Department of Earth Sciences

Course structure, Marks Scheme & Syllabi

for

M. Sc. – Applied Geology

2-year course
(Semester System)

Effective from

Academic Session 2013

University of Kashmir

Srinagar- 190 006

Course Structure & Marks Scheme

First Semester

Course No.	Subject	Marks		
		Total	Continuous Assessment*	Exam¥
Theory				
GL-T1	Structural Geology and Global Tectonics	100	20	80
GL-T2	Crystallography & Mineralogy	100	20	80
GL-T3	Igneous Petrology	100	20	80
GL-T4	Sedimentology	100	20	80
Practical				
GL-P1	Structural Geology	50	10	40
GL-P2	Crystallography & Mineralogy	50	10	40
GL-P3	Sedimentology & Igneous Petrology	50	10	40
Seminar				
GL-S1	Seminar Presentation	50	50	-
	Total marks for semester-I	**600**	**160**	**440**

Geological Field Training for 1 to 2 weeks is to be conducted within the state to be examined at the end of second semester. (see below)

Second Semester

Course No.	Subject	Marks		
		Total	Continuous Assessment*	Exam¥
Theory				
GL-T5	Geochemistry	100	20	80
GL-T6	Metamorphic Petrology	100	20	80
GL-T7	Paleobiology & Stratigraphy	100	20	80
GL-T8	Ore, Fuel & Exploration Geology	100	20	80
Practical				
GL-P4	Geochemistry & Metamorphic Petrology	50	10	40
GL-P5	Paleobiology & Stratigraphy	50	10	40
GL-P6	Ore, Fuel & Exploration Geology	50	10	40
Seminar				
GL-S2	Seminar Presentation	50	50	-
Field Training				
GL-FT	Geological Field Training for 4 to 5 weeks is to be conducted outside the state.	250	50	200
	Total marks for semester-II	**850**	**210**	**640**

Third Semester

Course No.	Subject	Marks		
		Total	Continuous Assessment*	Exam[¥]
Theory				
GL-T9	Tectonic Geomorphology	100	20	80
GL-T10	Hydrogeology	100	20	80
GL-T11	Remote Sensing & GIS	100	20	80
GL-T12	Engineering & Environmental Geology	100	20	80
Practical				
GL-P7	Hydrogeology	50	10	40
GL-P8	Remote Sensing & GIS	50	10	40
GL-P9	Engineering & Environmental Geology	50	10	40
Seminar				
GL-S3	Seminar Presentation	50	50	-
	Total marks for semester-III	**600**	**160**	**440**

Fourth Semester

Course No.	Subject	Marks		
		Total	Continuous Assessment*	Exam[¥]
Theory				
GL-T13	Elective Paper[e]	100	20	80
GL-T14	Elective Paper[@]	100	20	80
Project Work Dissertation				
GL-D	Project work dissertation on any topic to be decided by the Department[$] (i). Dissertation write-up (ii). Dissertation viva-voce	 100 100	 20 20	 80 80
		200	40	160
Grand viva-voce				
	Grand viva-voce[#] covering the syllabus of first three semesters.	100	-	100
	Total marks for semester-IV	**500**	**100**	**400**

Note:

* Marks to be awarded by teacher(s) concerned.

[¥] Marks to be awarded by the external examiner.

[e] Options for GL-T13 Elective Paper

GL-T13-A	Environmental Geology	GL-T13-E	Disaster, risk and hazard management
GL-T13-B	Geophysical Exploration	GL-T13-F	Mining and Exploration Geology
GL-T13-C	Geotectonics & Himalayan Geology	GL-T13-G	Climatology

GL-T13-D	Hydroinformatics		

[@] Options for GL-T14 Elective Paper:

GL-T14-A	Rock Deformation and Structural Analysis	GL-T14-E	Oceanography and Marine Geology
GL-T14-B	Sedimentary Environment and Sedimentary Basins	GL-T14-F	Petroleum Exploration
GL-T14-C	Advanced Hydrogeology	GL-T14-G	Glaciology
GL-T14-D	Advance Remote Sensing in Geosciences		

[$] Project work to be assigned individually to the student.

[#] Viva-voce to be conducted by the external examiner along with whole faculty.

Summary of Courses and Marks

Total no. of Courses			Marks		
			Total	**Continuous Assessment**	**Exam**
First Semester	Theory	4	400	80	320
	Practical	3	150	30	120
	Seminar Presentation	1	50	50	-
Second Semester	Theory	4	400	80	320
	Practical	3	150	30	120
	Seminar Presentation	1	50	50	-
	Geological Field Training	1	250	50	200
Third Semester	Theory	4	400	80	320
	Practical	3	150	30	120
	Seminar Presentation	1	50	50	-
Fourth Semester	Theory	2	200	40	160
	Project work	1	200	40	160
	Grand viva-voce	1	100	0	100
Total			**2550**	**630**	**1920**

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Detailed syllabi follows next.

Syllabi

Instructions for paper setters of M. Sc. (Applied Geology) Course

Paper setter is requested to follow the below mentioned instructions while setting the question papers.

1. The duration of examination of each theory paper is **two and half-hours** with **80** marks, unless otherwise mentioned.

2. The question paper should comprise of three sections: **A**, **B** and **C.**

   Section **A** should comprise of **Very Short Answer** questions,
   Section **B** should comprise of **Short Answer** questions,
   Section **C** should comprise of **Long Answer** questions.

3. Student will have to attempt all question from Section **A** and **B** and only two questions from Section **C.**

4. Section **A** will have **8 questions** with **2marks** for each question, covering all the four units in the paper. Students are expected to answer each question in **10-20 words**

5. Section **B** will have **4 questions** with **8marks** for each question, covering all the units in the paper. Students are expected to answer each question in **200-250 words**

6. Section **C** will have **4 questions** with **16marks** for each question, covering all the four units in the paper. Students are expected to answer each question in **400-500 words**

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First Semester

THEORY

GL-T1 Structural Geology and Global Tectonics

Unit	Course content
1.	Introduction:Mechanical principles and properties of rocks and their controlling factors. Theory of Rock failure. Concept of stress and strain: Two dimensional analyses of stress and strain. Types of strains ellipses and ellipsoids, their properties and geological significance.
2.	Fold: Mechanics of folding and buckling. Fold development and distribution of strain in folds. Fractures and joints: Their nomenclature, age relationship, origin and significance. Causes and dynamics of faulting, strike-slip faults, normal faults, over thrust and nappe. Shear zones, geological contacts.
3.	Concept of petro-fabrics and symmetry: Planer and linear fabrics in deformed rocks, their origin and significance. Objective field and laboratory techniques, graphic treatment, types of fabrics, fabric elements and interpretation of fabric data on microscopic and mesoscopic scale. Significance and limitations of π- and β-diagrams. Geometrical analysis of simple and complex structures on macroscopic scale.
4.	Global tectonics: Physiographic and crustal types. Seismic, density, thermal and chemical characters of the crust, mantle and core. Plate tectonics as a geodynamic model. Plate tectonics and mountain building. Models of mountain building – Pacific and Andean-type orogenies. Collision tectonics. Some basic data sets unexplained by Plate tectonics. Hot Spots and Triple junctions, Geomagnetism.

Books recommended:

Condie, K. C., 1976: *Plate tectonics and crustal evolution. Pergamon.*
Cox, A., 1996: *Plate Tectonics.* Blackwell.
Davis, G. R., 1984: *Structural Geology* of *Rocks and Region.* John Wiley.
Ghosh. S. K., 1995: *Structural Geology Fundamentals* of *modem Developments.* Pergamon Press.
Hobbs, B. E., Means, W. D. and Williams, P. F., 1976: *An Outline* of *Structural Geology.* John Wiley.
Kearey, P. and Vine, 2000: *Global Tectonics.* Black Well.
Meyerhoff et al., 1996: *Surge Tectonics,* Kluwer Pub.
Price, N. J. and Cosgrove, J. W., 1990: *Analysis* of *Geological Structure.* Cambridge Univ. press.
Ramsay, J. G, 1967: *Folding and Fracturing* of *Rocks.* McGraw Hill.
Ramsay, J. G. and Huber, M. I., 1987: *Modem Structural Geology,* Vol. I & II. Academic Press.

GL-T2 Crystallography and Mineralogy

Unit	Course content
1.	Elements of Crystallography: External & Internal symmetry in crystals; Symmetry elements; Improper axis; Combination of symmetry elements.
2.	Crystal Systems: 32 classes of crystals, spherical and stereographic projections.
3.	Optical Mineralogy: Concept and application of optical indicatrix. Interference phenomenon. Orthoscopic and conoscopic study of minerals. Optic figure, optic sign, dispersion, pleochroism and absorption. Determinative methods in mineralogy: Refractive index (Colored Backeline variation method), Pleochroism scheme and 2V Microscopic methods, Axiality and optic sign.
4.	Systematic mineralogy: Atomic structure, mineral chemistry and their PT-stability and mode of occurrence of silicates, native elements, sulphides, oxides, hydroxides and carbonates.

Books recommended:

Berry & Mason, 1988: *Mineralogy.* CBS Pub.
Hutchinson, C. S., 1974: *Laboratory Handbook of Petrographic Techniques.* John Wiley.
Kerr, P. F., 1977: *Optical Mineralogy.* McGraw Hill.
Kerr, P. F., 1977: *Optical Mineralogy.* McGraw Hill.
Nesse, 1987: *Optical Mineralogy*.
Phillips, Wm, R. and Griffen, D.T., 1986: *Optical Mineralogy.* CBS Edition.

Putnis, A., 2001: *Introduction to mineral Science*. Cambridge University Press.
Putnis, A., 1992: *Introduction to mineral Science*. Cambridge University Press.
Richard, V. G., 1997: *Dana's new Mineralogy*. John Wiley.
Spear, F. S. 1993: *Mineralogical Phase Equilibria and Pressure-Temperature Paths*. Mineralogical Society of America Pub.
Read, H. H.,1986: *Rutleys Elements of Mineralogy*.
Winchell, A. N., 1968: *Elements of optical mineralogy.* Wiley Eastern Pvt Ltd.
Winchell, A. W., 1937: *Elements of Optical Mineralogy*(Principles& Methods). John WileyPvt Ltd.

GL-T3 Igneous Petrology

Unit	Course content
1.	Introduction to igneous petrology: Magma: nature, cooling behavior, properties and chemistry; volatiles in silicate melts, magmatic crystallization. Mechanisms of partial melting and magma generation in the Earth; magma evolution by differentiation
2.	Rock associations and classification schemes of igneous rocks; IUGS and Chemical classification. Phase equilibria: Unary, Binary and Ternary systems. Mg-Number and other geochemical parameters; fractional crystallization and liquid lines of descent; lever rule.
3.	Genesis, source and tectonic setting of different Magma Types: Basaltic, granitic and alkaline magmas. Magmatism in relation to plate tectonics.
4.	Application of major and trace elements (including REE) and Sr, - Pb, - and Nd - isotopes studies in deciphering magma generation, mantle - crust interactions and tectonic environments.

Books recommended:

Albert, J., 1967: *Descriptive petrology of the Igneous Rocks*.Mc-Graw Hill, New York.
Alexander, Mc. B., 1987: *Igneous Petrology.* Prentice Hall.
Barth, T. F. W., 1956: *Theoretical Petrology*.Mc-Graw Hill, New York.
Best, M. G., 1986: *Igneous Petrology,* CBS Pub.
Bose, M. K., 1997: *Igneous Petrology*. World Press.
Hall, A., 1988: *Igneous petrology*. ELBSI Longman.
Harker, A., 1944: *Natural History of Igneous Rocks*. McMillan Press.
Hatch & Wells, *Text Book of Petrology*. CBS Pub.
McBirney, A. R., 1993: *Igneous Petrology*. John Wiley.
Philpotts, A., 1992: *Igneous and Metamorphic Petrology.* Prentice Hall.
Turner, F. J., 1960: *Igneous and Metamorphic Petrology*. Mc-Graw Hill, New York.
Turner &Verhoogen, 1999: *Igneous and Metamorphic Petrology*. CBS Pub.
Tyrrell, G. W., *Principles of Petrology*. CBS Pub.
Shand, S. J., 1977: *Eruptive Rocks.*Mc-Graw Hill, New York.
Shelley, D., 1995: *Descriptive Petrology of the Igneous Rocks.* Chapman & Hall.

GL-T4 Sedimentology

Unit	Course content
1.	Sedimentary processes:Introduction, Flow regimes. Textures: Textural elements of clastic and non-clastic rocks; Size, roundness, sphericity, fabric, form and surface textures, their measurement, statistical treatment and interpretation; mass properties of rocks. Sedimentary structures:Classification of sedimentary structures, their genesis and significance, Statistical treatment of plaeocurrent data. Use of textures and structures in sediment dispersal and basin studies.
2.	Petrography: General classification of sediments. Sandstone – light and heavy minerals, their relationship with provenance. Carbonates – classification, environment of deposition. Mudstones – classification and identification. Diagenesis: Diagenesis of mudstones, sandstones and carbonate rocks.
3.	Sedimentary environments: Physical and chemical parameters of depositional environments. Classification of environments, Lithologies, Structures and Vertical sequences formed in alluvial, deltaic, coastal, and deep sea, and glacial and aeolian environments, field recognisation, micromorphological features and paleoclimatic significance. Sedimentary facies:Concept and definition; Facies association; Walters Law of Facies and application. Sedimentary cycles and cyclothems. Facies models and environmental reconstruction.
4.	Paleocurrents and plaeogeography: Cross bedding, Ripple marks, Sole marks in reconstruction of paleogeography; fabric and paleocurrent. Scaler properties and paleocurrents; Down current size decrease of clasts; roundness, shape and paleocurrents. Bed thickness, isopach and paleocurrents. Paleocurrent and time. Paleocurrent and basin analysis, and paleogeography. Sedimentation and tectonics: Tectonic control on sedimentation, diastrophic cycle and sedimentation. Basin evolution in relation to plate tectonics.

Books recommended:

Collinson, J. D, 1999: *Sedimentary Structures.* Springer Verlag.
Ehlers and Blatt, 1999: *Petrology, (Igneous, Sedimentary and Metamorphic).* CBS Pub.
Einsele, G., 1992: *Sedimentary Basins.* Springer Verlag.
Friedman, G. M. and Sander, J. E., 1978: *Principles of Sedimentology*. John Wiley.
Miall, A. D.,1999: *Principles of Sedimentary Basin Analysis.* Springer-Verlag.
Pettijohn, F. J., Potter, P.E. and Siever, R, 1990: *Sand and Sandstone.* Springer Verlag.
Reading, J. G. 1996: *Sedimentary Environment and Facies*. Black well.
Reineck, H. E. and Singh, I.B., 1975: *Deposition Sedimentary Environment.* Spring-Verlag.
Selley, R. C., 1976: *Introduction of Sedimentology.* Academic Press, London.
Sengupta, S., 1997: *Introduction to Sedimentology.* Oxford-IBH.

PRACTICAL

GL-P1 Structural Geology

Structural Geology: Preparation and interpretation of geological maps and sections. Structural problems concerning economic mineral deposits. Exercises for determination of finite strain. Exercises for fold analysis by π- and β-diagrams. Plotting and interpretation of petro-fabric data and resultant diagrams. 3 to 4 exercises of structural analysis.

GL-P2 Crystallography & Mineralogy

Mineralogy & Crystallography: Drawing of crystallographic projections; Identification of some important rock forming minerals in hand specimens and thin sections. Exercises in mineral optics. Exercises on thin section and polished section making, etching and staining.

GL-P3 Sedimentology & Igneous Petrology

Sedimentary Petrology: Megascopic and microscopic study of sandstones, limestones and heavy minerals. Paleocurrent analysis - collection of azimuthal data, graphical representation of data and determination of statistical parameters. Identification and study of feldspars and carbonate minerals (calcite, ferroan calcite, ferroan dolomite, aragonite & magnesite) by staining technique.

Igneous Petrology: Megascopic and microscopic study of igneous lithotypes. Modal analysis. Chemo-graphic diagram (ACF & AFM ternary diagrams)

GL-FT Geological field Training

Local Geological Field Training for 1 to 2 weeks is to be conducted within the state.

GL-S1 Seminar Presentation

Students have to give seminar presentation related to the theory papers.

Second Semester

THEORY

GL-T5 Geochemistry

Unit	Course content
1.	Introduction to geochemistry: Polymorphism and pseudomorphism; Exsolution, Non-crystalline minerals (mineraloids). Origin and abundance of elements in the solar system and in the Earth. Geochemical cycle of elements. Geochemical classification of elements: major elements, trace elements (compatible and Incompatible elements) and PGEs. Goldschmidt's classification of trace elements. Goldschmidt's rules for ionic substitution. Camouflage, capture and admission of trace elements.
2.	Major, Trace & Rare Earth Element (REE) Geochemistry: Concepts of partitioning and distribution coefficients of trace elements between solid and liquid phases vis-à-vis partial melting and magma generation. Distribution of REE in earth's mantle and crust. Advanced analytical methods- AAS, XRF, ICP-ES, ICP-MS, EPMA.
3.	Radiogenic isotope geochemistry: Decay mechanism and growth of isotopes. Geochronological applications of Rb-Sr, K-Ar, U-Th-Pb, U-Pb, and Sm-Nd systematics.
4.	Stable isotope geochemistry (oxygen, hydrogen, carbon & sulphur): nature, abundance, fractionation and applications.

Books recommended:

Attendron, H. G., 1997: *Radioactive and Stable Isotopes Geology*.Pergamon Press.
Cox, P. A., 1995: *Elements of Earth.* OxfordUniv. Press.
Faure, G., 1986: *Principles of Isotope Geology.* John Wiley.
Garrels& Christ, 1966: *Solution Minerals and Equalibria*.Pergamon Press.
Gunter, F., *Principles and Applications of inorganic Geochemistry*.
Henderson, P., 1987: *Inorganic Geochemistry*. Pergamon Press.
Hoefs, J., 1980: *Stable Isotope Geochemistry.* Springer Verlag.
Krauskopf, K. B., 1967: *Introduction to Geochemistry.* McGraw Hill.
Marshal, C. P. and Fairbridge, R. W., 1999: *Encyclopedia of Geochemistry*. Kluwer Academic.
Mason, B. and Moore, C. B., 1991: *Introduction to Geochemistry.* Wiley Eastern.
Nordstrom, D. K. and Munoz, J. L., 1986: *Geochemical Thermodynamics*. Blackwell.
Raid, C. E., *Chemical Thermodynamics*. Chapman & Hall.

GL-T6 Metamorphic Petrology

Unit	Course content
1.	Introduction to metamorphic petrology: Metamorphism and metamorphic processes, factor controlling metamorphism, types of metamorphism, Metamorphic minerals, Index minerals, Mineral assemblages, Metamorphic differentiation. Metamorphic textures; projection in positive and negative space; ACF, AKF and AFM diagrams.
2.	Metamorphic facies classification and systematic description of regional and thermal metamorphism of pelitic, basic-ultra-basic and impure calcareous rocks.
3.	Metamorphic reactions: Basic characteristics of metamorphic reactions: solid-solid reactions, dehydration reactions, decarbonization and oxidation-reduction reactions and their implications to geothermo-barometry. Metasomatism and anataxis.

4.	Regional metamorphism and paired metamorphic belts in reference to plate tectonics. P-T - Time paths.

Books recommended:

Bucher, K. and Frey, M., 1994: *Petrogenesis of Metamorphic rocks.* Springer-Verlag.
Miyashiro, A., 1994: *Metamorphic Petrology.* UCL Press Ltd., London.
Philpotts, A., 1992: *Igneous and Metamorphic Petrology.* Prentice Hall.
Turner, F. J., 1960: *Igneous and Metamorphic Petrology*. Mc-Graw Hill, New York.
Turner, F. J., 1980: *Metamorehic Petrology.* McGraw Hill, New York. '
Turner &Verhoogen, 1999: *Igneous and Metamorphic Petrology*. CBS Pub.
Tyrrell, G. W., 1987: *Principles of Petrology.*CBS Pub
Yardley, B. W., 1989: *An Introduction to Metamorphic Petrology*. Longman, New York.

GL-T7 Paleobiology and Stratigraphy

Unit	Course content
1.	General aspects of paleobiology:Modern concepts of origin of life. Precambrian fossil record and Origin of Metazoa. Taphonomy and Fossil communities.Methodsand techniquesin Paleontology, Introduction to Molecular Paleontology. Invertebrate paleontology: Morphology and evolutionary trends in Mollusks, Brachiopods, and Trilobites.
2.	Micropaleontology: Introduction to various groups of microfossils, their importance in geology; Morphology, classification and evolutionary trends of Foraminifera, Ostracodes and Conodonts, their ecological and geological significance. Paleobotany: An account of important Gondwana fossils of India with respect to paleoclimatic conditions. Introductionto palynology and its applications; brief morphology of spores and pollens. Paleno - facies application to Hydrocabon exploration
3.	Vertebrate paleontology:Scope and application of Vertebrate Paleontology; Landmarks in Vertebrate evolution. Siwalik mammals, Phylogeny of Equidae and Proboscidae.
4.	Stratigraphy: Pre-Cambrian and Phanerozoic geology of India. Graphic representation of stratigraphic data. Outline idea about Seismic Stratigraphy, Magnetostratigraphy, Boundary problems: Boundary problems in stratigraphy with reference to Precambrian - Cambrian, Permian -Triassic, Cretaceous - Tertiary and Pliocene - Pleistocene boundaries. Mountain building activities in the Indian subcontinent from Late Cretaceous.

Books recommended:

Arnold, C. A., 1947: An introduction to Paleobotany. Mc Graw - Hill Book Co.
Bignot, G., 1985: *Elements of Micropaleontology*. Graham and Trotman.
Brasier, M. D., 1980: *Microfossils.* George Allen & Unwin.
Clerkson, E. N. K., 1998: *Invertebrate Paleontology and evolution.* Black Well
Colbert, E. H, 1955: *Evolution of Vertibrate.* Jhon Wiley& sons, London.
Dunbar, C. O, Rodger, J., 1957: *Principles of stratigraphy.* Wiley International.
Glassner, M. F., 1945: *Principles of Micropaleontology.* Hafner Pub.
Krishanan, M. S., 1968: *Geology of India and Burma.* Higginbothams Pvt. Ltd., Madras.
Kumar, R, 1998: *Fundamentals of Historical Geology and Stratigraphy.* Wiley Eastern Limited.
Shork&Twenholf, 1987: *Principles of invertibrate Paleontology*. CBS Pub., N. Delhi.
Wadia, D. N., 1957: *Geology of India.* Mcmillan, London.
Weller, J. M., 1960: *Stratigraphy Principles* &*Practice*. Harper & Row Pub.
Wood, H., 1968: Paleontology invertebrate. CBS Pub., N. Delhi.

GL-T8 Ore, Fuel & Exploration Geology

Unit	Course content
1.	OreGeology:Overview of space-time distribution of mineral deposits and global metallogeny. Synoptic view of the principal mechanisms of formation of the igneous, sedimentary and metamorphic mineral deposits. Weathering and Placer deposits. Ore deposits and plate tectonics. Mineral economics and its concept: National Mineral policy in relation to Strategic, critical and essential minerals

2.	Ore Microscopy: Quantitative methods in ore microscopy – reflectivity and microindentation hardness, equipment and measurement techniques thereof. Microchemical studies of ore minerals: Determinative etching, structural etching, and tests for specific chemical elements. Fluid inclusions in ore: principles, assumptions, limitations and applications.
3.	Fuel Geology: Origin and occurrence of petroleum, migration and accumulation of petroleum, reservoir rocks and traps, petroliferous basins of India. Coal: origin and classification of coal. Macroscopic and microscopic constituents of coal. Geological and geographical distribution of coal deposits in India with emphasis on Gondwana coal fields of India. Mode of occurrence and association of atomic minerals in nature. Productive geological horizons of atomic minerals in India.
4.	Exploration Geology: Concept of Geochemical Prospecting: dispersion, pathfinder elements, geochemical sampling, and geochemical field techniques. Geophysical prospecting:Basic principles, scope and application of geophysical prospecting. Principle, procedure, equipment used and applicability of gravity, magnetic, electrical, seismic and radiometric methods. Aerial geophysical surveys.

Books recommended:

Arogyaswamy, R. N. P., 1987: Courses in Mining Geology. Oxford &IBH Pub. Co. Pvt. ltd.
Craig, J. M. &Vaughan, D. J., 1981: *Ore Petrography and Mineralogy.* John Wiley.
Chatterjee, K. K., 1993: *An Introduction to Mineral economics.* Wiley Eastern Ltd.
Dahlkamp, F. J., 1993: *UraniumOre Deposits.* Springer Verlag.
Durrance, E. M., 1986: *Radioactivity in Geology. Principles and Application.* Ellis Hoorwool.
Evan, A. M., 1983: *Ore Geology and industrial Minerals.* Blackwell.
Holson, G. D. and Tiratsoo, E. N., 1985: *Introduction Petroleum Geology.* Gulf Pub. Houston,
Jensen, M. L. and Bateman, A. M., 1981: *Economic Mineral Deposits,* John Wiley.
Keller, S. E., 1994: *Mineral Resources, Economic and the Environment.* McMillanCollege Pub.
Levarson, 1985: *Geology of Petroleum.* CBS Pub.
Prasad, U., 1996: *Economic Geology.* CBS Pub. N. Delhi.
Selley, R.C., 1998: *Elements of Petroleum Geology.* Academic Press.
Sinha, R. K. and Sharma, N. L. 1993: *Mineral Economics.* Oxford & IBH Pub. Co. Pvt. Ltd.
Stach, E. and Others, 1982: *Stach's Text Book of Coal Petrology*. GebruderBorntraeger
Stanton, R. L, 1972: *Ore Petrology.* Mc-Graw Hill.
Tissot, B. P. and Welte, D. H, 1984: *Petroleum Formation and Occurrence.* Springer-Verlag.

PRACTICAL

GL-P4 Geochemistry& Metamorphic Petrology

Geochemistry: Depending upon analytical facilities, exercises in rock/sediment sample dissolution and determination of their elemental composition. Calculation CIPW norms, preparation of variation diagrams. Calculation of weathering indices in soil and sediments. Presentation of analytical data.

MetamorphicPetrology: Megascopic and microscopic study of metamorphic rocks of different facies. Modal analysis. Chemo-graphic diagram (ACF & AFM ternary diagrams)

GL-P5 Paleobiology & Stratigraphy

Paleobiology&Startigraphy: Identification, classification and morphological study of selected invertebrate fossils with lavelled diagrams. Taxonomic study of selected Gondwana plant fossils. Study of selected important rocks & fossils from Indian stratigraphic horizons and preparation of statigraphic column.

GL-P6 Ore, Fuel & Exploration Geology

Ore & Fuel Petrology: Megascopic study of structures and fabric of different ores and their associations. Mineralogical and textural studies of common ore minerals under ore microscope. Preparation of maps showing distribution of metallic and industrial minerals in India. Calculation of oil reserves. Completion of outcrops associated with coal geology. 3-points problems associated with borehole data.

GL-FT Geological Field Training

Geological Field Trainingof 4 to 6 weeks to be conducted outside the state.

GL-S2 Seminar Presentation

Students have to give seminar presentation related to the theory papers.

Third Semester

THEORY

GL-T9 Tectonic Geomorphology

Unit	Course content
1.	Overview of geomorphology: Geomorphic processes and resulting landforms.Geomorphological cycle. Soils: Their development and classification. Morphometric analysis of basins: Morphometric elements and parameter laws of drainage composition, drainage density, stream frequency, basin shape, hypsometry, relationship of morphometric parameters with discharge and sediment yield characters of basins. Morphometric evolution of Western Himalaya.
2.	Introduction to Tectonic Geomorphology: Energetics, Active Tectonics & Models of landscape development. Controversies in tectonic geomorphology. Geomorphic Markers: Planer and linear geomorphic markers, Marine Terraces, Beaches, Shorelines, lacustrine, Delta, River Terraces, Alluvial Fans, Lava flows, Debris flow, landslides.
3.	Landform dating techniques: Relative – Clast seismic velocity method, Weathering rinds, Obsidian hydration rinds, Soil development and Carbonate coating method, Lichenometry; Absolute – Tree rings, Carbon dating, Luminescence dating. Geomorphic Expression of Faults: Strike slip Faults, Normal Faults, Thrust Faults. Palaeoseismology: Introduction and scope of Paleoseismology, Study of field techniques in Paleoseismology, Direct and indirect observations of paleoseismic displacements. Paleoseismic landforms, Use of liquefaction-induced features and landslides for Paleoseismic analysis.
4.	Quaternary geomorphology:Cycles of climatic change (glacial and interglacial, pluvial and interfluvial) and their effect on landforms. Geomorphic sub-divisions of Indian subcontinent and their geomorphic features and evolution with special reference to Himalaya. Landslides: Types, Causes and remedial measures. Graphical analysis of slope stability. Calculation of factor of stability. Stability of slopes, flow and creep, Settlement and subsidence, Slope modification and reinforcement. Instruments for monitoring slope movements.

Books recommended:

Bloom, A. L., 2002: *Geomorphology, A Systematic Analysis of Late CenozoicLand Forms.* Prentice Hall Pvt. Ltd., N. Delhi.

Burbank, D. W. and Anderson, R.S., 2001: *Tectonic Geomorphology* Blackwell Sciences Easterbrook, Easterbrook, 1994: *Surface Processes and Land Forms.* Prentice Hall.

McCalpin, J., 1996: *Paleoseismology*Academic Press.

Pitty, A. F, 1982: *Nature of Geo-Morphology.* University Paper Backs.

Ritter, D. F., 1978: Process Geomorphology. Wm. C. Brown Publishers, Lowa

Sharma, V. K., 1986: *Geomorphology*. Tata McGraw Hill.

Thorrenberry, W. D., 1997: *Principles of Geomorphology* New Age International, Delhi.

Vishwas, S. K and Gupta, A., 2001: *Introduction to Geomorphology* Orient Longman.

GL-T10 Hydrogeology

Unit	Course content
1.	Introduction: Groundwater in the hydrologic cycle. Groundwater table - Groundwater table fluctuations and controlling factors. Subsurface inflow and outflow; Period of re-charge and discharge. Average groundwater fluctuations, effluent and influent streams. Elementary theory of groundwater flow:Darcy's law and its range of validity. Steady and unsteady flow.
2.	Hydrological properties of water-bearing materials: Porosity and permeability, transmissivity, storage coefficient, their definition and methods of determination. Water table maps and flow net analysis; differential equation for controlling groundwater flow. Well hydraulics:Steady, unsteady and radial flow into a well. Confined and leaky confined and unconfined aquifers. Determination of aquifer characteristics from pump-tests.

3.	Groundwater development: Groundwater exploration methods – geological & geophysical (resistivity, magnetic and seismic) methods. Borehole geophysical logging – electrical, resistivity and SP; Radiation logging – gama, gama-gama, and neutron logging. Cliper and temperature logging. Preparation of strata charts, design of tubewell assembly and water well design criteria. Water level development and yield tests, well completion reports. Groundwater modeling techniques, data requirement.
4.	Groundwater basin management methods:Basic ideas of groundwater management. Water logging – causes and remedial measures; artificial recharge. Fresh and saltwater relationship in coastal areas. Quality and geochemistry of water:Groundwater quality analysis – sampling methods, bacteriological, chemical and physical quality. Quality criteria for drinking, irrigation and industrial purposes. Pollution of groundwater. Groundwater and hydro-chemical provinces of India.

Books recommended:

Chow, V. T, 1988: *Advances in Hydrosciences,* McGraw Hill.
Freeze, R. A. & Cherry, J. A., 1979: *Ground Water.* Prentice Hall.
Fetter, C. W., 1990: *Applied Hydrogeology.* Merill Publishing.
Karanth, K. R., 1987: *Groundwater Assessment-Development and Management.* Tata McGraw Hill.
Todd, D. K.., 1980: *Groundwater Hydrogeology* John Wiley.
Raghunath, N. M., 1982: *Ground Water.* Wiley Eastern.
Ragunath, H. M., 1997: *Hydrology,* Principles, Analysis, Design. New Age Pub.
Roa, K. L., 1979: India's Water Wealth, Orient Blackswan.

GL-T11 Remote Sensing and GIS

Unit	**Course content**
1.	Remote sensing: basic concepts, fundamentals, data sources, Types of scanners and image acquisition: History and scope of remote sensing, concepts of remote sensing, electromagnetic radiations, matter interactions with atmosphere and terrain atmospheric windows, spectral reflectance of vegetation, soils, minerals and rocks.Elements of visual image interpretation. Factors governing image interpretation., verification and validation of RS data (Ground Truthing).
2.	Digital analysis of remote sensing data: Picture element and image statistics, Geometric and Radiometric Distortions, Pre-processing of satellite data(radiometric and geometrical corrections).Image enhancements techniques.Image filtering techniques. Spectral ratios and indices. Digital image classification: Supervised and unsupervised classification. Accuracy assessment: Sources of errors and measurement of map accuracy, kappa coefficient.
3.	Remote sensing applications to geosciences: Earth sciences: Lithology and structure (faults, folds), Environmental: Land use and land cover changes, monitoring erosion, urbanization and deforestation. Survey: cadastral mapping, digital terrain models. Hydrology: hydrological modeling and ground water prospecting.
4.	Geoinformatics and its applications to earth sciences: Overview of GIS, Components of GIS, GIS software packages, Concept and types of information, integration of spatial and non spatial data, Data models: raster and vector data models, geospatial analysis for disaster management with case studies on landslides and floods, GIS for environmental applications like lake management and soil mapping.

Books recommended:

Burrough, P.A., 2003: *Principles of Geographic Information* Systems. OxfordUniversity Press.
Campbell, J., 2002: *Introduction to Remote Sensing.* Guilford Press, New York.
Demers, M. N., 1999: *Fundamentals of Geographic Information Systems.* John Wiley.
Jensen, J. R., 2004: *Remote Sensing of the Environment.* Prentice Hall, New Jersey.
John, A. Richards, 1993: *Remote Sensing Digital Image Analysis.* Springer-Verlag.
John, R. Jensen, 2000: *Introductory Digital Image Processing, A Remote Sensing Perspective.*
Lillesand, T. M. and Kiefer, R. W., 1987: *Remote Sensing in Geology*. John Wiley. Prentice Hall, New Jersey.
Lillesand, T. M. and Kiefer, R. W., 2002: *Remote Sensing and Image Interpretation,J.Wiley*
Rees, W. G., 2001: *Physical Principles of Remote sensing.* CambridgeUniversity Press.
Sabbins, F. F., 1985: *Remote Sensing - Principles and Applications.* Freeman.

GL-T12 Engineering and Environmental Geology

Unit	Course content
1.	Principles of engineering geology: Engineering properties and classification of rocks. Factors affecting engineering services of rocks. Rock stability tests.Engineering properties of soils. Soil liquefaction and creep. Stress distribution in soil and foundation failure.
2.	Geological considerations for evaluation of dams, reservoir, buildings and tunnel sites: Dam foundation rock problems. Tunnel alignment and transportation routes. Methods of tunneling. Ground classification for tunneling purposes, various types of tunnel support.
3.	Foundation evaluation techniques. Influence of geological conditions on foundation and design of buildings and bridges, foundation improvement techniques. Mass movements with special emphasis on landslides and slope stability. Earthquakes and seismic zones of India.Case history of engineering projects and geological causes for mishaps and failures of engineering structures.
4.	Geological hazards: landslides, earthquakes, floods and volcanism; their effects, causes and preventive/remedial measures. Recent trends in geotechnical engineering. EIA of engineering projects; river valley projects; industrial sites and mining projects. Components of the geosphere and environment - lithosphere, biosphere, hydrosphere and atmosphere. Biogeochemical cycles – nitrogen cycle, carbon cycle and phosphorous cycle.

Books recommended:

Arms, K., 1990: *Environmental Science*. Saunders College Pub.
Bell, F. G., *Engineering Properties of Soils and Rocks.*
Bell, F. G., 1999: *Geological Hazards their assessment, Avoidance & Mitigation*. E&FN Spon London.
Bell, F. G., 1999: *Geological Hazards.* Routledge, London.
Bryant, E., 1985: *Natural Hazards.* Cambridge University Press.
Goodman, R. E., *Engineering Geology.*
Keller, E. A., 1978: *Environmental Geology.* Bell and Howell, USA.
Krynine, D. H. and Judd, W.R., 1998: *Principles of Engineering Geology*. CBS Pub.
Lanen, F., *Environmental Geology*.
Lawrence, L. *Environmental Geology*.
Lundgren, L, 1986, *Environmental Geology.* Prentice Hall.
Michael, A., *Basic of Environmental Science.*
Parasnis, D. S., 1975: *Principles of Applied Geophysics.* Chapman Hall.
Pipkin, B. W. & Trent, D. D., 1997: *Geology and the Environment*. West wardsworth.
Singh, A., *Modern Geo-Technical Engineering.*
Smith, K., 1992: *Environmental Hazards.* Rutledge, London.
Valdiya, K. S., 1987: *Environmental Geology -Indian Context.* Tata McGraw Hill.
Venkat, R. D., *Engineering Geology for Civil Engineers.*
Waltham, A. C., 1997: *Foundations of Engineering Geology*. Blackie Academic & Professional.
Subramaniam, V., 2001: Textbook in Environmental Science-Narosa International

PRACTICAL

GL-P7 Hydrogeology

Hydrogeology: Delineation of hydrological boundaries on water-table contour maps and estimation of permeability. Preparation of isohytal maps, Theissen's polygonal method. Analysis of aquifer performance test data Thiem's, Theis's and Jacob's method. Design of water well screen and gravel pack on the basis of mechanical analysis data of aquifer material. Analysis of hydrographs and estimation of infiltration capacity. Study of geophysical well logs. Estimation of TDS using resistivity and SP logs. Plotting of groundwater provinces of India.

GL-P8 Remote Sensing & GIS in Geology

Tutorial on different modules of image processing software; Import and export of satellite data; Different image and remote sensing data formats; Familiarization with the earth surface features on the images; Preparation of satellite data for analysis like rotate, reflect, subset, layer addition; Pre-processing of satellite data like image registration, geo-correction, filtering, image enhancements, math operations; Image ratios and other remote sensing and geological indices like SAVI; Lithologic, land use/land cover feature identification and

interpretation; Final processing (classification algorithms and statistical analysis).
Familiarization with GIS software systems; Data input; digitization, scanning; Data editing of spatial and non-spatial data, Use of attributes and other tabular data; Data query and analysis, Map making and production; Individual and group assignments.

GL-P9 Engineering and Environmental Geology

Engineering Geology: Study of maps and models of important engineering structures; dam sites and tunnels. Preparation of log chart for drill core logging. Preparation of 3-dimensional geological logs for tunnels, Slope stability analysis; EIA Case studies;

GL-S3 Seminar Presentation

Students have to give seminar presentation related to the theory papers.

FOURTH SEMESTER

THEORY

GL-T13 Elective paper

GL-T13 A Environmental Geology

Unit	Course content
1.	Environmental Geology: Introduction, Earth, man and environment – Basic environmental problems. Fundamental concepts of environmental geoscience. General relationship between landscape, climate and biomass. Geoscience factor in environmental planning. Earth processes; endogenic and exogenic
2.	Cenozoic climate extremes, their impact on evolution of life especially on human evolution. Health Geochemistry: essential and toxic elements & radon emission; impacts of aerosols including black carbon on environment.
3.	Impact assessment of degradation and contamination of surface water and groundwater quality due to industrialization and urbanization. Waterlogging problems due to the indiscrete construction of canals, reservoirs and dams. Soil profiles and soil quality degradation due to irrigation, use of fertilizers and pesticides.
4.	Seismic hazard assessment, seismic micro-zonation. Preparation of seismic hazard maps. Distribution, magnitude and intensity of earthquakes in Indian Himalayas. Tectonics and climate change. Disaster vulnerability assessment; earthquakes and floods.

GL-T13-B Geophysical Exploration

Unit	Course content
1.	Interrelationship between geology and geophysics - Role of geological and geophysical data in explaining geodynamical features ofthe earth.
2.	General and Exploration geophysics- Different types of geophysical methods; Gravity, magnetic, Electrical, Seismic- their principlesand applications. Concepts and Usage of corrections in geophysical data.
3.	Geophysical field operations.- Different types of surveys, grid and route surveys, profiling and sounding techniques, scales of survey,presentation of geophysical data.Application of Geophysical methods - Regional geophysics, oil and gas geophysics, ore geophysics, groundwater geophysics,engineering geophysics.
4.	Geophysical anomalies: Correction to measured quantities, geophysical, anomaly, regional and residual (local) anomalies, factorscontrolling anomaly, depth of exploration. Integrated geophysical methods - Ambiguities in geophysical interpretation, Planning and execution of geophysical surveys.

Books recommended:

Outlines of Geophysical Prospecting - A manual for geologists by RamachandraRao, M.B., Prasaranga, University of MysoreMysore 1975.
Exploration Geophysics - An Outline by Bhimasarikaram Y.L.S., Association of Exploration Geophysicists,

Osmania University,Hyderabad, 1990.
An introduction to Geophysical Prospecting by Oobrin, M.B. and Savit, C.H., McGraw Hill, New Delhi, 1988.
Applied Geophysics by Telford W.M. Geldart L.P., Sheriff, R.E. and Keys D.A. Oxford and IBH Publishing Co. Pvt., Ltd. New Delhi, 1976.

GL-T13-C Geotectonics & Himalayan Geology

Unit	Course content
1.	Geotectonics: Fundamental concept of geotectonics, its practical and theoretical importance. Organic and Epeirogenic Phases; Concept and theories of Isostasy; Origin and significance of Mid-Oceanic Ridges and Trenches; Island arcs and mountain chains, their global distribution and evolution. Concept of Sea floor spreading; Evidence of continental drift,
2.	Plate Tectonics: Concept of Plate Tectonics, Nature and types of Plate Margins, Geometry and Mechanism of Plate Motion. Tectonic and Economic significance of Plate Tectonics.Palaeomagnetism, Polar Wandering and reversal of earth's magnetic field. Geomagnetic time scale.Tectonics of Pre-cambrian Organic Belts of India.
3.	The Himalaya: Formation of Tethys, its paleogeography. Phases of upheaval of Himalaya. Geologic and Geographical subdivision, startigraphy, lithological units of Himalyas and their correlation. Petrologiocal study of various formations including sedimentation, igneous activity and metamorphic history of Himalaya. Mineral resources of Himalaya.
4.	Structure and Tectonics of Himalaya with reference to Kashmir and Ladakh Himalaya and its comparision with Alps. Controversial problems of Himalayan Geology-Age of unfossiliferous sedimentary and metamorphic rocks and traps. Age relationship of Himayan granites and Gnesses.

Books recommended:

Gass I.G. et al 1982: Understanding the Earth. Artemis Press (Pvt.) Ltd. U.K.
Windley B. 1973: The Evolving continents. John Wiley & Sons, New York.
Condie, Kent. C. 1982. Plate Tectonics and Crystal Evolution Pergamon Press Inc.
Gansser, A.Geology Of Himlayas,
Cox , Plate Tectonicsa and Geotectonic reversal,
Heim and Gansser, Central Himalaya,
Sinha, A.K., 1989. Geology of Higher Central Himalaya,
Sinha, A. K., Sassi, F. P. and Papinikolaou, D., 1997. Geodynamic domains in the Alpine- Himalayan Tethys,
Sinha, A.K., 1992. Himalayan Orogen and Global Tectonics.
Thakur, V. C., 1992. .Geology of Western Himalaya,
Sharma, K. K., 1991. Geology and Geodynamic evolution of the Himalayan Collission Zone.
Thakur, V. C. and Sharma, K. K., 1983. Geology of the Indus Suture Zone of Ladakh.

GL-T13-D Hydroinformatics

Unit	Course content
1.	Hydrological cycle and processes; Hydrological Processes: Precipitation, Evaporation, Transpiration, interception, Infiltration, Percolation and Groundwater recharge. Global water resources. Water resources in Kashmir Himalayas. Water resource assessment methods. Importance of hydrology to society w.r.t. Jammu and Kashmir state. Water Resources Planning and Management. Hydrometeorology. Biogeochemical cycling, Watershed management and conservation principles. Eco-hydrology, Land water interactions. Statistical analysis of hydro-meteorological data.
2.	Remote sensing for surface and ground water; Remote sensing techniques for water resources assessment: Interpretation of satellite data for water resources, impact of spatial resolution on water resources mapping, Monitoring the surface extent of water bodies. Surface water bodies mapping (visual interpretation and digital image processing for mapping irrigation tanks, ponds, reservoirs, lakes etc.). Role of remote sensing for quantifying the hydrological processes. Groundwater exploration using remote sensing and GIS. Geophysical investigations for Ground Water Hydrology.
3.	Geoinformatics for water resources; Watershed characterization and hydrological modelling. Concept of Runoff and overland flow, Factors affecting runoff processes. Watershed factors that affect runoff: size, topography, shape, orientation, aspect, geology, soil interflow and base flow. Geoinformatics for Watershed conservation and planning, DEM applications in water resources. Water quality and quantity modelling using remote sensing and GIS.

4.	Snow and Glacier studies using Geoinformatics: Snow and glacier resources of Kashmir. Climate change and glaciers. visible, infrared and microwave remote sensing for snow and glacier studies. Normalized Difference Snow Index (NDSI) and other ratio methods for snow/glacier mapping. Snow hydrology, snowmelt run-off modeling. Glacier inventory (areal extent, depth) Change detection studies of glaciers. Mass balance studies of glaciers. Traditional and remote sensing approaches for snow parameter retrieval (snow depth, snow water equivalence, snow density).

GL-T13-E Disaster, Risk and Hazard Management

Unit	Course content
1.	Principles of Disaster Management: Natural disasters, anthropogenic disasters hazards, risks and vulnerabilities. Assessment of disaster vulnerability of a location and vulnerable groups. Preparedness and mitigation measures for various disasters. Earthquake, floods, fire, landslides and other natural calamities. Information systems & decision making tools. Disaster management with respect to seismic, flood and other disaster prone areas of Jammu and Kashmir.
2.	Global scenarios of natural disasters: Climatic change and global sea rise, coastal erosion, environmental degradation (deforestation, changes in larger biomes, wetlands, lakes, etc), large dams and earthquake, road building and landslide, ports in cyclonic path, reclamation of land, urbanization and its intensity in eco-fragile area. Glacier related disasters.
3.	Remote sensing for disaster management: Satellite remote sensing for disaster management, real time disaster analysis and management, identification of flood prone areas using remote sensing and other ancillary data, post disaster analysis of inundated areas, area estimations, crop loss estimates etc. Forest fire identification and zonation using remote sensing data. Forest fire prevention strategies. Remote sensing based surveys for seismic zonation, identification of probable seismically active zones using geological studies.
4.	Geoinformatics for disaster assessment and management: Organizational structure for disaster management, disaster management schemes. Natural disasters and mitigation efforts, flood control, drought management, cyclones, avalanches, land use planning, operations management (OM). GPS for early warning system for earthquakes. Risk assessment and disaster response, Quantification techniques. Recent trends in disaster information provider laser scanning applications in disaster management, Statistical seismology, Quick reconstruction technologies.

GL-T13 F Mining Geology and Mineral Economics

Unit	Course content
1.	Mining Methods. Classification of mining methods. Planning, exploration and exploratory mining of surface and underground mineral deposits involving diamond drilling, shaft sinking, drifting, cross cutting, winzing, stoping, room and pillaring, top-slicing, sub-level caving and block caving.
2.	Cycles of surface and underground mining operations. Exploration for placer deposits. Types of drilling methods. Mining hazards: mine inundation, fire and rock burst. Mining and environmental concerns. Case studies of iron and coal mining in India.
3.	Principles of mineral exploration prospecting and exploration- conceptualization, methodology and stages; sampling, subsurface sampling including pitting, trenching and drilling, core and non-core drilling, planning of bore holes and location of bore holes on ground. Core- logging. geochemical exploration- nature of samples anomaly strength of anomaly and controlling factors, coefficient of aqueous migration.
4.	Mineral resources: definition, reserve calculations; Classification of mineral deposits. Economic Geology: Mineral Economics and its concept: National Mineral policy in relation to Strategic, critical and essential minerals. A detailed study of ore minerals related to the following minerals with special reference to their mineralogy, genesis, uses and distribution in India: Fe, Mn, Cr, Cu, Pb, Zn, Al.

GL-T13-G Climatology

Unit	Course content
1.	Atmospheric Layers and Thermal Variation: Nature, composition and layered structure of the atmosphere. Factors controlling insolation; heat budget of the atmosphere. Horizontal and vertical distribution of temperature; Inversion of temperature. Green house effect and importance of ozone layer.
2.	Atmospheric Layers and Wind Circulation: Global atmospheric pressure belts and their oscillation.

	General wind circulation.Jet stream and index cycle.Monsoon mechanism with reference to jet stream.General Circulation Models (GCM); Regional Climate Models; IPCCC climate Change scenarios. Climate Change Impact Studies; glaciers; water resources; food security; downscaling and upscaling of climate data;Paleo-climate inference from lake sediments, ice-core; paleosols.
3.	Precipitation and Air mass: Processes and forms of condensation. Mechanism and forms of precipitation- Ice Crystal theory, Collision-coalescence Theory.Airmass: typology, origin and characteristics. Warm and cold fronts; frontogenesis and frontolysis.
4.	Weather Disturbance and Climatic Classification: Tropical cyclone. Mid-latitude cyclone and anti-cyclone.Climatic classification after Koppen. Climatic Classification after Thornthwaite: 1931 and 1948.Hydrological cycle; Global climatic change and role and response of man in climatic changes, Applied climatology and Urban climate. Synoptic weather forecasting, prediction of weather elements such as rain, maximum and minimum temperature and fog; hazardous weather elements like thunderstorms, duststorms, tornadoes

GL-T14 Elective paper

GL-T14-A Rock Deformation and Structural Analysis

Unit	Course content
1.	Stress-strain relationship: Three-dimensional strain and stress analysis and its application in deformed rocks. Brittle failure and ductile deformation. Fluids in rocks and the importance of effective stresses, Temperature, time and scale effects on rock strength, Mechanism of deformation
2.	Experimental simulation of structures in laboratory: Experimental deformation of natural rocks. Significance of fractures, and brittle and ductile shear zones. Metamorphic foliation, their types and origin. Determination of fabrics in deformed rocks and interpretation. The relationship between cleavage and finite strain. The development of cleavage in a complex anisotropic material. Experimental and theoretical analyses of linear structure.
3.	Mechanism of deformation: Intracrystalline and intercrystalline slip; microstructures associated with them. Fold shape classifications and projection Techniques of fold orientations. Mechanism of single-layer and multi-layer folds and associated structures. Superposed folds. Buckling of anisotropic rocks, Theory of buckling and finite development of folds in mechanically anisotropic materials. Modeling of folds in anisotropic material using rocks and analogue, Relationship between various structures that develop in anisotropic material.
4.	Use of stereographic and equal-area projections for representing different types of fabrics. Processes of structural analysis on megascopic and macroscopic scales. Examples of structural analysis of area of multiple deformations.

Books recommended:

Davis, G.R.,1984: *Structural Geology of Rocks and Region.* John Wiley.
Ghosh. S. K., 1995: *Structural Geology Fundamentals of Modem Developments.* Pergamon Press.
Hobbs, B. E., Means, W. D. and Williams, P.F., 1976: *An Outline of Structural Geology.* John Wiley.
Lisle, R. J., 1988: *Geological Strain Analysis.* Pergamon.
Price, N. J. and Cosgrove, J. W., 1990: *Analysis of Geological Structure.* CambridgeUniv. Press.
Ramsay, J. G. and Huber, M. I., 1987: *Modem Structural Geology, Vol. 1&/1.* Academic Press.
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.

GL-T14-B Sedimentary Environment and Sedimentary Basins

Unit	Course content
1.	Kinds of sedimentary particles: Morphology of clastic, nonclastic and pyroclatic particles and their use in provenance studies. Study of labortary techniques in sedimentological studies.
2.	Processes of dolomitization and Phosphatization. Origin of various types of cements. Use of trace fossils, stramatolites, thrombolites and related structure in palaeo-environmental analysis. Methods of palaeocurrent determination and basin analysis.
3.	Tectonics and evolution of the sedimentary basins. Sedimentary cycles, rhythems and cyclothems. Analysis of sedimentary facies and preparation of facies maps; Study of lithofacies, biofacies, dynamics and primary structures associated with the following environments: desert, alluvial fans, river plains, glaciers, deltas, estuaries, clastic shorelines, clastic shelves, marine evaporite basins, carbonate

	platforms, deep sea and ocean bottom, deep sea trench and rise
4.	Sedimentation pattern and depositional environment of selected un-deformed and deformed sedimentary basins of Karewa, Indo-Gangetic and Shiwaliks.

Books recommended:

Bhattacharya, A. and Chakraborti, C., 2000: *Analysis of Sedimentary Successions.* Oxford
Blatt, H., Murray, G. V. and Middleton, R. C., 1980: *Origin of Sedimentary Rocks.* CBS, N. Delhi.
Davis, R. A. Jr., 1992: *Depositional Systems.* Prentice Hall.
Einsele, G., 1992: *Sedimentary Basins.* Springer Verlag.
Friedman, G. M. and Sander, J. E., 1978: *Principles of Sedimentology* John Wiley.
Miall, A. D., 2000*: Principles* of *sedimentary Basin Analysis.* Springer-Verlag.
Prothero,D. R.Schwab, F., 1996: *Sedimentary Geology*. Freeman.
Reading, J. G. 1996: *Sedimentary Environment and Facies.* Black well.
Reineck, H. E. & Singh, I. B., 1975: *Deposition Sedimentary Environment.* Springer-Verlag.
Tucker, M. 1988: *Techniques in Sedimentology*. Blackwell.

GL-T14-C Advanced Hydrogeology

Unit	Course content
1.	Hydrographic analysis: Annual, seasonal and storm hydrographs; Water balance studies; Hydrological equilibrium equations, determination of various components at watershed and basin scale, determination of recharge by stream hydrograph and base flow separation; Geological and structural controls of groundwater occurrence (give some case studies); Water level maps; groundwater-surface water interaction.
2.	Partial differential equations governing groundwater flow; Groundwater hydraulics:Groundwater system, groundwater flow equations, Darcy's law, steady and transient unidirectional and radial flow to a well in confined and unconfined conditions, estimation of aquifer parameters with the help of pumping tests.
3.	Groundwater modeling and management: Groundwater budgets, artificial recharge, conjunctive use of surface and groundwater, trends in water resources management; Mathematical modeling: concept, boundary conditions, analytical and numerical methods of solution, Finite element and finite difference models for steady state and transient flow, MODFLOW- introduction, Indian case studies.
4.	Groundwater chemistry: groundwater solution and its chemical constituents, Mineral dissolution, chemical reactions and chemical equilibrium, water-rock interactions, ion exchange; Environmental isotopes in hydrogeology: stable isotopes (oxygen and deuterium), radioisotopes (tritium and carbon-14), isotope fractionation, Global meteoric water line, regional/local meteoric water line, stable isotopes in precipitation- continental, seasonal and altitude effects.

Books recommended:

Chow, V. T., 1988: *Advances in Hydrosciences,* McGraw Hill.
Fetter, C. W., 1990: *Applied Hydrogeology,* Merill Publishing.
Freeze, R. A. & Cherry, J. A., 1979: *Ground Water*. Prentice Hall.
Karanth, K. R, 1987: *Groundwater Assessment-Development and Management.* Tata McGraw Hill.
Raghunath, N. M., 1982: *Ground Water.* Wiley Eastern.
Todd, D. K., 1980: *Ground water Hydrogeology.* John Wiley.
Walton, W. C., 1988: *Ground Water Resources Evaluation.* McGraw Hill.

GL-T14-D Advanced Remote Sensing & GIS

Unit	Course content
1.	Spaceborne remote sensing system and platforms: IRS, LANDSAT, SPOT, and IKONOS. Multi-spectral and hyper-spectral remote sensing, Geophysical Remote Sensing, Active Microwave remote sensing: SAR images, wavelength, penetration, polarization, topographic influences on SAR images, radar interferometry. Thermal remote sensing: Thermal infrared radiation properties, thermal radiation laws and thermal properties of the terrain.
2.	Multivariate image statistics, Optical remote sensing data filters, radar speckle/noise removal techniques, image data formats (BSQ, BIP and BIL), image ratios, Georeferencing and mosaicing of

	satellite data, data fusion techniques: integration of optical, radar and geospatial data. Knowledge based image classification, Post classification processing of data, classification accuracy estimation.
3.	Remote sensing application to geosciences: Complimentary use of remote sensing, GIS and field observations. Geological mapping (lithology, structural mapping of faults, folds and suture zones). Use of remote sensing data for snow and glacier mapping, change detection studies (deforestation), Remote sensing for crustal deformation, morphometric and hydrological analysis.
4.	Geospatial data representation techniques, database management systems, Surface mapping and interpolation methods, Digital Elevation Model (DEM) and its development from point, contour and stereo-image data, raster and vector data analysis, Applications of GIS for drainage analysis and active tectonics, use of GIS for flood risk assessment and landslide hazard zonation.

Books recommended:

Burrough, P. A., 2003: *Principles of Geographic Information* Systems. OxfordUniversity Press.
Campbell, J., 2002: *Introduction to Remote Sensing.* Guilford Press, New York.
Demers, M. N., 1999: *Fundamentals of Geographic Information Systems.* John Wiley.
Jensen, J. R., 2004: *Remote Sensing of the Environment.* Prentice Hall, New Jersey.
John, A., Richards, 1993: *Remote Sensing Digital Image Analysis.* Springer-Verlag.
John, R., Jensen, 2000: *Introductory Digital Image Processing, A Remote Sensing Perspective.*
Lillesand, T. M. and Kiefer, RW., 1987: *Remote Sensing in Geology.* John Wiley. Prentice Hall,
Lillesand, T. M. and Kiefer, RW, 2002: *Remote Sensing and Image Interpretation,* John Wiley.
Rees, W. G., 2001: *Physical Principles of Remote sensing.* CambridgeUniversity Press.
Sabbins, F. F., 1985: *Remote Sensing - Principles and Applications.* Freeman
Skidmore, A., 2002. *Environmental modeling with GIS and Remote Sensing.* Taylor& Francis, London.
Longley, D. A., Gordchild, M. F., Maguire, D. J. and Rhind, D. W., 2001: *Geographic Information Systems and Science*. John Wiley & Sons.

GL-T14-E Oceanography & Marine Geology

Unit	Course content
1.	Oceanography: An overview, Physiography of ocean floor - Bathymetric provinces. Ocean circulation: Horizontal circulation, vertical circulation. Circulation in different Oceans. Coastal erosion and Wave study. Changing levels of the Shoreline.
2.	Waves: Characteristics, Wind-generated waves, Tsunami, Internal waves. Tides: Characteristics and origin, Tidal currents, Tides as a source of power.
3.	Marine geomorphology: Introduction, modern deep-ocean mapping, charting and geodesy; Ocean morphology: Feature definitions. Ocean ridges, seamounts, guyots, fracture zones, continental shelf, continental slope and trenches,
4.	Marine sedimentation: Sediments in the sea, Shelf sedimentation, Deep-sea sedimentation Sedimentary features Canyons, sea channels, fans, abyssal plains. Distribution of marine microfossils, stratigraphy and geochronometry of deep-sea deposits. Mineral resources of the oceans, NeogenePaleo-oceanography.

Books recommended:

Kennett, J. P., 1982: *Marine Geology.* Prentice Hall.
Pinet, P. R., 1992: *Oceanography, An Introduction to the Planet Oceanus.* West Pub. Co.
Seibold, E. and Berger, W. H., 1982: *The Sea Floor.* Springer-Verlag.
Smoot, N. C., Choi, D. R & Bhat, M. I., 2002. *Marine Geomorphology*. XLIBRIS Corp.
Smoot, N. C., Choi, D. R. &Bhat, M. I., 2002. *Active Margin Geomorphology.* XLIBRIS Corporation
Thurman, H. B., 1978: *Introductory,Oceanography*. Charles, E. Merrill Pub. Co.

GL-T14-F Petroleum Exploration

Unit	Course content
1.	Identification and characterization of petroleum source rocks: Amount, type and maturation of organic matter. Oil and source rock correlation. Locating petroleum prospects based on principles of petroleum generation and migration (geological modeling). Quantitative evaluation of oil and gas prospects through geochemical modeling. Migration modeling. Inputs for the assessment of accumulation of petroleum
2.	Elements of geophysical methods of exploration: Magnetic, gravity and seismic methods.

	Interpretation of seismic data in basin modeling and preparation of subsurface geological maps. Application of remote sensing techniques in basin analysis.
3.	Petroleum provinces and petroliferous basin: Basin studies and basin analysis. Basin classification in plate tectonics. Fundamental types of petroliferous basin; relation between basin type and hydrocarbon richness. Factors favoring hydrocarbon abundance. Petroleum provinces of India and world Case studies of some giant oil fields
4.	Elements of well drilling: Cable-tool drilling, rotary drilling, various types of drilling units. Elements of logging. Electric, radio active and sonic logs. Nuclear magnetic resonance and dielectric logging Application of logs in petro-physical analysis and facies analysis

Books recommended:

Guillemot, J., 1986: Oil and Gas Exploration Techniques. Additions Technip.
Glennie, K. W., 1998: Petroleum Geology of the North Sea. Blackwell Science.
Holson, G. D. and Tiratsoo, E.N., 1985: *Introduction Petroleum Geology*. Gulf Pub. Houston,
Keller, S. E., 1994: *Mineral Resources, Economic and the Environment.* McMillan College Pub.
Levarson, 1985: *Geology of Petroleum.* CBS Pub.
Landon, R. C., 1996: Principles of Petroleum Development Geology. Printice Hall.
North, F. K., 1985: *Petroleum Geology.* Allen &Unwin
Salley, R. C., 1988. *Elements of Petroleum Geology.* Academic Press.
Tedesco, S. A., 1995: Surface Geochemistry in Petroleum Exploration. Chapman Hall.
Tissot, B. P. &Welte, D. H., 1984: *Petroleum Formation and Occurrence*, Springer Verlag.

GL-T14-G Glaciology

Unit	Course content
1.	Glaciers: Glacier Formation, glacier features and types. Movement of glaciers and transport by glaciers. Glacier and ice sheet reconstructions. Glacial deposits, Glacial and interglacial periods. Glacial Sedimentation and landforms of glacial deposition on land. Subglacial landforms formed by ice or sediment flow. Glacial sedimentation in water. Landforms of glacial deposition in water.
2.	Himalayan cryosphere; extent, status and behavior; Glacier surge phenomena, Last glacial maximum with special references to alpine glacial system; Glacier dynamics: ELA, AAR, velocity; Glaciers as fresh water reserves, contribution of glacier and snow to stram-flows. Instrumentation for glacier studies;
3.	Mass balance studies of glaciers; geological, photogrammetric, GPS/GPR mass balance. Use of remote sensing for snow and glacier studies; glacier geometry and dynamics, mass balance, remote sensing approaches for snow parameter retrieval (snow cover, snow depth, snow water equivalence, snow density). Snow depletion curves., Glacier Facies. ice sheets and fluctuations in sea levels.
4.	Snow and glacier resources of Kashmir. Climate change and glaciers. Snow hydrology, snowmelt run-off modeling. Black carbon deposition on glaciers and its impacts on melting, and other feedbacks. Impacts of changing Himalayan cryosphere on political stability in south Asia.

Books recommended:

Bennett, M. R. and Glasser, N. F., 2000. Glacial Geology Ice Sheets and Landforms. Wiley
Sharp, M., Richards, K. S. and Tranter M., 1998. Glacier Hyrology and Hydrochemistry. Wiley
Allan, T. D.: Satellite microwave remote sensing. Chichester, Ellis Hardwood
Benn D.I. and Evans J A D., 1997. Glaciers and Glaciation.Woody's Books USA
Hubbard, B. and Glasser N. F. 2005. Field Techniques in Glaciology and Glacial Geomorphology. Wiley

GL-D Project work

Project work to be assigned individual decided in consultation with concerned course teachers. Depending upon the requirements, the project work could be undertaken within or outside the Department.

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