

**MGS UNIVERSITY
BIKANER**



**Faculty of Science
M.Sc. Geology CBCS Syllabus**

Semester Scheme

**Semester I /II - 2023
Semester III/IV- 2024**

Programme: M.Sc. in Geology

Credit: 100

Semester: 4

Duration: 16 weeks per semester

Program Outcome

The Masters of Science program in MGS University is designed with the objective of educating students for success as a geo-scientist having employability in government sector, public sector, private sector, research institutes, or further qualifying NET or Gate examinations so as to pursue research for Doctoral studies. The students are likely to get regular placements in GSI, ONGC, CIL, etc. apart from reputed private organizations related to oil industries, mineral exploration & mining industries and organisations working in the fields of exploration using remote sensing & GIS Techniques. In addition, the holistic development of students helps them in getting placements in various national institutes.

Programme Specific Outcome

During the proposed four semesters, students identify, examine and understand different geological materials, geological settings and associations. The students with their robust foundation learn to interpret various geological maps, prepare cross sections, geologic field mapping, understanding of stratigraphic concepts, geological successions of Precambrian to Recent rocks, sediments and their lateral and vertical disposition; rock identification on the basis of minerals composition and basic physical, megascopic and microscopic characters. They learn about the origin and evolution of landforms, fossil identification up to generic level, their evolution and mode of life, in-depth understanding of the sedimentary structures and facies analysis, various rock types based on petrological thin sections, palaeoclimatic and palaeogeographic changes, origin and distribution of economic mineral and energy resources of the country etc. The students also develop basic aptitude and understanding of the environmental issues related to planet earth. At the end of the program student will be able to amalgamate the spatial and temporal relationships between earth processes and products, and development and evolution of earth spheres (Lithosphere, Hydrosphere, Atmosphere and Biosphere). Exploration for economically useful Earth material is another important outcome of the present program.

Geological excursion and research-based dissertation would be important components of the Masters Program in Geology for laying a robust foundation to the budding geologists. During the dissertation, students will take-up a geological problem utilize theoretical knowledge along with analytical or experimental approach to solve it. The students will have to defend their dissertation outcome in an open forum.

Scheme of Teaching, Examination and Courses of Study (Syllabus) in M.Sc. Geology Programme

M.Sc. Geology Programme of Two Years duration is divided into Four Semesters.

Every student shall complete 100 credits in a minimum of four semesters. All Semesters will have 25 credits each.

- Four credits, one each in four semesters, have been allocated for Field work.
- Each Semester will have Four Theory Papers, each of 50 marks.
- Each Semester will have Two Practical Papers, related to four Theory Papers, each of 50 Marks.

Eligibility:

- * B.Sc. with Geology as one of the subject/ B.Sc. honours in Geology.

Terms and Conditions

The students seeking admission to M.Sc. Geology course are hereby informed that they are supposed to adhere to the following rules:

- A minimum of 75 % attendance for lectures / practicals is the pre-requisite for Grant of Terms.
- The students opting for dissertation course shall follow the rules framed for the same.
- To conduct optional theory credit courses minimum number of students required will be decided by the Departmental committee.
- **Field Work Component:** Fieldwork is a compulsory component of the syllabus. The students are supposed to attend all the field tours / field cum-Laboratory Workshops organized by the department from time to time to cover credit Nos. GEOL107, GEOL 207, GEOL 307 and GEOL 407 related to field components. The students shall attend the tours at their own cost and risk.
- Four credits based on field work component, one in each semester, will constitute the compulsory part. There will be a continuous evaluation of the field work. The evaluation will be based on following four heads:

Heads	Marks	Evaluating Authority
Performance of the student in the field	5	By faculty members accompanying the study tour
Punctuality, enthusiasm, and aptitude of students while completing the report	5	By faculty members accompanying the study tour
Tour report	10	By members of Examination committee

Viva-voce	5	By members of Examination committee
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- The final grade for fieldwork component - courses comprising of GEOL 107, GEOL 207, GEOL 307 and GEOL 407 will be awarded as a four credits course at the end of fourth semester.

Teaching Work-load:

- * Each Theory Paper will have four lectures, each of 60 minutes duration, per week.
- * Each Practical Paper will have Eight lectures, each of 60 minutes duration, per week.

Seminars and Tutorials

- * Regular Seminars and Tutorials based on each paper will be conducted in the Department from time to time. It is compulsory for every student. Students not completing their seminars and tutorials will not be allowed to appear for practical examination.

Evaluation in the Theory papers in First, Second, Third and Fourth

Semesters:

For the **Continuous Internal Assessment** of the candidates, 30 marks shall be awarded by the teacher(s), teaching that course, for which the breakup of the marks will be as follows:

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|---|----------|
| (a) Class Test(s) | 10 marks |
| (b) Assignment(s)/ Presentation(s) | 10 marks |
| (c) Class Participation, interaction, punctuality, performance and aptitude | 05 marks |

Where more than one teacher is teaching a paper, the average of the marks awarded by all the teachers shall be considered.

For the **Semester End Examination**, the theory question paper for each course will be of 75 marks.

Teaching and Examination Scheme
M.Sc. Geology Programme Semester I

Paper No.	Course Nomenclature	Theory Hours per week	Practical Hours per week	Theory Exam. Hours	Credit
GEOL 101	Structural Geology	4	0	3	4
GEOL 102	Geomorphology & Geotectonics	4	0	3	4
GEOL 103	Crystallography & Mineralogy	4	0	3	4
GEOL 104	Principles of Stratigraphy & Precambrian Geology of India	4	0	3	4
GEOL 105	Lab: Structural Geology and Geomorphology & Geotectonics	0	8	4	4
GEOL 106	Lab: Crystallography, Mineralogy and Principles of Stratigraphy & Precambrian Geology of India	0	8	4	4
GEOL 107	Fieldwork Component – Core General Geological Tour of Two weeks duration				1
GEOLF 101	Application of Computers in Geology	4	0	3	4

GEOL101 - Structural Geology -Core- 4 Credits

<p>Course Outcome: After learning this course a student will be able to</p> <ol style="list-style-type: none"> 1. Describe the different structural elements 2. Understand the application of forces in the formation of structures. 	<p>Suggested Pedagogies</p> <p>1. Use appropriate ICT tool, wherever necessary, for effective teaching.</p> <p>Discuss recent research papers related to development of stratigraphy.</p>
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Marks: 75

Periods: 40

Note: – Each Theory paper is divided into 5 units. The question paper is divided into three parts, Part A, Part B and Part C. Part A (20 Marks) is compulsory and contain one question containing 10 parts, two from each unit, each question is of 2 marks (Answer limit 50 Words). Part B (25 Marks) is compulsory and contains five questions with internal choice, one from each unit. Candidate is required to attempt all five questions; each question is of Five marks each (Answer limit 200 words). Part C (30 Marks) contains five questions one from each unit, Candidate is required to attempt three questions; each question is of 10 Marks (Answer limit 500 hundred words).

Unit - I

Mechanical Principles- Analysis of stress, component of stress, stress ellipsoid. Types and Analysis of deformation, strain ellipsoid. Homogeneous and inhomogeneous deformation, progressive strain, strain paths. Factors controlling behaviour of rock materials. Determination of Strain in deformed rocks. Ductile behaviour of rocks. (8 Periods)

Unit - II

Morphology of folds. Geometric and genetic classification of folds. Mechanism of folding. Superimposed folding and interference patterns. Structural analysis in terrains with multiple deformations. (8 Periods)

Unit - III

Types of Linear structures and their tectonic significance. Deformation of linear structures. Types and origin of Cleavages; cleavage fans and axial plane cleavage; refraction of cleavage; relation of cleavage to major structures. (8 Periods)

Unit - IV

Fractures and Joints- their nomenclature, age relationship, origin and significance. Geometry & mechanics of shear zones; shear zone structures; shear zone indicators; folding in shear zones. Mylonites and pseudotachylite. (8 Periods)

Unit - V

Nomenclature of faults; minor structures associated with faults; effects of faulting on outcrop pattern; classification of faults; mechanics of faulting; recognition of faults. (8 Periods)

Suggested Books:

1. Ragan, D.M. – Structural Geology (J. Wiley & Sons)
2. Badgley, P.C. – Structural Geology for Exploration Geologists (Oxford Univ. Press)
3. Billings, M.P. – Structural Geology
4. Hobbs, B.E. Means, W.D. & Williams P.F. – An outline of Structural Geology (J. Wiley & Sons)
5. Ramsay, J.G. – Folding & Fracturing of Rocks (McGraw Hill)
6. Davis, G.R.,- Structural Geology of Rocks and Region. John Willey.
7. Ramsay, J.G. and Huber, M.I. – Modern Structural Geology. Vol I & II. Academic Press.

GEOL 102- Geomorphology & Geotectonics -Core- 4 Credits

Course Outcome: After learning this course a student will be able to <ol style="list-style-type: none">1. Describe the different tectonic elements2. Understand the tectonic evolution of earth	Suggested Pedagogies <ol style="list-style-type: none">1. Use appropriate ICT tool, wherever necessary, for effective teaching. Discuss recent research papers related to development of stratigraphy.
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Marks: 75

Periods: 40

Note: – Each Theory paper is divided into 5 units. The question paper is divided into three parts, Part A, Part B and Part C. Part A (20 Marks) is compulsory and contain one question containing 10 parts, two from each unit, each question is of 2 marks (Answer limit 50 Words). Part B (25 Marks) is compulsory and contains five questions with internal choice, one from each unit. Candidate is required to attempt all five questions; each question is of Five marks each (Answer limit 200 words). Part C (30 Marks) contains five questions one from each unit, Candidate is required to attempt three questions; each question is of 10 Marks (Answer limit 500 hundred words).

Unit - I

Fundamental concepts of Geomorphology. Analysis of geomorphic process: Exogenic, Endogenic and Extra-terrestrial Processes. Concept of morphogenetic regions. Fluvial geomorphic Cycle: Streams and valleys, Classification of valleys; Stages in drainage system evolution, their pattern, textural implications; rejuvenation. Peniplaination concept. Erosional and depositional features associated with fluvial cycles. (8 Periods)

Unit - II

Landforms, their types and nature of development. Landforms in relation to structure and tectonics. Karst topography. Glaciers: types & characteristics. Erosional and depositional features associated with glacial cycles. Arid cycles: origin and types of deserts, eolian landforms; expansion and control of desertification in India. (8 Periods)

Unit - III

Geomorphology of coasts. Geomorphology of shorelines and ocean floors, geomorphometric analysis and modeling. Major geomorphological sub division of India, their characteristics and evolution. (8 Periods)

Unit - IV

Crust: composition, seismic, gravity and magnetic characters. Crustal types: shields, platforms, mountain chains, rift valleys, mid oceanic ridges, trenches, island arcs and ocean basin. Heat flow; Gravity & Magnetic Anomalies. Crustal Provinces. Mantle: different zones; seismic characters; gravity anomalies; Core. (8 Periods)

Unit - V

Orogeny and epeirogeny. Tectonic theories: Isostasy, Geosynclines; Sea-floor spreading, Palaeomagnetism. Continental drift. Plate Tectonics. (8 Periods)

Suggested Books:

1. Spencer, E.W. – Introduction to the Earth's Crust (McGraw Hill)
2. Wylie, P.J. – Dynamic Earth (J. Wiley & Sons)
3. Holmes A.– Physical Geology (Nelson)
4. Strahler – Physical Geology.
5. Summerfield, M.A. – Geomorphology and Global Tectonics. Springer Verlag.
6. Moores, P. and Twiss, R.J., - Tectonics. Freeman.
7. Bloom, A. – Geomorphology (Prentice Hall)
8. Thornbury, W.D. – Principles of Geomorphology (J. Wiley & Sons)
9. Lobeck, A.K. – Geomorphology (Mc-Graw Hill)

GEOL 103–Crystallography & Mineralogy -Core- 4 Credits

Course Outcome: After learning this course a student will be able to <ol style="list-style-type: none">1. Describe the different tectonic elements2. Understand the tectonic evolution of earth	Suggested Pedagogies <ol style="list-style-type: none">1. Use appropriate ICT tool, wherever necessary, for effective teaching. Discuss recent research papers related to development of stratigraphy.
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Marks: 75

Periods: 40

Note: – Each Theory paper is divided into 5 units. The question paper is divided into three parts, Part A, Part B and Part C. Part A (20 Marks) is compulsory and contain one question containing 10 parts, two from each unit, each question is of 2 marks (Answer limit 50 Words). Part B (25 Marks) is compulsory and contains five questions with internal choice, one from each unit. Candidate is required to attempt all five questions, each question is of Five marks each (Answer limit 200 words). Part C (30 Marks) contains five questions one from each unit, Candidate is required to attempt three questions; each question is of 10 Marks (Answer limit 500 hundred words).

Unit -I

Crystallography: crystal growth, symmetry operations. Laws of crystallography. Goniometry. Thirty two crystal classes. Crystal projections: spherical, stereographic and gnomonic. (8 Periods)

Unit -II

Twinning. Space lattices. Elements of symmetry in internal structure. X- Ray crystallography: Bragg's equation; powder and single crystal methods, Laue method. (8 Periods)

Unit -III

Mineralogy; classification of mineral kingdom. Physical & Optical properties of minerals; determination of refringence, birefringence; vibration direction, interference figures, optic sign, optic axial angle; indicatrix; dispersion; universal stage and Berek compensator.

Systematic Mineralogy of native elements, sulphides, sulfosalts, oxides, hydroxides and carbonates. Silicate structures. (8 Periods)

Unit -IV

Detailed study of the following rock forming mineral groups with respect to their chemical constitution, crystal structure & forms, physical and optical properties, mode of origin, association, occurrence and alteration:

Neso silicates- Olivine group, Garnet group, Kyanite, Andalusite, Sillimanite.

Soro silicates- Epidote group. Cyclo Silicate- Beryl, Tourmaline, Axinite, Cordierite

Ino- silicates- Pyroxene group, Pyroxinoid group and Amphibole group. (8 Periods)

Unit -V

Detailed study of the following rock forming mineral groups with respect to their chemical constitution, crystal forms, physical and optical properties, mode of origin, association, occurrence and alteration:

Phyllo silicates- Mica group, Chlorite, Talc.

Tecto silicates- Feldspar group, Feldspathoid group, Zeolite group, Quartz, and other forms of Silica.

Gem minerals: gem properties and varieties. (8 Periods)

Suggested Readings:

1. Phillips, F.C. – An Introduction to Crystallography (ELBS)
2. Burger, M.J. – Elementry Crystallography (J. Wiley & Sons)
3. Evans, R.C. – Crystal Chemistry (Cambridge University Press)
4. Dana, E. Ford W.E. – A Text book of Mineralogy (Asia Public House)
5. Deer, Howie & Zussman – Introduction to Rock Forming Minerals (ELBS)
6. Winchel & Winchel – Elements of Optical Mineralogy (ELBS)
7. Read, H.H. – Rutley's Elements of Mineralogy (Thomas Murby & Co.)
8. Mason, Berry – Minerology. (Asian Pub.)
9. Sharma, N.L. – Determinative Tables (ISM, Dhanbad).
10. Klein, C.and Hurlbut, Jr., C.S.,- Manual of Mineralogy. (J. Wiley & Sons)

GEOL 104 – Principles of Stratigraphy & Precambrian Geology of India-Core- 4 Credits

Course Outcomes After learning this course, a student will be able to <ol style="list-style-type: none">1. Describe the different Stratigraphy units2. Their correlation to understand the stratigraphic framework of India.	Suggested Pedagogies <ol style="list-style-type: none">1. Use appropriate ICT tool, wherever necessary, for effective teaching.2. Discuss recent research papers related to development of stratigraphy.
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Marks: 75

Periods: 40

Note: – Each Theory paper is divided into 5 units. The question paper is divided into three parts, Part A, Part B and Part C. Part A (20 Marks) is compulsory and contain one question containing 10 parts, two from each unit, each question is of 2 marks (Answer limit 50 Words). Part B (25 Marks) is compulsory and contains five questions with internal choice, one from each unit. Candidate is required to attempt all five questions; each question is of Five marks each (Answer limit 200 words). Part C (30 Marks) contains five questions one from each unit, Candidate is required to attempt three questions; each question is of 10 Marks (Answer limit 500 hundred words).

Unit - I

Code of stratigraphic nomenclature. Geochronology: Radio isotopes and measuring geological time. Development of stratigraphy and founding of geologic systems, Stratigraphic relationships- lithosome, shape, vertical and lateral relationship. Principles of stratigraphic classification. Principles of correlation. Time stratigraphic units. Standard stratigraphic scale and its equivalents in Indian sub- continent. (8 Periods)

Unit - II

Elements of palaeoecology. Dating of rocks and fossils. Imperfection of geological records. Early history of the Earth. Nature of early crust; Precambrian geochronology and early crustal evolution. Formation and Evolution of greenstone, granite and granulite terrains. Archaean and Proterozoic tectonic patterns. (8 Periods)

Unit – III

Distribution, stratigraphic correlation, succession, geochronology and economic importance of Archaean and Palaeoproterozoic rocks of India; Dharwar Province, Eastern Ghat Province, Central Indian Province, and Singhbhum -Orissa Province. (8 Periods)

Unit – IV

Meso- and Neoproterozoic rocks in India; Cuddapah-Kurnool, Kaladgi, Bhima, Pakhal and Vindhyan basins. Distribution, stratigraphic correlation, succession and economic importance Precambrian- Cambrian boundary problem. (8 Periods)

Unit – V

Precambrian geology of Rajasthan; Banded Gneissic Complex (Bhilwara Supergroup), Aravalli Supergroup, Delhi Supergroup, Marwar Super group, Vindhyan Super group, Post Delhi Intrusives and Malani Igneous Suite. (8 Periods)

Suggested Readings:

1. Krumbein and Sloss – Stratigraphy and Sedimentation (WH Freeman & Co.)
2. Dunber, C.O. & Rodgers, J. – Principles of Stratigraphy (J.Wiley & Sons)
3. Krishnan, M.S. – Geology of India & Burma (CBS)
4. Pascoe, E.H. – A Manual of Geology of India & Burma (GSI)
5. Ravindra Kumar – Introduction of Historical Geology and Principles of Stratigraphy (CBS)
6. Rankama, K. – The Geologic Systems-The Pre cambrian Vol.-III Ed.(J. Wiley & Sons)
7. Eicher, Don, L. – Geologic Time (Prentice Hall)
8. Sinha Roy, S. Malhotra, G & Mohanty, M. – Geology of Rajasthan (Geol. Soc. Ind.)

M.Sc. Semester I Practicals

Practical Course GEOL 105-Core- 4 Credits

Maximum Marks: 100 (25 Internal Assessment +75 End Semester Exam) Exam Duration: 4 Hrs

(Practicals of Structural Geology, Geotectonics & Geomorphology and Remote Sensing)

Structural Geology 30 Marks

1. Solution of structural problems by stereographic and orthographic projection methods.
2. Identification of structural elements and their chronology in hand specimens.
3. Completion of outcrop patterns.
4. Study of Geological Maps, Preparation of Geological sections, determination of Thickness of beds, Geological History.

Geomorphology & Geotectonics 25 Marks

1. Study of topographic maps and their interpretation.
2. Representation of geomorphic features.
3. Geomorphic surveys, leveling and contouring.

Record 10 Marks

Viva-Voce 10 Marks

Mid Semester Assessment (Attendance-5, Seminars -20) 25 Marks

M.Sc. Semester I Practicals

Practical Course GEOL 106-Core- 4 Credits

Maximum Marks: 100 (25 Internal Assessment +75 End Semester Exam) Exam Duration: 4 Hrs

(Practicals of Crystallography & Mineralogy and Geochemistry)

Mineralogy **75 Marks**

1. Identification of important rock forming minerals by physical examination.
2. Identification of important rock forming minerals by optical examination.
3. Determination of 2V and pleochroic schemes of important rock forming minerals.

Crystallography **75 Marks**

1. Identification and description of crystal models in hand specimens.
2. Construction of Stereographic projections and determination of axial Ratio.
3. Problems related to stereographic projection of crystals.

Record **10 Marks**

Viva-Voce **15 Marks**

Mid Semester Assessment (Attendance-5, Seminars -20) **25 Marks**

M.Sc. Semester I Geological Tour

Course GEOL 107 -Core- 1 credit

General Geological tour of two weeks duration and Submission of report and Viva- voce Assessment should be done on

Teaching and Examination Scheme

Semester II

Paper No.	Course Nomenclature	Theory Hours per week	Practical Hours per week	Theory Exam. Hours	Credit
GEOL 201	Phanerozoic Stratigraphy of India	4	0	3	4
GEOL 202	Palaeontology	4	0	3	4
GEOL 203	Environmental Geology	4	0	3	4
GEOL 204	Economic Geology & Mineral Economics	4	0	3	4
GEOL 205	Lab: Phanerozoic Stratigraphy of India and Palaeontology	0	6	4	4
GEOL 206	Lab: Environmental Geology and Economic Geology & Mineral Economics	0	6	4	4
GEOL 207	Fieldwork Component – Core Geological Mapping Camp of one week duration at selected area and report thereon				

GEOL 201 – Phanerozoic Stratigraphy of India-Core- 4 Credits

Course Outcomes After learning this course, a student will be able to 1. Describe the different Stratigraphy units and their correlation to understand the stratigraphic framework of India.	Suggested Pedagogies 1. Use appropriate ICT tool, wherever necessary, for effective teaching. 2. Discuss recent research papers related to development of stratigraphy.
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Marks: 75

Periods: 40

Note: – Each Theory paper is divided into 5 units. The question paper is divided into three parts, Part A, Part B and Part C. Part A (20 Marks) is compulsory and contain one question containing 10 parts, two from each unit, each question is of 2 marks (Answer limit 50 Words). Part B (25 Marks) is compulsory and contains five questions with internal choice, one from each unit. Candidate is required to attempt all five questions; each question is of Five marks each (Answer limit 200 words). Part C (30 Marks) contains five questions one from each unit, Candidate is required to attempt three questions; each question is of 10 Marks (Answer limit 500 hundred words).

Unit - I

Precambrian- Cambrian boundary problem. Succession, fauna, flora, sedimentation, palaeogeography, age problems and regional correlation of the Palaeozoics of Indian sub- continent. (8 Periods)

Unit - II

Nomenclature, extent, division, succession, sedimentation, structures, palaeogeography; flora, fauna and regional correlation of the following: Triassics, Jurassics, Cretaceous of India. Cretaceous –Tertiary (K-T) boundary problem. (8 Periods)

Unit – III

Detailed study of Gondwana Supergroup: Succession, fauna, flora, sedimentation, palaeogeography, age problems and regional correlation of the Gondwana Group of rocks, Deccan Traps: Succession, fauna, flora, age problems and regional correlation, Intertrappean and Infratrappean beds. (8 Periods)

Unit – IV

Tertiary of Extra Peninsular India with special reference to Assam Lesser Himalayas. Tertiary of coastal region. (8 Periods)

Unit -V

Phanerozoic Stratigraphy of Rajasthan. Neogene- Quaternary boundary Problem. Quaternary Geology of Rajasthan.(8 Periods)

Suggested Readings:

1. Krishnan, M.S. – Geology of India & Burma (CBS)
2. Pascoe, E.H. – A Manual of Geology of India & Burma (GSI)
3. Ravindra Kumar – Introduction of Historical Geology and Principles of Stratigraphy (CBS)
4. Sinha Roy, S. Malhotra, G & Mohanty, M. – Geology of Rajasthan (Geol. Soc. Ind.)

GEOL 202 –Palaeontology -Core- 4 Credits

Course Outcome: After learning this course a student will be able to <ol style="list-style-type: none">1. Describe the different tectonic elements2. Understand the tectonic evolution of earth	Suggested Pedagogies <ol style="list-style-type: none">1. Use appropriate ICT tool, wherever necessary, for effective teaching.2. Discuss recent research papers related to development of stratigraphy.
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Marks: 75

Periods: 40

Note: – Each Theory paper is divided into 5 units. The question paper is divided into three parts, Part A, Part B and Part C. Part A (20 Marks) is compulsory and contain one question containing 10 parts, two from each unit, each question is of 2 marks (Answer limit 50 Words). Part B (25 Marks) is compulsory and contains five questions with internal choice, one from each unit. Candidate is required to attempt all five questions; each question is of Five marks each (Answer limit 200 words). Part C (30 Marks) contains five questions one from each unit, Candidate is required to attempt three questions; each question is of 10 Marks (Answer limit 500 hundred words).

Unit - I

Organic Evolution. Nomenclature of organisms. Classification of organisms. Distribution, migration, dispersal and extinction of animals and plants.

Fossil: Techniques of collection, preparation, preservation & nomenclature of fossils. Graptolites: their systematic position, evolution and geological history.

Unit - II

Anthozoa: Morphology and geological history of Tetracoralla, Hexacoralla and Tabulata; appearance of septa in Tetracoralla. Echinoidea: Change in symmetry, variation in oculo-genital system; ambulacral areas and compound plates, classification and geological history. Trilobita: Growth stages, evolutionary trends and

geological history. Brachiopoda: Variation in Brachial skeleton, pedicle opening and commissure, classification and geological history.

Unit – III

Bivalvia: Evolution of hinge and dentition, adaptive modification, classification and geological history.

Gastropoda: Forms, twisting of nervous system, aperture, classification and geological history.

Cephalopoda: variation in shape of Conch of nautiloidea, ornamentation and siphuncle of ammonoidea and geological history.

Unit – IV

Elements of Micropalaeontology, micro fossils–their classification, techniques of collection, separation, preparation and preservation. Environmental & geological significance of micro– fossils.

Foraminifera: Morphology, classification and significance in palaeo-ecological studies & oil exploration.

Ostrocods: Morphology, classification, ecology and geological history.

Conodonts: Morphology, classification, ecology and geological history. Nannofossils: morphology and geological distribution.

Unit -V

Palaeobotany –Study of Indian flora of the past with special reference to the Gondwana plant life. Elementary ideas about Pollens and Spores.

Vertebrate Palaeontology– classification of vertebrates and their sequence through geological time.

Study of Indian vertebrate fauna with special reference to Siwaliks.

Evolutionary trends of Horse, Elephant, Man and Giraffe

Suggested Readings:

1. Shrock & Twenhofel – Principles of Invertebrate Palaeontology (McGraw Hill)
2. Moore, Laliker & Fisher – Invertebrate fossils (McGraw Hill)
3. Colbert, E.H. – Evolution of the Vertebrates (J.Wiley & Sons)
4. Woods, H. – Invertebrate Palaeontology (CBS)
5. Jain and Anantharaman – Introduction to Palaeontology Vishal Publications. Jalandhar.
6. Black, R.M. - The Elements of Palaeontology. Cambridge University Press.

GEOL 203 – Environmental Geology-Core- 4 Credits

Course Outcome: After learning this course a student will be able to <ol style="list-style-type: none">1. Describe the different tectonic elements2. Understand the tectonic evolution of earth	Suggested Pedagogies <ol style="list-style-type: none">1. Use appropriate ICT tool, wherever necessary, for effective teaching.2. Discuss recent research papers related to development of stratigraphy.
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Marks: 75

Periods: 40

Note: – Each Theory paper is divided into 5 units. The question paper is divided into three parts, Part A, Part B and Part C. Part A (20 Marks) is compulsory and contain one question containing 10 parts, two from each unit, each question is of 2 marks (Answer limit 50 Words). Part B (25 Marks) is compulsory and contains five questions with internal choice, one from each unit. Candidate is required to attempt all five questions; each question is of Five marks each (Answer limit 200 words). Part C (30 Marks) contains five questions one from each unit, Candidate is required to attempt three questions; each question is of 10 Marks (Answer limit 500 hundred words).

Unit -I

Fundamental concepts of Environmental Geology. Geologic Cycles-Tectonic cycle, hydrologic cycle, rock cycle. Earth materials- minerals, rocks, soils, water, and air. Environmental Degradation. Pollution- types, Factors. Air pollution. Water resources; Surface Water Hydrology, Ground Water Hydrology; Surface and Ground Water water pollution. Water Management. Sediments and soil erosion. Sediment Pollution.

Wastes: Solid wastes, Hazardous Chemical wastes, Radio-active wastes, Liquid- Semi liquid (sewerage & waste water) Wastes and their disposal.

Unit -II

Environmental degradation and Pollution in India. Environmental Impact Assessment (EIA). Geologic aspects of environmental health: Determining health factors; Geologic factors of environmental health; Trace elements and health; Chronic diseases and geologic health. Hazardous Earth Processes:

River flooding: Magnitude & Frequency; Relationship with Urbanisation: Nature & extent of hazard: Perception of River flooding.

Unit -III

Landslides: Types; Slope stability; Forces on slopes; Factors effecting Landslides- Earth material type, slope & topography, climate & vegetation, water and the time; Causes of LS- real, immediate, external/ internal; Identification, prevention and correction (control) of LS; Snow Avalanche; Subsidence; Perception of LS hazard.

Earthquakes: EQ Waves, Focus and Epicentre; Effects of EQ- primary & secondary; Magnitude, intensity & frequency of EQ; Human impact on EQ- in cusing or reducing EQ; EQ Prediction; Adjustments to EQ; Perception to EQ.

Volcanoes: Types; Effects of volcanic activity; Prediction of volcanic activity; Adjustment to & Perception of Volcanic Hazard.

Coastal Hazards: Features of coasts; Tropical Cyclones/ Hurricanes; Tidal Floods; Tsunamis; Coastal Erosion; Engineering structures on coasts; Adjustment to & Perception of Coastal Hazards.

Unit -IV

Earth Resources and Environment: Minerals & Population; Resources & Reserves; Geology of Mineral Resources; Minerals from Sea; Environmental Impact of Mineral Development; Recycling Resources.

Energy and Environment: Energy and People; Coal- Geology; Classification; Distribution; Impact of coal mining; Petroleum- Geology; Distribution. Fossil Fuel & Acid Rain. Nuclear Energy: Fission; Geology &

distribution of Uranium; Nuclear Energy & Environment; Nuclear Energy: Fusion. Geothermal Energy- Geology of Geothermal Energy; Environmental Impact of Geothermal Energy; Future of Geothermal Energy. Renewable Energy Resources- Solar Energy, Water Power, Wind Power & Biomass Energy; Energy for tomorrow.

Unit – V

Landscape Evaluation: Land Use Planning Management; Site Selection and Evaluation; Landscape Aesthetics. Desertification and environmental impact.

Anthropogenic Impact and Environmental planning to open cast mining & quarrying, river valley projects, agriculture & use of fertilizers, excess withdrawal of ground water, urbanization & urban air environment, global climatic change.

Global environmental problems and international co-operation.

Environmental Laws.

Suggested Readings:

1. Keller, E.A. – Environmental Geology (CBS)
2. Valdiya K.S. – Environmental Geology. Tata MGH
3. Coates, D.R. – Environmental Geology
4. Flames, P.T. – Environmental Geology, Conservation land use planning and Resource Development.
5. Cooke and Drunkamp – Geomorphology in Environment Pollution.
6. Horn, B. & Scott, M. – Geological Hazards (Springer Verlag)
7. Tank, R.W. – Focus on Environmental Geology (Oxford)
8. Savindra Singh – Environmental Geography. Prayag Pustak Bhawan.
9. Pratap Singh – Sustainable Development with Renewable Energy Resources. (Yash Publi; Bikaner)
10. Abbasi & Abbasi - Renewable Energy Resources & their Implication. (Prentice Hall India)

GEOL 204 – Economic Geology & Mineral Economics -Core- 4 Credits

<p>Course Outcome: After learning this course a student will be able to</p> <ol style="list-style-type: none"> 1. Describe the different tectonic elements 2. Understand the tectonic evolution of earth 	<p>Suggested Pedagogies</p> <ol style="list-style-type: none"> 1. Use appropriate ICT tool, wherever necessary, for effective teaching. 2. Discuss recent research papers related to development of stratigraphy.
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Marks: 75

Periods: 40

Note: – Each Theory paper is divided into 5 units. The question paper is divided into three parts, Part A, Part B and Part C. Part A (20 Marks) is compulsory and contain one question containing 10 parts, two from each unit, each question is of 2 marks (Answer limit 50 Words). Part B (25 Marks) is compulsory and contains five questions with internal choice, one from each unit. Candidate is required to attempt all five questions; each

question is of Five marks each (Answer limit 200 words). Part C (30 Marks) contains five questions one from each unit, Candidate is required to attempt three questions; each question is of 10 Marks (Answer limit 500 hundred words).

Unit I

Magma and its relation with the mineral deposits. The development of modern theories of ore deposition. Physical and chemical characteristics of ore bearing fluids and their genesis. Migration of ore bearing fluids and deposition of ores. Fluid inclusion. Geothermometry and isotope studies in relation to ore deposits. Concept of ore microscopy. Classification of ore deposits, stratiform and stratabound ore deposits. Structural controls of mineralisation. Metallogenic epoch and provinces; Global metallogeny related to crustal evolution. (Period- 8)

Unit- II

Study of the processes of formation of mineral deposits:
Magmatic concentration, Sublimation, Contact metasomatism, Metamorphism, Hydrothermal, Sedimentation, Bacteriogenic, Submarine exhalative & Volcanogenic, Evaporation, Residual and Mechanical concentration, Oxidation and supergene sulphide enrichment. (Period- 8)

Unit- III

The study of metallic mineral deposits with reference to geology, mode of occurrence, origin, uses and distribution in India of Gold, Copper, Lead-Zinc, Iron, Manganese, Aluminium, Magnesium, Chromium and strategic minerals of India. (Period- 8)

Unit- IV

The study of non- metallic mineral deposits with reference to geology, mode of occurrence, origin, uses and distribution in India of Mica, Asbestos, Barytes, Gypsum, Limestone Garnet, Corundum, wollastonite, calcite, quartz, feldspar, clays, Kyanite, Sillimanite, Graphite, Talc, Fluorite, Beryl and Rock phosphate, Gem minerals and radio-active minerals. Non- metallic minerals used in refractories, abrasives, ceramics, glass making materials, fertilizers, natural paints & pigments and cement (Period- 8)

Unit- V

(Period- 8)

Suggested Readings:

1. Bateman, A.M. – Economic Mineral Deposits (J. Wiley & Sons)
2. Smirov, V.I. – Geology of Mineral Deposits (M.R. Pub)
3. Park C.F. and McDiarmid R.A. – Ore Deposits (W.H. Freeman & Co.)
4. Stanton R.L. – Ore Petrology (McGraw Hill)
5. Krishnaswami – Mineral Resources of India (CBS)

M.Sc. Semester II Practicals
Practical Course GEOL 205-Core- 4 Credits

Maximum Marks: 50

Exam Duration: 4 Hrs

(Practicals of Phanerozoic Stratigraphy of India and Palaeontology)

Marks: 50

Exam Duration: 4 Hours

Phanerozoic Stratigraphy

15 Marks

1. Study of rocks in Hand specimens from Precambrian terrain of India.
2. Showing boundaries of the Precambrian terrains of India on map.
3. Stratigraphic and Palaeogeographic maps with special reference to India.
- 4 Identification of stratigraphic rocks in hand specimen.
5. Preparation of Lithology and their correlation, correlation problems.

Palaeontology

20 Marks

1. Identification, drawing and description of common representatives of Fossil groups covered in theory syllabus.
2. Sketching of evolutionary trends of important fossils groups.
3. Evolutionary trends of invertebrate and vertebrates

Record

5 Marks

Viva-Voce

10 Marks

M.Sc. Semester II Practicals
Practical Course GEOL 206-Core- 4 Credits

Maximum Marks: 50

Exam Duration: 4 Hrs

(Practicals of Environmental Geology & Economic Geology & Mineral Economics)

Environmental Geology

15 Marks

1. Diagrammatic representation of Geologic cycles- tectonic, hydrological, rock & geo chemical cycles.
2. Laboratory problems related to environmental geology.
3. Application of geological data for environmental purposes.
4. Graphical representation of geo-environmental data etc

Economic Geology & Mineral Economics

20 Marks

1. Study of economic minerals in hand specimens, their distribution and genesis.
2. Determination of important ore minerals under reflected light.

3. Distribution of important minerals in the maps of India and Rajasthan

Record

5 Marks

Viva-Voce

10 Marks

M.Sc. Semester II Geological Mapping

Course GEOL 207 -Core- 1 credit

General Mapping Camp of one week duration and Submission of report and Viva- voce

Teaching and Examination Scheme

Semester III

Paper No.	Course Nomenclature	Theory Hours per week	Practical Hours per week	Theory Exam. Hours	Credit
GEOL 301	Igneous & Metamorphic Petrology	4	0	3	4
GEOL 302	Geochemistry & Analytical Methods	4	0	3	4
GEOL 303	Sedimentology	4	0	3	4
GEOL 304	Hydrogeology & Engg. Geology	4	0	3	4
GEOL 305	Lab: Economic Geology & Mineral Economics and Igneous & Metamorphic Petrology	0	6	4	4
GEOL 306	Lab: Sedimentology & Petroleum Geology and Environmental Geology	0	6	4	4
GEOL 307	Fieldwork Component- Core General Geological Tour of Two Weeks Duration				

GEOL 301 – Igneous and Metamorphic Petrology-Core- 4 Credits

Course Outcome: After learning this course a student will be able to <ol style="list-style-type: none">1. Describe the different tectonic elements2. Understand the tectonic evolution of earth	Suggested Pedagogies <ol style="list-style-type: none">1. Use appropriate ICT tool, wherever necessary, for effective teaching.2. Discuss recent research papers related to development of stratigraphy.
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Marks: 75

Periods: 40

Note: – Each Theory paper is divided into 5 units. The question paper is divided into three parts, Part A, Part B and Part C. Part A (20 Marks) is compulsory and contain one question containing 10 parts, two from each unit, each question is of 2 marks (Answer limit 50 Words). Part B (25 Marks) is compulsory and contains five questions with internal choice, one from each unit. Candidate is required to attempt all five questions; each question is of Five marks each (Answer limit 200 words). Part C (30 Marks) contains five questions one from each unit, Candidate is required to attempt three questions; each question is of 10 Marks (Answer limit 500 hundred words).

Unit-I

Composition, constitution & behaviour of magma. Magma types and their classification. Origin of magma. Differentiation and assimilation of magma. End-stage crystallisation of magma. Magma generation and its relation with plate margins. Fabric study of plutonic and volcanic rocks. Classification of Igneous rocks. Petrographic provinces of India.

Unit-II

Crystallisation process in silicate melts including system: Albite- Anorthite, Albite-Anorthite-Orthoclase, Foresterite- Silica, Leucite-Silica, Diopside- Anorthite-Albite, Diopside- Foresterite-Silica, Nepheline-Kaliophylite-silica, Foresterite- Faylite-Silica; Reaction principles. Forms, structure and textures of igneous rocks.

Unit-III

Petrography, mode of occurrence and petrogenesis of the following rock groups and associations: Basic and Ultrabasic plutonic association; Granite and Granodiorite plutonic association; Nepheline Syenite, Ophiolites and cumulates, Anorthosite and Pegmatite; Tholeites and alkali Olivine basalt. Dacite and Rhyolite association of Orogenic regions.

Unit-IV

Element analysis of rocks and minerals. Principles and geological applications of cathodoluminescence, thermoluminescence, atomic absorption spectrophotometry, XRF spectrometry and XRD.

Working knowledge of AAS, Flame- photometer, DTA, ICP spectrometer, UV- IR spectrophotometer and working techniques.

Metamorphism: concept, factors and types. Texture and structure of metamorphic rocks. Phase rule.

Concept of the depth zone, zone of progressive metamorphism. Retrogressive metamorphism; stress and anti stress minerals. Anatexis and migmatites. ACF, AKF, & AFM diagrams and their significance.

Unit- V

Detailed study of facies of contact and regional metamorphism. Paired metamorphic belts.

Mineralogical and textural changes accompanying progressive regional metamorphism of mafic and ultramafic rocks, pelites and carbonate rocks. Metasomatism and metamorphic differentiation.

Petrographic and petrogenetic study of important metamorphic rocks; granulites, charnockites and eclogites etc;

Ultra-high temperature, ultra-high pressure and ocean floor metamorphism and their significance.

Suggested Readings:

1. Bowen, N.L. – Evolution of Igneous rocks (Princeton University Press)
2. Jackson – Text book of Lithology
3. Best – Igneous and Metamorphic Petrology (CBS)
4. Winkler H.G.F. - Petrogenesis of Metamorphic Rocks (Springer-Verlog)
5. Miashiros – Metamorphism and metamorphic Rocks (George Allen University)
6. Moorehouse – A study of Thin Sections (CBS)
7. Ghose, M.K. – Igneous Petrology (World Press Pvt. Ltd., Kolkata)
8. Chatterjee, S.C. – Igneous & metamorphic Rocks
9. Johanneson, A – A Descriptive Petrology of Igneous Rocks –Vol. I-IV (University of Chicago Press).
10. Turner, F.J. - Metamorphic Petrology. Mc Graw Hill.
11. Philipots, A. - Igneous and Metamorphic Petrology. Prentice Hall.
12. Mason, Brian - Principles of Geochemistry.
13. Hutchinson, C.S. - Laboratory Hand Book of Petrographic Techniques. John Wiley.
14. Mason, B. and Moore, C.B. - Introduction to Geochemistry. Wiley Eastern.
15. Krauskopf, K.B. - Introduction to Geochemistry. McGrew Hill.
16. Faure, G. - Principles of Isotope Geology. John Wiley.
17. Govett, G.J.S. - Hand Book of Exploration Geochemistry. Elsevier.

GEOL 302– Geochemistry & Analytical Methods -Core- 4 Credits

<p>Course Outcome: After learning this course a student will be able to</p> <ol style="list-style-type: none">3. Describe the different tectonic elements4. Understand the tectonic evolution of earth	<p>Suggested Pedagogies</p> <ol style="list-style-type: none">1. Use appropriate ICT tool, wherever necessary, for effective teaching. <p>Discuss recent research papers related to development of stratigraphy.</p>
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Marks: 75

Periods: 40

Note: – Each Theory paper is divided into 5 units. The question paper is divided into three parts, Part A, Part B and Part C. Part A (20 Marks) is compulsory and contain one question containing 10 parts, two from each unit, each question is of 2 marks (Answer limit 50 Words). Part B (25 Marks) is compulsory and contains five questions with internal choice, one from each unit. Candidate is required to attempt all five questions, each question is of Five marks each (Answer limit 200 words). Part C (30 Marks) contains five questions one from each unit, Candidate is required to attempt three questions; each question is of 10 Marks (Answer limit 500 hundred words).

Unit -I

Introduction of Geochemistry and Cosmochemistry. Chemical composition and properties of Earth's layers. Atmosphere: its layers, chemical composition and evolution of Atmosphere. Meteorites. Gold- Schmidt geochemical classification. Concept of enthalpy, free energy; chemical potential; fugacity, Structure and types of atoms. Internal structure of atoms, atomic weights. Types of chemical bonding. Ionic radii. Coordination number. (8 Periods)

Unit -II

Lattice energy. Ionization potential. Electronegativity. Pauling's rule. Isomorphism and polymorphism. Principles of ionic substitution in minerals. Eh and pH diagrams, limits of Eh and pH in nature; oxidation and reduction in sedimentation. Geochemical cycle; Minor cycle and Major cycle. Geochemical classification of elements. distribution of elements in igneous, metamorphic and sedimentary rocks. Periodic table with special reference to rare earth elements and transition elements. (8 Periods)

Unit -III

Isotope Geochemistry: stable isotopes, oxygen isotopes, sulphur isotopes, carbon isotopes, hydrogen isotopes. Use of isotope geochemistry in solving problems of ore genesis, ground water and petrogenesis. Element analysis of rocks and minerals. Geochemistry of Uranium and Lithium. (8 Periods)

Unit -IV

Concept of geochemical- biogeochemical cycling and global climate; Hydrosphere: the hydrological cycle, composition of natural waters, some characteristics of river waters and ground water; Biosphere: Introduction: the mass of the biosphere: composition of the biosphere: biogenic deposits; geochemical cycle of carbon. (8 Periods)

Unit -V

Principles and geological applications of cathodoluminescence, thermoluminescence, atomic absorption spectrophotometry, XRF spectrometry and XRD. Working knowledge of AAS, Flame- photometer, DTA, ICP spectrometer, UV- IR spectrophotometer and working techniques. (8 Periods)

Suggested Readings:

1. Mason, B. – Principles of Geochemistry (McGraw Hill)
2. Kraushopf – Introduction to Geochemistry (McGraw Hill)

3. Fyfe – Geochemistry (Clereton Press Oxford)
4. Sharma, N.L. – Determinative Tables (ISM, Dhanbad).
5. Mason, Brian - Principles of Geochemistry.
6. Mason, B. and Moore, C.B. - Introduction to Geochemistry. Wiley Eastern.
7. Faure, G. - Principles of Isotope Geology. John Wiley.
8. Govett, G.J.S. - Hand Book of Exploration Geochemistry. Elsevier.

GEOL 303– Sedimentology -Core- 4 Credits

<p>Course Outcome: After learning this course a student will be able to</p> <ol style="list-style-type: none"> 1. Describe the different tectonic elements 2. Understand the tectonic evolution of earth 	<p>Suggested Pedagogies</p> <ol style="list-style-type: none"> 1. Use appropriate ICT tool, wherever necessary, for effective teaching. 2. Discuss recent research papers related to development of stratigraphy.
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Marks: 75

Periods: 40

Note: – Each Theory paper is divided into 5 units. The question paper is divided into three parts, Part A, Part B and Part C. Part A (20 Marks) is compulsory and contain one question containing 10 parts, two from each unit, each question is of 2 marks (Answer limit 50 Words). Part B (25 Marks) is compulsory and contains five questions with internal choice, one from each unit. Candidate is required to attempt all five questions; each question is of Five marks each (Answer limit 200 words). Part C (30 Marks) contains five questions one from each unit, Candidate is required to attempt three questions; each question is of 10 Marks (Answer limit 500 hundred words).

Unit-I

Introduction, scope, history of development of sedimentology.

Processes of sedimentation. Post depositional changes in sediments. Surface processes and rock weathering. Mineral stability. Provenance sources of sediments.

Mineral composition: quartz, feldspar, rock fragments, clay minerals, heavy minerals, carbonates, cement and matrix. Soil forming processes, soil profile. Identification of clay minerals by X-Ray diffraction method. (8 Periods)

Unit-II

Texture and structures of sedimentary rocks. Trace fossils–introduction, classification, identification and description.

Transportation of sediments. Settling velocity of spheres. Stock's law. Impact law. fluid flow movements of particles, suspension and traction transport, saltation movement, selective transportation, particle weathering during transport, sediment maturity. (8 Periods)

Unit-III

Deposition of clastic and non-clastic sediments. Classification of sedimentary rocks.

Study of common sedimentary rocks: Clastic sedimentary rocks – deposits of gravels, conglomerates, breccia, sandstone, graywacke, shale, siltstone etc.

Non-clastic sedimentary rocks– limestone, dolomite, evaporites. Organic sediments. (8 Periods)

Unit-IV

Sedimentary environment and facies: continental alluvial- fluvial, lacustrine, desert – Aeolian and glacial sedimentary systems. Shallow coastal clastics. Marine and continental evaporates. Shallow water carbonates.

Deep sea basins. Volcanoclastics: onland and marine. (8 Periods)

Unit- V

Tectonics and sedimentation. Stratigraphy and sedimentation; Reconstruction of palaeoenvironment. Basin analysis. (8 Periods)

Suggested Readings:

1. Sengupta, S.M. – Introduction of Sedimentology (Oxford & IBH)
2. Pettijohn, F.J. – Sedimentary Rocks (CBS)
3. Slley, R.C. – Introduction to Sedimentary Rocks (Academic Press London)
4. Folk, R.L. – Petrology of Sedimentary Rocks (Hemphill Pub. Co.)
5. Allen – Sedimentary Structures
6. Thomson – Sedimentary Structures
7. Green smith – Sedimentary Petrology (CBS)
8. Krumbein and Sloss – Stratigraphy and Sedimentation (W.H. Freeman & Co.)
9. Reineck and Singh – Depositional Environments.
10. Landes, K.K. – Petroleum Geology (Robert, Kraieger Pub. Co.).
11. Kinghorn, R.R.F. – An Introduction to the Physics and chemistry of Petroleum (J. Wiley & Sons).
12. Levorson – Petroleum Geology
13. Selley, R.C. - Elements of Petroleum Geology. Academic Press.

GEOL 304 – Hydrogeology & Engineering Geology

Course Outcomes	Suggested Pedagogies
<p>After learning the course, a student will be able to</p> <p>1. Describe the rock hydrological properties to</p>	<p>Use appropriate ICT tool, wherever necessary, for effective teaching.</p>

<p>understand the aquifer and its characteristics.</p> <p>2. Carry out hydro geological investigation for any region and propose watershed development measures.</p>	<p>Discuss case studies related to ground water issues in India.</p> <p>One day field work for hydro geological investigation.</p>
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Marks: 75

Periods: 40

Note: – Each Theory paper is divided into 5 units. The question paper is divided into three parts, Part A, Part B and Part C. Part A (20 Marks) is compulsory and contain one question containing 10 parts, two from each unit, each question is of 2 marks (Answer limit 50 Words). Part B (25 Marks) is compulsory and contains five questions with internal choice, one from each unit. Candidate is required to attempt all five questions; each question is of Five marks each (Answer limit 200 words). Part C (30 Marks) contains five questions one from each unit, Candidate is required to attempt three questions; each question is of 10 Marks (Answer limit 500 hundred words).

Unit-I

Hydrogeology- Introduction: scope, historical background and utilization of groundwater.

Hydrological cycle. Sources of groundwater;

Rock properties affecting groundwater; Porosity and Permeability.

Vertical distribution of groundwater; Aquifers and their types. groundwater Basins.

Unit -II

Groundwater movement. Darcy's law.

Coefficient of permeability. Measurement of permeability.

Tracing groundwater movement and dating; flow lines.

Water wells: their types and construction methods; collector wells and infiltration galleries.

groundwater level fluctuation. Hydrogeologic characteristics of common types of rocks.

Unit- III

Ground water quality: Measures of water quality; physical, chemical & bacteriological analysis; water quality criteria for drinking, irrigation & industrial purposes.

Groundwater Pollution and Restoration; collection of water samples, analysis of groundwater. Groundwater monitoring,

Basin wide groundwater development: Safe yield & overdraft.

Equations of hydrologic equilibrium. Data collection for basin investigation; method of computing safe yield; variability of safe yield.

Conjunctive use of surface & groundwater Reservoirs.

Unit- IV

Groundwater Exploration: Geologic and hydrogeologic methods; Geophysical exploration; Test drilling.

Hydrogeologic and geophysical well logging.

Artificial recharge: need and benefits, methods of artificial recharge: induced recharge, recharge well method, recharge through pits and shafts.

Sewage and wastewater recharge; subsurface dams; recharge wells for storm drainage.

G.W. Development & Potentials in India. G.W. Potentials of Rajasthan.

Unit- V

Application of Geology in Civil engineering.

Engineering properties of rocks. Rocks as construction material.

Importance and stages of geological exploration; including Subsurface & Subsurface exploration for important engineering projects.

Dams: Terminology, Classification & types of Dams, Problems related to Dams, geology of damsite, Foundation & abutment competency; Reservoirs: Reservoir site, Reservoir problems, geology of Reservoir site; Geological Investigation of Dam & Reservoir.

Tunnels: Terminology, Classification of Tunnels; Geologic Parameters & Problems Earth Tunneling; Geologic Parameters & Problems Rock Tunneling;

M.Sc. Semester III Practicals Practical Course GEOL 305-Core- 4 Credits

Maximum Marks: 50

Exam Duration: 4 Hrs

(Practicals of Economic Geology and Igneous & Metamorphic Petrology)

Marks: 50

Exam Duration: 4 Hours

Igneous and Metamorphic Petrology

25 Marks

1. Description and identification of Igneous and Metamorphic rocks in Hand Specimens and under microscope.
2. Petrographic methods and calculation of CIPW norms and Niggli values and their plotting.
3. Petrochemical calculations and representation (ACF & AKF diagrams)

Geochemistry

1. Preparation and interpretation of geochemical maps;
2. Rock/ sediments/ water/ soil analysis;
3. Preparation of classificatory and variation diagrams, REE normalized plots and their interpretation

10 Marks

Record

5 Marks

Viva-Voce

10 Marks

M.Sc. Semester III Practicals Practical Course GEOL 306-Core- 4 Credits

Maximum Marks: 50

Exam Duration: 4 Hrs

(Practicals of Sedimentology & Petroleum Geology and Environmental Geology and Submission of report and Viva- voce on General Geological Tour of selected Areas)

Marks: 50

Exam Duration: 4 Hours

Sedimentology**20 Marks**

1. Study of common sedimentary rocks in hand specimens and in thin section.
2. Graphic representation of grain size data, histograms, cumulative curve,
3. frequency curves, rose diagram etc.
4. Palaeocurrent analysis and their representations.

Hydrogeology & Engineering Geology**15 Marks**

1. Preparation and study of water table maps, depth to water maps & fluctuation maps.
2. Study of hydrological and engineering properties of rocks.
3. Study of ground water quality & Preparation and study of ground water quality maps
4. Study of Important Indian Dams, Tunnels and other engineering projects

Record**5 Marks****Viva-Voce****10 Marks****M.Sc. Semester III Geological Mapping****Course GEOL 307 -Core- 1 credit**

General Geological Tour of two weeks duration and Submission of report and Viva- voce

Teaching and Examination Scheme**Semester III**

Paper No.	Course Nomenclature	Theory Hours per week	Practical Hours per week	Theory Exam. Hours	Credit
GEOL 401	Exploration & Remote Sensing	4	0	3	4
GEOL 402	Elements of Mining & Mineral Dressing	4	0	3	4
GEOL 403	Mineral Economics	4	0	3	4
GEOL 404	Geo-Energy Resources	4	0	3	4
GEOL 405	Lab: Exploration & Remote Sensing and Elements of Mining & Mineral Dressing	0	6	4	4
GEOL 406	Lab: Mineral Economics & and Geo- Energy Resources	0	6	4	4
GEOL 407	Fieldwork Component- Core- Mining Camp of two weeks duration				

GEOL 401 – Exploration & Remote Sensing -Core- 4 Credits

Course Outcomes	Suggested Pedagogies
<p>After learning the course a student will be able to</p> <ol style="list-style-type: none">1. Describe the principles and procedures of different exploration techniques used to measure and map geologic, geophysical and geochemical characteristics of the subsurface.2. To study the applications of various exploration techniques for mineral and energy exploration.3. To understand the importance of data-quality, collection, analysis, data processing techniques, strength and limitation of each techniques.	<ol style="list-style-type: none">1. Use appropriate ICT tool, wherever necessary, for effective teaching2. Discuss recent developments in exploration techniques.3. Discussion on case studies for comparative studies of different techniques.

Marks: 75

Periods: 40

Note: – Each Theory paper is divided into 5 units. The question paper is divided into three parts, Part A, Part B and Part C. Part A (20 Marks) is compulsory and contain one question containing 10 parts, two from each unit, each question is of 2 marks (Answer limit 50 Words). Part B (25 Marks) is compulsory and contains five questions with internal choice, one from each unit. Candidate is required to attempt all five questions; each question is of Five marks each (Answer limit 200 words). Part C (30 Marks) contains five questions one from each unit, Candidate is required to attempt three questions; each question is of 10 Marks (Answer limit 500 hundred words).

Unit- I

Exploration and its types. Surface exploration.

Topographic surveying – chain, compass and tape, plane table, theodolite; leveling and contouring. Geologic mapping- reconnaissance and detailed surface mapping- Base map and topo sheet, mapping techniques for lithologies, field data collection. Subsurface mapping. Guides to ores: Targets, loci, regional guides.

Classification of guides; geochemical guides; physiographic guides; mineralogical guides; stratigraphic and lithologic guides; structural guides- fractures, folds, faults.

Unit -II

Sampling and tonnage: Sampling and types; average assays. Geochemical prospecting: geochemical processes- primary and secondary; pathfinder; anomalies; geochemical field techniques and analysis; geobotanical surveys; Subsurface exploration: drilling and types, bore hole problems, bore hole samplings. Preservation and sampling of cores. Geophysical prospecting- electrical, gravity, magnetic, seismic, radio active method, well logging, aerial geophysical survey.

Unit- III

Maps and aerial photographs; Aerial photographs- types, errors and distortion. Instruments used in Photo interpretation, plotting & measurements from aerial photographs. Rectification. Vertical exaggeration and its estimation.

Flight procedure and computation of flight lines, mosaic, preparation of base map by radial triangulation methods.

Geometric characteristics of aerial photograph. Simple relative orientation, displacement in single photograph and in stereo-pairs and their corrections. Stereoscopic vision, pseudoscopic vision, measuring instrument and their uses, calculation of height of an object by parallax method.

Unit- IV

Remote sensing. Aero visual survey. Infrared photography, multiple band photography. Imageries.

Types of satellites. Satellite remote sensing and its limitations. Global and Indian space missions.

Advantages, limitations and factors affecting photo interpretation.

Application of aerial photographs in the interpretation of geomorphology, geological structures/ lithologies, soils, mineral exploration, petroleum exploration and ground water exploration.

Application of Remote sensing in the interpretation of geomorphology, geological structures/ lithologies, soils, mineral exploration, petroleum exploration and ground water exploration.

Geographic Information System (GIS): Principles and Applications. Vector and Raster Analysis

Remote sensing and GIS.

Unit- V

Mining: Methods of breaking rocks. Explosives and blasting

Mining: Mining terminology. Classification of mining methods: Alluvial mining; open cast mining; under ground mining and coal mining methods.

Suggested Readings:

1. Singh & Sahni – Advanced Surveying (IBH)
2. Krynine & Judd – Principles of Engineering Geology and Geotectonics (McGraw Hill)
3. Parbin Singh – Engineering and General Geology
4. SathyaNarayan swami, B.S. – Engineering Geology (Dhanpat Rai & Co.)
5. Blyth – Geology of Engineers (ELBS)

GEOL 402 – Elements of Mining & Mineral Dressing-Core- 4 Credits

Course Outcomes	Suggested Pedagogies
<p>After learning the course, a student will be able to</p> <ol style="list-style-type: none">1. Describe the principles and procedures of different exploration techniques used to measure and map geologic, geophysical and geochemical characteristics of the subsurface.2. To study the applications of various exploration techniques for mineral and energy exploration.3. To understand the importance of data-quality, collection, analysis, data processing techniques, strength and limitation of each techniques.	<ol style="list-style-type: none">1. Use appropriate ICT tool, wherever necessary, for effective teaching2. Discuss recent developments in exploration techniques.3. Discussion on case studies for comparative studies of different techniques.

Marks: 75

Periods: 40

Note: – Each Theory paper is divided into 5 units. The question paper is divided into three parts, Part A, Part B and Part C. Part A (20 Marks) is compulsory and contain one question containing 10 parts, two from each unit, each question is of 2 marks (Answer limit 50 Words). Part B (25 Marks) is compulsory and contains five questions with internal choice, one from each unit. Candidate is required to attempt all five questions; each question is of Five marks each (Answer limit 200 words). Part C (30 Marks) contains five questions one from each unit, Candidate is required to attempt three questions; each question is of 10 Marks (Answer limit 500 hundred words).

Unit-I

Elements of Mining: Classification of mining methods. Mining: Methods of breaking rocks. Explosives and blasting. Mining Methods: Placer mining methods, open pit methods, their advantages and disadvantages.

Unit -II

Underground mining methods, Coal Mining methods and Ocean bottom mining methods; their advantages and disadvantages.

Ventilation in underground mining: Purpose, types and arrangements of ventilation in underground mining.

Mining hazards and safety measures.

Unit- III

Mineral Dressing and its importance, low grade ores and their beneficiation; Ore-microscopy and its contribution to ore-dressing techniques. Aggregate properties of minerals and rocks and their consideration in ore dressing techniques.

Principles & Methods of Mineral dressing: approach; preparation; methods- gravity separation, magnetic separation, electrostatic separation, flotation; reagents; Collectors; Frothers; Modifiers; Agglomeration; miscellaneous processes- amalgamation, thickening, filtration, dewatering, drying.

Role of Bacteria in Beneficiation of coal and lean grade ores.

Unit- IV

Phases of mineral processing, mineral dressing and hand picking, crushing, grinding, sizing, classification, air sizing, blending, concentration, washing, gravity separation – jigging, tabling, vanners and miscellaneous floatations.

Unit- V

Dressing of Indian Metallic and non-metallic ores, Beach Sand & coal.

Flow sheets for Chromite, Gold, Copper, Lead, Zinc, Manganese, Gypsum, Clay and Coal.

Introduction to mineral information system.

Suggested Readings:

6. Singh & Sahni – Advanced Surveying (IBH)
7. Krynine & Judd – Principles of Engineering Geology and Geotectonics (McGraw Hill)
8. Parbin Singh – Engineering and General Geology
9. SathyaNarayan swami, B.S. – Engineering Geology (Dhanpat Rai & Co.)
10. Blyth – Geology of Engineers (ELBS)

GEOL 403 – Mineral Economics -Core- 4 Credits

<p>Course Outcome: After learning this course a student will be able to</p> <ol style="list-style-type: none"> 1. Describe the different tectonic elements 2. Understand the tectonic evolution of earth 	<p>Suggested Pedagogies</p> <ol style="list-style-type: none"> 1. Use appropriate ICT tool, wherever necessary, for effective teaching. 2. Discuss recent research papers related to development of stratigraphy.
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Marks: 75

Periods: 40

Note: – Each Theory paper is divided into 5 units. The question paper is divided into three parts, Part A, Part B and Part C. Part A (20 Marks) is compulsory and contain one question containing 10 parts, two from each unit, each question is of 2 marks (Answer limit 50 Words). Part B (25 Marks) is compulsory and contains five questions with internal choice, one from each unit. Candidate is required to attempt all five questions; each

question is of Five marks each (Answer limit 200 words). Part C (30 Marks) contains five questions one from each unit, Candidate is required to attempt three questions; each question is of 10 Marks (Answer limit 500 hundred words).

Unit-I

Mineral Economics: Concept and scope of mineral economics.

Peculiarities inherent in mineral industry

Mineral Resources of India. Future Sources of Mineral supply.

Mining Laws of various Lands. Marine Mineral Resources & Law of the Sea. Tenor, grade & specification.

Strategic, critical and essential minerals.

Conservation and substitution. Changing patterns of mineral consumption.

Unit-II

Mining & Mineral Legislation of India: Categories of minerals for grant of concessions; Minor & Major Minerals. United Nations Framework Classification (UNFC).

Economic consideration in mineral exploration: cost of exploration, macro-economic consideration, organization & management.

Unit-III

Methods of Estimation of Reserves: Classification of Reserves (International & National); sampling; Spacing of pits, trenches, bore holes & grooves; Assay; Processing & interpretation of Sampling data; reserve calculation; Estimation of reserve by exploratory mining; Economic consideration in Reserve estimation; estimation of primary oil reserves; estimation of natural gas reserves. Feasibility study.

Unit-IV

Infrastructure: Common types of Infrastructure, Infrastructure development policy.

Production: guiding factors & sectors of production; economics of factors; Actual Production.

Processing before, during and after mining. Co-products & By-products.

Mineral inventory concept, characteristics, composition, economic significance.

Internal & External Trade. Price.

Monopoly & Stock Pile. Demand Analysis & Market Survey.

Unit-V

Small Mines & small deposits: Concept of small mines, socio-economic importance of small mines, problems of small mines, Definition of a small mines, Defining a small deposit.

Growth of mineral industry and economy. National mineral policy and states mineral policies.

Quantitative techniques for estimating mineral demand.

Suggested Readings:

1. Arogyaswami, R.N.P. – Courses in mining Geology (oxford & IBH)

2. Sinha, R.K. and Sharma, N.L. – Mineral Economics (oxford & IBH)
3. Chatterjee, K.K. – An introduction to mineral economics (willey eastern).

GEOL 404 – Geo-Energy Resources-Core- 4 Credits

Course Outcomes	Suggested Pedagogies
<p>After learning the course a student will be able to</p> <ol style="list-style-type: none"> 1. Describe the origin, occurrence and distribution of petroleum and natural gas. 1. Describe the origin, occurrence and distribution of coal. 2. Describe the origin, occurrence and distribution of non-renewable energy resources. 2. To understand global scenario of coal and petroleum industries and opportunities. 	<ol style="list-style-type: none"> 1. Use appropriate ICT tool, wherever necessary, for effective teaching. 2. Case studies on various petroleum reservoirs in India and at global level. 3. Discuss the emerging techniques for hydrocarbon explorations.

Marks: 75

Periods: 40

Note: – Each Theory paper is divided into 5 units. The question paper is divided into three parts, Part A, Part B and Part C. Part A (20 Marks) is compulsory and contain one question containing 10 parts, two from each unit, each question is of 2 marks (Answer limit 50 Words). Part B (25 Marks) is compulsory and contains five questions with internal choice, one from each unit. Candidate is required to attempt all five questions; each question is of Five marks each (Answer limit 200 words). Part C (30 Marks) contains five questions one from each unit, Candidate is required to attempt three questions; each question is of 10 Marks (Answer limit 500 hundred words).

Unit-I

Classification of Energy Resources and Geoenergy Resources.

Origin of coal.

Rank, grade and type of coal. Classification of coal.

Chemical characterization: proximate and ultimate analysis.

Coal petrology and its application. Concept of maceral, litho types and microlithotypes. Reflectance.

Coal carbonisation.

Distribution and geology of Indian Coal fields, Reserves, utilization and conservation of coal in India.

Coal distribution in World.

Coal based industries in India. Coal bed methane.

Unit-II

Petroleum: Surface & subsurface Occurrences, geographic Location, geologic age and reservoir rock.
Petroleum- chemical and physical properties. Origin of Petroleum. Migration and accumulation of Petroleum.
Reservoir rock: Classification – fragmental, chemical & bio-chemical and micellaneous rocks; well logs; marine & non-marine reservoir rocks.
Reservoir Pore Space: Porosity; permeability; Classification & origin of pore space; relation between Porosity & permeability.
Reservoir fluids (water, oil & gas): Fluid content – source of data, distribution of gas, oil & water, classification of waters, character of oil-field water, oil field brine; Oil – measurement, chemical & physical properties; Gas - measurement, composition, impurities.

Unit- III

Reservoir Traps: Anticlinal theory; classification; structural traps; stratigraphic traps (primary & secondary); fluid traps; combination traps; salt domes.
Reservoir pressure and temperature. Reservoir mechanics.
Types of reservoirs of oil and gas, oil and gas traps. Geology of the petroliferous basins of India.

Unit- IV

Principles and techniques of petroleum exploration.
Application of subsurface mapping in Petroleum exploration – Structural maps & sections, isopach maps, facies maps, paleogeologic & subcrop maps, geophysical maps, geochemical maps; Dry Holes.
Elements of well drilling and logging. Various types of drilling in petroleum.
Prospects of new discoveries of petroleum in the Indian mainland and the adjoining seas.

Unit- V

General idea about radioactivity and atomic fuels. Geology and mineralogy of Uranium and Thorium bearing minerals, their geographic distribution with reference to India. Prospecting for radioactive minerals.
Non- Renewable energy Resources- Tide energy and Wind Energy.
Geothermal resources: classification of geothermal waters, geothermal system, geothermal regions of India and world, geothermal water deposits associated with thermal springs, industrial uses of Geothermal Energy.

Suggested Readings:

1. Landes, K.K. – Petroleum Geology (Robert, Kraieger Pub. Co.).
2. Kinghorn, R.R.F. – An Introduction to the Physics and chemistry of Petroleum (J. Wiley & Sons).
3. Stach, E. et al. – Coal Petrology. Gebruder Borntraeger, Stuttgart
4. Lybach, L., Muffer, L.J.P. – Geothermal systems (J. Wiley & Sons)..
5. S. Eanga Raja Rao – Coal Preparation and use (Oxford IBM Pub. Co.)
6. Armstrong, H.C. – Geothermal Energy (Span London)
7. Levorson – Petroleum Geology
8. Singh, R.D. – Principles and Practices of Modern coal Mining.
9. Taylor, G.H. et al. – Organic Petrology. Gebruder Borntraeger, Stuttgart.
10. Chandra, D., Singh, R.M. and Singh, M.P., - Text Book of Coal. Tara Book Agency, Varanasi.

11. Selley, R.C. - Elements of Petroleum Geology. Academic Press.
12. Dahlkamp, F.J. - Uranium Ore Deposits. Springer verlag.

M.Sc. Semester IV Practicals
Practical Course GEOL 405-Core- 4 Credits

Maximum Marks: 50

Exam Duration: 4 Hrs

(Practicals of Exploration & Remote Sensing and Elements of Mining and Mineral Dressing)

Marks: 50

Exam Duration: 4 Hours

Exploration & Remote Sensing and Elements of Mining and Mineral Dressing **20 Marks**

1. Survey with Prismatic compass, Plane table, Theodolite.
2. Leveling and contouring.
3. Calculation of assay value & Ore reserve estimation.
4. Study of flow sheet for ore beneficiation.
5. Diagrammatic representation of exploration equipments and machines.
6. Lab calculation related to mining and exploration.
7. Interpretation of aerial photographs with the help of stereoscope.

Remote Sensing

10 Marks

1. Interpretation of aerial photographs with the help of stereoscope.
2. Photogrammetric exercises.
3. Study and interpretation of satellite imageries

Record

5 Marks

Viva-Voce

10 Marks

M.Sc. Semester III Practicals
Practical Course GEOL 406- Core- 4 Credits

Maximum Marks: 50

Exam Duration: 4 Hrs

(Practicals of Mineral Economics and Geo- Energy Resources and Submission of report and Viva- voce on General Geological Tour of selected Areas)

Marks: 50

Exam Duration: 4 Hours

Mineral Economics

20 Marks

1. Survey with various methods
2. Laboratory calculation for ore reserve estimation.
3. Flow sheets for ore beneficiation.
4. Diagrammatic representation of equipments and machines employed in exploration and ore dressing.

Geo-Energy Resources

15 Marks

1. Distribution of Energy minerals in the Indian Map.
2. Diagrams of Oil Traps.

3. Application of geological data for making various Maps.
4. Graphical representation of geological data etc.

Record

5 Marks

Viva-Voce

10 Marks

M.Sc. Semester IV Mining Camp
Course GEOL 307 -Core- 1 credit

Mining Camp of two weeks duration and Submission of report and Viva- voce

Elective Courses

Course No. (Theoretical): GEOL/ET/301 and GEOL/ET/401 2 credits

Course No. (Practical): GEOL/EP/301 and GEOL/EP/401 1 credit

Elective paper: Ocean Science (Theoretical)

Ocean Science

Physical Oceanography: Different mixing processes; important water masses- Characteristics; T-S diagrams; Properties of waves: Propagation, refraction, and reflection of waves; Wave spectrum, wave forecasting: principles; Coastal processes: Factors; transformation of waves in shallow water; effects of stratification; effect of bottom friction, nourishment; harbour resonance; seiches; tsunami; interaction of waves and structure.

Tide: Cause and magnitudes; prediction of tides; tides and tidal currents in shallow seas, estuaries and rivers.

Estuaries: Introduction, classification and nomenclature; circulation and mixing: Different models; tides in estuaries; sedimentation; salinity intrusion in estuaries; effect of stratification; coastal pollution; coastal management.

Global Wind system; Ekman's theory; Sverdrup, Stommel and Munk's theories; upwelling and sinking: Indian ocean. Ocean currents: Inertial currents; divergences and convergences; geostrophic motion; barotropic and baroclinic conditions; oceanic eddies, relative and slope currents. Wind driven coastal currents; Global conveyor belt circulation: Characteristics and causes.

Subtropical gyres: Cause; western boundary currents; equatorial current systems; El Nino; monsoonal winds and currents: North Indian Ocean; Somali current; southern ocean; Arabian Sea: Upwelling processes.

Chemical Oceanography: Seawater Composition; Elements: Types, Classification and distribution; Behavior and chemical exchanges across interfaces and residence times in seawater. Chemistry of Element: estuaries, hydrothermal vents, anoxic basins, HNLC waters, sediment pore fluid and anthropogenic inputs. Biological-Chemical interactions: Ionic interactions; nutrients

cycle, trace metals and organic matter. Atmosphere-Ocean Interaction: Important biogenic dissolved gases; carbon dioxide -carbonate system; alkalinity and control of pH; biological pump.

Biological Oceanography: Marine environment and marine organisms; Important factors affecting marine life; Production of marine life: Types; Phytoplankton and Zooplankton: Abundance and diversity; nekton; benthic organisms; coastal communities; Ecology and community: estuaries, coral reefs and mangrove; deep-sea ecology.

Energy flow and mineral cycling: energy transfer and transfer efficiencies through different trophic levels; food webs.

Anthropogenic impacts on marine biota; climate change and marine biodiversity; Pollution and marine environments including fisheries.

Ocean Science (Practical) Term paper/presentation/practical assigned by the Teacher(s)

Elective paper: Climatology and Environmental Geology (Theoretical) Group A:

Climatology

Introduction, Climate: Classification; Koppen's and Thornthwaite's classification; Composition and structure of the atmosphere; Energy Balance: Solar Radiation; Temperature and Moisture; Distribution of temperature.

General circulation of winds; Monsoons and Jet Streams; Air Masses; Fronts, Cyclones: temperate and tropical.

Precipitation: Types and distribution; Global warming; Changes in Atmospheric Chemistry; Climate changes: Past, present and future.

Group B: Environmental Geology Fundamental concepts; Problems and issues: local, regional and global.

Pollution: air, water and land. Nature and effects of air and water pollution, disposal of solid wastes and nuclear wastes.

Global climate change, deforestation, soil degradation.

Hazardous geological processes: Types, prediction and warning, disaster management.

Mineral resources: Mineral consumption on reserves, conservation of mineral resources, impact of mining activity on the environment, environmental management in mining.

Geological and environmental considerations for construction of dams, roads and tunnels;

Concepts of Environmental Impact Assessment (EIA).

Climatology and Environmental Geology (Practical) Term paper/presentation/practical assigned by the Teacher(s)

Elective paper: Sedimentary Basin Analysis (Theoretical)

Mechanism of sedimentary basin formation: Rheological characteristics of the earth; basin formation and plate tectonics; Palaeocurrent analysis: Methods and use in basin analysis. Sedimentary basin fills: Sediment routing system; Erosion and regolith; Terrestrial sediment and solute yield; BQART equation; Chemical weathering and global biogeochemical cycles; measurement of erosion rate.

Basin stratigraphy: Introduction; Accommodation, sediment supply and sea level; Stratigraphic cycles: definition and recognition; Hierarchy; Mechanism.

Subsidence: Introduction; compaction of porous sediments: fundamentals; Porosity and permeability of sediments and sedimentary rocks; Subsidence history and backstripping; Signatures of Tectonic subsidence.

Thermal history: Introduction; Arrhenius equation and maturation indices; Factors influencing temperatures and paleotemperatures in sedimentary basins; Measurements of thermal maturity in sedimentary basins.

Application to petroleum Geology: Petroleum system and concept of play; Source rock and source rock prediction; Reservoir rocks: Introduction, Reservoir properties: porosity and permeability; Factors controlling reservoir quality; diagenetic changes in reservoir rocks; Classic and unconventional plays.

Sedimentary Basin Analysis (Practical) Term paper/presentation/practical assigned by the
Teacher(s)

Elective paper: Isotope Geochemistry (Theoretical)

Introduction: General characteristics of Isotopes, Isotope effects, Isotope fractionation process of some important elements.

Mass Spectrometry: Basic principles; Equations of motion of ions; Ion Microprobe and Electrostatic Tandem Accelerators; Isotope Dilution Analysis.

Principles of Radioactivity, Decay mechanism of radioactive atoms; Radioactive decay and growth, Radiogenic isotope in Geochronology and Petrogenesis, Fission-track dating. Stable isotope geochemistry: Scope of Stable Isotope Geochemistry, Variations of Stable Isotope Ratios in Nature, Isotope Geothermometry, Isotope Fractionation in the Hydrologic and Biological System.

Isotope Geochemistry (Practical)

Term paper/presentation/practical assigned by the Teacher(s)

Elective paper: Quaternary Geology (Theoretical)

Introduction: Definition and scope of Quaternary Geology.

Quaternary Geomorphology: Evolution of landscape and interactions between tectonic, climatic, and geomorphic processes.

Quaternary Geochronology: Radiogenic Carbon and Optical stimulated luminescence (OSL) dating method.

Quaternary Stratigraphy: Glacial varves; Dendrochronology; Tephrochronology, Climatostratigraphy, Magnetostratigraphy.

Global climate pattern, Climate controlling factors and Milankovitch Hypothesis, Quaternary Environments, Quaternary Sea-level changes.

Fossil records of the Quaternary; Pollen analysis, Mammalian fauna, Deep sea Biostratigraphy Continental and marine Quaternary record of India; Neotectonic, stratigraphic, sedimentologic and geomorphic evolution of Quaternary terrain of India.

Paleoclimatic reconstruction; Pleistocene Glacial-Interglacial cycles, Anthropocene; Effect of Anthropogenic activity on Global climate

Quaternary Geology (Practical)

Term paper/presentation/practical assigned by the Teacher(s)

Skill Development Course in Semester I, II and III

Non Credit Course

Skill Development Course i. Survey in Field

1. Principles of surveying. Survey equipments.
2. Radial method of plane table survey.
3. Plane table survey with intersection methods.
4. Pace/Tape and compass methods survey with theodolite with various applications.

SKILL DEVELOPMENT COURSE

(Any One)

207(A). 1. Introduction to minerals and rocks: common rock forming mineral.

2. Common non silicate minerals.

3. Igneous rocks.

4. Sedimentary rocks

5. Metamorphic rocks

207(B). 1. Principles of remote sensing.

2. tool and techniques to study with areal photographs.
3. Study of topography with areal photos.
4. Study of structural features with areal photos.
5. Study of rock types with areal photos.

Skill Development Course

Ore Reserve estimation, calculation of all category of proved, probable and possible estimation of ore reserves of all types of deposits including vein, Bedded, load etc.

Skill Course

Groundwater

1. Science of Groundwater occurrence. Water cycle.
2. Well hydraulics and Exploration of Groundwater.
3. Chemical quality of Groundwater for various application.
4. Conservation of groundwater, artificial recharge.
5. Legislations and management of groundwater sources.