002

UNIVERSITY OF DELHI

Syllabus for the

M. Sc.
IN
GEOLOGY

(Four Semester Course)

Department of Geology
Centre of Advanced **Studies**
University of Delhi
Delhi-110007

Revised syllabus applicable for the students seeking admission to the MSc. in Geology course in the Academic Year 2009-2010

Price Rs. 30.00

Syllabus for the
M.Sc. in Geology

Candidates who have passed the three year B.Sc. (Hons.) examination of the University of Delhi or any other equivalent examination of other universities with Geology as one of the major subjects will be considered eligible for admission to the Four Semester M.Sc. Course in Geology.

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 and internal assessment including practical as per the marks given against each course. The M.Sc. Geology will consist of (a) Core Courses (b) Elective Courses and (c) Interdisciplinary courses from other departments.

(a) The Core courses will be compulsory for all the students admitted to M.Sc. Geology. There will be fourteen core courses and four practicals covering major branches of Geology and two sessions of two to three weeks of Geological Field training and Viva-voce examination. Each Core Course shall be of 100 marks (70 Theory plus 30 internal assessment). Internal assessment will be done on the basis of Seminar / Class *Test*/Assignments. The attendance 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. The field training and Viva-Voce examination will be conducted by at least two internal examiners during first and third semesters. For the Geological Field Training, 35 marks shall be assigned to evaluation of the report and field work while 15 marks shall be assigned to Viva-voce examination. The semester breaks can also be utilized for the geological field training.

(b) The Elective Courses shall be consisting of one Elective Paper and Project Oriented Dissertation in a specialized field of Geology. The area of Dissertation shall be assigned to the students in the beginning of 3rd Semester based on the overall merit of the students during previous two Semesters and expertise available in the Department. The students will be required to submit the Project Oriented Dissertation by the end of fourth Semester followed by an open seminar before the faculty members and the board of examiners for the purpose of evaluation. The marks for the Viva- Voce will be given by the Board of examiners appointed by the Head of the Department each year. The board of examiners will include the supervisor of the Dissertation besides two other members from the department. During the course of completion of the Dissertation work the students will be required to complete various assignments given to them by their respective supervisors for the purpose of their evaluation. The Dissertation shall be of200 marks out of which 150 marks will be based on evaluation of the Dissertation Work (Thesis) and 50 for the Seminar presentation followed. by Viva-Voce examination.
The Dissertation thesis will be evaluated by the respective Supervisors only.

(c) All courses will include 4 Theory periods, and will be equivalent to 4 credits.

(d) 'Practicals' in each semester will include practical exercises related to all theory papers in the same semester (excluding the interdisciplinary course). This will be of 100 marks and will be equivalent to 4 credits.

(e) The field training in Semester I & III will be equivalent to 2 credit points. Dissertation work will be equivalent to 8 credit points.

(f) All the students will have to take two courses of interdisciplinary nature from other departments, one each during 2nd and 4th Semester. These courses should be equivalent to at least 4 credit points.

(g) The students from other departments can select interdisciplinary courses from Geology syllabus. the following courses will be open for students from other departments –

GLG 101 Earth Surface Processes (4 credits)

GLG 204 Hydrogeology (4 credits)

GLG 401 Remote Sensing and GIS (4 credits).

GLG 404 (i) Paleoceanography and Paleoclimatology (4 credits)

GLG 404 (v) Applied Hydrogeology (4 credits)

GLG 404 (vii) Environmental Geology (4 credits)

GLG 404 (ix) Natural Hazards and Disaster Management (4 credits)

Summary of Course Structure
(M.Sc. in Geology)

Number of Papers	:	**15 (14 Compulsory + 4 Practicals + 01 Elective + 02 interdisciplinary)**
Field-work	:	**02 (Two to three weeks at the end of lst and 3rd Semester)**
Summer Training	:	**01 (Minimum 04 weeks, during summer break between 2nd and 3rd Semester)**
Project Oriented Dissertation	:	**4thSemester**
Total Marks	:	**2400**
Total Credits	:	**96**

Time-schedule of Four Semester M. Se. Geology Course:

1st Semester
Paper 101-104+Field-work (105)

Teaching
16thJuly to.31st October

Field Work
1st November to 21st November

Examination
8th December – 21st December

3rd Semester
Paper 30 l-304+Field-work (305)

Teaching
16thJuly to 31st October

Field Work
1st November to 21st November

Examination
8th December – 21st December

Summer Training
In the Summer Break Between 2nd and 3rd Semester

2nd Semester
Paper 201-205

Teaching
8th January to 7th April

Examination
21st to 30th April

4th Semester
Paper 14 (401), 15 (Elective, 402) and Dissertation (403)

Teaching
8th January to 7th April

Examination + Dissertation
21SIApril to 30thApril

Semester 1:

COURSE NO.	COURSE	Scheme of Examinations	Examination Internal Assessment
GLG 101 *	Earth Surface Processes (4 credits)*	70	30
GLG 102	Structural Geology and Tectonics (4 credits)	70	30
GLG 103	Igneous Petrology (4 credits)	70	30
GLG 104	Sedimentary Geology (4 credits)	70	30
GLG 105	Field Work consisting of Geological Mapping and Structural Analysis (2 credits)	15 (viva-voce)	35 (field work +report)
GLG 106	Practicals (4 credits)	80	20
Total	**Credits - 22**		**Marks - 550**

Semester 2:

COURSE NO.	COURSE	Scheme of Examinations	Examination Internal Assessment
GLG 201	Metamorphic Petrology (4 credits)	70	30
GLG 202	Stratigraphy (4 credits)	70	30
GLG 203	Micropaleontology and Oceanography (4 credits)	70	30
GLG 204*	Hydrogeology (4 credits)*	70	30
GLG 205	Interdisciplinary course from other department (4 credits)	70	30
GLG 206	Practicals (4 credits)	80	20
Total	**Credits - 24**		**Marks - 600**

Semester 3:

COURSE NO.	COURSE	Scheme of Examinations	Examination Internal Assessment
GLG 301	Ore Geology and Mineral Economics (4 credits)	70	30
GLG 302	Oil and Coal Geology (4 credits)	70	30
GLG 303	Geo-Exploration (4 credits)	70	30
GLG 304	Engineering Geology (4 credits)	70	30
GLG 305	Practicals (4 credits)	80	20
GLG 306	Geological Field Training (2 credits)	15 (viva-voce)	35 (field work +report)
Total	**Credits - 22**		**Marks - 550**

Semester 4:

COURSE NO.	COURSE	Scheme of Examinations	Examination Internal Assessment
GLG 401*	Remote Sensing and GIS (4 credits)*	70	30
GLG 402	Geophysics (4 credits)	70	30
GLG 403	Interdisciplinary course from other department (4 credits)	70	30
GLG 404	Elective Courses (4 credits) (i)* Paleoceanography and Paleoclimatology* (ii) Geochemistry and Isotope Geology (iii) Advanced Mineralogy (iv) Earthquake Geology and Seismotectonics (v)* Applied Hydrogeology* (vi) Active Tectonics and Geomorphology (vii)* Environmental Geology* (viii) Sedimentary Environments (ix)* Natural Hazards and Disaster Management* (x) Rock Mechanics and Rock Engineering	70	30

GLG 405	Practicals (4 credits)	80	20
GLG 406	Dissertation (8 credits)	150(Thesis)	50(Seminar+ Viva)
Total	**Credits - 28**	**Marks - 700**	

Interdisciplinary courses open for students from other departments

Scheme of Examinations

- English shall be the medium of instruction and examination.
- Examinatioins shall be conducted at the end of each semester as per the Academic Calendar notified by the University of Delhi.
- 'Practical' in each Semester will include practical exercises related to all Theory papers in the same semester (excluding the interdisciplinary course.
- Each course will carry 100 marks and will have two components:

Theory Papers

(i)	**Internal Assessment (Attendance/Seminar/quiz/test etc..)**	**30 marks**
(ii)	**End-Semester Examination**	**70 marks**

Practicals

(iii)	**Internal Assessment (Attendance/ Lab Records)**	**20 marks**
(iv)	**End-Semester Examination**	**80 marks**
	i. Examination	60 marks
	Viva-voce	20 marks

Core Courses

1st Semester

GLG-101- Earth Surface Processes

Theory:

- Introduction to earth surface processes and historical development in concepts, terrestrial relief, scales in geomorphology, energy flow and relative energy of surface processes.
- Weathering and formation of soils, karst and speleology.
- Slope and catchment erosion processes, a).fluvial, b) eolian, c) glacial, d) periglacial and e) coastal processes and resultant landfonns, Water and sediment flux in river systems.
- Morphometric analysis of drainage basin and geomorphology-hydrology relationship.
- Rates and changes in surface processes; Techniques for process measurement.
- Sediment budgeting, rock magnetism.
- Isotope geochemical tracers, cosmogenic nuclides, OSL & C-14 dating.
- Controlling factors (tectonics, climate, sea level changes and anthropogenic) and surface processes.
- Climate change and geomorphic response of fluvial systems of arid and humid regions; Geomorphic response to tectonics, sea level/base level change.
- Anthropogenic affects, Introduction to Anthropocene.
- Geomorphic concepts in cause-effect relationship.
- Spatial & temporal scales, geomorphic system.
- Connectivity, buffering, magnitude-frequency concept, timelag, sensitivity, equilibrium, threshold.
- Non-linearity & complexities.
- Megageomorphology and process interrelationship.
- Surface processes and natural razards.
- Applied aspects of geomorphology.
- Introduction to planetary geomorphology.

Practical:

- Mapping of different landforms and interpretation of surface processes
- Exercises on hill slope development, fluvial channel, sediment erosion and transport, sediment budgeting, aggradation and degradation events, drainage basin, drainage morphometry
- Basic exercises on computation of rate for different surface processes.

Suggested books:

1. Alien, P.A., 1997. *Earth Surface Processes,* Blackwell publishing.

2. Bloom, A.L., 1998. *Geomorphology: A Systematic Analysis of Late Cenozoic Landforms,* Pearson Education.

3. Bridge, J.S. and Demicco, R. V., 2008. *Earth Surface Processes, Landforms and Sediment Deposits,* Cambridge University Press.

4. Easterbrook, D.J., 1992. *Surface-Processes and Landforms,* MacMillan Publ.

5. Kale, V.S. and Gupta, A., 2001. *Introduction to Geomorphology,* Orient Longman Ltd.

6. Leeder, M. and Perez-Arlucea, M., 2005. Physical processes in earth and environmental sciences, Blackwell Publishing. -

7. Summerfield, M.A., 1991. *Global Geomorphology,* Prentice Hall.

8. Wilcock, P.R., Iverson, R.M. (2003) *Prediction in geomorphology,* AGU Publication.

GLG-102 Structural Geology and Tectonics

Theory:
Introduction to rock mechanics:

- Concept of Stress and Strain.
- 2-D stress and strain analysis.
- Strain ellipses: *types* and their geological significance.
- Mohr diagrams and their use; concept of stress-strain compatibility.
- Behaviour of rocks under stress.
- Elastic, plastic, viscous and visco-elastic responses and their geological significance.
- Concept of continuous and discontinuous media.
- Deformation mechanism at grain scale.
- Dislocation and diffusion creep.
- Strain hardening and softening mechanisms.
- Lattice preferred orientation
- Superplasticity.
- Mechanics of rock fracturing.
- Fracture nitiation and propagation.
- Coulomb's criterion and Griffith's theory.
- Crack inkage and their importa.ice.

Folds:

- Mechanical aspects of folding.
- Buckling, bending, flexural slip and flow folding, ptygmatic folds etc.
- Fold interference and superposed folds.
- Strain distribution n a folded layer and its significance.
- Evolution of axial planar and transacted cleavages with folds; Lineations.

Faults:

- Mechanics of faulting.
- Anderson's theory and its limitations.
- Complex geometry normal, strike slip and thrust faults with natural examples.
- Concept of fault tone weakening, fault reactivation and its significance.
- Palaeostress analysis using fault-slip data.
- Geometric analyses of joints - mesofracture analyses and fractography.
- Shear zones: geometry and kinematics; their significance in continental crustal evolution.
- Mylonites, Pseudotachylytes.

Crustal deformation:

- Brittle-plastic transition and seismic behaviour of the upper crust.
- Plate convergence and continental deformation.
- Transpressional and transtensional tectonics.
- Indian and overseas examples.

Global Tectonics:

- Concept of suubduction and orogeny
- Major global orogenic events in the geological past and their correlation with Indian examples.
- Himalayan Geology.

Practical:

• Practical strain measurement techniques (R_f–φ method, Fry method etc.)

• Balanced cross-sectional techniques

• Stereographic analysis of structural data (connected with M.Sc. fieldwork) - also should introduce some softwares at this stage.

• Analysis and interpretation of geological maps

• Stereographic techniques: Significance of contour diagrams: orientation analyses of foliation and lineation data for regional structural geometry. Analysis of petrofabric data (including concept of symmetry)

Suggested Books:

1. Bayly, B., 1992. *Mechanics in Structural Geology,* Springer.
2. Davis, GH. and Reynolds, S.J., 1996. *Structural Geology of rocks and regions,* John Wiley. and Sons. . .
3. Ghosh, S.K., 1993. *Structural Geology: Fundamentals, and modern developments,* Pergamon Press.
4. Leyson, P:R. and Lisle, R.J., 1996. *Stereographic projection techniques in structural geology,* Cambridge University Press.
5. Passhier, C. and Trouw, RAJ, 2005. *Microtectonics.* Springer, Berlin.
6. Pollard, D.D. and Fletcher, R.C., 2005. *Fundamentals of structural geology,* Cambridge University Press.
7. Ramsay, J.G and Huber, M.I., 1983. *Techniques of Modern Structural Geology: Vol.*I & 11. Academic Press
8. Ramsay, J. G, 1967. *Folding and Fracturing of Rocks,* McGraw-Hill Book Company, New York .
9. Rowland, S.M., Duebendorier, E. and Schiefelbein, I.M., 2007. *Structural analysis and synthesis: a laboratory course in structural geology,* Balckwell Pub.
10. Suppe, J., *The Principles of Structural Geology,* Prentice-Hall, Inc., New Jersey, 1985.
11. Twiss,R.J. and Moores, E.M., 2007. *Structural Geology.* Freeman.
12. Van der Pluijm, B.A. and Marshak, S., 2004. *Earth structure: an introduction to structural geology and tectonics,* W.W. Norton & Company Ltd.

GLG-103- Igneous Petrology

Theory:

- Earth as a heat engine.
- Melting and crystallization.
- Magma and magmatic processes.
- Forms and types of igneous bodies.
- Extrusive bodies- Flood basalts.
- Volcanoes and types of volcanoes Pyroclastic deposits.
- Forms and structures of lntrusive bodies: concept of concordant and discordant intrusion.
- Forms and structures of hypabasal rocks.
- Well studied Indian examples for the above rocks.
- Genetic aspects of structures and textures of igneous rocks.
- Classification of igneous rocks- concept of mode and norm.
- Phase rule and concept of phase diagrams and their application.
- General principles of the rmodynamics.
- Mineralogical and chemical description and significance of important igneous rocks of continental and oceanic association.
- Relationship of magma types and tectonic settings.
- Introduction to geochemistry.
- Isotope geology and its application in igneous petrology.
- Mobility of elements during post crystallization processes.
- Trace element partitioning, factors governing values of partition coefficient.
- Application of trace elements in petrogenesis and source characterization.

Practical:

• Study of hand specimen of various igneous rocks.
• Microscopic study of mineralogical and textural characteristics of igneous rocks.
• Calculations of Norms, normalized plots of trace elements and rare earth elements and their interpretations.
• Introduction to various analytical techniques.

Suggested Books:

1. Best, M.G, 2002. *Igneous Petrology,* 2nd Edition, Blackwell Publishers
2. Bose, M.K., 1997. *Igneous Petrology,* World Press, Kolkata.
3. Cox, K.G, Bell, J.D. and Pankhurst, R.J., 1993. *The Interpretation of Igneous Rocks.* Champman & Hall, London.
4. Hall, A., 1997. *Igneous Petrology,* Longman.
5. LeMaitre, R.W., 2002. *Igneous Rocks. A Classification and Glossary of Terms,* Cambridge University Press.
6. McBirney, 1994. *Igneous Petrology,* CBS Publishers, Delhi.
7. Phillpotts, A.R., 1994. *Principles of Igneous and Metamorphic Petrology,* Prentice Hall of India.
8. Philpotts, A.R., *Petrography of Igneous and metamorphic rocks under the microscope,* Prentice Hall.

9. Vernon;: R. H., 2004. *A Practical Guide to Rock Microstructure,* Cambridge University Press.
10. Winter, J.D., 200 l. *AnTntroduction to Igneous and Metamorphic Petrology,* Prentice Hall.
11. Yardley, B.W., 1989. *An Introduction to Metamorphic Petrology,* Longman.

GLG-I04- Sedimentary Geology

Theory:

Sedimentary Processes and Products:

- Introduction to basic concepts.
- Developments in sedimentology.
- Description and classification of sedimentary rocks.
- Sedimentary environments and facies.
- Earth's sedimentary shell.
- Weathering and sedimentary flux: Physical and chemical weathering.
- Submarine weathering.
- Soils and paleosols.
- Fluid flow, sediment transport and sedimentary structures.
- Types of fluids, Laminar vs. turbulent flow, Reynolds number, Froude Number, Boundary layer effect.
- Particle entrainment, transport and deposition, sediment gravity flows.
- Concept of flow regimes and bedforms.

Siliciclastic sediments and environments:

- Sedimentary texture: Grain size scale, particle size distribution.
- Statistical treatment of particle size data, particle shape and fabric.
- Sedimentary structures: Primary and secondary sedimentary structures.
- Paleocurrent analysis.
- Siliciclastic rocks: Conglomerates, sandstones, mudrocks (texture, composition, classification and origin and occurrence).
- Diagenetic processes and histories, terrestrial, coastal and marine sedimentary environments.
- Lithification anddiagenesis of siliciclastic rocks

Non-siliciclastic rocks and environments:

- Carbonate rocks, controls of carbonate deposition.
- Components and classificationof limestone, dolomite and dolomitisatiion.
- Carbonate sedimentary environments.
- Chert and siliceous sediments, phosphorites.
- Carbonaceous sediments.
- Iron rich sediments and evaporates.
- Lithification and diagenesis of carbonate rocks, chert and siliceous sediments.

Paleoenvironment analysis:

- Application of radioactive and stable isotopes in reconstruction of paleoenvironments

Basin Analysis:

- Sedimentary basins and their classification.
- Basin analysis (maps, cross sections, petrofacies, geological history, applications)

Tectonics and Sedimentation:

- Sedimentation in orogenic belts and cratons.
- Plate tectonics and sedimentation (sedimentation-divergent margins, convergent margins, transform margins).
- Secular changes in sedimentary record '

Practical:
• Exercises on sedimentary structures and their paleoenvironmental significance
• Particle size distribution and statistical treatment
• Heavy mineral analysis and provenance, paleocurrent analysis.
• Exercises based on vertical sedimentary sequences of different terrestrial, coastal and marine environments, petrography of clastic and non-clastic rocks.

Suggested Books:

1. Allen, P.A., 1997. *Earth Surface Processes,* Blackwell publishing.
2. Collinson, J.D. and Thompson, D.B., 1988. *Sedimentary Structures,* Unwin-Hyman, London.
3. Hsu, K.J., 2004. *Physics of Sedimentology,* Springer Verlag, Berlin.
4. Leeder, M.R., 1982. *Sedimentology: Process and Product.* George Alien &Unwin, London, 344p.
5. Lindholm, R.C., 1987. *A Practical Approach to Sedimentology,* Allcn ane Unwin, London.
6. Pettijohn, F.J., 1975. *Sedimentary Rocks,* Harper and Row Publ. New Delhi.
7. Prothoreo and Schwab, 2004. *Sedimentary Geology,* Freernam and <. ,,New York, 557p
8. Miall, A.D., 1999. *Principles of Sedimentary Basin Analysis 3rd Fd* Springer Verlag, New York.
9. Nichols, G., 1999. *Sedimentology and Stratigraphy,* Blackwell publishing.
10. Sam Boggs, 1995. *Principles of Sedimentology and Stratigraphy,* Print ice Hall, New Jersey.
11. Tucker, M.E., 2006. *Sedimentary Petrology.* Blackwell Publishing.

2nd Semester

GLG-201- Metamorphic Petrology

Theory:

- Closed and Open Systems.
- Nature of Metamorphic Reactions.
- Isograds and Reaction Isograds.
- Schrienemakers Rule and Construction of Petrogenetic Grids.
- Application of mineral chemistry and isotope geology in metamorphic petrology.
- Quantitative Geothermobarometry.
- P-T evolution paths of metamorphic rocks.
- Overview of different types of metamorphism.
- Concept and Classification of Metamorphic Facies and Facies Series.
- Textures and structures in relation to deformation and metamorphism in regional terrains.
- Dynamic metamorphism Processes and kinetics of thrust and fault rocks.
- Metamorphism of pelites, mafic, ultramafic and calcareous rocks.
- Hi PIT ratio metamorphism, Metasomatism.
- Metamorphic Differentiation.
- Anatexis and Origin of Migmatites in the light of experimental studies.
- Exhumation and Uplift rates.
- Erosion.
- Geodynamics and the Geomorphology of Metamorphic Terrains
- Geochronology/Dating methods (Fission-Track) and isotope studies in metamorphism.
- Diffusion and Kinetics of metamorphic reactions.

Practical:
• Identification of Minerals, reactants and products in Hand specimensand thin sections
• Metapelites, Metabasic and calcareous rocks
• Deciphering deformational and metamorphic history in thin sections
• Hands on Analytical Techniques SEM-EPMA, XRF, XRD etc.
• Mineral analyses and projections (Practical/homework)
• Mineral Analyses and the AFM Projection
• Mineral Formula calculation: step-by-step instructions for the recalculation of a mineral analysis from weight percent into cations per formula unit, using computer programmes e.g. formula.xls
• P-T calculations from EPMA data - Computer programs

Suggested Books:

1. Bard 1986. *Microtextures of Igneous and Metamorphic Rocks.* Reidel, Dordrecht.
2. Best, M.G., 2003. *Igneous and Metamorphic Petrology,* Blackwell Science.
3. Bucher, K. and Frey, M., 1994. *Petrogenesis of Metamorphic Rocks,* Springer Verlag.
4. Fry, N., 1985. *Field Description of Metamorphic Rocks,* New York, Geological Society of London Handbook Series.
5. Mason R., 1990. *Petrology of Metamorphic Rocks,* Springer, London.
6. Miyashiro, A., 1994. *Metamorphic Petrology,* Oxford University Press.
7. Shelley 1993. *Igneous and Metamorphic Rocks Under the Microscope.* Chapman and Hall.
8. Vernon, R. H., 2004. *A Practical Guide to Rock Microstructure,* Cambridge University Press.
9. Winter, 1.D., 2001. *An Introduction to Igneous and MetamorphicPetrology,* Prentice Hall.
10. Yardley, B.W.D., 1989. *An Introduction to Metamorphic Petrology,* Longman Earth Science Series.
11. Yardley et al., 1990. *Atlas of Metamorphic Rocks and their Textures.*Longmans.

GLG-202- Stratigraphy

Theory:

General principles

- International Strati graphic Code- development of a standardized stratigraphic nomenclature. Concepts of Stratotypes, Global Stratotype Section and Point (GSSP).
- Principles of stratigraphy.
- Facies Concept in Stratigraphy: Walther's Law of Facies. Concepts of Sequence stratigraphy.
- Application of Sequence stratigraphy in hydrocarbon exploration.
- Basic concepts of magneto-, seismicand chemo- stratigraphy.
- Methods of measurements of Geological time.
- Recent advances in refinement of Geological time Scale.
- Stratigraphic Correlation.
- Paleogeographic reconstructions and its application in oil exploration.

Precambrian stratigraphy

- Precambrian and its subdivisions.
- Plate tectonics during Precambrian.
- Precambrian / Cambrian boundary with special reference to India.
- Sequence of major Precambrian events in terms of rock record in Indian Stratigraphy.
- Precambrian biota and their application in stratigraphy.
- Potential Precambrian petroliferous basins of India and their brief stratigraphic framework.

Phanerozoic Stratigraphy

- Major plate movements during Phanerozoic.
- Subdivisions of Phanerozoic up to Stage level.
- Stratigraphic framework of Marine Paleozoic rocks of Himalaya.
- Stratigraphic framework of and Mesozoic rocks of Himalaya with special reference to Kashmir and Spiti.
- Marine Mesozoic Rocks of Peninsular India and their correlation with those of Himalaya.
- Depositional history and economic potential of Gondwana Supergroup.
- Straigraphic framework of marine Cenozoic rocks of India with special emphasis on Petroliferous horizons.
- Stratigraphy of Siwalik Supergroup and correlation with its marine equivalents.
- Recognizing criteria for major stratigraphic boundaries of Phanerozoic and their GSSPs.
- PermianlTriassic boundary.
- Cretaceous / Tertiary boundary in Indian sections. Continental Quaternary deposits and their significance

Practicals:

- Exercises on stratigraphic/lithostratigraphic classification
- Exercises on biostratigraphic subdivisions based on range charts of'taxa.
- Exercises on Strati graphic correlation
- Exercises on Sequence stratigraphyinterpretations.
- Study and understanding of plate movements through important periods during Phanerozoic Eon.
- Study and understanding of Evolution of surface ocean circulation during Phanerozoic.

Suggested Books:

1. Doyle, P. and Bennett, M.R., 1996. *Unlocking the Stratigraphic Record,*John Willey.
2. Dunbar, C.O. and Rodgers, J., 1957. *Principles of Stratigraphy.* JohnWiley & Sons.
3. Krishnan, M.S., 1982. *Geology of India and Burma,* C.B.S.Publishers, Delhi
4. Naqvi, S.M. 2005. *Geology and Evolution of the Indian Plate: FromHadean to Holocene-4 Ga to* 4 *Ka.* Capital Pub., New Delhi.
5. Naqvi, S.M. and Rogers, J.J.W., 1987. *Precambrian Geology of India.*Oxford University Press.
6. Pascoe, E.H., 1968. *A Manual of the Geology of India* & *Burma* (Vols.I*N),* Govt. of India Press, Delhi.
7. Pomerol, C., 1982. *The Cenozoic Era? Tertiary and Quaternary.* EIIis Harwood Ltd., Halsted Press.
8. Schoch," R.M., 1989. *Stratigraphy: Principles and Methods,* Van Nostrand Reinhold, New York.

GLG-203 Micropaleontology and Oceanography

Theory:

Oceanography

- (Physical Oceanography)History of development of Marine Geology and Oceanography.
- Components of thermohaline circulation and its role in controlling world's climate.
- Concept of mixed layer, thermocline and pycnocline, Coriolis Force and Ekman Spiral, Upwelling.
- El Nino-Southern Oscillation.
- Global warming and the role of oceans.
- The great oceanic conveyor belt and its role in global climate change.

Chemical Oceanography:

- General introduction to chemical oceanography. Properties of water and seawater.
- Techniques for measurement of various properties Major ions of seawater.
- Origin and implications of Oxygen Minimum Zone and denitrification.
- Carbon dioxide and carbonate cycle.
- Calcite and Aragonite Compensation depth and its significance.
- Chemical Equilibrium. Mass balance, redence time, chemical inflow from the rivers.
- Ocean's biological productivity, proxies to measure paleoproductivities of the oceans.

Geological Oceanography:

- Ocean floor morphology
- Deep-sea sediments in time and space as related to tectonic models and their relation to oceanic processes
- Deep Sea hiatuses and their causes.
- Tsunamis.
- Paleoceanographic changes in relation to earth system history including impact of the oceans on climate change.
- Marine Stratigraphy, correlation and chronology.
- Evolution of Oceans in the Cenozoic.
- Ocean Gateways of the Cenozoic and their role in controlling global climates.
- Sea level changes during Quaternary with special reference to India.
- Marine pollution emphasizing geochemical aspects of the sources, transport, and fate of pollutants in the coastal marine environment.
- Exclusive economic zone, law of the sea, mineral resources of the sea

Micropaleontology

- Definition and scope of Micro pale ontology.
- Relationship of Micro paleontology with Ocean Science.
- Surface and Subsurface sampling methods including deep sea drilling (ODP, DSDP, IODP).
- Sampling Modern Ocean Biogenic Flux including Joint Global Ocean Flux Studies (JGOFS).
- Sample processing techniques.
- Equipments for micropaleontological studies.
- Study of following groups of microfossils with reference to their outline of morphology, modern biogeography, application in paleoceanographic and paleoclimatic reconstruction and oceanic biostratigraphy with special reference to India.
- Calcareous microfossils including Foraminifera.
- Calcareous nannofossils. Ostracoda, pteropods, calpionellids and calcareous algae.
- Siliceous microfossils including Radiolaria, Diatoms, Silicoflagellates.
- Phosphatic microfossils including Conodonts. Organic Walled Microfossils including Acritarchs and Dianoflagellates.

- Pollens and Spores.
- Applications of stable isotopic and elemental composition of various microfossils in paleoclimatic/paleoceanographic reconstruction.
- Organo-geochernical proxies for paleoclimatic / paleoceanographic studies.
- Application of Micro pale ontology in Hydrocarbon Exploration.

Practical:

• Techniques of separation of microfossils from matrix
• Types of microfossils: Calcareous, Siliceous, Phosphatic and organicwalled microfossils
• Study of important planktic foraminifera useful in surface water paleoceanography and biostratigraphy
• Study of larger benthic foraminifera useful in Indian stratigraphy with special reference to Cenozoic petroliferous basins of India.
• Study of modern surface water mass assemblages of planktic foraminifera from Indian, Atlantic and Pacific Ocean
• Depth biotopes and estimation of paleodepth of the ocean using benthic foraminiferal assemblages
• Identification ofbenthic foraminifera characteristic of various deep sea environment
• Identification of planktic foraminifera characteristic of Warm Mixed Layer, Thermocline and deep surface waters of the modern oceans
• Identification of modern and ancient surface water mass with the help of plank tic foraminifera

Suggested Books:

1. Bignot, G, 1985. *Elements of micropalaeontology; Microfossils, their geological and palaeobiological applications,* Graham & Trotman, London, United Kingdom.
2. Braiser, M.D., 1980. *Microfossils,* Geogrge Alien and Unwin Publisher.
3. Fischer, G and Wefer, G, 1999. *Use of Proxies in Paleoceanography: Examples from the South Atlantic,* Springer,
4. Gross, M.G, 1977. *Oceanography: A view of the Earth,* Prentice Hall.
5. Haq and Boersma, 1978. *Introduction to Marine Micropaleontology,* Elsevier.
6. Hasllett, S.K., 2002. *Quaternary Environmental Micropalaeontology,* Oxford University Press, New York.
7. Jones, R.W., 1996. *Micropaleontology in Petroleum exploration,* Clarendon Press Oxford.
8. Kennett and Srinivasan, 1983. *Neogene Planktonic Foraminifera: A phylogenetic Atlas,* Hutchinson Ross, USA.
9. Sinha, D.K., 2007. *Micropaleontology: Application in Stratigraphy and Paleoceanography,* Alpha Science International, Oxford & Narosa Publishing House Pvt. Ltd. Delhi.
10. Tolmazin, D., 1985. *Elements of Dynamic Oceanography,* AlIen and Unwin.

GLG-204- Hydrogeology

Theory:

- Origin of water: meteoric, juvenile, magmatic and sea waters.
- Hydrologic cycle:clouds, type of clouds.
- Precipitation, measurement of precipitation, rainfall-runoff analysis.
- Stream discharge parameters and its measurement, infiltration and evapotranspiration. Hydrographs; Stage-discharge relationship and rating curves.
- Flood frequency Analysis, flood routing.
- Surface water and groundwater interaction.
- Subsurface movement and vertical distribution of groundwater.
- Springs.
- Classification of aquifers. Flow nets.
- Concepts of drainage basin and groundwater basin.
- Hydrological properties of rocks - specific yield, specific retention, porosity, hydraulic conductivity, transmissivity, storage coefficient.
- Water table fluctuations - causative factors, concept of barometric and tidal efficiencies.
- Water table contour maps. Classification of rocks with respect to their water bearing characteristics.
- Hydrostratigraphic units.
- Groundwater provinces of India.
- Hydrogeology of arid zones of India.

Well hydraulics and well design

- Theory of groundwater flow, Darcy's Law and its applications.
- Types of wells, drilling methods, construction, design, development and maintenance of wells, specific capacity and its determination.
- Unconfmed, confined, steady, unsteady and radial flow conditions.
- Pumping tests - methods, data analysis and interpretation for hydrogeologic boundaries.
- Evaluation of aquifer parameters using Thiem, Theis, Jacob and Walton methods.
- Groundwater modelling -numerical and electrical models.

Groundwater chemistry

- Groundwater quality - physical and chemical properties of water, quality criteria for different uses, graphical presentation of water quality data.
- Ground water quality in different provinces of India - problems of arsenic and fluoride.
- Saline water intrusion in coastal and other aquifers and its prevention.
- Radioisotopes in hydrogeological studies. Groundwater contamination.
- Application of isotopes as tracer and budgeting tool.

Groundwater exploration

- Geological - lithological and structural mapping, fracture trace analysis.
- Hydrogeological-lithological classification with respect to hydrologic properties.
- Hydraulic continuity in relation to geologic structures.
- Location of springs.
- Remote sensing - Hydrogeomorphic mapping of the terrain using different images of different satellite missions.
- Lineament mapping. Shallow groundwater potential zone mapping using satellite images.
- Surface geophysical methods - seismic, gravity, geo-electrical and magnetic.
- Subsurface geophysical methods- well logging for delineation of aquifers and estimation of water quality.

Groundwater problems and management

- Groundwater problems related to foundation work, mining, canals, dams, reservoirs and tunnels.
- Problems of overexploitation and groundwater mining.
- Groundwater development in urban areas and rain water harvesting.
- Artificial recharge methods. Groundwater problems in arid regions and remediation.
- Groundwater balance and methods of estimation.
- Groundwater legislation.
- Sustainability criteria and managing renewable and nonrenewable ground water resources.

Practicals:

• Deciphering of hydro geological boundaries on water table contour maps
• Analysis of Hydro graphs
• Determination of permeability in laboratory and in field.
• Determination of specific analytical conductance,
• Hydrochemical facies on Trilinear (Hill-Piper) diagram
• Problems on radial flow to a well in confined and unconfined aquifers
• Determination of aquifer parameters using Theis and Jacob's methods
• Calculation of salt water encroachment in coastal aquifers
• Electrical resistivity surveys for aquifer delineation
• Application of Arc-Hydro, River-Morph, Aquit-Solv, GW Chart, Flow- .Net, SWAT, Mod-Flow, etc

Suggested Books:

1. Davies, S.N. and De-West, R.J.N., 1966. *Hydrogeology,* John Wiley &Sons, New York.
2. Driscoll, F.G., 1988. *Ground Water and Wells,* UOP, Johnson, Div. St. Paul. Min. USA.
3. Fetter, C.W., 1984. *Applied Hydrogeology,* McGraw-Hill Book Co., NewYork.
4. Fitts, C.R., 2006. *Groundwater Science,* Academic Press.
5. Freeze, R.A. and Cherry, J.A., 1979. *Groundwater,* Englewood Cliffs, New Jersey: Prentice-Hall.
6. Karanth K.R., 198'7. *Groundwater: Assessment, Development and Management,* Tata McGraw-Hill Pub. Co. Ltd.
7. Raghunath, H.M., 1987. *Ground Water,* Wiley Eastern Ltd., Calcutta.
8. Schward and Zhang, 2003. *Fundamentals of Ground water,* John Willeyand Sons.
9. Todd, D.K., 2004. *Ground Water Hydrology,* John Wiley & Sons, New York.

3rd Semester

GLG- 301- Ore Geology and Mineral Economics

Theory:

- Historical background to the development of Ore Geology.
- Field and laboratory studies of ores.
- Brief Survey of Geological, Geochemical, Geophysical Exploration.
- Remote Sensing,
- Sampling methods.
- Distribution, morphology and disposition of Ore bodies.
- Physical characteristics.
- Optical properties, ore microscopy, Structure of ore minerals, Experimental ore petrology.
- Fluid inclusion, trace element and isotope studies in ore.
- Ore Minerals, Their texture and structure, development in open space and polycrystalline aggregates.
- Process of formation and transformation of ores.
- Endogenous: magmatic, pegmatitic, contact metasomatic (skarn, greisen, and hydrothermal ore generation- emphasis on critical aspects and physicochemical conditions.
- Exogenous: residual, chemical weathering and mechanical weathering accumulation; sedimentary including bacteriogenic and submarine exhalative, emphasis on chemical and biochemical factor.
- Transformation: Metamorphic and Metamorphosed.
- Petrological ore association-consideration with reference to distinct ore types.
- Classical occurrences and details of Indian Ore Deposits.
- Ore associated with ultramafic and related mafic plutonic rocksr.Sudbury -type Fe -Ni -Cu sulphides, apatite rich and Ti -V bearing magmetites. Fe-Ti oxides and anothsites.
- Ores associated with felsic plutonic rock: porphyry deposit of Cu, Mo Greisen and skarn deposit of Wand Sn Various Pegmatoid deposit.
- Ores associated with acid mafic volcanic rocks, including those in greenstone belits: Kabalda type, Kuroko type, Cypruss Types of ores.
- Stratabound ore deposit associated with nonvolcanic, Meta Sedimentary rocks, Kupferschiefer, Rhodesia -Katanga, Broken Hill.
- McArthur, Mississippi valley type, Witwatersrand type.
- Bog iron manganese ores ironstone.
- Banded iron formation manganese ores orthoquartzite-clay association.
- Jaspilite and volcanic association, metamorphosed manganese ores. Colorado Plateau type U-V ores, Surficial deposits: Lateritoid and Karst deposit ofF e, Mn, AI, and Ni: Placer deposit of Gold, Tin, Tungsten, monazite. oxidation and supergine enrichment sulphide enrichment. Ocean floor deposit of Mn, Ni-Cu-Co.
- Crustal evolution and metallogenesis.
- Discussion on Various environment of Ore formation.

Mineral Economics

- Importance of Minerals in National Economy.
- Basic pattern of Mineral economy and changing mineral requirements.

- Concepts of straregic Minerals and their supplies in time of peace and war.
- Material in various important industries, problem relating to their marketing.
- Developing substitute to cover internal shortage, production cost & its relation to mineral in short supply.
- Internal controls (monopolies and cartel), trade restriction and production incentives.
- Concession rules, world resources and production of important mineral.
- Importance of steel &Fuels in Modem Economy.
- Impact of atomic Energy over conventional fuels.
- Conservation of non renewable & associated Renewable resources.

Practical:

• Drawing maps of the major and important mineral deposits of India.
• Study of important metallic ores and industrial non-metallic minerals with reference to their distinguishing physical characters, association, form and structure. Prepartion of polished ore-specimens. Ore: miscroscopic study of the following minertals, their tecxtural rewlationships and para-genesis of both metamorphosed and nonmetamorphosed ores
• Cha copyrite; chalcosite; covellite; pentlandite; sphalerite; galena; pyrite; marcasite; arsenopyrite; melybdenite; stibnite; megnatite; ilmenite; goethite; psillomaline; pyrolusite; braunite; bixbyite;jacobsite; chromite; uraninite; pitchblende
• Additional practical work exercises in comprehensive tests in mineral identification including physical, optical and associational characters

Suggested Books:

1. Barnes, H.L., 1979. *Geochemistry of Hydrothermal Ore Deposits,* John Wiley.
2. Evans, A.M., 1993. *Ore Geology and Industrial Minerals,* Blackwell.
3. Guilbert, J.M. and Park, Jr. c.F., 1986. *The Geology of Ore Deposits.* Freeman.
4. Klemm, D.D. and Schneider, H.J., 1977. *TIme and Strata Bound Ore Deposits.* Springer Verlag. .
5. Mookherjee, A, 2000. *Ore Genesis - A Holistic Approach.* Allied Publisher.
6. Ramdohr, P., 1969. *The Ore Minerals and their Intergrowths.* Pergamon Press.
7. Stanton, R.L., 1972. *Ore Petrology,* McGraw Hill.
8. Wolf, K.H., 1976-1981. *Hand Book of Stratabouond and Stratiform Ore Deposits.* Elsevier.

GLG-302- Oil and Coal Geology

Theory:

Petroleum

- Introduction to Petroleum geology.
- Physical properties of petroleum .
- Chemical properties of petroleum.
- Subsurface environment, generation and migration of petroleum.
- Hydrocarbon traps and seals.
- Sedimentary basins, assessment of basin reserves and global reserves.
- Reservoir characteristics.
- Identification and demarcation of flow units, relationship between porosity, permeability and texture.
- Correlation of well log parameters with seismic properties.
- Bulk properties and pore fluid conditions.
- Oil and gas fields of India.

Coal

- Definition, origin of coal.
- Stratigraphy of coal measures.
- Fundamentals of coal petrology.
- Peat, lignite, bituminous and anthracite coal.
- Microscopic constituents of coal.
- Industrial application of coal petrology.
- Indian coal deposits. .

Practical:

• Exercises based on source rock, reservoir and traps, well logging andreserve estimation
• Case studies of petroliferous basins of India
• Coal petrography

Suggested, Books:

1. Chandra, D., Singh, R.M. and Singh, M.P., 2000. *Textbook of Coal (Indian context),* Tara Book Agency, Varanasi.
2. Holson, GD. and Tiratso, E.N., 1985. *Introduction to Petroleum Geology,* Gulf Publishing, Houston, Texas.
3. Leverson, AI., 1970. *Geology of Petroleum,* Freeman and Co.
4. North, F.K., 1985. *Petroleum Geology.* Alien Unwin.
5. Scott, AC., 1987. *Coal and Coal-bearing Strata: Recent Advances,* The geological Society of London, Publication no. 32, Blackwell Scientific Publications.
6. Selley, R.C., 1998. *Elements of Petroleum Geology,* Academic Press.
7. Singh, M.P., 1998. *Coal and Organic Petrology.* Hindustan Publishing Corporation, New Delhi.
8: Stach, E., Mackowsky, M~Th., Taylor, GH., Chandra, D., Teichumullelr, M. and Teichmuller R., 1982. *Textbook of Coal Petrology,* Gebruder
Bomtraeger, Stuttgart.

GLG-303- Geo-Exploration

Tbeory:
Exploration

- Methods of prospecting and exploration.
- Airborne and subsurface survey including geophysical methods such as seismic gravity.
- Magnetic and electrical, geochemical prospecting.
- Geobotanical prospecting.
- Types of drilling-core and non core.
- Parts of drilling machine, drill hole deviation.
- Surveys and method.
- Bore hole logging and preparation of drill hole section and plans.
- Various sampling methods.
- Ore reserve estimation techniques.

Mining

- Mining parameters for selecting mining methods.
- Open cast or underground mining.
- Various underground mining methods like sub level open scooping method.
- Cut and fill and high productive VCR method.
- Mine safety and ventilation.

Practical:

• Preparation of assay plans
• Ore reserve estimation by section, plan & longitudinal vertical sectionmethod.
• Scatter plots, correlation and regression analysis
• Application of various softwares (Datamine, Surfer, Drill-hole Explorer,Rockworks)

Suggested Books:

1. Arogyaswami, R.P.N., 1996. *Courses in Mining Geology,* 4th Ed. OxfordffiH.
2. Bagchi, T.C., Sengupta, D.K. and Rao, S.Y.L.N., 1979. *Elements of Prospecting and Exploration.*
3. Banerjee, P.K. and Ghosh, S., 1997. *Elements of prospecting for nonfuel mineral deposits,* Allied Publishers Limited.
4. Sinha, R.K. and Sharma, N.L, 1993. An Introduction to Mineral Economics, Wiley Eastern.

GLG-304- Engineering Geology

Theory:

Rock Mechanics and Rock Engineering:

- Engineering properties of rocks and their determination.
- Rock mass Classification.
- Rating, Quality Determination and Characterization.
- In-situ and Induced Stresses.
- Factor of Safety and Probability of Failure.
- Strain and strength of rock.
- S Various strength tests.
- Effect of discontinuities on Rock Mass Strength.

Soil Mechanics

- Soil Profile and Classification.
- Engineering properties of Soils and their determination.
- Consistency limits.

Site Investigation:

- Study of maps & plans.
- Aerial Photographs and Images.
- Remote Sensing.
- Site reconnaissance.

Site Investigation Report:

- Style and Content.
- Factual Reports and its interpretation:

Site Characterization:

- Geotechnical treatments including Grouting and Rock Bolting.
- Foundation Treatment.

Ground Investigation:

- Boreholes and Trial Pits.
- Drilling.
- Sampling and Logging etc.

Environmental Considerations:

- Impact of civil engineering projects. On Environment, Nature's Equilibrium.
- Reservoir Induced Seismicity; Alternatives for environmental protection.

Geological & Geotechnical Investigation:

- Dams (Dam-break Analysis).
- Reservoirs and Spillways.
- Tunnels; Powerhouse and other Caverns.
- Bridges; Highways.
- Geotechnical Treatment for the above mentioned structures.
- Structural analysis of engineering projects.

Natural Disasters:

- Effect of natural disasters on engineering structures and its remedial/preventive measures.
- Earthquakes and landslides hazard zonation.

Case Histories:

- Examples and Case histories from India and other important worldwide projects.

Practical:

• Map oriented comments on proposed sites.
• Study of rocks in various construction purposes.
• Determination of engineering properties of rocks & soils viz: Specific gravity, Porosity, Moisture content, void ratio Permeability Atterberg limits.
• Rock mechanical tests including unconfined compression tests point load index test, Schmidt's Hammer tests, Brazilian tests

• Software based analysis (Rock-Slide, Rock-Galena, fall, Dip, Stereonet, Rockworks, MicroDEM, RMR classification, Dam-break Analysis Software, HEC-res, etc.)

Suggested Books:

1. Bell: F.?-, 2006. *Basic Environmental and Engineering Geology* Whittles Publishing.
2. Bell, .F.G, 2007. *Engineering Geology,* Butterworth-Heinemann
3. Krynine, .D.H. and Judd, W.R., 1998. *Principles of Engineering Geology* CBS Edition. '
4. Murthy, Y.N.S:, 2002. *Geotechnical Engineering: Principles and Practices of Sol! Mechanics and Foundation Engineering* CRC P
5. Schultz, J .R. and Cleaves,..A, B 1951. *Geology in Engineering,*, John Willey & Sons, New York.

4th Semester

GLG-401- Remote Sensing and GIS

Theory:

Remote Sensing

- Concepts in Remote sensing.
- EM radiation and its interaction with atmosphere.
- Platform, sensors and scanners.
- Earth resources satellites; Data acquisition, Data formats- Raster, Vector Data, TIN, DEM.
- Introduction to Microwave remote sensing and its applications.

Digital Image Processing

- Image rectification and restoration; Image enhancement - single image & multiimage: contrast stretching, filtering.
- PCA images, FCC, Image ratioing.
- Image classification and accuracy assessment - supervised & unsupervised classification, error estimation.
- Data merging and GIS integration; Case studies- Indian Examples.

GIS

- Introduction, Coordinate systems and datum Projection systems.
- Spatial data models and data structures.
- Attribute data input and management.
- Data editing, exploration and analysis.
- Digital terrain analysis using DEM data, Path analysis, network applications and morphometry; Introduction to GIS models and mode ling.

GPS

- Concepts of GPS; GPS receivers.
- GPS positioning mode- point positioning & relative positioning (DGPS & RTK GPS).
- GPS accuracy and error sources, Integrating GPS data with GIS.
- Applications in earth system sciences.

Practical:

- Analysis of satellite data in different bands and interpret various objects on the base of their spectral signature
- Introduction to DIP and GIS software (ERDAS, ArcGIS, MapInfo, Geomedia, Tin-mips, MicroDEM, River morph, HEC-RAS)
- Digital Image Processing exercises including
    1. Registration of satellite data with a toposheet of the area
    2. Generating contrast stretched images from raw data
    3. Creating a FCC from raw data
    4. Generating NDVI images and other image ratio and its Interpretation
    5. Creating PCA images and its interpretation
    6. Classification of images based on supervised and unsupervised classification unsupervrss
    7. DEM analysis
    8. Generating. Slope map, aspect map and drainage network map and Its applications

Suggested Books:

1. Demers: M.N., 1997. *Fundamentals of Geographic Information system,* John Willey & sons. Inc.
2. Gupta, R. P., 2003. *Remote Sensing Geology* Springer

3. Hoffmann-Wellenhof, B., ,Lichtenberger, H. and Collins J 2001 *GPS. Theory* & *Practice,* Springer Wien New York.

4. ~ens~n, ~R., 199? *Intro~uctory Digital Ima~e Processing: A Remote ~nsmg erspecuve,* Springer. Verlag.

5. Ltllesand, T. M & Kiefer R W 2007 *Interpretation,* Wiley. "" . *Remote Sensing and Image*

6. ~~~~:::~~~~:d Jia, X.,]999. *Remote Sensing Digital Image Analysis,*

7. Sabin, F. F., 2007 *Remote Se . . Pri .* Waveland Pr Inc. . *nsmg. rinciples and Interpretation,*

8. Verbyla, D.L., 2002. *Practical GIS Analysis,* Taylor & Francis.

GLG-402- Geophysics

Theory:

- Gravity and Magnetic fields of the earth: Normal-gravity field.
- Shape of the earth.
- Bouguer and isostatic anomalies, isostatic models for local regional compensation.
- Geomagnetic field, secular and transient variations and their Suggested Books: theories.
- Palaeomagnetism.
- Construction of polar wandering curves.
- Plate Tectonics and Geodynamics.
- Sea floor spreading and mid-oceanic ridges.
- Plate boundaries and seismicity.
- Seismology &. Tomography.
- Elements of earthquake seismology.
- Seismometry; Seismic moment tensor, focal mechanism and fault plane solutions; seismic gaps; Seismotectonics and structure of the earth.
- Himalayan and stable continental region earthquakes.
- Reservoir induced seismicity.
- Seismic hazards.
- Gravity and Magnetic Methods.
- Gravimeters and magnetometers.
- Data acquisition and corrections.
- Regional and residual separation.
- Interpretation of anomalies of simple geometric bodies, e.g. single pole, sphere, horizontal cylinder, sheet, dyke and fault.
- Electrical and Electromagnetic Methods.
- Electrical profiling and sounding.
- Resistivity transform and direct interpretation.
- Electromagnetic field techniques and interpretation.
- Magnetotelluric method.
- Geomagnetic depth sounding.
- Seismic Methods
- Reflection, refraction, diffraction methods and data processing.
- Seismic noises and noise profile analysis.
- Seismic data recording and telemetry devices.
- Introduction to 3D seismic; seismic stratigraphy.
- Well logging and other methods.
- Electrical logs.
- Sonic log.
- Nuclear logging.
- Cross plotting;
- Determination of porosity; permeability, formation factor and density.
- Principles of radioactive and geothermal

Practical:

- Determination of density by Nettleton method.
- Handling of gravimeter, Magnetometers and calibration.
- Structure contouring from subsurface information.
- Preparation of a residual map by (a) Graphical method and (b) Grid method.
- Upward and downward continuation of gravity and magnet ic fields.
- Computation of gravity effect of a sphere horizontal cylinder and fault.
- Computation of effect of a magnetic dipole of finite length, sphere and horizontal cylinder.
- Computation of dip angle response over sheet type bodies.
- Analysis of dip angle data and its interpretation.
- Computation of Turam profiles over sheet type bodies.
- Reduction of Turam data and its interpretation.
- Interpretation of Slingram profiles over sheet conductors using phasor diagrams.

Suggested Books:

1. Dobrin, M.B and Savit, C. H., 1988. *Introduction to Geophysical Prospecting,* McGraw-Hill.

2. Grant, F.S. and West, G.F., 1965. *Interpretation Theory in Applied Geophysics* McGraw Hill, New York.

3. Murthy, LY.R. and Mishra, D.C., 1989. *Interpretation of Gravity and Magnetic Anomalies in Space and Frequency Domain,* AEG publication, Hyderabad, India

4. Nettleton, L.L., 1976. *Gravity and Magnetics in Oil Prospecting,* McGraw Hill.

5. Parasnis, D.S., 1966. *Mining Geophysics,* Elsevier.

6. Patra, H.P. and Mallick, K., 1980. *Geosounding Principles Vol. IITimel/ arying Geoelectric Soundings.* Amsterdam:Elsevier.

7. Telford, W.M., Geldart, L.P. and Sheriff, R.E., 1990. *Applied Geophysics,* Cambridge University Press.

Elective Courses

GLG-403(i) Paleoceanography and Paleoclimatology

Theory:

- Weather, Climate, Components of climate.
- Climate classification.
- Insolation, short and long-term changes in Insolation.
- Aerosols: Definition, origin, role in climate change.
- Greenhouse gases: Introduction, causes of changing concentration, role in climate change.
- Origin and evolution of Oceans.
- Oceanic sediments, Terrigenous, biogenic sediments and their distribution.
- Sea-level: factors affecting sea-level changes.
- Short and long-term sea-level variability, evidences of sea-level change from marine sediments.
- Ocean-climate linkage.
- Effect of topography/tectonics on climate.
- Natural variability in climate.
- Human influence on climate change.
- Historical evidences of climate change.
- Effects of climate change on mankind.
- Sampling methods for retrieving archives of climate/oceanographic change.
- Various dating methods, merits and demerits of various dating methods.
- Paleoclimatic/paleoceanographic reconstruction from clay, ice, pollens and spores, diatoms, radiolarian, foraminifera.
- Organo-geochemical proxies.
- Corals, speleothems.
- Loess-paleosols.
- Geomorphologic changes and climate.

- Elemental and isotopic analysis for paleoclimatic/paleoceanographic reconstruction.
- Instruments used for paleoclimatic/paleoceanographic studies.
- Modeling climate change, IPee climate change projections

Practical:
• Collection of samples for paleoclimatic/paleoceanographic studies
• Processing of various types of samples for paleoclimatic/ paleoceanographic studies
• Identification of different types of microfossils used for paleoclimatic/ paleoceanographic reconstruction
• Preparation of micro fossils for isotopic and elemental analysis
• Exercises on establishing chronology
• Interpretation of various types of paleocl imaticfdc/paleoceanographic data

Suggested Books:
1. Bignot, G., 1985. *Elements* of Micropaleontology, London: Graham and Trotman Ltd.

2. Bradley, R.S., *Paleoclimatology: Reconstructing Climates of the Quaternary,* Academic. *Press.*

3. Brasier, M.D. 1980 Microfossils, Geogrge Allen and Unwin.
4. Cronin, T.M., 1999. Principles *of Paleoclimatology,* Columbia UniversityPress.

5 Fischer, G. and Wefer, G 1999 *Use of Proxies in Paleoceanography: Examples from the South Atlantic,* Springer.

6. Haq and Boersma, 1978. In*troduction to Marine Micropaleontology,* Elsevier.
7. kennett, J.P.1982 Marine Geology, Prentice-Hall Inc.
8. North, G.R. and Crowley, T.J., 1995. Paleoclimatology, Oxford University Press
9. Schopf, TJ.M., 1980. *Plaleoceanography,* Harvard University Press.
10. Tolmazin, D., 1985. *Elements of Dynamic Oceanography , Allen and Unwin.*

GLG-404 (ii) Geochemistry and Isotope Geology

Theory:
- Origin of chemical elements abundance of elements in cosmos, solar system and earth.
- Distribution of elements in core, mantle, hydrosphere and atmosphere.
- Nuclides and atoms.
- Electronic configuration of atoms arrangement of atoms in periodic table, electronegativity iomzatron potential, chemical bonding.
- Geochemistry of igneous rocks. Distribution coefficients and its application with numerical examples.
- Trace elements geochemistry and its application in patrogenesis and as tectonic discriminannts.
- Concept box model and mixing, and its applications.
- Geochemistry of weathering transportation and deposition.
- Application of Geochemistry in mineral exploration and in solving environmental problems.
- Radioactivity, Decay of radioactive atoms and growth of radiogenic atoms.
- Application of radioactivity in geochronology and in understanding geological processes.
- Stable isotope geochemistry.
- Introduction to cosmogenic isotope geochemistry.

Practical:
• Analysis of samples/geological material, using different analytical techniques including wet and dry chemical methods.

Suggested Books:

1. Dickin'.A P., 1995, *Rdiogenic Isotope Geology, Cambridgy* University Press.

2. Faure, G., 1986. Principle of Isotope Geology, J. Wiley & Sons.

3. Henderson, P., 1982. Inorganic Geochmistry, Pergamon Press, Oxford.

4 Krauskopf, K.B., 1979 Introduction to Geochmistry. McGraw Hill.

5. Mason, B. 1982 *Principles of Isotope Geology, J. Willey &* Sons.

GLG-404(iii) Advanced Mineralogy

Theory:

Crystallography:

- Group theory and its application. Space lattice.
- Diffraction of X-ray by atoms and ideal crystal: Reciprocal lattice and diffraction experiments.
- Single crystal-and powder methods.
- Indexing of the diffraction pattern.

Optical Mineralogy:

- Concept of indicatrics; extinction angle-study under conoscopic condition.
- Interference figures; optic sign; optic orientation; dispersion; optical anomalies;
- Universal stage, principles and application.
- Mineral spectroscopy and its applications.

Crystal Chemistry:

- Structure of atoms.
- Elements of crystal bonding.
- Principles of crystal field, valency bond and molecular orbital theories.
- Isomorphism, polymorphism; polytypism AA and M2 structures.
- Silicon tetrahedron and classification of silicates.
- Study of structures of the different groups of rock forming minerals: silica polymorphs, feldspars. ziolites, micas, pyroxenes, amphiboles, olivine, chlorite, serpentine, aluminium silicates, garnets, epidotes, cordierite, staurolite, clay minerals.
- Non- silicates: carbonates, spinels, sulfides and oxide ore minerals.

Practical:

• Crystallography: calculation of the axial ratios and stereographic projections. Exercises on international Tables involving equi-points, indexing of simple powder patterns and study of XR Diffractograms of common minerals.
• Mineralogy: Megascopic study of the common rock forming minerals of the groups mentioned 'in theory, their physical properties' and associations. Optical properties of minerals: use of the .optical accessories; determination of direction of elongation, order of interference colours, pleochroic schemes, extinction angle and birefringence of minerals. Interference figures and the determination sign of uniaxial and biaxial minerals Determination, of 2V, universal stage methods, Optical study of important. minerals

Suggested Books:

1. Berry, L.G., Mason, B. and Dietrich, R.V., 1983. *Mineralogy* CBS Publishers. . '
2. Dana, E.S. and Ford, W.E., 1932. *A textbook of Mineralogy,* Wiley Eastern Limited
3. Deer, W.A Howie, R.A. and Zussman, J., 1992. *An Introduction to the Rock Forming Minerals,* ELBS and Longman.
4. Kerr, P.F., 1942. *Optical Mineralogy,* McGraw Hill Book Company.
5. Moorhouse, W.W., 1959. *The Study of Rocks in Thin Section,* Harper & Row, New York. ,
6. Nesse, W. D., 1991. *Introduction to Optical Mineralogy,* Oxford University Press. ,
7. Phillips, F.C., 1971. *Introduction to'Crystallography,* London, Longmans.
8. Winchell, A.N 1937. *Elements of Optical Mineralogy:* An Introduction to Microscopic Petrography, Wiley.

GLG-404(iv) Earthquake Geology and Seismotectonics

Theory:

Rock fracturing

- Griffith's crack theory; Fracturemechanics: elastic fracturing and subcritical cracks.
- Experimental data on rock strength; pore fluids and 'effective' strength.
- Brittle-plastic transition and strength of upper crust.

Rock friction

- Basic laws offriction: Amonton's law, Byerlee's law.
- Surface friction and asperity contacts.
- Experimental observations.
- Abrasive and adhesive wear.
- Stick-slip and stable sliding behaviour: qualitative approach

Geology of Faults and Earthquakes

- Anderson's theory of faulting.
- Mechanical paradox of overthrusts and Hubbert- Rubey theory.
- Fault formation and development.
- Mohr-coulomb analysis.
- Fault shear zone rocks and their deformation mechanism.
- Strength and rheology oil faults.
- The strong vs. weak fault debate.
- Geology of earthquake source regions.
- Simple earthquake ruptures, earthquake scaling relations.
- Mechanics of complex and compound earthquakes: earthquake recurrence.

Introductory Seismotectonics

- Qualitative Seismotectonics analysis.
- Seismotectonics of transcurrent faults.
- Subductions zones; intraplate seismicity.
- Aseismic vis-a-vis seismic faulting.
- Induced seismicity. reservoir and mining-induced, with suitable examples.
- Earthquake prediction: problems and strategies Case studies {Indian Examples)

Practical:

• Plotting of major earthquake zones of the world
• Fault plane solution and characterization of earthquakes
• Introduction to different instruments related to seismic studies

Suggested Books:

1. Scholz, C.H., 1990. *The Mechanics of Earthquakes and Faulting* Cambridge University Press.
2. Yeats, R.S., Sieh, K. and AlIen, C.R., 1997. *The Geology of Earthquakes.* Oxford University Press.

GLG-404(v) Applied Hydrogeology

Theory:

Introduction:

- Water, Hydrology, Hydrogeology, Geohydrology.
- Hydrologic cycle, and Hydrologic equation.

Evaporation and Precipitation:

- Evaporation, Transpiration.
- Formation and Measurement of precipitation.

Runoff and Stream flow:

- Runoff Cycle, Influent and Effluent streams.
- Hydrograph compositions, River Hydrograph,
- Calculation of base flow equation and recession constant.

Soil Moisture and Groundwater

- Porosity and Hydraulic Conductivity of rocks and sediments.
- Darcy's Law and Dupuit's assumptions, Effective Porosity.
- Forces acting on Groundwater, Water Table and Piezometric Surface.
- Aquifers and their characteristics. '

Principles of Groundwater Flow:

- Hydraulic Head, Pumping Tests, Reynold's number.
- Force Potential and Hydraulic Head.
- Equations of groundwater flow for confined and unconfmed aquifers.
- Flow Nets, Steady Radial Flow in confined and unconfined aquifers.
- Unsteady Radial Flow, Well Hydraulics in completely confined aerially extensive aquifer.
- Theis Method, Jacob Straight-Line Method.
- Time-recovery Test and Theis Recovery Method.
- Pumping test for a leaky artesian aquifer: Walton method.
- Hydrology of lakes, hydrology of wetlands.

Assessment of Groundwater Quality:

- Physical, Chemical and Bacteriological quality.
- Graphical representation of chemical quality data.
- Quality criteria for potable and irrigation waters using WHO, ISI standards, and C-S diagrams.
- Understanding of hydrochemical evolution on Hill and Piper and Durov diagrams Chebotareb sequence.

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Groundwater Modeling Techniques:

- Various types of modeling techniques through softwares.

Groundwater Recharge:

- Natural processes and Artificial Techniques in view of urbanization.

Surface and Subsurface water development and management:

- Various methods and techniques

Practical:

• Water tables contour maps and hydrogeological boundaries.
• Analysis of hydro graphs and unit hydrographs.
• Analysis of hydrochemical facies on Hill and Piper; and Durov diagrams.
• Refraction Seismic surveys; fan-shooting for mapping of direction of buried channels, offset of water table etc.
• Application of Remote Sensing data in detection of soil moisture and shallow aquifers.

Suggested Books:

1. Davies, S.N. and De-West, RJ.N., 1966. *Hydrogeology,* John Wiley & Sons, New York.
2. Driscoll, F.G., 1988. *Ground Water and Wells,* UOP, Johnson, Div. St. Paul. Min. USA
3. Fetter, C.W., 1984. *Applied Hydrogeology,* McGraw-Hill Book Co., New York. .
4. Freeze, R.A. and Cherry, J.A., 1979. *Groundwater,* Englewood Cliffs, New Jersey: Prentice-Hall.
5. Karanth K.R., 1987. *Groundwater: Assessment, Development and Management,* Tata McGraw-Hill Pub. Co. Ltd.
6. Mansell, M.G., 2003. *Rural and Urban Hydrogeology,* Thomas and Telford.
7. Raghunath, H.M., 1987. *Ground Water,* Wiley Eastern Ltd., Calcutta
8. Todd, D.K., 2004. *Ground Water Hydrology,* John Wiley & Sons, New York.

GLG-404(vi) Active Tectonics and Geomorphology

Theory:

- Introduction to neotectonics and active tectonics.
- Mountain building process.
- Thrust and fold belts; Active faults: concepts, methods and case studies.
- Geomorphic markers of tectonic deformation.
- Active tectonics and alluvial rivers.
- Tectonics and erosion.
- Application of isotopic and fission-track data for uplifterosion- incision relationships.
- Tectonic-climate interaction; Landscape response to active tectonics.
- GPS geodesy and its applications to lithospheric deformation.
- Rate of deformation and seismicity; Introduction to paleoseismology.

- Seismic Hazard zonation at regional and local scale.
- Tectonic geomorphology of mountains (landscape response to isostatic and tectonic uplift, terraces, mountain front: escarpments, fault segmentation, mountain front sinuosity, scarp morphological changes with time).
- Introduction to the Himalayan tectonics.
- Longitudinal, transverse and out of sequence faults.
- Rate of deformation in the Himalaya - Quaternary, Holocene and GPS based rates.
- Tectonic deformation and seismicity in the Himalaya.
- Indo-Gangetic Plains &Peninsular India.

Practical:

• Lab exercise related to mapping of geomorphic markers and interpretation of active tectonic activity
• Computation of incision rate and uplift rate from terraces
• Identification of anomalous fluvial features and its application towards tectonic interpretation
• Lab exercise related to application of isotopic and fission-track data to derive uplift history of the area
• Determination of seismic hazard zonation on the basis of deformation rate
• Mapping of local scale seismic hazard zonation

Suggested Books:

1. Bull, W.B., 1991. *Geomorphic Response to Climate Change,* Oxford University Press.

2. Bull, W.B., 2007. *Tectonic Geomorphology of Mountains,* Blackwell Publishing.

3. Burbank, W.B., and Anderson, R.S., 2001. *Tectonic Geomorphology,* Blackwell Science.

4. Keller, E.A. and Pinter N., 2001. *Active Tectonics: Earthquakes, Uplift, and Landscape,* Prentice Hall.

5. McCalpin, J., 1998. *Paleoseismology,* Academic Press.

6. Schumm, S.A. and Holbrook, 2000. *Active Tectonic and Alluvial Rivers,* Cambridge University Press.

7. Willett, S. D., 2006. *Tectonics, Climate, and Landscape Evolution,* Geological Society of America Publication.

8. Yeats R.S., Sieh. K.E. and Alien, C.R., 1997. *The geology of earthquakes,* New York. Oxford University Press.

GLG-404(vii) Environmental Geology

Theory:

- Concept and definition of Environmental Geology.
- Processes of soil formation.
- Types of soils, soil degradation and changing land use pattern.
- Concepts of natural ecosystems on the Earth
- Mutual inter-relations and interactions between (atmosphere, hydrosphere, lithosphere and biosphere).
- Environmental changes due to influence of human-dominated environment over nature-dominated system.
- Concept of biodiversity. Mobility of elements.
- Impact assessment of water availability.
- Quality and contamination of surface water and groundwater.
- Atmosphere and air pollution. Soil contamination due to urbanization, industrialization and mining.
- Basic tenets of environmental laws.
- Distribution, magnitude and intensity of earthquakes.
- Neotectonics and seismic hazard assessment.
- Preparation of seismic hazard maps.
- Impact of seismic hazards on long and short term environmental conditions.
- Mechanism of landslides, causes of major floods.
- Cyclones and storms.
- Deforestation and land degradation.

Practical:

• Study of seismic and flood-prone areas in India.

• Analyses for alkalinity, acidity, pH and conductivity (electrical) in water samples.
• Classification of ground water for use in drinking, irrigation and industrial purposes. .
• Presentation of chemical analyses data and plotting chemical classification diagram.
• Evaluation of environmental impact of air pollution groundwater, landslides, deforestation, cultivation and building construction in specified areas.

Suggested Books:

1. Bell, F.G, 1999. *Geological Hazards,* Routledge, London.

2. Bryant, E., 1985. *Natural Hazards,* Cambridge University Press.

3. Keller, E.A., 1978. *Environmental Geology,* Bell and Howell, USA.

4. Patwardhan, A.M., 1999. *The Dynamic Earth System.* Prentice Hall.

5. Smith, K., 1992. *Environmental Hazards.Routledge,* London.

6. Subramaniam, V., 2001. *Textbook in Environmental Science,* Narosa International.

7. Valdiya, K.S., 1987. *Environmental Geology - Indian Context.* Tata McGraw Hill.

GLG-404(viii) Sedimentary Environments

Theory:

- Introduction to sedimentary environments and classification, controls, facies and sequence stratigraphy.
- Continental sedimentary environments (fluvial, lacustrine, desert).
- Marginal sedimentary environments (shore line, deltas, tidal flat, beach barrier, estuaries, evaporites), Shallow marine clastic (shelf processes and sediments).
- Shallow water carbonate environments (controls, platform, reefs, sea level changes and carbonate. sequence).
- Deep sea environments (pelagic sedmenmts, black shales, conturites, turbidites, submarine fans).
- Glacial sedimentary environments (processes, facies, periglacial, glacio-eustacy, glacioisostacy, glacial-terrestrial, glacial-marine associations).
- Volcanoclastic sedimentary environments (sedimentary processes, classification of volcanoclastics, tuffs).
- Sedimentary Basin formation, Tectonics & sedimentary environments.

Practical:

Reconstruction of sedimentary environments based on assemblage of sedimentary structures and rocks and vertical sedimentary sequences. Exercises based on textural, mineralogical and chemical characters to infer the sedimentary processes and environments. Compilation and synthesis of characteristic features of regional sedimentary environments from India.

Suggested Books:

1. Allen, P.A., 1997. *Earth Surface Processes,* Blackwell publishing.

2. Lindholm, R.C., 1987. *A Practical Approach to Sedimentology,* Allen and Unwin, London.

3. Miall, A.D., 1999. *Principles of Sedimentary Basin Analysis,* 3rd Ed., Springer Verlag, New York.

4. Nichols, G, 1999. *Sedimentology and Stratigraphy,* Blackwell publishing.

5. Prothoreo and Schwab, 2004. *Sedimentary Geology,* Freeman and Co. New York.

6. Reading, H.G, 1996. *Sedimentary Environments: Processes, Facies, and Stratigraphy;* Blackwell Publishing.

7. Sam Boggs, 1995. *Principles of Sedimentology and Stratigraphy,* Printice Hall, New Jersey.

8. Tucker, M.E., 2006. *Sedimentary Petrology,* Blackwell Publishing.

GLG-404(ix) Natural Hazards and Disaster Management

Theory:

- Concepts of disaster.
- Types of disaster: natural and manmade.
- Cyclone, flood, land slide, land subsidence, fire and earthquake.
- Issues and concern for various causes of disasters.
- Disaster management, mitigation, and preparedness.
- Techniques of monitoring and design against the disasters.
- Management issues related to disaster.
- Mitigation through capacity building.
- Legislative responsibilities of disaster management. Disaster mapping, assessment, pre-disaster risk &vulnerability reduction, post disaster recovery & rehabilitation.
- Disaster related infrastructure development.
- Remote-sensing and GIS applications in real time disaster monitoring.
- Prevention and rehabilitation.
- The Lithosphere and Related Hazards.
- Earthquakes and Faults, Measures of an Earthquake.
- Earthquake Hazards.
- Earthquake Control and Prediction
- Magma: Origin and Types, Volcanic Products and Hazards.
- Monitoring.
- Risk Evaluation.
- Prediciton.
- Tectonics and Climate.
- Meteorite Impacts

Atmospheric Hazards:

- Introduction to the Atmosphere.
- What Makes the Weather?.
- Water Vapor, Clouds, and Precipitation.
- What Makes the Winds?.
- Forces and Air Motion.
- Winter Storms I - Air Masses, Fronts and Jet Streams.
- Winter Storms II - Evolution of Cyclones and Anticyclones.
- Spring Storms I -, Atmospheric Stability.
- Spring Storms IT - Thunderstorms and Lightning.
- Spring Storms III - Hail and Flash Flooding.
- Spring Storms IV- Tornadoes.
- Summer Storms I - Tropical Weather Systems.
- Summer Storms IT - Hurricanes and Storm Surge
- Drought, Air Pollution

The Hydrosphere and Related Hazards:

- Living on the Water Planet.
- Fluvial hazards - flooding, channel migration, bank erosion, catchment erosion.
- Tsunamis and Coastal Hazards I.
- Sea Level is Rising - Why, Where & How Fast?.
- Coastal Hazards 11:Our Shorelines Are Retreating, How and Why?
- Coastal Hazards ill: Should We Armor Our Coastal Zone?
- Additional Coastal Zone Impacts Forced by Sea-Level Rise.
- Landslides.
- Types of slope failure.
- Slope Mass Rating (SMR) classification.
- Causative factors.
- Landslide Hazard Zonation.
- Factor of Safety analysis.

- Slope stabilization measures.
- Sinkholes and Subsidence.
- Estuarine Pollution.
- Biological Pollution.
- Alien Species and Emerging Diseases.
- Mass Extinction, Evolution and Extinction

Practical:

- Evaluation of environmental impact of air pollution groundwater, landslides, deforestation, cultivation and building construction in specified areas

Suggested Books:

1. Bell, F.G., 1999. *Geological Hazards ,Routledge,* London.
2. Bryant, E., 1985. *Natural Hazards, Cambridge* University Press.
3. Patwardhan, A.M., 1999. *The Dynamic Earth System.* Prentice Hall.
4. Smith, K., 1992. *Environmental Hazards.* Routledge, London.
5. Subramamam, V 2001 . *Textbook in Environmental Science,* Narosa International.

GLG-404(x) Rock Mechanics and Rock Engineering

Theory:

- *History* of development of engineering geology as a subject.
- Geologists and Engineers.
- Geologists as a planner, designer and developer.
- Engineering geology as a tool for national growth.
- Economic, environmental and social impact of hydroprojecrs, Large dams as nation builders.
- Economic growth vs growth in engineering geological projects.
- Engineering geology, a boom for power, agriculture, flood control, disaster correction and groundwater augmentation.
- Highways.
- Tunnels.
- Bridges
- Shore engineering.
- Important case histories from India and abroad.

Practical:

- Identification of sites for dams and reservoirs, tunnels, highways and bridges using topographic sheets and satellite imageries
- Comparison of alternative sites for a given project citing its merits and demerits
- Use of geological maps in identification of best sites

- Computation of various mechanical properties of rocks and soils viz compressive, tensile and shear strengths by index and direct methods

- Computation of durability indices for various types of construction materials,
- Determination of Atterberg Limits

- Assessment of economic growth vis-a-vis various types of projects in pipeline

Suggested Books:

l. George, D., 2008. *Engineering Geology: Principles and Practice,* Springer.

2. Goodman, R.E., 1993. *Engineering Geology: Rock in Engineering Construction,* John Wiley and Sons, New York.

3. Kehew, A.E., 1995. *Geology for Engineers Environmental Scientists,* Prentice Hall.

4. Krynine, D. and Judd, 1957. *Principals of Engineering Geology* and Geotechnics, McGraw-Hill.

5. Rahn, P.H., 1996. *Engineering Geology: An Environmental Approach,* Prentice Hall.

6. Reddy, D.V., 1996. *Engineering Geology for Civil Engineers,* Oxford & IBH, India.

7. Waltham, T., 200l. *Foundations of Engineering Geology,* Taylor and Francis.