Syllabus
for

M.Sc. (Geology)

(Four Semester Course)

Effective Since
2019-2020

Department of Geology
Dr. Nityanand Himalayan Research & Study Centre,
Doon University, Dehradun, Uttarakhand (India)
(A State Government University as per Doon University Act 2005)

Summary of Course Structure

Number of Papers	-	24 (15 Core + 01 Elective + 8 Lab)
Fieldwork Training	-	02 (1 -2 weeks at the end of odd semester i.e., 1st and 3rd Semesters)
Seminar	-	2nd semester (related to problem and research methodology of dissertation)
Project Oriented Dissertation	-	4th Semester
Total duration	-	04 Semester course
Total Credits	-	88

1.0 Guidelines for the Course and Scheme of Examinations

Candidates who have passed the B.Sc. in science subjects with geology will be considered eligible for admission to the Four Semester M.Sc. (Geology). The admission will be made on the basis of the merit of entrance examination conducted by the university.

The M.Sc. course in Geology shall be imparted to the students for two academic sessions consisting of four semesters as given below. Candidates will be examined and evaluated at the end of each semester in the different courses of theory including internal assessment and practical (wherever applicable) as per the grade points obtained against each course. The M.Sc. Geology will consist of (a) Core Courses and (b) Elective Course (c) Lab work (d) Field training (e) Seminar and (f) Project oriented dissertation.

2.0 Scheme of Examinations

(a) English, as an official language, shall be the medium of instruction and examination.

(b) Examinations shall be conducted at the end of each semester as per the Academic Calendar notified by the Doon University.

(c) The courses will be compulsory for all the students admitted to M.Sc. Geology. There will be fifteen core courses, one elective paper and eight labs covering major branches of Geology and two sessions of 1-2 weeks of Geological Field Training. Each Course shall be of 2 to 4 credits and 25 % of the evaluation will be based on internal assessment by the concerned teacher. Internal assessment will be done on the basis of Seminar/Class Test/Assignments/ Attendance etc.

(d) The Elective Course will be offered in the fourth semester. An advisory group consisting of faculty members of department will suggest the students about the selection of elective paper depending upon the available specialization.

(e) The participation in the Geological Field Training will be compulsory for all the students. After the field training, the students will be required to submit a detailed field report to the concerned teacher for evaluation.

(f) Students will need to carry out project-oriented dissertation work during 3 and 4 semesters. The area of Dissertation shall be assigned to the students during the 2nd semester based on the overall merit of the students. Each student will be offered three branches of geology in order of preference in her/his application and Department will decide candidate's potential supervisors. The students may however be

allowed opting dissertation works with the Scientists of organization with whom department of geology has signed MoU or with an individual scientist/academician from any organization after approval of Head of the Department. In such cases either supervisor or co-supervisor should be from the department. The students will be required to submit the Project Oriented Dissertation by the end of 4th semester.

(g) The project-oriented dissertation will be evaluated jointly by supervisor/co-supervisor and one external examiner. For the purpose of evaluation after 4th semester, the 25% of the grade points will be based on Final Presentation while 75% will be based on evaluation of the thesis.

(h) As the evaluation will be done by the Grading system, each examination (theory, Lab work, Seminar, field training and dissertation) will be evaluated for 100 marks each. Following system will be applicable for calculating SPA (Semester Grade Point Average- SPA and Composite Grade Point Average -CGPA). Candidate has to clear each paper with minimum of SGPA of 4.5 point.

(i) General Promotion from One to next semester will be as per the existing rules of the university.

(j) Improvement examination and/or back paper examination will be as per the existing rules of the university will be applicable.

3.0 Grading System

% Age of Marks	Letter Grade	Grade Points (P)
Greater than or equal to 90	S	10
Greater than or equal to 80 and less than 90	A	9
Greater than or equal to 70 and less than 80	B	8
Greater than or equal to 60 and less than 70	C	7
Greater than or equal to 50 and less than 60	D	6
Greater than or equal to 40 and less than 50	E	5
Passed with Grace	P	0
Below 40	F	-
Non-appearance in examinations (Incomplete)	I	-
Incomplete Project/Dissertation/Training	X	
Non-Completion of Course	Z	

4.0 Declaration of Result

After appearing at the Examination of Fourth Semester the Candidates can be put into the following two categories.

1. **Passed:** A candidate who has passed in all courses of examinations of I to IV Semesters.
2. **Failed**: All the students who have not PASSED will be categorized as "FAILED".

A candidate shall be considered to have PASSED Four Semester course, if he/she has obtained minimum Grade of E or P in each subject of the Four Semester courses and minimum SGPA of 4.5.

SGPA= Sum of (credits X grade points) obtained/Total Credit of concerned semester

CGPA= Sum of (Credits X Grade points) obtained in I, II, III, & IV semesters/ Total credit of I to IV semesters

5.0 Conversion of CGPA/SGPA To Percentage

Conversion of CGPA/SGPA into equivalent percentage of marks can be done as per following formula.

Equivalent Percentage of Marks = (CGPA/SGPA) x 10

6.0 Declaration of Division

A candidate who has passed in all the courses of examinations of all the Four Semesters taken together will be declared as Passed. Such passed candidates may be awarded with the division according to the following criterion:

(i) First Division: CGPA ≥6.5

(in) Second Division: CGPA <6.5

7.0 Credit Score

1 credit = 1 hr lecture/week/semester or 2 hr lab work/week/semester.

The field trainings will be equivalent to a total of 4 credit points (2 Credit Ist Semester and 2 Credit IIIrd Semester). Dissertation work will be equivalent to 04 credit points. Practical of each subject will be of 2 credit points.

8.0 Theory and Practical share

Each theory will have two components:

Internal Assessment (Attendance/Seminar/Assignment/Test etc.)	25 %
End-Semester Examination	75 %

Lab work will be divided into the following two components:

Internal Assessment (Attendance/ Class performance/Lab Records)	25 %
End-Semester Examination	75 %
▪ Final examination	60 %
▪ Viva-voice	15%

M.Sc. (Geology) Syllabus

There shall be five (05) questions in each paper and all of which shall he compulsory. The structure of the paper shall be as follows: (a) All the questions shall carry equal marks. (b) question no. 1 shall be of objective type covering the entire syllabus and there shall be two questions from each unit (unit I to IV) of which one question is to be attempted. (d) The questions no. 2 to 5 could be long answer type/short answer type including short notes/reasoning/differentiate amongst etc.

SEMESTER-I

COURSE NO.	TITLE OF THE COURSES	Credit	Remark
GEOL/C/101	Igneous & Metamorphic Petrology	4	Core course
GEOL/C/102	Sedimentology	4	Core course
GEOL/C/103	Structural Geology	4	Core course
GEOL/C/104	Mineralogy and Geochemistry	4	Core course
GEOL/C/105	Lab- GEOL/L/101 & GEOL/C/102	2	Lab work
GEOL/C/106	Lab- GEOL/C/103 & GEOL/C/104	2	Lab work
GEOL/C/107	**Field Training**	2	Field Training
	Total No. of Credits	22	

SEMESTER-II

COURSE NO.	TITLE OF THE COURSES	Credit	Remark
GEOL/C/108	Palaeontology	4	Core course
GEOL/C/109	Stratigraphy	4	Core course
GEOL/C/110	Economic Geology	4	Core course
GEOL/C/111	Tectonic geomorphology	4	Core course
GEOL/C/112	Lab- GEOL/L/108 & GEOL/C/109	2	Lab work
GEOL/C/113	Lab- GEOL/L/110 & GEOL/C/11	2	Lab work
GEOL/C/114	Seminar (related to dissertation)	2	Seminar
	Total No. of Credits	22	

SEMESTER-III

COURSE NO.	TITLE OF THE COURSES	Credit	Remark
GEOL/C/115	Engineering Geology	4	Core course
GEOL/C/116	Mineral exploration and Mineral economics	4	Core course
GEOL/C/117	Geodynamics	4	Core course
GEOL/C/118	Geohydrology	4	Core course
GEOL/L/119	Lab- GEOL/L/115 & GEOL/C/116	2	Lab work
GEOL/L/120	Lab- GEOL/L/117 & GEOL/C/118	2	Lab work
GEOL/F/121	**Field Training**	2	Field Training
	Total No. of Credits	22	

SEMESTER-IV

COURSE NO.	TITLE OF THE COURSES	Credit	Remark
GEOL/C/122	Remote Sensing and GIS	4	Core course
GEOL/C/123	Glaciology and Paleoclimate	4	Core course
GEOL/C/124	Himalayan Geology	4	Core course
GEOL/E/125	Elective Course (Sequence Stratigraphy & Basin Analysis; Quaternary Geology; Marine Geology; Environmental Geology)	4	Core course
GEOL/L/126	Lab- GEOL/C/122 & GEOL/C/123	2	Lab work
GEOL/L/127	Lab- GEOL/C/124 & GEOL/C/125	2	Lab work
GEOL/D/128	**Project oriented dissertation**	2	Dissertation
	Total No. of Credits	22	

SEMESTER -I

GEOL/C/101: Igneous and Metamorphic Petrology (4 credit, Max marks: 100 = (75 external exam+25 internal assessment)

Theory

Unit-I: Magma differentiation, fractional crystallization, assimilation, liquid immiscibility; Gibbs Phase rule, Study of phase equilibria in binary (Diopside-Anorthite, Forsterite- Silica, Leucite-Silica, Albite- Anorthite, Orthoclase-Anorthite) and ternary silicate systems (Orthoclase-Albite-Silica, Diopsite-Albite-Anorthite, Diopside-Foresterite-Silica, Fayalite-Leucite-Silica) in the light of modern experimental works.

Unit-II: Texture, Structure and IUGS classification schemes of igneous rocks; Petrognesis and tectonic setting of major igneous rock types and suites: Ultramafic rocks- komatiite, lamprophyres, kimberlite; Ophiolites, flood basalt, anorthosite, Tonalite-Trondhjemite- Granodiorite (TTG), granitoids, alkaline rocks and carbonatites with special reference to Indian examples.

Unit-III: Mineralogical Phase rule, Types of metamorphism; Texture of regional & contact metamorphic rocks, deformation and metamorphism; Nature and types of metamorphic reactions; Concept and classification of metamorphic facies; Faces series; Graphical representation of minerals in ACF, AKF, AFM and A'F'M' diagrams; Time relation between phases of deformation and metamorphic crystallization.

Unit-IV: Description of metamorphic faces with special reference to their characteristics minerals, mineral assemblages, metamorphic reactions and pressure-temperature conditions of metamorphism. Metamorphism of shale, mafic and calcareous rocks; Isograds and Reaction Isograds; Metamorphic differentiation; Anatexis and origin of migmatites; Paired metamorphic belts.; Geothermobarometry; Pressure-Temperature-Time(P-T-t) paths.

Suggested Readings:

- Phillpotts, A.R. (1994) Principles of Igneous and Metamorphic Petrology, Prentice Hall.
- Best, R. G. (2003) Igneous and Metamorphic Petrology, 2nd Edn., Blackwell.
- Bose, M. K. (1997) Igneous Petrology, World Press, Kolkata.
- Turner, F.J. (1980) Metamorphic Petrology, McGraw Hill, New York.
- Winter, J.D. (2001) An introduction to Igneous and Metamorphic Petrology, Prentice Hall.

GEOL/C/102: Sedimentology (4 credit, Max marks-100= (75 external exam+25 internal assessment)

Theory

Unit- I: Shape, size, fabric and surface texture of sedimentary rocks; Fluid flow mechanics and formation of sedimentary bed forms. Concept of faces and implication of facies in environmental interpretation and basin analysis. Diagenesis -Physical and chemical processes.

Unit- II: Conglomerates, Petrogenesis of sandstone, problem of greywacke, plate tectonics and sandstone composition, Argillaceous rocks-composition and classification. Dolomites, limestones - their petrographic characteristic.

Unit-III: Walthers law and sedimentary environments. Sedimentary cycles, rhythms and cyclothems. Modern and ancient sedimentary environments. Continental clastic depositional sedimentary models- alluvial, fluvial, lacustrine, aeolian and glacial deposits.

Unit-IV: Transitional and marine sedimentary facies models - deltaic, tidal flats, barrier islands terrigenous shelves and shallow seas. Carbonate platforms and reefs and sabakhas, Continental rise and ocean basins: Tectonic classification of sedimentary basins.

Suggested Readings:

- Reading H. G. 1996 : Sedimentary Environments and Facies, Blackwell
- Boggs Sam Jr, 1995 . Principles of Sedimentary and Stratigraphy, Prentice Hall
- Collins, J.D., and Thompson. D.B. (1982): Sedimentary Structures, George Allen and Unwin. London.
- Lindholm. R.C. (1987) A Practical approach to Sedimentary, Allen and Unwin, London
- Selley, .C. (2000) Applied Sedimentology, Academic Press.
- Tucker, M.E. (1981) : Sedimentary Petrology: An Introduction, Wiley & Sons, New york.

GEOL/C/103: Structural Geology (4 credit, Max marks- 100 = (75 external exam+25 internal assessment)

Theory

Unit-1: Concept of stress and strain. Stress-strain relationships of elastic, plastic and viscous materials. Types of strain ellipses and ellipsoids; their properties and significance. Measurement of strain in deformed rocks; Mechanical principles and properties of rocks and their controlling factors. Theory of rock failure; brittle and ductile deformation.

Unit-II: Mechanics of folding and buckling. Folds geometry, and classification. Superimposed folds and their interference patterns. Analytical methods of determining fold style. Causes and dynamics of faulting. Normal faults and strike - slip faults. Overthrust and nappe within implications to thrust tectonics. Thin skinned deformation and decollement. Salt domes and diapers. Concept of balanced cross sections.

Unit-Ill: Joints, rock cleavage and foliations; their origin, domain character, relationship with major structures and geological significance. Transposed foliations. Linear structures and boudinage; their origin, relationship with major structures and significance. Deformation of linear structures.

Unit-IV: Brittle and ductile shear zones; their geometry, strain pattern, kinematics and significance. Rotation of structural elements. Concept of Petro fabric analysis. Use of stereographic and equal area projections for representing different types of fabric.

Suggested Readings:

- Ramsay J. G, 1967. Folding and Fracturing of Rocks. McGraw Hill.
- Turner F.J and Weiss, L.E., 1963. Structural Analysis of Metamorphic Tectonites McGraw Hill.
- Davis G. R., 1984. Structural Geology of Rocks and Region. John Wiley.
- Ghosh, S. K., 1995. Structural Geology: Fundamentals of Modern Development. Pergamon.
- Valdiya K.S, 1998. Dynamic Himalaya. University Press.

GEOL/C/104: Mineralogy and Geochemistry (4 credit, Max marks- 100 = (75 external exam+25 internal assessment)

Theory

Unit- GEOL/C/104: Mineralogy and Geochemistry (4 credit, Max marks- 100 = (75 External Exam+25 internal assessment)

Unit-I: Introduction to space group, space lattice and x-ray crystallography; Structural classification of silicates; Study of following group of minerals with reference to chemical and structural formula, classification, atomic structure, chemistry, physical and optical properties, occurrences: Olivine, Garnet, Epidote, Calcite, Beryl, Pyroxene, Amphibole, Mica, Feldspars, Feldspathoids, Silica and Al silicates.

Unit-II: Pleochroism and determination of pleochroic scheme, Interference figures and determination of optic sign; Extinction; Uniaxial and Biaxial indicatrix and dispersion in minerals. Formation of Uniaxial and Bi-axial interference figures, Mica, Gypsum and Quartz plates; Universal stage and their uses in the determination of optical properties of minerals.

Unit-Ill: Composition of Earth and its constituents (Crust, mantle and core); Ionic and co-ordination number; Rules of ionic substitution, coupled substitution; Distribution coefficient: Capture admission and camouflage, Geochemical classification of elements; Behaviour of major and trace including rare earth elements during magmatic crystallization.

Unit-IV: Near-surface geochemical environment: Eh-pHI diagram; Principle of chemical mass balance and rock- cycle; Chemical weathering of minerals and rocks. Radiogenic isotopes in geochronology and petrogenesis: Rb-Sr, Sm-Nd, -Pb isotopic system.

Suggested Readings:

- Balley, M.. (1981) Mineralogy for students 2nd Edn. Longmans.
- Faure, G. (1986) Principles of Isotope Geology, 2nd Edn., John Wiley.
- Krausko pf, K.B. (1967) Introduction to Geochemistry, McGraw Hill.
- Mason, B. and Moore, C.B. (1991) Introduction to Geochemistry, Wiley Eastern.
- Rollinson. H.R. (1993) Using geochemical data: Evaluation, Presentation, Interpretation, Longman. U.K.

GEOL/L/105: Lab work (Credit 2, Maximum Marks- 100 (75 marks for external and 25 marks for Internal assessment)

LAB WORK: (GEOL/C/101+ GEOL/C/102)

Igneous petrology: Megascopic and microscopic studies of major igneous rock types: CIPW non calculation.

Metamorphic Petrology: Study of metamorphic rocks in thin sections with reference to texture/structure, time relation between phases of deformation and metamorphic crystallization, mineral parent rock, metamorphic facies/sub-facies/zones to which rock can be assigned and representation of assemblage in ACF, AKF, AFM and A'F'M' diagrams; estimation of pressure and temperature from

important models of Geothermobarometry.

GEOL/L/106: Lab work (Credit 2, Maximum Marks- 100 (75 marks for External and 25 marks for Internal assessment)

LAB WORK: (GEOL/C/103 + GEOL/C/104)

Sedimentology: Detailed study of clastic and non-clastic rocks in hand specimen. Study of assemblages of sedimentary structures in context to their palaeo-environment significance. Microscopic examination of important rock types. Heavy mineral separation, their petrographic characters, graphical representation and representation and interpretation. Grain size analysis by sieving method, plotting of size distribution data as frequency and cumulative curves. Computation of statistical parameters and interpretation.

Structural Geology: Study of naturally deformed rocks in hand specimens. Geometrical analysis of folds and faults. Preparation and interpretation of geological maps. Applications of stereographic and equal arca projections. Strain analysis using software and manually.

GEOL/F/107: Field Training (2 credit, Max marks 100; 75 marks for External and 25 marks for Internal assessment))

Students will be required to do the mapping in structurally deformed terrain under the supervision of faculty members. The field work should be at least 2 to 3 weeks duration and the students will submit a report of the field training to the department for the evaluation purposes.

SEMESTER-II

GEOL/C/108: Palaeontology (4 credit, Max marks- 100 = (75 external exam + 25 internal assessment)

Theory

Unit I: Theories of origin of life. Organic evolution-Punctuated equilibrium and phyletic gradualism models. Mass extinctions and their causes. Early Precambrian life and Edi acaran fossil assemblage; Ichnology, classification and use.

Unit II: Palaeobiology (palaeoecology, communities, functional morphology and taphonomy); Gondwana flora.

Unit III: Brief morphology, evolution and Classification of Brachiopoda, Mollusca, Cephalopoda, Gastropoda, Bivalvia, Trilobita, Echinoids, Foraminifera, Radiolaria, Ostrocoda and diatoms.; Significance of microfossils in oil exploration.

Unit IV: Evolution of vertebrates with special reference to horse, elephants, man. Dinosaurs and cause of their extinction.

Suggested Readings:

- Raup and Stanley, Principles of Palaeontology,
- Bilal U. Haq and A. Boersome, Introduction to Marine Micropalaeontology, G.Bignot, Elements of Micropalaeontology,
- David Raup and Stanley (1985). Principles of Palaeontology., CBS Pub., Delhi
- Glaessner, M.F. (1945). Principles of Micropaleontology. Melbourne Univ. Press.
- Schrock, Twenhofel and Williams (1953). Principles of Invertebrate Paleontology. CBS, Delhi

GEOL/C/109: Stratigraphy (4 credit, Max marks- 100 = (75 external exam + 25 internal assessment)

Theory

Unit I: Recent development in stratigraphic classification, Code of stratigraphic nomenclature. Concept of sequence stratigraphy. Modern methods of stratigraphic correlation. Steps in stratigraphic studies. Approaches of paleogeography. Earth's climatic history.

Unit II: Brief ideas of quantitative, magneto, sesmic, chemo and event stratigrphy. Evolution and biostratigraphy - controlling factor, zonation, time significance, quantitative stratigraphy, cyclostratigraphy. pedostratigraphy.

Unit Ill: Evolution of the early crust, lithological, geochemical and stratigraphic characteristics of granite, Greenstone and granulite belts of India and global correlation. Proterozoic formations of Peninsular - Extra peninsular India.

Unit IV: Precambrian life, stratigraphic records India. Boundary problems: Archean-ProterozoicPrecambrian- Cambrian, Permo-Triassic, Cretaceous -Tertiary, Neogene-Quaternery. In Brief: Paleozoic-Mesozoic and Cenozoic stratigraphy, fossils, Paleogeography, Paleoclimate, Tectonism and economic deposits. Outline of Phanerozoic type sections of the world.

Suggested Readings:

- Stratigraphic Principles & Practice, J. Marvin Weller
- Principles of stratigraphy V-2, Amadeus W. Grabau
- Stratigraphy by D.N. Wadia
- Geology of India & Burma by M.S. Krishnan

GEOL/C/110: Economic Geology (4 credit, Max marks- 100 = (75 external exam + 25 internal assessment)

Theory

Unit-I: Mineralization and tectonism; Geological setting, characteristics and genesis of ferrous, base and noble metals. Important process of ore formation.

Unit-II: Methods of mineral deposit studies including ore microscopy, fluid inclusions and isotopic systematic. Metallogenic epochs and provinces of India.

Unit-IlI: Origin, migration and entrapment of petroleum. Properties of source and reservoir rocks. Structural, stratigraphic and combination traps. Petroliferous basins of India.

Unit-IV: Origin of coal deposits. Classification, rank and grading of coal. Coal resources of India. Gas hydrates, coal bed methane and nuclear mineral resources. Occurrence of mineral resources in the Himalaya.

Suggested Readings:

- Craig, J.M. & Vaughan, D.J, 1981: Ore Petrography and Mineralogy-John wiley
- Evans, A.M., 1993: Ore Geology and Industrial Minerals-Blackwell
- Torling, D.H, 1981: Economic Geology and Geotectonies-blackwell Sci publ.

GEOL/C/111: Tectonic Geomorphology (4 credit, Max marks- 100 = (75 external exam + 25 internal assessment)

Theory

Unit-1: Definition and scope of tectonic geomorphology. Concept of landform – Process relationship in the evolution of landscape.

Unit-Il: Geomorphic Markers of active tectonics: Planar and Linear. Landforms of active strike-slip faults, normal faults, reverse faults and folds. River response to active tectonics. Sudden (coseismic) versus gradual modifications in river systems. Tectonic modifications of

alluvial and bedrock-channeled rivers: longitudinal profiles, river pattern, sinuosity, drainage patterns and drainage anomalies. Effects of base level.

Unit-lIl: Geomorphic Indices of active tectonics - Morphometric analysis: mountain-front sinuosity, hypsometric curve and hypsometric integral, drainage basin asymmetry, stream length gradient index, and valley-floor width to valley height ratio.

Unit-IV: Fundamentals of space geodetic techniques of measuring active tectonic deformations: Differential Global Positioning System (GPS) and Radar Interferometry.

Suggested Readings:

- Burbank, D.W. and Anderson, R.S. (2011). Tectonic Geomorphology 2nd Edition. Blackwell Science.
- Burbank, D.W. and Anderson, R.S. (2001). Tectonic Geomorphology 1st Edition. Blackwell Science.
- Keller, E.A, and Pinter, N. (1996). Active tectonics: Earthquakes, Uplift, and Landscape. Prentice Hall

GEOL1/112: Lab work (Credit 2, Maximum Marks- 100 (75 marks for external and 25 marks for Internal assessment)

LAB WORK: (GEOL/C/108+ GEOL/C/109)

Palaeontology: Systematic description of Brachiopoda, Mollusca, Cephalopoda, Gastropoda, Bivalvia, Trilobita, Echinoids. Foraminfera, Radiolaria, Ostrocoda, diatoms and vertebrates. Study of important Gondwana plant fossils.

Stratigraphy: Study of characteristics stratigraphic rocks of India and their distribution. Study of Paleogeographic maps of Phanerozoic.

GEOL/L/113: Lab work (Credit 2,, Maximum Marks- 100 (75 marks for External and 25 marks for Internal assessment)

LAB WORK: (GEOL/C/110+ GEOL/C/111)

Economic Geology: Study of ores in hand specimen. Geographical distribution of classic ore deposits of India and world. Study of metallic minerals under the reflecting microscope. Tectonic Geomorphology: Exercises on mapping of tectonic geomorphological features andcomputation of geomorphic indices, using map and remote sensing data.

GEOL/S/114: Seminar (Credit 2, Maximum Marks- 100 (75 marks for External and 25 marks for Internal assessment)

Student will deliver a seminar related to the problem and research methodology of the dissertation before the faculty members, research scholars and M.Sc. students. Head of the department will constitute a board to evaluate the presentation of the candidate.

SEMESTER - III

GEOL/C/115: Engineering Geology (4 credit, Max marks- 100 = (75 external exam + 25 internal assessment)

Theory

Unit-I: Role of geology in major engineering projects. Engineering properties of rocks and physical characteristics of building stones and road aggregates. Elementary idea about rock mechanics and soil mechanics.

Unit-Il: Geological consideration for evaluation of Dams and reservoir sites. Reservoir induced seismicity. Dam foundation rock problems. Grouting and Rock bolting. Problem of piping in reservoir areas.

Unit-Ill: Geotechnical evaluation of tunnels- types, methods and problems. Stress conditions in tunnels. Bridges, their types and causes of their failure. Influence of geological conditions on Building foundation.

Unit-IV: Mass movement with emphasis on landslide. Causes of hill slope instability and preventive measure

Suggested Readings:

- Sharma P.V, Environmental and Engineering Geophysics
- Krynine D.P and Judd W.R., Principles of Engineering Geology and Geotechniques
- Bell F.G., Fundamental of Engineering Geology
- Jeger C., Rock Mechanics and Engineering
- Valdiya KS., Environmental Geology

GEOL/C/116: Mineral Exploration and Mineral Economics (4 credit, Max marks- 100 = (75 External Exam + 25 internal assessment)

Theory

Unit-1: Concept of exploration. Geological, geophysical, geochemical and geobotanical criteria and methods of surface and sub-surface exploration. Application of Remote Sensing in mineral exploration.

Unit-Il: Pitting, trenching, drilling and sampling methods. Methods of petroleum and ground water exploration. Estimation of grade and reserve of ores. Techniques of well logging.

Unit-Ill: Principles of mineral beneficiation. Comminution classification, liberation, concentration. floatation methods, jigging, electromagnetic and magnetic separation, amalgamation, syndication.

Unit-IV: Strategic, critical and essential minerals. India's status in mineral production. National: Mineral Policy. Substitution and conservation. Mineral concession rules. Marine minerals resources and Law of Sea.

Suggested Readings:

- Mckinstry, H.E., 1962: Mining Geology. I Ed.-Asia Publishing House
- Clark, G.B., 1967: Elements of Mining.III Ed.-John Wiley
- Arogyaswami, R.P.N., 1996: Courses in Mining Geology. IV Ed.-Oxford IBH
- Mason, B.C. (1982). Principles of Geochemistry, Johi. Wilay & Sons.
- Jeffery, G.H, Basett, J., Mendhan, J. and Denney, R.C. (1989). Vogel's text book of
- quantitative Chemical analysis. 5th ed. ELBS.

GEOL/C/17: Geodynamics (4 credit, Max marks- 100 = (75 External Exar + 25 internal assessment)

Theory

Unit-I: Planetary evolution of the earth and its internal structure. Heterogeneity of the Earth crust. Major tectonic features of the Oceanic and Continental crusts. Isostacy and epeirogeny.

Unit-II: Gravity and magnetic anomalies and heat flow patterns at Mid- Ocean ridges, deep-sea trenches, continental shield areas and mountain chains. Continental drift-geological and geophysical evidence, mechanics, objections, present status. Nature of plate margins.

Unit-III: Palaeomagnetism, magnetostratigraphic, seafloor spreading, mechanics of' plate motion and Plate Tectonics. Island arcs, oceanic islands, hotspots and plume tectonics. Seismic belts of the earth vis-a-vis plate movements.

Unit-IV: Orogeny, geodynamic evolution of Indian cratons and mobile belts. Structure and' origin of the Himalaya. Metallogeny in relation to plate tectonics. Neotectonics movements concepts and evidence.

Suggested Readings:

- Valdiva, K.S. Aspects of tectonics
- Kearey P.. Klepeis K.A, & Nive F.J., Global Tectonics
- Valdiya, K.S, Making of India
- Condie, K.C., Plate Tectonics

GEOL/C/118: Geohydrology (4 credit, Max marks- 100 = (75 External Exam + 25 internal assessment)

Theory

Unit-I: Hydrological Cycle, Ground Water- origin, type and occurrence. Hydrological properties of rocks- porosity, permeability, specific yield, specific retention, hydraulic conductivity, transmissibility and storage coefficient. Subsurface movement and vertical distribution of Ground Water.

Unit- II: Aquifer and their types. Significance of perched aquifers, Confined and unconfined aquifers. Darcy Law, its range and validity. Springs hydrology.

Unit-Ill: Quality of Ground water: Chemical characteristics of ground water in relation to various uses- domestic, irrigation and industrial purposes. Ground water artificial recharge-methods and factors controlling recharge.

Unit-IV: Geological and geophysical methods of ground water exploration. Ground water management, artificial recharge, ground water legislation and ground water provinces of India.

Suggested Readings:

- Todd, D.K., 1980: Groundwater Hydrology- John Wiley
- Davis, S.N and De Wiest, R.J.M., 1966: Hydrogeology- Johm Wiley
- Freeze, R.A and Cherry, J.A., 1979: Ground Water- Prentice Hall

GEOL/L/119: Lab work (Credit 2, Maximum. Marks- 100 (75 marks for External and 25 marks for Internal assessment)

LAB WORK: (GEOL/C/115+ GEOL/C/116)

Engineering Geology: Study of engineering geological maps, preparation of cross sections and description of the terrain. Exercise in calculation of engineering properties of rocks. Problems related to hill slope instability and interpretation of geological maps for landslide problems

Mineral Exploration and Mineral Economics: Ore reserve estimation and vetting of easy values. Interpretation of bore hole logs. Interpretation of seismic and resistivity data. Study of gravity data maps and their interpretation.

GEOL/L/120: Lab work (Credit 2, Maximum Marks- 100 (75 marks for External and 25 marks for Internal assessment)

LAB WORK: (GEOL/C/117+ GEOL/C/118)

Geodynamics: Study of block diagrams related to plate motion. Study of major tectonic features of the world.

Geohydrology: Hydrological properties of rock and soil characteristics- Specific gravity, degree of saturation, moisture content, void ratio, porosity and permeability. Delineation and description of hydro chemical and Ground water provinces of India. Chemistry of ground water.

GEOL/F/121: Field Training (2 credit, Max marks 100; 75 marks for External and 25 marks for Internal assessment)

Students will be required to visit geologically important areas including mines, dams, oil fields, fossiliferous sequences and laboratories/Institute of repute and submit a report thereon to the department for the evaluation purposes under the supervision of faculty members. The field work will be of the duration 2 to 3 weeks.

SEMESTER-IV

GEOL/C/122: REMOTE SENSING AND GIS (4 credit, Max marks-100 = (75 External Exam+25 internal assessment)

Theory

Unit-1: Definition of' remote. Remote sensing platforms: Air- and space-based.

Unit-Il: Types and characteristics of sensors. Concepts of mono-band, multispectral and hyperspectral remote sensing. Basics of optical, thermal and microwave remote sensing. Concept of LiDAR. Characteristics of IRS sensors.

Unit-Ill: The structure of Digital Image. Conceptual aspects of Digital Image Processing. Basic processes of image rectification, enhancement and classification. Definition and components of Geographic Information System (GIS). Raster and vector data formats. Basic knowledge about data acquisition, manipulation, analyses and representation in GIS.

Unit-IV: Application of remote sensing and GIS in geomorphological investigations, tectonic investigations, lithological mapping, groundwater exploration, mineral exploration, Oil & Gas exploration and geohazard management.

Suggested Readings:

- Lillesand, T.M., Kiefer, R. W. and Chapman, J. (2007): Remote Sensing and Image Interpretation, 6' Edition. Wiley
- Gupta, R. P. (2003). Remote Sensing Geology. 2' Edition. Springer
- Drury, S.A. (1993). Image Interpretation in Geology. 2nd Edition. Chapman & Hall

GEOL/C/123: GLACIOLOGY (4 credit, Max marks-100 = (75 External Exam+25 internal assessment)

Theory

Unit-I: Introduction, importance and implication of glaciological studies, Inventory of Himalayan glaciers, Identification system of glaciers. Preservation and future of glaciers.

Unit-Il: Glacial morphology, glacial deposits and paleo-glaciation, Hydrometery of glaciated basins, suspended sediment transport. Reconstruction of paleoclimatic history.

Unit-Ill: Mass balance studies; Net balance, Ablation, accumulation and snow density measurements, Relationship of mass balance to climate, Snow melt processes. Ice surface velocity, Contribution of avalanche in glacier health.

Unit-IV: Physics of ice and snow, Mechanics of snow/ice creep. lee crystals, engineering properties of glacial material, glacial hydrochemistry. Application of remote sensing techniques in glaciology, Application of advanced surveying techniques, Global positioning system, geodetic techniques and Ground penetrating radar.

Suggested Readings:

- V.F. Petrenko and Robert, W., 1999. Physics of Ice 1st Edition, Kindle Edition
- MM Bennett and N F Glasser, 2009, Glacial Geology: Ice Sheets and Landforms, Wiley
- Jon Erickson, 1996: Glacial Geology, Facts on File
- Peter Martin, Michael E. Brookfield, Steven Sadura, 2001: Principles of Glacial

GEOL/C/124: HIMALAYAN GEOLOGY (4 credit, Max marks-100 = (75 External Exam+25 internal assessment)

Theory

Unit-1: Introduction and subdivision of the Himalayas; Geological terrains of Indian Subcontinent. Precambrian-Proterozoic rocks the Himalaya, their sedimentation, metamorphism and igneous activities.

Unit-ll: Himalayan province between Cambrian and Permian. Gondwana tectonics and pre-Himalayan palacogeograpgy.

Unit-lIl: Paleaotectonics, palaeogeography and closure of the Tethys Sea. Crelaceous volcanism and the Himalayan stratigraphy of different tectono-geomorphic units. Collision of India with Asia and the emergence and evolution of the Himalaya, evolution of Himalayan Foreland basin.

Unit-IV: Quaternary development and Holocene-recent tectonic movements and earthquakes in the Himalaya. Himalayan geochronology and tectonics

Suggested Readings:

- Gansser, A., 1959. Geology of the Himalayas.
- Wadia, D., 1973. Geology of India. McGraw Hill Book co.
- Krishnan, M.S., 1982. Geology of India and Burma, 6th Edition. CBS Publ.
- Valdiya, K.S, 1980. Geology of the Kumaon Himalayas. WIG Publ.
- Valdiya, K.S., 1998. Dynamic Himalya.

GEOL/E/125: Elective Course (any one of the following)

(a): Sequence Stratigraphy and Basin Analysis (4 credit, Max marks- 100= (75 External Exam+25 internal assessment)

Theory

Unit- 1: Concept of sequence Stratigraphy. Evolution, order and duration of sequences. Applications and significance of sequence Stratigraphy

Unit-2: Concept of faces and basin analysis. Walthers law and sedimentary environments. Sedimentary cycles, rhythms and cyclothems. Modern and ancient sedimentary environments. Continental clastic depositional sedimentary models-alluvial, fluvial, lacustrine, aeolian and glacial deposits.

Unit-3: Transitional and marine sedimentary faces models - deltaic, tidal flats, barrier islands terrigenous shelves and shallow seas. Carbonate platforms and reefs and sabakhas, Continental rise and ocean basins.

Unit-4: Sedimentation pattern and depositional environments of selected undeformed sedimentary basins of India. Himalayan sedimentary basins, Tectonic classification of sedimentary basins.

Suggested Readings:

- Reading H. G. 1996 : Sedimentary Environments and Facies, Balckwell
- Reading H.E and Singh, I.B. 1980 : Depositional Sedimentary Environments, Springer Verlag
- Boggs Sam Jr, 1995 . Principles of Sedimentary and Stratigraphy , Prentice Hall
- Selley .C., 1998. Applied Sedimentology, Academic Press
- Mill, A.D. 2000 : Principles of Sedimentary Basin Analysis, Springer Verlag
- Eirsele, G. 1992 : Sedimentary Basins, Springers Verlag.
- Bhattacharya A and Chakraborti , C .2000 . Analysis of Sedimentary Successions, Oxford and IBH

(b): Quaternary Geology (4 credit, Max marks- 100 = (75 External Exam+25 internal assessment)

Theory

Unit-I: Importance of Quaternary period and location of Quaternary basin. Oxygen Isotope stratigraphy, biostratigraphy and magneto stratigraphy. Quaternary climates glacial-interglacial cycles, eustatic changes.

Unit-Il: Proxy indicators of paleoenvironmental/' paleoclimatic changes, - land, ocean and cryosphere (ice core studies). Responses of geomorphic systems to climate, sea level and tectonics on variable time scales in the Quaternary.

Unit-Ill: Quaternary dating methods, -radiocarbon, Uranium series, luminescence, amino-acid, relative dating methods. Quaternary stratigraphy of India- continental records (fluvial, glacial, acolian, palaeosols, spleothems and durierust); marine records; continental-marine correlation of Quaternary record.

Unit-IV: Evolution of man and Stone Age cultures. Plant and animal life in relation to glacial and interglacial cycles during Quaternary. Indo-Gangetic Plain, Himalayan glaciations. Climate change and global warming; neotectonies.

Suggested Readings:

- D. Q. Bowen, 1978: Quaternary Geology, Pergamon
- R. F. Flint, 1971: Glacial and Quaternary geology
- A.G. Dawson, 1992, Ice age earth. Late quaternary geology and climate. Routledge,
- London
- Griffith Taylo, 2008: History of Geomorphology and Quaternary Geology

(c): Marine Geology (4 credit, Max marks- 100 = (75 External Exam+25 internal assessment)

Theory

Unit-I: Definition and Scope of the subject. History of development of Oceanography, Ocean Drilling Programme (OP),and its major accomplishments.

Unit-Il: Ocean Circulation, Surface Circulation, Concept of mixed layers, Thermocline and pycnocline, Concept of upwelling, El Nino, Deep Ocean circulation, Formations of Bottom waters, Water masses of the world oceans and sea sediments (oozes etc.).

Unit-IlI: Palaeoceanography: Approaches to palaeoceanographic reconstructions. Reconstruction of monsoon variability by using marine proxy records. Eustatic Changes.

Unit-IV: Global climate pattern and energy budget, Climate controlling factors. Plate tectonics and climate change Milankovitch cycles, Atmosphere and Ocean interaction and its effect on climate. An overview of Paleoclimatic reconstruction; Pleistocene Glacial-Interglacial cycles; Future climate: Anthropogenic activity and its effect on Global climate.

Suggested Readings:

- Palaeoceanography by J.J. Bhatt
- Ocenography by Savander Singh
- Paleoclimatology: climate through ages by C.. Brooks
- Climate Change in Pre history by W.J. Burrough
- Introduction to Physical Oceanography by R.h. Stewart
- Gross, M.G, 1977. Oceanography: A view of the Earth, Prentice Hall. Hag and Boersma, 1978. Intro duction to Marine Micropalcontology, Elsevier.
- Hasllett, S.K, 2002. Quaternary Environmental Micropalacontology, Oxford University Press, New York.

GEOL/L/126: Lab work (Credit 2, Maximum Marks- 100 (75 marks for External and 25 marks for Internal assessment)

LAB WORK: (GEOL/C/122+ GEOL/C/123)

Remote Sensing and GIS: Determination of the scale of aerial photographs and imageries. Visual interpretation of aerial photographs and imageries for geomorphological, lithological, tectonic and mapping

Glaciology: Calculation of heat balance equation; Exercise on flow movement/discharge; Meteorological and microclimatic parameters; Suspended sediment transport; Interpretation of glacial morphological maps; Exercise on mass balance.

GEOL/L/127: Lab work (Credit 2, Maximum Marks- 100 (75 marks for External and 25 marks for Internal assessment)

LAB WORK: (GEOL/C/124+ GEOL/C/125)

Himalayan Geology: Construction of physiographic and structural profiles, Interpretation of geological, structural and geomorphological features from the toposheets, Identification of deformation patterns in the rock specimens. Study of major tectonic features and paleogeographic reconstruction through times.
Sequence Stratigraphy and basin analysis: Preparation of lithology, Interpretation and reading depositional environments from the given idealized lithology and data, Heavy mineral identification and provenance interpretation. Petrography of selected sedimentary rock types.
Staining and Mineral identification in Carbonate rocks.

Quaternary Geology: Exercises related to topographic maps; Study of major lineaments and tectonic features from topographic maps and satellite imagery; Exercise related to neotectonics using lithlogs.

OR

Marine geology: Study of modern surface water mass assemblages of various microfossils from different oceans. Depth biotopes and estimation of paleodepth of the ocean using microfossils group. Thermocline and deep surface waters of the modern oceans.

GEOL/D/128: DISSERTATION (2 credit, Max marks 100; 75 marks for External and 25 marks for Internal assessment))

The project-oriented dissertation must be submitted by the end of fourth semester. During the course of completion of dissertation work, the students will be required to complete various assignments given to them by their respective supervisors or the Head of Department for the purpose of their evaluation.

Beside classroom seminars, the students will have to present their dissertation work in the form of seminar before the board of examiners including the supervisors, which will be followed by viva Examination.