatial and attribute data in GIS platform.	12
	Total	**48**

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.
3. Jensen, J. R., 2011: Remote Sensing of the Environment – An Earth Resource Perspective, 3rd Impression, Chapter-14, Pearson, 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.
4. Pandey, S. N. 2001: Principles & Applications of Photogeology; New Age International Publishers.
5. Gupta, R. P., 2003; Remote Sensing Geology; Springer.
6. Bhatta, B. 2011: Remote Sensing and GIS: Oxford Univ. Press.
7. Lillesand, T.M. & Kieffer, R.W., 1987: Remote Sensing & Image Interpretation; John Wiley & Sons.

Paper: DSE 3 Discipline Specific Elective	RESEARCH METHODOLOGY AND GEOSTATISTICS			Subject Code:
	L-T-P-C: 4-0-0-4	Credit Units: 4	Scheme of Evaluation: (T)	GEOL164D303

Course Objectives: The design of the course intends to make the students explore and develop new skills related to research in geo-sciences: research defining problem, research design, data analysis and scientific writing. It also provides systematic structure to data classification and presentation and statistical processing and analysis of geological data.

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

1. Interpret and develop better insight into the theories and philosophy of research.
2. Apply the basic approach in conducting statistical analysis, including the calculation of experimental data, directional analysis (Rose Diagram and variogram surface) and variogram modelling.
3. Evaluate the mathematical and statistical principles behind correlation, regression analysis, variance and covariance, as well as how to apply these geostatistical methods in spatial interpolation based on a set of 2D sampled data.

Detailed Syllabus:

Modules	Topics and Course Content	Periods
Unit 1	Theory and philosophy of research concept in context to Geological sciences; techniques involved in defining a problem. Surveying the related literature. Research Design: Subject of study; Place of study; Research objective; Type of data required; Method of data collection; Defining major concept in various operational terms; Periods of study; data analysis and interpretation.	12
Unit 2	Sampling technique/field methods, parametric analysis and Quantitative and qualitative methods in Geosciences. Scientific writing: Concepts of article, notes, reports, review article, monographs, dissertations, popular science articles. Outline preparation, drafting title, sub titles, tables, illustrations; Formatting tables- title, body, footnotes; figures & graphs - structure, title and legends, bibliographies, impact factor, citation indices, plagiarism.	12
Unit 3	Basic Statistics – Classification and presentation of statistical data, Measures of central tendency and dispersion, probability and probability distributions, concept of population and sample, Sampling and sample distributions. Characteristics of Binomial and Normal Distributions. Standardization of normal distribution, Joint distribution.	12
Unit 4	Correlation, least square method and regression analysis, variance and covariance, standard and probable error of correlation coefficient. Sampling distributions: Estimators, sampling distribution of mean, confidence limits, Student t-distribution. Test of significance, setting up a hypothesis, null and alternative hypothesis, z-test, t-test, F-test, Chi-square test.	12
	Total	**48**

Text Books:

1. Research Design: Qualitative, Quantitative and Mixed Methods Approaches by John, W. C., 2011, Sage Publications, Thousand Oaks.
2. Statistics and Data analysis in Geology, Third Edition, by John C. Davis, Kansas Geological Survey; John Wiley and Sons, Inc., 2005.

Reference Books:

1. Survey Methodology by Robert, M. B, et al., 2009, Wiley, New Jersey.
2. The Structure of Scientific Revolutions by Thomas K., 1996, University of Chicago Press, Chicago.
3. Concepts in Geostatistics, Ed. By Richard B. McCammon, Springer-Verlag, New York Inc.
4. Statistical analysis in the geological sciences, Miller and Kahn, John Wiley and Sons, New York
5. Aspects of Multivariate Statistical Analysis in Geology by Richard A. Reyment and Enrico Savazzi, Elsivier, 1999.

Paper: DSE 4 Discipline Specific Elective	MARINE GEOLOGY			Subject Code:
	L-T-P-C: 4-0-0-4	Credit Units: 4	Scheme of Evaluation: (T)	GEOL164D304

Course Objectives:

This course focuses on providing general information about the history, structure and evolution of the ocean floor and its related distribution of sediments. It involves geophysical, geochemical, sedimentological and paleontological investigations of the ocean floor and coastal zone.

Course Outcomes:

By the end of this course the students will be competent enough to:

- Identify the marine sediments and understand its composition and distribution.
- Understand the resources available on the ocean floor and its economic impact on a global scale.
- Decipher the Holocene paleoenvironments based on estuarine and marine core.
- Apply the knowledge of coastal geology in support for coastal management.

Detailed Syllabus:

Modules	Topics and Course Content	Periods
Unit 1	Marine sediments; sources, composition and distribution. Coastal processes and sedimentation. Deep sea sediments and their relation to oceanic processes such as productivity, solution and dilution; sedimentation rates; Calcite and aragonite compensation depth. Methods and instruments for exploring the ocean floor, Deep Sea Drilling Project (DSDP), Ocean Drilling Program (ODP) and International Ocean Discovery Program (IODP): their objectives and major accomplishments.	12
Unit 2	Sediment distribution in time and space as related to tectonic models; Marine stratigraphy, correlation and chronology; Deep-sea hiatuses and their causes. Multidisciplinary approaches to paleoceanographic and paleoclimatic reconstructions. Paleoceanographic changes in relation to earth system history including impact of the oceans on climate change.	12
Unit 3	Record of Ocean Anoxic Events (OAE)- chronology, tectonic and paleo-oceanographic implications. Evolution of oceans through the Cenozoic; ocean gateways and their role in controlling global climates. Sea level changes during Quaternary with special reference to India. Quaternary climatic and oceanographic history on shorter time scales using marine records.	12
Unit 4	Mineral resources of the ocean including polymetallic nodules; Hydrocarbons beneath the sea floor; Marine gas hydrates and their economic potential. Marine pollution and interpreting marine pollution with the help of micropaleontological and geochemical tracers. Law of the Sea Treaty: Introduction to UNCLOS (United Nations Convention on the Law of the Sea); Exclusive Economic Zone.	12
	Total	**48**

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 Excercises in Oceanography Marine Geology, Prentice Hall.

M. Sc. Course in Geology: Semester-IV

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

Course Objectives: The main objective of this programme is to understand the process of coalification, geographical distribution of Indian coal deposits, nature and origin of petroleum and various rock types related to the petroleum system. This programme also focusses on the migration pattern of petroleum and various Petroliferous basins of India.

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

1. Understand the evolutionary development of flora, factors related to the coalification process and distribution of Indian coal deposits, analyse coal samples for proximate and ultimate analysis.
2. Illustrate and explain the composition of crude oils, reservoir properties of sedimentary rocks for petroleum deposits and various Petroliferous basins of India.
3. Explain the process of migration of petroleum and the techniques of exploration and geophysical logging and assess their application.

Detailed Syllabus:

Modules	Topics and Course Content	Periods
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.	10
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: Macroscopic 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	12
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	12
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.	14
	Total	**48**

Text Books Suggested:

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 AND EXPLORATION GEOLOGY** **L-T-P-C: 4-0-0-4** **Credit Units: 4** **Scheme of Evaluation:** (T)	**Subject Code:** **GEOL164C402**

Course Objectives: Purpose of this course is to identify new ore deposits for excavation as well as understanding how ore deposits are generated and localized within Earth's crust. Exploration Geology will let us to know a range of activities that help determine if there are commercially viable mineral resources.

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

1. Explain different ore formation theories
2. Identify the various exploration techniques
3. Compare the drilling and logging techniques

Detailed Syllabus:

Modules	Topics and Course Content	Periods
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. 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.	13
Unit 2	**Indian deposits** Metallic mineral deposits of India, their distribution, mode of occurrence, mineralogy and genesis: iron, manganese, chromium, copper, lead and zinc, gold, silver, aluminum, nickel and molybdenum. Non- metallic mineral deposits: Diamond, limestone and dolomite, magnesite, phosphates, asbestos, gemstone, refractory minerals. Clay mineral deposits of NE India. Critical and essential minerals. Radioactive minerals: uranium, thorium: their distribution, mode of occurrence, mineralogy and genesis. Uranium mineralization in North eastern part of India. Distribution of Rare Earth minerals.	13
Unit 3	**An overview of exploration and drilling technique** Physical properties of rock- density, susceptibility, resistivity, and elastic wave velocities, factors controlling the properties. Drilling and drilling fluids–parameters, usefulness types; Duties of well site geologists; Well logging: Basics of well logging, Different well logging – SP, GR, Resistivity log, neutron log, Density logs, sonic log, conventional electric log. Exploration of hydrocarbon–geological, geochemical and geophysical exploration.	10
Unit 4	**Exploration and mining** Geophysical exploration of hydrocarbon: seismic survey - reflection and refraction methods; gravimetric survey: gravity anomaly, interpretation of anomaly maps and interpretation of results. Classification of mineral reserve; Methods of mineral prospecting and exploration: Different methods of surface and subsurface mining for metallic and non-metallic minerals; mining of coal; Alluvial mining.	12
	Total	**48**

Text Books Suggested:

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

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

Paper III **Core Course**	**PRACTICAL IV**			**Subject Code:**
	L-T-P-C: 0-0-3-3	**Credit Units: 3**	**Scheme of Evaluation:** (P)	**GEOL164C414**

Course Objectives: The main objectives of this practical programme are to identify opaque metallic minerals under ore microscope and study petrography and geochemistry of coal as well as to understand the process of reserve estimation and calculation.

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

1. Identify and describe the textures and structures of ore minerals under microscope and in hand specimen.
2. Identify the industrial minerals for different mineral-based industries and analyse the proximate analysis in the laboratory.
3. Identify macerals in polished pellets of coal and prepare structure contour and isopach maps.

Detailed Syllabus:

Modules	**Topics and Course Content**	**Periods**
Unit 1	Identification of opaque metallic minerals under ore microscope - galena, sphalerite, pyrite, pyrrhotite, chalcopyrite, arsenopyrite, magnetite, haematite, ilmenite, goethite, chromite, cassiterite, covellite, cobaltite, niccolite 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.	12
Unit 2	Study of coal in hand specimen: Identification of different types of coal, lithotypes; Proximate analysis of coal- determination of moisture, ash and volatile matter; Petrography of coal- polished block study under microscope. Structure contour, isopay and isopach maps. Interpretation of structure contour maps; Reserve estimation and calculation.	12
Unit 3	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.	12
Unit 4	Use of Brunton Pocket Transit for bearing, estimation of height of objects, Plane table survey. Traverse using theodolite-close loop and open-end survey, use of Dumpy level. Topographic mapping/contouring; GPS (Hand held) based survey and mapping. Contouring from DEM.	12
	Total	**48**

Text Books Suggested:

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.
3) Petroleum Geology (Developments in Petroleum Science), by R.E. Chapman
4) Oil well drilling technology, McCray, A.W. and Cole, F.W.; English Book Depot.

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

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

Course Objectives: The main objective to include minor project is to generate a pragmatic and research attitude in the students and to make students acquainted with technique of field survey, geological mapping.

Course Outcome:

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

1. Formulate a research problem from a geological terrain and prepare a model to address it with detailed laboratory analyses.
2. Apply the remote sensing and GIS tools for various environmental and geological studies.

Detailed Syllabus:

Module	Topics and Course Content	Periods
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.	48

Paper: DSE 5 Discipline Specific Elective	ENGINEERING GEOLOGY			Subject Code:
	L-T-P-C: 4-0-0-4	Credit Units: 4	Scheme of Evaluation: (T)	GEOL164D401

Course Objectives: The objective of this course is to provide skills in geological investigation for an engineering structure along with possible mitigations for the geological effect. This course also provides geological and geotechnical recommendations, analysis, and design associated with human development and various types of civil structural construction.

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

1. Understand the different soil and rock properties that are necessary to analyse before any Mega constructions.
2. Explain the required Geotechnical considerations of Mega structures.
3. Illustrate and explain the importance of Disaster Management along with different environmental impacts.

Detailed Syllabus:

Modules	Topics and Course Content	Periods
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.	12
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.	12
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.	12
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
	Total	**48**

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: DSE 6 Discipline Specific Elective	ENVIRONMENTAL GEOLOGY, MAPPING AND SURVEYING			Subject Code:
	L-T-P-C: 4-0-0-4	Credit Units: 4	Scheme of Evaluation: (T)	GEOL164D402

Course Objectives: For a solid understanding of not only currently occurring geologic events, yet chronicled geologic occasions, for example, past quakes and floods. This information on the past is significant in light of the fact that it encourages them to show signs of improvement thought of what kinds of geologic occasions rehash themselves, with what recurrence they may happen, and what sorts of harm happened in view of those occasions.

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

1) Able to know the basic earth science as applied to the interaction between human activity and natural environment.
2) Explain how earth processes create hazards to life and property.
3) Describe the major sources of water, soil, and sediment pollution and methods for their management.

Detailed Syllabus:

Modules	Topics and Course Content	Periods
Unit 1	Definition, fundamental concepts and scope of environmental geology, pollution and hazards due to mining activities, pollution due to radioactive mineral mining. Landslides, causal factors, impact of landslides on environment, landslide hazard zonation, preventive measures. Soil erosion.	12
Unit 2	Flood – definition, causes, flood in fluvial systems, method of flood frequency analysis, flood management, structural and non-structural methods of flood management, dams and flood, flood in Assam Water pollution - sources of pollution of surface and ground water, water pollution parameters, types of water pollution, causal factors, case studies. Parameters of potable water as per Indian and WHO's standards.	12
Unit 3	Maps - types and basic elements, projection system, datum and datum transformation, digital mapping techniques, GPS/GNSS and mapping. Surveying: Basic principles, types and procedures of field survey. Closed loop and open traverse, principles of theodolite, dumpy level and total station survey, RL transfer.	12
Unit 4	Geologic surveying: Definition and scope, study of outcrops, use of compass and clinometers. Base maps: Locating field data on base map, geologic traverses, detail and reconnaissance mapping; Geological field mapping in sedimentary and hard rock terrain.	12
	Total	**48**

Text Books:

1) Valdiya, K. S., (1987) Environmental Geology - Indian Context. Tata McGraw Hill New Delhi.
2) Lahee Fredrick H. (1961) Geology in the field by Robert R. Compton, John Wiley & Sons.
3) Duggal, S.K. (2004) Surveying Vol. I and II, Tata McGraw Hill.

Reference Books:

1) Keller, E. A., (2000) Environmental Geology. Shales E. Merril Publishing Co., Columbus, Ohio.
2) Montgomery, C., (1984) Environmental Geology. John Wiley and Sons, London.
3) Field Geology McGraw – Hill Book Company, Inc. 6thed.
4) Compton Robert R. (1962) Manual of Field Geology John Wiley & Sons.
5) Punmia, B.C. (1994) Surveying Vol.I and II, Standard Publishers.
6) Arora, K. R. (1996) Surveying Vol. I and II, Standard Book House

Paper: DSE 7 Discipline Specific Elective	BASIN ANALYSIS			Subject Code:
	L-T-P-C: 4-0-0-4	Credit Units: 4	Scheme of Evaluation: (T)	GEOL164D403

Course Objectives: The main objectives of this programme are to understand the sedimentary basins, geodynamic entities, surface and subsurface methods employed for characterizing a sedimentary basin as well as application of sequence stratigraphy in drawing tectonic and sedimentation history of a sedimentary basin and its petroleum potential.

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

1) Understand and describe the sedimentary basins, geodynamic entities as well as compositional and rheological zonation of the earth.
2) Analyse the role of plate tectonics in formation of a sedimentary basin and functioning of sedimentary routing systems.
3) Establishment of stratigraphy and thermal history of a sedimentary basin and correlate stratigraphical columns based on lithological, heavy mineral assemblage and paleontological data as well as interpret and correlate geophysical logs in terms of petroleum exploration.

Detailed Syllabus:

Modules	Topics and Course Content	Periods
Unit 1	**Introduction** Basin analysis - the integrated study of sedimentary basins as geodynamic entities; Basins in their plate tectonic environment. Compositional and rheological zonation of the earth; Classification of the sedimentary basins. Basins due to lithospheric stretching, basins due to flexure; Effects of mantle dynamics; Basins associated with strike-slip deformation.	12
Unit 2	**Tools and methods of basin analysis** Surface and subsurface investigation methods – outcrop section, field measurement and documentation, sampling; subsurface stratigraphic sections from well cuttings and cores, petrophysical logs, preparation of structure contour, isopach, lithofacies, clastic ratio and paleocurrent maps; siliciclastic petrofacies.	12
Unit 3	**Sedimentation and Basin stratigraphy** Terrestrial sediments and solute yields, measurements of erosion rates, functioning of sediment routing systems. Stratigraphic cycles – definition and recognition, driving mechanism for stratigraphic pattern, numerical simulation of stratigraphy, depositional systems, relation of depositional style to basin setting; subsidence and thermal history.	12
Unit 4	**Sequence stratigraphy and Petroleum exploration** Introduction to Sequence stratigraphy, depositional systems and system tracts, sequence boundaries, system tracts and sequences in siliciclastic and carbonate deposits, sequence stratigraphy and petroleum exploration. From basin analysis to play concept, the petroleum charge system, reservoir and trap.	12
	Total	**48**

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: DSE 8 Discipline Specific Elective	GEOPHYSICAL EXPLORATION AND SEISMOLOGY			Subject Code:
	L-T-P-C: 4-0-0-4	Credit Units: 4	Scheme of Evaluation: (T)	GEOL164D404

Course Objectives: The main objectives of this programme are to understand the techniques of gravimetric and magnetic surveys and their applications in mineral explorations and correlate spatial distribution of earthquakes in the light of plate tectonics as well as interpret seismic waves and crustal velocity structures.

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

1) Describe the principles and procedures of different exploration techniques. Interpret seismic, gravity, magnetic data and paleoseismological data.
2) Analyse the data generated from different exploration methods and identify anomalies and delineate discontinuities.
3) Prepare and interpret geophysical maps of a given area and identify seismic waves in seismograms during pre-, syn- and post-seismic activities.

Detailed Syllabus:

Modules	Topics and Course Content	Periods
Unit 1	**Geophysics:** Basic principles. Detailed knowledge of different types of geophysics methods involving gravity, magnetic & seismic. Gravity methods: introduction, Gravity potential and field due to different simple bodies and structures. Field procedure. Bouguer gravity anomalies, interpretations & field-cases Magnetic methods: introduction, magnetic properties of rocks, geomagnetic field, field procedure, measurement of magnetic anomalies, interpretation.	12
Unit 2	Electrical method: Introduction, Self-potential, earth resistivity, different arrays, profiling & sounding techniques, interpretation & field cases. Induced polarization. Telluric & electromagnetic methods. Seismic method: introduction, refraction methods, layered earth refraction studies, hidden layer problem, correction, instruments, field procedures, interpretation. Various well-logging techniques.	12
Unit 3	**Seismology:** Introductory terminology and basic principles, crustal phases, travel time and magnitude of earthquake. Earthquake as natural hazard- prediction and seismic hazard management, seismic gap, Seismic waves, Snell's law, travel time curve, velocity model, b-value. Focal depth, earthquake-fault relation in tectonic domain. M, Mb, Ms, Mw, MM scale. Peaked ground acceleration (PGA) and peaked ground velocity (PGV), focal plane solution, Benioff zone.	12
Unit 4	**Palaeoseismology** Concept of paleoseismology and its importance, active faults, identification of seismogenic active faults, paleoseismological structures, identification of paleoseismic deformational features and structures from syn-sedimentary and other deformational structures, use of dating techniques for paleoseismic features and their reliability, materials suitable for dating, interpretation of dates, use of historical and archaeological data in paleoseismic data interpretation.	12
	Total	**48**

Text Books:

1) Geophysical methods in Geology by P.V. Sharma; Elsevier.
2) Earthquake Seismology, Treatise on Geophysics, by Hiroo Kanamari and Gerald Schubert, Elsivier Pub, 2007.

Reference Books:

1) Geological Methods in Mineral Exploration and Mining – by Roger Marjoribanks; Springer, 2010, 233pp.
2) Paleoseismology, 2nd edition, edited by Mc Calpin, Academic Press
3) Microtectonics C. W. Passchier and R. Trouw, Springer.
4) Dobrin, M. B., Savit, C.H.,1988: Introduction to Geophysical Prospecting; 4th edn., McGraw-Hill.
5) Lowrie, W.,2007: Fundamentals of Geophysics; Cambridge Univ. Press.
6) Robinson, E.S., Coruh, C., 1988: Basic Exploration Geophysics, 1st edn., Wiley.