MGS UNIVERSITY
BIKANER

Faculty of Science
M.Sc. Geology CBCS Syllabus

Semester Scheme

Semester I /II – 2024-25
Semester III/IV- 2025-26

Programme: M.Sc. Geology
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.

- Each Semester will have Four Theory Papers, each of 50 marks including internal assessment.
- Each Semester will have Two Practical Papers, related to four Theory Papers, each of 50 Marks including internal assessment and field trainings.

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.
- Fieldwork is a compulsory component/part of each semester. Students not attending the tour and training programme shall not be eligible to appear in University examination. 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	2	By faculty members accompanying the field tour
Punctuality, enthusiasm, and aptitude of students while completing the report	2	By faculty members accompanying the field tour
Tour report	4	By members of Examination committee
Viva-voce	2	By members of Examination committee

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, class tests 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, tests 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, 10 marks shall be awarded by the teacher(s), teaching that course, for which the breakup of the marks will be as follows:

(a) Class Test(s) 4 marks
(b) Assignment(s)/ Presentation(s) 4 marks
(c) Class Participation, interaction, punctuality, performance and aptitude 2 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 40 marks.

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

Paper No.	Course Nomenclature	Theory Hrs./week	Practical Hrs./week	Theory Exam. Hours	Credit
GEOL 101	Geomorphology & Geotectonics	4	0	3	4
GEOL 102	Crystallography& Mineralogy	4	0	3	4
GEOL 103	Palaeontology	4	0	3	4
GEOL 104	Principles of Stratigraphy & Precambrian Geology of India	4	0	3	4
GEOL 105	Lab: Geomorphology & Geotectonics and Crystallography& Mineralogy	0	8	4	4
GEOL 106	Lab: Palaeontology and Principles of Stratigraphy & Precambrian Geology of India	0	8	4	4

GEOL 101- Geomorphology & Geotectonics

Course Outcome: After learning this course a student will be able to	Suggested Pedagogies
1.Describe the different Geomorphologic & Geotectonic features. 2. Understand the geomorphometrics and tectonics.	1. Use appropriate ICT tool, wherever necessary, for effective teaching. 2.Discuss recent research papers related to development of Geomorphology and Geotectonics.

Marks: 50 (40 Theory + 10 Internal assessment) **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 (10 Marks) is compulsory and contain one question containing 10 parts, two from each unit, each question is of 1 marks (Answer limit 50 Words). Part B (15 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 3 marks each (Answer limit 200 words). Part C (15 Marks) contains five questions one from each unit, Candidate is required to attempt three questions; each question is of 5 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 development, types and nature. 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

Coastal Geomorphology. 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 102–Crystallography & Mineralogy

Course Outcome:	**Suggested Pedagogies**
After learning this course a student will be able to 1.Describe the mineral groups and crystals. 2.Understand the physical, optical properties and projections.	1. Use appropriate ICT tool, wherever necessary, for effective teaching. 2. Discuss recent research papers related to Crystallography & Mineralogy

Marks: 50 (40 Theory + 10 Internal assessment) **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 (10 Marks) is compulsory and contain one question containing 10 parts, two from each unit, each question is of 1 marks (Answer limit 50 Words). Part B (15 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 3 marks each (Answer limit 200 words). Part C (15 Marks) contains five questions one from each unit, Candidate is required to attempt three questions; each question is of 5 Marks (Answer limit 500 hundred words).

Unit -I

Crystallography: crystal growth, symmetry operations. Laws of crystallography. Goniometery. 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 103 –Palaeontology

Course Outcome: After learning this course a student will be able to	Suggested Pedagogies
1.Describe the different types of fossils. 2.Understand the evolution, morphology and geological history.	1. Use appropriate ICT tool, wherever necessary, for effective teaching. 2. Discuss recent research papers related to development of Palaeontology.

Marks: 50 (40 Theory + 10 Internal assessment) **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 (10 Marks) is compulsory and contain one question containing 10 parts, two from each unit, each question is of 1 marks (Answer limit 50 Words). Part B (15 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 3 marks each (Answer limit 200 words). Part C (15 Marks) contains five questions one from each unit, Candidate is required to attempt three questions; each question is of 5 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, separation, preparation, preservation & nomenclature of micro and mega 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 oculogenital 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, Foraminifera: Morphology, classification and significance in palaeo-ecological studies & oil exploration. Ostrocoda: Morphology, classification, ecology and geological history. Conodonts: Morphology, classification, ecology and geological history. Nano fossils: 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 104 – Principles of Stratigraphy & Precambrian Geology of India

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

Marks: 50 (40 Theory + 10 Internal assessment) **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 (10 Marks) is compulsory and contain one question containing 10 parts, two from each unit, each question is of 1 mark (Answer limit 50 Words). Part B (15 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 3 marks each (Answer limit 200 words). Part C (15 Marks) contains five questions one from each unit, Candidate is required to attempt three questions; each question is of 5 Marks (Answer limit 500 hundred words).

Unit - I

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

Unit - II

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

Unit – III

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

Unit – IV

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

Unit – V

Precambrian geology of Rajasthan; Banded Gneissic Complex (Bhilwara Supergroup), Aravalli Supergroup, Delhi Supergroup, Vindhyan Supergroup, Marwar Supergroup, 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. – Princples of Stratigraphy (J. Wiley & Sons)
3. Pascoe, E.H. – A Manual of Geology of India & Burma (GSI)
4. Ravindra Kumar – Introduction of Historical Geology and Principles of Stratigraphy (CBS)
5. Rankama, K. – The Geologic Systems-The Pre cambrian Vol.-III Ed. (J. Wiley & Sons)
6. Eicher, Don, L. – Geologic Time (Prentice Hall)

7. Sinha Roy, S. Malhotra, G & Mohanty, M. – Geology of Rajasthan (Geol. Soc. Ind.
8. Roy and Jakhar- Geology of Rajasthan, Scientific Publ. Jodhpur

M.Sc. Semester I Practicals
Practical Course GEOL 105

Maximum Marks: 50 (10 Internal Assessment +40 End Semester Exam) Exam Duration: 4 Hrs
(Practicals of Structural Geology, Geomorphology and Geotectonics)

Geomorphology & Geotectonics **10 Marks**

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

Crystallography **10 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.

Mineralogy **10 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.

Record **5 Marks**
Viva-Voce **5 Marks**
Mid Semester Assessment (Attendence-2, Seminars -3 and Field report-5) **10 Marks**

M.Sc. Semester I Practicals
Practical Course GEOL 106

Maximum Marks: 50 (10 Internal Assessment +40 End Semester Exam) Exam Duration: 4 Hrs
(Practicals of palaeontology and Principles of Stratigraphy & Precambrian Geology of India)

Palaeontology **15 Marks**

1.Identification, drawing and description of common representatives of Fossil groups

2. Sketching of evolutionary trends of important invertebrate fossils groups.

Evolutionary trends of vertebrates

Principles of Stratigraphy & Precambrian Geology of India **10 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. Preparation of Lithology and their correlation, correlation problems

Record **5 Marks**
Viva-Voce **5 Marks**
Mid Semester Assessment (Attendence-2, Seminars -3 and Field report-5) **10 Marks**

General Geological tour and Submission of report and Viva- voce before examination

Teaching and Examination Scheme
Semester II

Paper No.	Course Nomenclature	Theory Hrs/week	Practical Hrs/week	Theory Exam. Hours	Credit
GEOL 201	Phanerozoic Stratigraphy of India	4	0	3	4
GEOL 202	Structural Geology	4	0	3	4
GEOL 203	Igneous and Metamorhic Petrology	4	0	3	4
GEOL 204	Geochemistry and Analytical Methods	4	0	3	4
GEOL 205	Lab: Phanerozoic Stratigraphy of India and Palaeontology	0	8	4	4
GEOL 206	Lab: Igneous and Metamorhic Petrology Geochemistry and Analytical Methods	0	8	4	4

GEOL 201 – Phanerozoic Stratigraphy of India

Course Outcomes	Suggested Pedagogies
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.	1. Use appropriate ICT tool, wherever necessary, for effective teaching. 2. Discuss recent research papers related to development of stratigraphy.

Marks: 50 (40 Theory + 10 Internal assessment) **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 (10 Marks) is compulsory and contain one question containing 10 parts, two from each unit, each question is of 1 marks (Answer limit 50 Words). Part B (15 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 3 marks each (Answer limit 200 words). Part C (15 Marks) contains five questions one from each unit, Candidate is required to attempt three questions; each question is of 5 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. Neogene-Quarternary boundary Problem. (8 Periods)

Unit -V

Phanerozoic Stratigraphy of Rajasthan. Quarternary Geology of Rajasthan.(8 Periods)

Suggested Readings:

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

GEOL202 - Structural Geology

Course Outcome: After learning this course a student will be able to	**Suggested Pedagogies**
1.Describe the different structural elements 2.Understand the application of forces in the formation of structures.	1. Use appropriate ICT tool, wherever necessary, for effective teaching. 2. Discuss recent research papers related to development of Structural Geology.

Marks: 50 (40 Theory + 10 Internal assessment) **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 (10 Marks) is compulsory and contain one question containing 10 parts, two from each unit, each question is of 1 marks (Answer limit 50 Words). Part B (15 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 3 marks each (Answer limit 200 words). Part C (15 Marks) contains five questions one from each unit, Candidate is required to attempt three questions; each question is of 5 Marks (Answer limit 500 hundred words).

Unit - I

Concept of Stress and Strain; Two-dimensional analysis of stress and strain; Types of strain ellipses and ellipsoids- their properties and geological significance; Strain markers, Behaviour of rocks under stress. Mohr circle. Various states of stress and their representation by Mohr circles. Brittle and ductile behavior of rocks**.** (8 Periods)

Unit - II

Folds: Morphology, classification, mechanism and recognisation. Superimposed folding and interference patterns. Structural analysis in terrains with multiple deformations. Stereographic projections and π and β diagrams (8 Periods)

Unit – III

Fault- Morphology, classification, mechanism and recognisation. Effects of faulting on outcrop pattern. Fault-related folding. (8 Periods)

Unit – IV

Joint –Nomenclature, types, origin and significance. Types of Linear structures and their tectonic significance. Basic concept of cleavage, Lineation and Foliation and their origin and types. (8 Periods)

Unit – V

Shear zones; Brittle and ductile shear zones; Geometry and products of shear zones. Shear zone indicators. Balanced Cross section. Geological mapping: principles, procedure**.** (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 StructuralGeology (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.
8. Hakkon Fossen- Structural Geology, Cambridge University Press

GEOL 203 – Igneous and Metamorphic Petrology

Course Outcome: After learning this course a student will be able to	Suggested Pedagogies
1. Describe the different types of igneous and metamorphic rocks. 2. Understand the petrography and petrogenesis.	1. Use appropriate ICT tool, wherever necessary, for effective teaching. 2. Discuss recent research papers related to development of Petrology.

Marks: 50 (40 Theory + 10 Internal assessment) **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 (10 Marks) is compulsory and contain one question containing 10 parts, two from each unit, each question is of 1 mark (Answer limit 50 Words). Part B (15 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 3 marks each (Answer limit 200 words). Part C (15 Marks) contains five questions one from each unit, Candidate is required to attempt three questions; each question is of 5 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

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.

GEOL 204– Geochemistry & Analytical Methods

Course Outcome: After learning this course, student will be able to	Suggested Pedagogies
1. Describe the different geochemical aspects. 2. Understand the Analytical techniques.	1. Use appropriate ICT tool, wherever necessary, for effective teaching. 2. Discuss recent research papers related to development of Geochemistry.

Marks: 50 (40 Theory + 10 Internal assessment) **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 (10 Marks) is compulsory and contain one question containing 10 parts, two from each unit, each question is of 1 mark (Answer limit 50 Words). Part B (15 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 3 marks each (Answer limit 200 words). Part C (15 Marks) contains five questions one from each unit, Candidate is required to attempt three questions; each question is of 5 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 cathodoluminiscence, thermoluminiscence, atomic absorption spectophotometry, XRF spectrometry, FTIR and XRD.

Working knowledge of AAS, Flame- photometer, DTA, ICP spectrometer, UV- IR spectophotometer 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, B. and Moore, C.B. - Introduction to Geochemistry. Wiley Eastern.
6. Faure, G. - Principles of Isotope Geology. John Wiley.
7. Govett, G.J.S. - Hand Book of Exploration Geochemistry. Elsevier.

M.Sc. Semester II Practicals
Practical Course GEOL 205

Maximum Marks: 50 (10 Internal Assessment +40 End Semester Exam) Exam Duration: 4 Hrs

Phanerozoic Stratigraphy **15 Marks**

1.Study of rocks in Hand specimens from Phanerozoic terrain of India.

2.Showing boundaries of the Phanerozoic terrains of India on map.

3.Stratigraphic and Palaeogeographic maps with special reference to India.

4.Preparation of Lithologs and their correlation, correlation problems.

Structural Geology **20 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, Prepration of Geological sections, determination of Thickness of beds, Geological History

Record **5 Marks**

Viva-Voce **5 Marks**

Mid Semester Assessment (Attendence-2, Seminars-3 Field report -5) **10 Marks**

Practical Course GEOL 206

Maximum Marks: 50 (10 Internal Assessment +40 End Semester Exam) Exam Duration: 4 Hrs

Igneous and Metamorphic Petrology 20 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)
4. Phase diagrams of important binary and ternary crystallization systems.

Geochemistry and Analytical techniques 10 Marks

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

Record 5 Marks

Viva-Voce 5 Marks

Mid Semester Assessment (Attendence-2, Seminars-3 Field report -5) 10 Marks

Compusory General geological tour of two week, submission of report and viva-voce before examination.

Teaching and Examination Scheme
Semester III

Paper No.	Course Nomenclature	Theory Hrs/week	Practical Hrs/week	Theory Exam. Hours	Credit
GEOL 301	Remote Sensing and Mineral Exploration	4	0	3	4
GEOL 302	Sedimentology	4	0	3	4
GEOL 303	Geo-energy Resources	4	0	3	4
GEOL 304	Economic Geology & Mineral Economics	4	0	3	4
GEOL 305	Lab: Remote Sensing, Mineral Exploration and Sedimentology	0	8	4	4
GEOL 306	Lab: Mining Geology and Economic Geology & Mineral Economics	0	8	4	4

GEOL 301 – Remote Sensing and Mineral Exploration

Course Outcome: After learning this course, a student will be able to	Suggested Pedagogies
1.Describe the different mineral exploration techniques. 2.Understand the technique of RS and photogeology.	1. Use appropriate ICT tool, wherever necessary, for effective teaching. 2. Discuss recent research papers related to development of Remote Sensing and Mineral Exploration.

Marks: 50 (40 Theory + 10 Internal assessment) **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 (10 Marks) is compulsory and contain one question containing 10 parts, two from each unit, each question is of 1 mark (Answer limit 50 Words). Part B (15 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 3 marks each (Answer limit 200 words). Part C (15 Marks) contains five questions one from each unit, Candidate is required to attempt three questions; each question is of 5 Marks (Answer limit 500 hundred words).

Unit- I

Maps and aerial photographs; Aerial photographs- types, errors and distortion. Rectification. Vertical exaggeration and its estimation. mosaic, preparation of base map by radial triangulation methods. Stereoscopic vision, pseudoscopic vision, measuring instrument and their uses, calculation of height of an object by parallax method. (8 Periods)

Unit- II

Remote sensing. Aero visual survey. Infrared photography, multiple band photography. Imageries. Types of satellites. RS Satellite characteristics-orbits and swaths. Sensors used in remote sensing. Satellite remote sensing and its limitations. Global and Indian space missions. (8 Periods)

Unit- III

Application of aerial photographs, Application of Remote sensing, Geographic Information System (GIS): Principles and Applications. Vector and Raster Analysis, Global Positioning system (GPS)

(8 Periods)

Unit-IV

Exploration and its types. Surface and sub-surface exploration. 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. (8 Periods)

Unit -V

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, borehole problems, borehole samplings. Geophysical prospecting- electrical, gravity, magnetic, seismic, radioactive method, well logging. (8 Periods)

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. Sathya Narayan swami, B.S. – Engineering Geology (Dhanpat Rai & Co.)
5. Blyth – Geology of Engineers (ELBS)
6. S. N. Pandey- Remote Sensing and Photo-Geology
7. S. K. Haldar-Mineral exploration: Principles and Applications. (Elsevier)

GEOL-302-Sedimentology

Course Outcome: After learning this course a student will be able to	Suggested Pedagogies
1. Describe the different sedimentary rocks. 2. Understand the sedimentary basins.	1. Use appropriate ICT tool, wherever necessary, for effective teaching. 2. Discuss recent research papers related to development of Sedimentology.

Marks: 50 (40 Theory + 10 Internal assessment) **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 (10 Marks) is compulsory and contain one question containing 10 parts, two from each unit, each question is of 1 mark (Answer limit 50 Words). Part B (15 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 3 marks each (Answer limit 200 words). Part C (15 Marks) contains five questions one from each unit, Candidate is required to attempt three questions; each question is of 5 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 sedimentry rocks: Clastic sedimentry rocks – deposits of gravels, conglomerates, breccia, sandstone, graywacke, shale, siltstone etc. Non–clastic sedimentry rocks– limestone, dolomite, evaporites. Organic sediments. (8 Periods)

Unit-IV

Sedimentry 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.

GEOL 303 –Geo-Energy Resources

Course Outcomes	Suggested Pedagogies
After learning the course, a student will be able to 1.Describe the geo-energy resources. 2.Carry out study of basins.	Use appropriate ICT tool, wherever necessary, for effective teaching. Discuss case studies related cola and petroleum fields.

Marks: 50 (40 Theory + 10 Internal assessment) **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 (10 Marks) is compulsory and contain one question containing 10 parts, two from each unit, each question is of 1 mark (Answer limit 50 Words). Part B (15 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 3 marks each (Answer limit 200 words). Part C (15 Marks) contains five questions one from each unit, Candidate is required to attempt three questions; each question is of 5 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 & subsurfce 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 micellaneousrocks; 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, Stutgart
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, Stutgart.
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.

GEOL 304 – Economic Geology & Mineral Economics

Course Outcome: After learning this course a student will be able to	Suggested Pedagogies
1.Describe the different ore forming processes 2. Understand the distribution and uses of ores.	1. Use appropriate ICT tool, wherever necessary, for effective teaching. 2. Discuss recent research papers related to development of Economic Geology & Mineral Economics.

Marks: 50 (40 Theory + 10 Internal assessment) **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 (10 Marks) is compulsory and contain one question containing 10 parts, two from each unit, each question is of 1 mark (Answer limit 50 Words). Part B (15 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 3 marks each (Answer limit 200 words). Part C (15 Marks) contains five questions one from each unit, Candidate is required to attempt three questions; each question is of 5 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.Fluid inclusion. Geothermometry and isotope studies in relation to ore deposits. Clasification 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, wolllastonite, 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

Mineral Economics: Concept and scope of mineral economics. Peculiarities inherent in mineral industry. Future Sources of Mineral supply. Tenor, grade & specification. Strategic, critical and essential minerals. Conservation and substitution. Changing patterns of mineral consumption. 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. (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 III Practicals

Practical Course GEOL 305

Maximum Marks: 50 (10 Internal Assessment +40 End Sem. Exam) Exam Duration: 4 Hrs

Remote Sensing and Mineral Exploration 15 **Marks**

1. Interpretation of aerial photographs with the help of stereoscope.
2. Photogrammatric exercises.
3. Study and interpretation of satellite imageries
4. Leveling and contouring
5. Exercises related to ore reserve estimation, tonnage and grades.

Sedimentology **15 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.

Record **5 Marks**
Viva **5 Marks**
Mid Semester Assessment (Attendence-2, Seminars -3 and field report-5) **10 Marks**

Practical Course GEOL 306

Maximum Marks: 50 (10 Internal Assessment +40 End Semester Exam) Exam Duration: 4 Hrs

Geo-Energy Resources **15 Marks**

1.Distribution of Coal, Petroleum and Atomic 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.

Economic Geology & Mineral Economics **15 Marks**

1. Study of economic minerals in hand specimens, their distribution, genesis and uses.
2. Determination of important ore minerals under reflected light.
3. Distribution of important ore forming minerals in the maps of India and Rajasthan

Record **5 Marks**
Viva **5 Marks**
Mid Semester Assessment (Attendence-2, Seminars -3 and field report-5) **10 Marks**

General geological tour of two-week, submission of report and viva-voce before examination.

Teaching and Examination Scheme

Semester IV

Paper No.	Course Nomenclature	Theory Hrs/week	Practical Hrs/week	Theory Exam. Hours	Credit
GEOL 401	Environmental Geology and Engineering Geology	4	0	3	4
GEOL 402	Hydrogeology	4	0	3	4
GEOL 403	Oceanography and Climatotology	4	0	3	4
GEOL 404	Mining Geology	4	0	3	4
GEOL 405	Lab: Environmental Geology and Engineering Geology, Hydrogeology	0	8	4	4
GEOL 406	Lab: Oceanography and Climatotology and Mining Geology	0	8	4	4

GEOL 401 –Environment Geology and Engineering Geology

Course Outcome: After learning this course a student will be able to	Suggested Pedagogies
1. Describe the different Environmental pollution. 2. Understand the different cycles	1. Use appropriate ICT tool, wherever necessary, for effective teaching. 2. Discuss recent research papers related to development of Environmental Geology and Engineering Geology.

Marks: 50 (40 Theory + 10 Internal assessment) **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 (10 Marks) is compulsory and contain one question containing 10 parts, two from each unit, each question is of 1 marks (Answer limit 50 Words). Part B (15 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 3 marks each (Answer limit 200 words). Part C (15 Marks) contains five questions one from each unit, Candidate is required to attempt three questions; each question is of 5 Marks (Answer limit 500 hundred words).

Unit -I

Environment: definition and types of environments; Definition and Fundamental concepts of Environmental Geology. Environmental degradation and Pollution with special reference to India. Pollution- types, (Air pollution, Noise pollution, Water pollution) causes, impact and remedial strategies; groundwater pollution and health issues. Wastes: Solid wastes, Hazardous Chemical wastes, Radioactive wastes, Liquid- Semi liquid (sewerage & wastewater) Wastes and their disposal.

Unit- II

Environmental problems - Acid Rain, global warming, greenhouse effect, global climatic change, Desertification and depletion of the ozone layer, Hazardous Earth Processes: - River flooding: Magnitude & Frequency; Relationship with Urbanisation: Nature & extent of hazard: Perception of River flooding. Landslides: Types; Slope stability; Forces on slopes; Factors affecting 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

Unit –III

Earthquakes: Effects of EQ- primary & secondary; Magnitude, intensity & frequency of EQ; Human impact on EQ- in causing or reducing EQ; EQ Prediction; Adjusments to EQ; Perception to EQ.

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

Unit –IV

Earth Resources and Environment: Minerals & Population; Resources & Reserves; Geology of Mineral Resources; Minerals from Sea; Environmental Impact of Mineral Development; Recycling Resources.Landscape Evaluation: Land Use Planning Management; Site Selection and Evaluation; Landscape Aesthetics. Environmental impacts of mining activities; the concept of eco-friendly mining; laws governing protection of the environment and control of pollution; environmental impact assessment (EIA). Elements of Environmental Management Plan (EMP), Global environmental problems and international co-operation.

Unit – V

Application of Geology in Civil engineering. Engineering properties of rocks. Rocks as construction material. Importance and stages of geological exploration for important engineering projects.

Dams: Terminology, Classification & types of Dams, Problems related to Dams, geology of dam site, 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

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. – Environ. Geology, Conservation land use planning and Resource Development.
5. Cooke and Drunkamp – Geomorphology in Environment Pollution.
6. Horn, B. & Scott, M. – Geological Hazards (Springer Verlog)
7. Tank, R.W. – Focus on Environmental Geology (Oxford)
8. Savindra Singh – Environmental Geography. Prayag Pustak Bhawan.
9. Pratap Singh – Sustenable Devel. With Renewawable Energy Resources. (Yash Publi; Bikaner)
10. Abbasi & Abbasi - Renewawable Energy Resources & their Implication. (Prentice Hall India)

GEOL 402 –Hydrogeology

Course Outcomes After learning the course, a student will be able to	Suggested Pedagogies Use appropriate ICT tool, wherever necessary, for effective teaching.
1. Describe the rock hydrological properties to understand the aquifer and its characteristics. 2. Carry out hydro geological investigationfor any region and propose watershed development measures.	Discuss case studies related to ground water issues in India. One day field work for hydro geological investigation.

Marks: 50 (40 Theory + 10 Internal assessment) **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 (10 Marks) is compulsory and contain one question containing 10 parts, two from each unit, each question is of 1 mark (Answer limit 50 Words). Part B (15 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 3 marks each (Answer limit 200 words). Part C (15 Marks) contains five questions one from each unit, Candidate is required to attempt three questions; each question is of 5 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.

Unit- IV

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 & grounwater Reservoirs. GW Modeling.

Unit- V

Grounwater 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

Suggested Readings:

1. Todd D. K. : Groundwater hydrology
2. Sanjay Akhuri: Fundamentals Of Hydrogeology
3. Fetter: Applied Hydrogeology
4. Nandipati Subba Rao: Hydrogeology Problems with Solutions
5. Karanth: Groundwater assessment and management.

GEOL 403 –Oceanography and Climatology

Course Outcomes After learning the course, a student will be able to	Suggested Pedagogies Use appropriate ICT tool, wherever necessary, for effective teaching.
1. Describe the coastal Geology and oceans. 2. To learn concept of climatology and climate change.	Discuss case studies related to oceanographyand climatology.

Marks: 50 (40 Theory + 10 Internal assessment) **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 (10 Marks) is compulsory and contain one question containing 10 parts, two from each unit, each question is of 1 mark (Answer limit 50 Words). Part B (15 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 3 marks each (Answer limit 200 words). Part C (15 Marks) contains five questions one from each unit, Candidate is required to attempt three questions; each question is of 5 Marks (Answer limit 500 hundred words).

Unit- I

Physical properties of seawater: Temperature, Salinity and Density and their distributions. Transparency of seawater, Sound in the sea, Light in the sea, Colour of seawater, Sea Ice.

Waves and tides: wave parameters, deep water waves, transformation of waves in shallow water, wave generation. Types of tides, tide producing forces, tidal theories.

Unit-II

Ocean circulation: wind induced currents, Up welling, sinking; equatorial current system, west ward intensification of currents, warm and cold currents of major world ocean, seasonal currents in North Indian Ocean, Thermohaline circulation. Water masses: T-S diagram, Characteristics of water masses, Deep circulation water masses, Major water masses of the world oceans.

Unit- III

Marine geology: Continental shelf, Slope, Shelf sediments, mineral resources of the world ocean, submarine topography, mid oceanic ridge system. Manganese and other deposits and the factors controlling their distribution. Marine biology: Classification of marine environment, Bio geo chemical cycles. Influence of Physical parameters (Temperature, salinity, waves, currents, tides etc.). Mangroves

Unit-IV

Coastal processes – transformation of waves in shallow water – refraction, diffraction, reflection. Coastal and near shore circulation-long shore currents, rip currents and tidal currents. Sediment transport rate – onshore and offshore transport – coastal features – LEO observation, Sea level changes: Periodic Sea level changes – short term variations – long term changes – Impact of global warming on sea level – impacts of sea level rise. Strom surge and tsunamis. Beach features: Beach cycles, beach profiles-erosion and accretion, beach stability – artificial nourishment – coastal defence structures – planning and design of coastal structures – tidal inlets and Lakes, deltas.

Unit-V

Fundamental principles of climatology. Earth‟s radiation balance; latitudinal and seasonal variation of insolation, temperature, pressure, wind belts, humidity, cloud formation and precipitation, water balance. Air masses, monsoon, Jet streams, tropical cyclones, and ENSO. Classification of climates – Koppen‟s and Thornthwaite‟s scheme of classification. Climate change.

Suggested readings:

1. Introduction to Physical oceanography by M.P.M. Reddy.
2. Introduction to Physical oceanography by Robert. H. Stewart.
3. Introduction to dynamical oceanography by S. Pond and G.L. Pickard.
4. Oceans by Sverdrup, Johnson and Flemming.
5. Coastal and Estuarine Dynamics by A.T. Ippen
6. Estuaries: A Physical Introduction by K.R. Dyer
7. Coastal Engineering by Kiyoshi Horikawa

GEOL 404 –Mining Geology

Course Outcome: After learning this course a student will be able to	Suggested Pedagogies
1.Describe the different types of Mining 2.Understand the sampling and ore dressing.	1. Use appropriate ICT tool, wherever necessary, for effective teaching. 2. Discuss recent research papers related to development of Mining Geology.

Marks: 50 (40 Theory + 10 Internal assessment) **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 (10 Marks) is compulsory and contain one question containing 10 parts, two from each unit, each question is of 1 mark (Answer limit 50 Words). Part B (15 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 3 marks each (Answer limit 200 words). Part C (15 Marks) contains five questions one from each unit, Candidate is required to attempt three questions; each question is of 5 Marks (Answer limit 500 hundred words).

Unit- I

Elements of Mining: Classification of mining methods. 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; prepration; Phases of mineral processing: hand picking, crushing, grinding, sizing, classification, air sizing, blending, concentration, washing, methods. Role of Bacteria in Beneficiation of coal and low-grade ores.

Unit- IV

Methods of separation: gravity separation, magnetic separation, electrostatic separation – jigging, tabling, vanners and miscellaneous floatations. Flotation; reagents; Collectors; Frothers; Modifiers; Agglomeration; miscellaneous processes- amalgamation, thickening, filtration, dewatering, drying.

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:

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.Sathya Narayan swami, B.S. – Engineering Geology (Dhanpat Rai & Co.)
5.Blyth – Geology of Engineers (ELBS)
6.Arogyaswami, R.N.P. – Courses in mining Geology (oxford & IBH)

M.Sc. Semester IV Practicals

Practical Course GEOL 405

Maximum Marks: 50 (10 Internal Assessment +40 End Semester Exam Exam Duration: 4 Hrs

(Practicals of Environmental Geology, Engineering geology and Hydrogeology)

Environmental Geology and Engineerinng Geology 15 Marks

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

Hydrogeology 15 Marks

1. Preparation and study of water table maps, depth to water maps & fluctuation maps.
2. Study of hydrological properties of rocks.
3. Study of ground water quality & Preparation and study of ground water quality maps.
4. Representation of groundwater analyses.
5. Analyses data plots

Record 5 Marks

Viva-Voce 5 Marks

Mid Semester Assessment (Attendence-2, Seminars -3 and Field report- 5) 10 Marks

Practical Course GEOL 406

Maximum Marks: 50 (10 Internal Assessment +40 End Semester Exam) Exam Duration: 4 Hrs

(Practicals of, oceanography, Climatology and Mining Geology)

Oceanography and Climatology 15 Marks

1. Determination of Density using temperature and salinity.
2. Determination of Specific volume anomaly using S, T and D.
3. Stability and Richardson number.
4. Analysis of temperature data (a) Vertical profiles (b) Horizontal profiles (c) Identification of Upwelling and sinking
5. Determination of Heat budget parameters. (a) Latent heat (b) Sensible heat (c) Evaporation

Mining Geology 15 Marks

1. Diagrammatic representation of mining methods.
2. Study of flow sheet for ore beneficiation.
3. Diagrammatic representation of exploration equipments and machines.
4. Lab calculation related to mining.
5. Survey with Prismatic compass, Plane table, Theodolite.

Record 5 Marks

Viva-Voce 5 Marks

Mid Semester Assessment (Attendence-2, Seminars -3 and Field report- 5) 10 Marks

Mining training camp of one week's duration and Submission of report and Viva-voce before examination.