SYLLABUS FOR

Bachelor of Science (Honors)

GEOLOGY

THREE YEAR DEGREE COURSE

SEMESTER SYSTEM

(Under New UGC CBCS Guidelines)

2021

DEPARTMENT OF GEOLOGY
KOHIMA SCIENCE COLLEGE
(An Autonomous Govt. P.G. College)
JOTSOMA, NAGALAND

COURSE STRUCTURE

SEMESTER	COURSE	COURSE NAME	COURSE CODE	CREDIT
I	CORE-1	Earth System Science (Theory)	GLC 1.11	4
		Earth System Science (Practical)	GLC 1.12	2
	CORE-2	Mineral Science (Theory)	GLC 1.21	4
		Mineral Science (Practical)	GLC 1.22	2
II	CORE-3	Geomorphology (Theory)	GLC 2.11	4
		Geomorphology (Practical)	GLC 2.12	2
	CORE-4	Structural Geology (Theory)	GLC 2.21	4
		Structural Geology (Practical)	GLC 2.22	2
III	CORE-5	Igneous Petrology (Theory)	GLC 3.11	4
		Igneous Petrology (Practical)	GLC 3.12	2
	CORE-6	Sedimentary Petrology (Theory)	GLC 3.21	4
		Sedimentary Petrology (Practical)	GLC 3.22	2
	CORE-7	Elements Geochemistry (Theory)	GLC 3.31	4
		Elements Of Geochemistry (Practical)	GLC 3.32	2
	SEC-1	Field work I- Basic Field Training	GLS 3.12	2
IV	CORE-8	Metamorphic Petrology (Theory)	GLC 4.11	4
		Metamorphic Petrology (Practical)	GLC 4.12	2
	CORE-9	Stratigraphic Principles And Indian Stratigraphy (Theory)	GLC 4.21	4
		Stratigraphic Principles And Indian Stratigraphy (Practical)	GLC 4.22	2
	CORE-10	Paleontology (Theory)	GLC 4.31	4
		Paleontology (Practical)	GLC 4.32	2
	SEC-2	Geology Of Nagaland	GLS 4.12	2
V	CORE-11	Economic Geology (Theory)	GLC 5.11	4
		Economic Geology (Practical)	GLC 5.12	2
	CORE-12	Hydrogeology (Theory)	GLC 5.21	4
		Hydrogeology (Practical)	GLC 5.22	2
	DSE-1	Exploration Geology (Theory) OR Evolution Of Life Through Time (Theory)	GLD 5.11(a) GLD 5.11(b)	4
		Exploration Geology (Practical) OR Evolution Of Life Through Time (Practical)	GLD 5.12(a) GLD 5.12(b)	2
	DSE-2	Environmental Geology (Theory) OR Introduction To Geophysics (Theory)	GLD 5.21(a) GLD 5.21(b)	4
		Environmental Geology (Practical) OR Introduction To Geophysics (Practical)	GLD 5.22(a) GLD 5.22(b)	2
		Engineering Geology (Theory)	GLC 6.11	4

VI	CORE-13	Engineering Geology (Practical)	GLC 6.12	2
	CORE-14	Remote Sensing And GIS (Theory)	GLC 6.21	4
		Remote Sensing And GIS (Practical)	GLC 6.22	2
	DSE-3	Fuel Geology(Theory) OR Urban Geology (Theory)	GLD 6.11(a) GLD 6.11(b)	4
		Fuel Geology (Practical) OR Urban Geology (Practical)	GLD 6.12(a) GLD 6.12(b)	2
	DSE-4	Field Work II OR Earth And Climate (Theory)	GLD 6.21(a) GLD 6.21(b)	4
		Seminar OR Earth And Climate (Practical)	GLD 6.22(a) GLD 6.2(b)	2
				100

SEC: Skill Enhancement Course
DSE: Discipline Specific Elective

SEMESTER – I

CORE 1 (GLC 1.11)
EARTH SYSTEM SCIENCES

Theory Credit: 4

UNIT I
Introduction to various branches of Geology.
General characteristics and origin of the Universe. The terrestrial and jovian planets.
Earth in the solar system - origin, size, shape, mass, density, rotational and revolution parameters and its age. Formation of core, mantle, crust, hydrosphere, atmosphere and biosphere.
Convection in Earth's core and production of its magnetic field

UNIT II
Concept of Plate tectonics: Continental drift and Seafloor spreading
Geodynamic elements of Earth: Mid-Oceanic Ridges, trenches, transform faults and island arcs.
Earthquake and earthquake belts. Volcanoes: Types, products and their distribution.

UNIT III
Earth's heat budget. Atmospheric circulation. Density and salinity of sea water.
Oceanic current system and Coriolis effect; Weather and climate change. Concept of eustasy.

UNIT IV
Nature of stratigraphic records. Standard stratigraphic time scale and introduction to the concept of time in geological studies. Introduction to geochronological methods and their application in geological studies. History of development in the concepts of uniformitarianism, catastrophism and neptunism. Laws of superposition and faunal succession. Introduction to geomorphology of Indian subcontinent.

UNIT V
Distribution of elements in solar system and in Earth. Chemical differentiation and composition of the Earth. General concepts about geochemical cycles and mass balance. Geochemical behavior of major elements. Mass conservation of elements and isotopic fractionation

CORE 1 (GLC 1.12)
EARTH SYSTEM SCIENCES

Practical Credit: 2

1. Study of major geomorphic features and their relationships with outcrops through physiographic models.
2. Study of distribution of major lithostratigraphic units on the map of India
3. Study of major ocean currents of the World
4. Problems on plate tectonics

SUGGESTED READINGS:

1. Duff, P. M. D., & Duff, D. (Eds.). (1993). *Holmes' principles of physical geology*. Taylor & Francis.
2. Emiliani, C. (1992). *Planet earth: cosmology, geology, and the evolution of life and environment*. Cambridge University Press.
3. Gross, M. G. (1977). Oceanography: A view of the earth.

CORE 2 (GLC 1.21)
MINERAL SCIENCE

Theory Credit: 4

UNIT I

Elementary ideas about crystal morphology in relation to internal structures. Crystal parameters and indices. Crystal symmetry and common crystal forms- dome, prism, pyramid and pinacoid.

UNIT II

Study of normal classes of the Isometric, Tetragonal, Hexagonal, Orthorhombic, Monoclinic and Triclinic systems.

UNIT III

Minerals - Definition. Classification and Physical properties. Silicate structures. Radioactivity. Solid solution. Allotrophy. Isomorphism, Polymorphism and Pseudomorphism.

UNIT IV

Study of common rock-forming minerals – Silica, Feldspar, Olivine, Pyroxene, Amphibole, Mica, Alumino silicate and Garnet Family

UNIT V

Introduction to the petrological microscope. Nature of light: Isotropic and anisotropic substances, Ordinary and polarised light, Refractive index, Birefringence, Pleochroism, Twinkling, Interference colour, Extinction and Twinning

CORE 2 (GLC 1.22)
MINERAL SCIENCE

Practical Credit: 2

1. Observation and documentation on symmetry of crystals
2. Study of physical properties of minerals in hand specimen
3. Silicates: Olivine, Garnet, Andalusite, Sillimanite, Kyanite, Staurolite, Beryl, Tourmaline, Augite, Actinolite, Tremolite, Hornblende, Serpentine, Talc, Muscovite, Biotite, Phlogopite, Quartz, Orthoclase, Plagioclase, Microcline, Nepheline, Sodalite, Zeolite

4. Quartz varieties: Chert, Flint, Chalcedony, Agate, Jasper, Amethyst, Rose quartz, Smoky quartz, Rock crystal. Native Metals/non-metals, Sulfides, Oxides- Copper, Sulfur, Graphite, Pyrite, Corundum, Magnetite Hydroxides, Halides, Carbonates, Sulfates, Phosphates: Psilomelane, Fluorite, Calcite, Malachite, Gypsum, Apatite. 5. Study of some key silicate minerals under optical microscope and their characteristic properties

Recommended Books and References:

1. Klein, C., Dutrow, B., Dwight, J., & Klein, The 23rd Edition of the Manual of MineralScience (after James D. Dana). J. Wiley & Sons. 225
2. Kerr, P. F. (1959). Optical Mineralogy. McGraw-Hill.
3. Verma, P. K. (2010). Optical Mineralogy (Four Colour). Ane Books Pvt Ltd.
4. Deer, W. A., Howie, R. A., &Zussman, J. (1992). An introduction to the rock-formingminerals (Vol. 696). London: Longman.

SEMESTER – II

CORE 3 (GLC 2.11)
GEOMORPHOLOGY

Theory Credit: 4

UNIT I
Introduction to Geomorphology, Endogenic - Diastropism and Exogenic processes- Degradational, Aggradational, Extraterrestrial, Anthropogenic processes.

UNIT II
Topography, Hypsometry, Large Scale Topography - Ocean basins, Plate tectonics overview, Large scale mountain ranges (with emphasis on Himalaya).

UNIT III
Weathering and associated landforms. Glacial processes and landforms. Fluvial processes and landforms. Aeolian processes and landforms. Coastal processes and landforms.

UNIT IV
Rates of uplift and denudation, Tectonics and drainage development, Sea-level change, Long-term landscape development

UNIT V
Overview of Indian Geomorphology: Northern Mountains, the Great Plains, Peninsular Plateau, Coastal Plains, Desert and the Islands.

CORE 7 (GLC 2.12)
GEOMORPHOLOGY

Practical Credit: 2

Reading topographic maps; Concept of scale; Preparation of a topographic profile; Preparation of longitudinal profile of a river; Morphometry of a drainage basin; Calculating different morphometric parameters; Preparation of geomorphic maps; Interpretation of geomorphic processes from the geomorphology of the area.

Recommended Books and References:
1. Robert S. Anderson and Suzzane P. Anderson (2010): Geomorphology - The Mechanics and Chemistry of Landscapes. Cambridge University Press.
2. M.A. Summerfield (1991) Global Geomorphology. Wiley & Sons.
3. W.D.Thornburry: Principles of Geomorphology.
4. Richard John Huggett: Fundamentals of Geomorphology

CORE 4 (GLC 2.21)
STRUCTURAL GEOLOGY

Theory Credit: 4

UNIT I
Effects of topography on outcrop: Rules of 'V', topographic and structural maps; important representative factors of the map

UNIT II
Concept of rock deformation: Stress and Strain in rocks and their geological significance, Planar and linear structures; dip and strike; Outcrop patterns of different structures.

UNIT III
Fold morphology; Geometric and genetic classification of folds. Mechanics of folding: Buckling, Bending, Flexural slip and flow folding.

UNIT IV
Description and origin of foliations: axial plane cleavage and its tectonic significance.
Description and origin of lineation and relationship with the major structures

UNIT V
Geometric and genetic classification of Joints and Faults. Effects of faulting on the outcrops. Criteria for recognition of faults. Unconformity: formation and types.

CORE 4 (GLC 2.22)
STRUCTURAL GEOLOGY

Practical Credit: 2

1. Basic idea of topographic contours, Topographic sheets of various scales.
2. Introduction to Geological maps: Lithological and Structural maps
3. Structural contouring and 3-point problems of dip and strike
4. Drawing profile sections and interpretation of geological maps of different complexities
5. Exercises of stereographic projections of mesoscopic structural data (planar, linear, folded etc.)

Recommended Books and References:
1. Davis, G. R. (1984) Structural Geology of Rocks and Region. John Wiley
2. Billings, M. P. (1987) Structural Geology, 4th edition, Prentice-Hall.
3. Park, R. G. (2004) Foundations of Structural Geology. Chapman & Hall.
4. Pollard, D. D. (2005) Fundamental of Structural Geology. Cambridge University Press.
5. Ragan, D. M. (2009) Structural Geology: an introduction to geometrical techniques (4th Ed). Cambridge University Press (For Practical)
6. Lahee F. H. (1962) Field Geology. McGraw Hill

SEMESTER – III

CORE 5 (GLC 3.11)
IGNEOUS PETROLOGY

Theory Credit: 4

UNIT I
Introduction to Igneous petrology: Pressure-Temperature variation with depth. Origin, nature and emplacement of magma; magmatic differentiation and assimilation. Bowen's reaction series.

UNIT II
Classification of igneous rocks: mineralogical and chemical classification, Textures and structures of igneous rocks, Mode of occurrence of igneous rocks.

UNIT III
Phase diagrams and petrogenesis: Phase rule and Lever's rule. Binary and Ternary Phase diagrams in understanding crystal-melt equilibrium in basaltic and granitic magmas.

UNIT IV
Magmatism in different tectonic settings. Magmatism in the oceanic domains (MORB, OIB). Magmatism along the plate margins (Island arcs/continental arcs)

UNIT V
Petrogenesis of felsic, mafic and ultramafic igneous rocks: Granite, Basalt, Gabbro and Komatiites. Alkaline rocks: Kimberlites, Lamproites and Carbonatites.

CORE 5 (GLC 3.12)
IGNEOUS PETROLOGY

Practical Credit: 2

Study of important igneous rocks in hand specimens and thin sections- granite, granodiorite, diorite, gabbro, anorthosites, ultramafic rocks, basalts, andesites, trachyte, rhyolite, dacite,

Recommended Books and References:
1. Philpotts, A., & Ague, J. (2009). Principles of igneous and metamorphic petrology. Cambridge University Press.
2. Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson.
3. Rollinson, H. R. (2014). Using geochemical data: evaluation, presentation, interpretation. Routledge.
4. Raymond, L. A. (2002). Petrology: the study of igneous, sedimentary, and metamorphic rocks. McGraw-Hill Science Engineering.
5. McBirney, A. R. (1984). Igneous Petrology. San Francisco (Freeman, Cooper & Company) and Oxford (Oxford Univ. Press)

6. Myron G. Best (2001). Igneous and Metamorphic Petrology
7. K. G. Cox, J. D. Bell. (1979). The Interpretation of Igneous Rocks. Springer/Chapman & Hall.
8. Bose M.K. (1997). Igneous Petrology.
9. G W Tyrrell. (1926). Principles of Petrology. Springer

CORE 6 (GLC 3.21)
SEDIMENTARY PETROLOGY

Theory Credit: 4

UNIT I
Origin of sediments. Physical and chemical weathering. Soils - processes of formation. Soil profile and soil types. Paleosols.

UNIT II
Classification of sedimentary rocks. Textures, Grain size scale, particle size distribution, particle shape and fabric.

UNIT III
Laminar and turbulent flow, transportation and deposition. Palaeocurrent analysis: Palaeocurrents for different sedimentary environments. Sedimentary structures: Ripple marks, cross beds, mudcracks, gradded bedding, flute marks, loadcast, tracks, trails and related structures.

UNIT IV
Siliciclastic rocks: Conglomerates, sandstones, mudrocks. Carbonate rocks: limestone and its classification, dolomite and dolomitisation

UNIT V
Concepts and stages of diagenesis: Compaction, cementation and authigenesis / neomorphism. Diagenesis of sandstone.

CORE 6 (GLC 3.22)
SEDIMENTARY PETROLOGY

Practical Credit: 2

Exercises on sedimentary structures. Particle size distribution and statistical treatment
Paleocurrent analysis Petrography of clastic and non-clastic rocks through hand specimens and thin sections

Recommended Books and References:
1. Prothero, D. R., & Schwab, F. (2004). Sedimentary geology. Macmillan.

2. Tucker, M. E. (2006) Sedimenary Petrology, Blackwell Publishing.
1. 3. Collinson, J. D. & Thompson, D. B. (1988) Sedimentary structures, Unwin- Hyman, London.
3. Nichols, G. (2009) Sedimentology and Stratigraphy Second Edition. Wiley Blackwell

CORE 7 (GLC 3.31)
ELEMENTS OF GEOCHEMISTRY

Theory Credit: 4

UNIT I
Geochemistry: Definition. Elements, atoms and chemical bonding. Behaviour of elements: Goldschmidt classification of elements. Geochemical periodic table.

UNIT II
Radiogenic isotopes geochemistry: Introduction. Radioactive decays; Alpha, Beta, Gamma, Electron Capture, Spontaneous Fission. Radioactive decay equation and Geochronology.

UNIT III
Stable isotopes geochemistry: Introduction and Scope. Delta notation and Fractionation factor. Marine Quaternary $\delta^{18}O$ record and Milankovitch cycle.

UNIT IV
The solid Earth – geochemical variability of magma and its products.
The Earth in the solar system. Composition of the bulk silicate Earth. Meteorites

UNIT V
Geochemical behaviour of selected elements like Si, Al, Fe K, Na and Mg

CORE 7 (GLC 3.32)
ELEMENTS OF GEOCHEMISTRY

Practical Credit: 2

1. Types of geochemical data analysis and interpretation; of common geochemical plots.
2. Geochemical analysis of geological materials.
3. Geochemical variation diagrams and its interpretations.
4. Calculation of radioactive decay constant, half-life and parent to daughter ratios.
5. Exercises on behavior of elements in a melt.

Recommended Books and References:

1. Mason, B. (1986) Principles of Geochemistry. 3rd Edition, Wiley New York.
2. Rollinson, H. (2007) Using geochemical data – evaluation, presentation and interpretation. 2nd Edition. Publisher Longman Scientific & Technical.
3. Walther, J. V. (2009). Essentials of geochemistry. Jones & Bartlett Publishers.
4. Albarède, F. (2003). Geochemistry: an introduction. Cambridge University Press.
5. Faure, Gunter and Teresa M. Mensing (2004). Isotopes: Principles and Applications, Wiley India Pvt. Ltd
6. W.M.White Geochemistry

SKILL ENHANCEMENT COURSE

SKILL ENHANCEMENT COURSE 1 (GLS 3.12)
FIELD WORK I: BASIC FIELD TRAINING

Credit: 2

UNIT I
Orientation of Topographic sheet in field, marking location in toposheet, Bearing (Front and back). Concepts of map reading, Distance, height and pace approximation

UNIT II
Identification of rock types in field; structures and texture of rocks, Use of hand lens.

UNIT III
Basic field measurement techniques: Bedding dip and strike, Litholog measurement

UNIT IV
Reading contours and topography

SEMESTER – IV

CORE 8 (GLC 4.11)
METAMORPHIC PETROLOGY

Theory Credit: 4

UNIT I
Metamorphism: Definition of metamorphism. Factors controlling metamorphism.
Types of metamorphism - contact, regional, fault zone metamorphism, impact metamorphism.

UNIT II
Metamorphic facies and grades: Index minerals, Concept of metamorphic facies and grade, Chemographic projections, Mineralogical phase rule, Structure and textures of metamorphic rocks.

UNIT III
Metamorphism and Tectonism: Relationship between metamorphism and deformation, Prograde and retrograde metamorphism.

UNIT IV
Brief idea of anatexis and origin of migmatites. Metasomatism and role of fluids in metamorphism.

UNIT V
Metamorphic rock associations- schists, gneisses, khondalites, charnockites, eclogites, quartzite and marble.

CORE 8 (GLC 4.12)
METAMORPHIC PETROLOGY

Practical Credit: 2

Megascopic and microscopic study (textural and mineralogical) of the following metamorphic rocks:
Low grade metamorphic rocks: serpentinites, albite-epidote-chlorite quartz schist, slate, ta1c, tremolite, calcite-quartz schist.
Medium to high grade metamorphic rocks: Gneisses, amphibolite, hornfels, garnetiferous schists, sillimanite-kyanite-bearing rocks, Granulites, eclogite, diopside-forsterite marble.
Laboratory exercises in graphic plots for petrochemistry and interpretation of assemblages.

Recommended Books and References:
1. Philpotts, A., & Ague, J. (2009). *Principles of igneous and metamorphic petrology*. Cambridge University Press.
2. Winter, J. D. (2014). *Principles of igneous and metamorphic petrology*. Pearson.
3. Rollinson, H. R. (2014). *Using geochemical data: evaluation, presentation, interpretation*. Routledge.

4. Raymond, L. A. (2002). *Petrology: the study of igneous, sedimentary, and metamorphic rocks*. McGraw-Hill Science Engineering.
5. Yardley, B. W., & Yardley, B. W. D. (1989). An introduction to metamorphic petrology. Longman Earth Science Series.

CORE 9 (GLC 4.21)
STRATIGRAPHIC PRINCIPLES AND INDIAN STRATIGRAPHY

Theory Credit: 4

UNIT I
Concepts of litho-, bio- and chrono-stratigraphy. Dynamic stratigraphy: chemostratigraphy, seismic stratigraphy, sequence stratigraphy. Magnetostratigraphy.

UNIT II
International Stratigraphic Code – development of a standardized stratigraphic nomenclature. Concepts of Stratotypes. Global Stratotype Section and Point (GSSP).Concept of paleogeographic reconstruction.

UNIT III
Brief introduction to tectonic subdivisions of India.
Introduction to Indian Shield: Cratons (Dharwar, Singhbhum and Aravalli) and mobile belts.
Introduction to Proterozoic basins of India: Geology of Vindhyan and Cudappah basins.

UNIT IV
Palaeozoic succession of Kashmir and Spiti.
Mesozoic stratigraphy of India: Triassic successions of Spiti, Jurassic of Kutch, Cretaceous of Trichinopoly. Cenozoic stratigraphy of Northeast India.

UNIT V
Important Stratigraphic boundaries in India: Precambrian-Cambrian boundary, Permian-Triassic boundary and Cretaceous-Tertiary boundary. Volcanic provinces of India: Deccan, Rajmahal and Sylhet Trap.

CORE 9 (GLC 4.22)
STRATIGRAPHIC PRINCIPLES AND INDIAN STRATIGRAPHY

Practical Credit: 2

1. Study of geological map of India and identification of major stratigraphic units.
2. Study of rocks in hand specimens from known Indian stratigraphic horizons
3. Drawing various paleogeographic maps of Precambrian time
4. Study of different Proterozoic supercontinent reconstructions.

Recommended Books and References:

1. Krishnan, M. S. (1982) Geology of India and Burma, CBS Publishers, Delhi
2. Doyle, P. & Bennett, M. R. (1996) Unlocking the Stratigraphic Record. John Wiley
3. Ramakrishnan, M. &Vaidyanadhan, R. (2008) Geology of India Volumes 1 & 2, Geological society of India, Bangalore.
4. Valdiya, K. S. (2010) The making of India, Macmillan India Pvt. Ltd.

CORE 10 (GLC 4.31)
PALAEONTOLOGY

Theory Credit: 4

UNIT I

Fossilization and fossil record: Nature and importance of fossil record; Fossilization processes and modes of preservation, Introduction to Paleobotany and Gondwana Flora.

UNIT II

Species concept, Taxonomic hierarchy. Theory of organic evolution interpreted from fossil record. Ichnology.

UNIT III

Brief introduction to important invertebrate groups (Bivalvia, Gastropoda, Brachiopoda and Echinoidea) and their biostratigraphic significance. Significance of ammonites in Mesozoic biostratigraphy.

UNIT IV

Mesozoic reptiles with special reference to origin, diversity and extinction of dinosaurs. Evolution of horse and intercontinental migrations. Human Evolution.

UNIT V

Application of Fossils in stratigraphy: Biozones, index fossils and correlation. Fossils and paleoenvironmental analysis. Application of palaeontology in palaeoecology.

CORE 10 (GLC 4.32)
PALAEONTOLOGY

Practical Credit: 2

1. Study of fossils showing various modes of preservation

2. Study of diagnostic morphological characters, systematic position, stratigraphic position and age of various invertebrates, vertebrates and plant fossils

Recommended Books and References:

1. Raup, D. M., Stanley, S. M., Freeman, W. H. (1971) Principles of Paleontology
2. Clarkson, E. N. K. (2012) Invertebrate paleontology and evolution 4th Edition by Blackwell Publishing.
3. Benton, M. (2009). Vertebrate paleontology. John Wiley & Sons.
4. Shukla, A. C., &Misra, S. P. (1975). Essentials of paleobotany. Vikas Publisher
5. Armstrong, H. A., &Brasier, M.D. (2005) Microfossils. Blackwell Publishing

SEC-2 (GLS 4.12)
GEOLOGY OF NAGALAND

Theory Credit: 2

UNIT I
Introduction to Geology of Nagaland: physiography, stratigraphy and tectonic setting.

UNIT II
Schuppen belt: structure and litho-units. Inner fold belt: structure and litho-units.

UNIT III
Ophiolite belt: major litho-units, structure, tectonic setting and evolution of Naga Ophiolite Belt

UNIT IV
Mineral resources of Nagaland with special reference to coal, petroleum, limestone, metaliferrous deposits and dimensional stones.

UNIT V
Mineral resources of Nagaland with special reference to coal, petroleum, limestone, metaliferrous deposits (chromium, nickel and cobalt) and dimensional stones (marble and serpentinite).

Recommended Books and References:

1. Geology of India and Burma – M.S. Krishnan, 1982. CBS Publishers & Distributors.
2. Fundamentals of Historical Geology and Stratigraphy of India – Ravindra Kumar.
3. Geology of India – D.N. Wadia. Tata McGraw Hill Publishing.
4. Phanerozoic Ophiolites of India – P.C. Ghose. Sumna Publishers & Distributors,

SEMESTER – V

CORE 11 (GLC 5.11)
ECONOMIC GEOLOGY

Theory Credit: 4

UNIT I
Ores, gangue minerals, tenor. Metallic and non-metallic minerals. Resources and reserves. Metallogenetic provinces and Epochs. Textures and structures of ores.

UNIT II
Processes of formation of ore deposits: Magmatic, hydrothermal, metamorphic, sedimentation, residual and mechanical concentration and oxidation and supergene enrichment.

UNIT III Chemical composition, occurrence, origin, uses and distribution of the following economic mineral deposits in India: iron, manganese, chromium, copper, aluminium and gold.

UNIT IV
Chemical composition, occurrence, origin, uses and distribution of the following industrial mineral deposits in India: magnesite, graphite, mica, asbestos, sillimanite and kyanite.

UNIT V
Brief account on the following economic deposits in the North East India: coal, petroleum, limestone and uranium. Introduction to gemstones.

CORE 11 (GLC 5.12)
ECONOMIC GEOLOGY

Practical Credit: 2

Megascopic identification
Study of microscopic properties of ore forming minerals (Oxides and sulphides).
Preparation of maps: Distribution of important ores and other economic minerals in India.

Recommended Books and References:
1. Guilbert, J.M. and Park Jr., C.F. (1986) The Geology of Ore deposits. Freeman & Co.
2. Bateman, A.M. and Jensen, M.L. (1990) Economic Mineral Deposits. John Wiley.
3. Evans, A.M. (1993) Ore Geology and Industrial minerals. Wiley
4. Laurence Robb. (2005) Introduction to ore forming processes. Wiley.
5. Gokhale, K.V.G.K. and Rao, T.C. (1978) Ore deposits of India their distribution and processing, Tata-McGraw Hill, New Delhi.
6. Deb, S. (1980) Industrial minerals and rocks of India. Allied Publishers.
7. Sarkar, S.C. and Gupta, A. (2014) Crustal Evolution and Metallogeny in India. Cambridge Publications.

CORE 12 (GLC 5.21)
HYDROGEOLOGY

Theory Credit: 4

UNIT I
Origin of groundwater. Hydrologic cycle, precipitation, evapo-transpiration, run-off, interception and infiltration. Rock properties affecting groundwater, Vertical distribution of subsurface water. Aquifer parameters, Types of aquifer. Geological formations as aquifers.

UNIT II
Darcy's law, Intrinsic permeability and hydraulic conductivity, Laminar and turbulent groundwater flow. Springs, Hydrothermal phenomenon, Groundwater in permafrost region.

UNIT III
Basic concepts of well hydraulics and groundwater exploration. Surface-based groundwater exploration methods. Introduction to subsurface borehole logging methods.

UNIT IV
Physical and chemical properties of water and water quality. Introduction to methods of interpreting groundwater quality data using standard graphical plots, Sea water intrusion in coastal aquifers.

UNIT V
Surface and subsurface water interaction. Groundwater level fluctuations. Basic concepts of water balance studies, issues related to groundwater resources development and management. Rainwater harvesting.

CORE 3 (GLC 5.22)
HYDROGEOLOGY

Practical Credit: 2

Preparation and interpretation of water level contour maps and depth to water level maps
Study, preparation and analysis of hydrographs for differing groundwater conditions
Water potential zones of India (map study).
Graphical representation of chemical quality data and water classification (C-S and Trilinear diagrams)
Simple numerical problems related to: determination of permeability in field and laboratory, Groundwater flow, Well hydraulics etc.

Recommended Books and References:

1. Todd, D. K. 2006. Groundwater hydrology, 2nd Ed., John Wiley & Sons, N.Y.
2. Davis, S. N. and De Weist, R.J.M. 1966. Hydrogeology, John Wiley & Sons Inc., N.Y.
3. Karanth K.R., 1987, Groundwater: Assessment, Development and management, Tata McGraw- Hill Pub. Co. Ltd.

DISCIPLINE SPECIFIC ELECTIVE

DISCIPLINE SPECIFIC ELECTIVE 1 (GLD 5.11(a))
EXPLORATION GEOLOGY

Theory Credit: 4

UNIT I

Prospecting and exploration-conceptualization, methodology and stages. Principles of mineral exploration.

UNIT II

Geological mapping and sampling methods. Geochemical exploration. Remote sensing. Principles of Geophysical prospecting methods (Gravity, Magnetic, Seismic and Radioactive methods).

UNIT III

Core and non-core drilling, Planning of bore holes and location of boreholes on ground Core-logging

UNIT IV

Reserve estimations and Errors, Principles of reserve estimation, density and bulk density, Factors affecting reliability of reserve estimation, Reserve estimation based on geometrical models (square, rectangular, triangular and polygon blocks).

UNIT V

Principles of Mineral economics: strategic, critical and essential minerals. National and domestic mineral policies. Mineral concession rules. Marine mineral resources. Laws of the sea

DISCIPLINE SPECIFIC ELECTIVE 1 (GLD 5.12(a))
EXPLORATION GEOLOGY

Practical Credit: 2

1. Seismic prospecting exercises
2. Gravity prospecting exercises
3. Identification of anomalies
4. Concept of weighted average in anomaly detection
5. Geological cross-section
6. Ore reserve estimation

Recommended Books and References:

1. Mineral exploration: Principles and Applications. S.K Haldar
2. Clark, G.B. 1967. Elements of Mining. 3rd Ed. John Wiley & Sons.
3. Arogyaswami, R.P.N. 1996 Courses in Mining Geology. 4th Ed. Oxford-IBH.
4. Moon, C.J., Whateley, M.K.G., Evans, A.M., 2006, Introduction to Mineral Exploration, Blackwell Publishing

DISCIPLINE SPECIFIC ELECTIVE 1 (GLD 5.11(b))
EVOLUTION OF LIFE THROUGH TIME

Theory Credit: 4

UNIT I

Fossils and chemical remains of ancient life. Geological Time Scale with emphasis on major bio-events. Fossilization processes and modes of fossil preservation.

UNIT II

Biosphere as a system, processes and products. Biogeochemical cycles. Microbes mineral interactions, microbial mats.

UNIT III

Archean life: Earth's oldest life, Transition from Archean to Proterozoic, the oxygen revolution and radiation of life. Precambrian macrofossils – The garden of Ediacara.

UNIT IV

The Cambrian Explosion. Origin of vertebrates and radiation of fishes. Origin of tetrapods - Life out of water. Early land plants and impact of land vegetation.

UNIT V

Life after the largest (P/T) mass extinction, life in the Jurassic seas. Origin of mammals. Rise and fall of dinosaurs. Origin of birds; and spread of flowering plants.

DISCIPLINE SPECIFIC ELECTIVE 1 (GLD 5.12(b))
EVOLUTION OF LIFE THROUGH TIME

Practical Credit: 2

1. Study of modes of fossil preservation
2. Study of fossils from different stratigraphic levels
3. Exercises related to major evolutionary trends in important groups of animals and plants

Recommended Books and References:

1. Stanley, S.M., 2008 Earth System History
2. Jonathan I. LumineW.H.Freeman Earth-Evolution of a Habitable World, Cambridge

University Press.
3. Canfield, D.E. &Konhauser, K.O., 2012 Fundamentals of Geobiology Blackwell
4. Cowen, R., 2000 History of Life, Blackwell

DISCIPLINE SPECIFIC ELECTIVE 2 (GLD 5.21(a))
ENVIRONMENTAL GEOLOGY

Theory Credit: 4

UNIT I
Introduction to environmental geology; cultural and environmental awareness, geology a basic environment awareness, geology as a basic environmental Science. Earth as a system, Sustainability and limitation of resources.

UNIT II Environmental pollution: causes, impacts, remediation/mitigation measures of air and water pollution. Vehicular pollution.

UNIT III Geological hazards: Primary and secondary hazards, Seismic engineering, easy warning systems, Planning and education. Stabilizing hill slopes and controlling landslides, Vulnerability zone, types and mitigation measures.

UNIT IV Anthropogenic hazard: causes, impact and preventive measures on deforestation. Soil sickness, soil loss equation, conservation method.

UNIT V
Geo- environmental Problems of NE India: Geological and topographic characteristics, climate, drainage, groundwater, soil, land use, land capability, forest cover and their mitigation.

DISCIPLINE SPECIFIC ELECTIVE 3 (GLD 5.22(a))
ENVIRONMENTAL GEOLOGY

Practical Credit: 2

Case studies on population growth, deforestation, water and air pollution, earthquake zones of the world, landslide zonation maps and geo environmental problems of North east India.

Recommended Books and References:
1. Environmental Geology - E.A. Keller.
2. Environmental Problems and Solutions - D.K. Asthana.
3. Environmental Science and Engineering – R. Sivakumar.
4. Ecology and Environment - P.D. Sharma.

DISCIPLINE SPECIFIC ELECTIVE 2 (GLD 5.21(b))
INTRODUCTION TO GEOPHYSICS

Theory Credit: 4

UNIT I
Interrelationship between geology and geophysics, Role of geological and geophysical data in explaining geodynamical features of the earth.

UNIT II
Different types of geophysical methods - gravity, magnetic, electrical and seismic; their principles and applications. Concepts and Usage of corrections in geophysical data.

UNIT III
Different types of surveys, grid and route surveys, profiling and sounding techniques. Scales of survey, Presentation of geophysical data.

UNIT IV
Regional geophysics, oil and gas geophysics, ore geophysics, groundwater geophysics, engineering geophysics.

UNIT V
Correction to measured quantities, geophysical, anomaly, regional and residual (local) anomalies, factors controlling anomaly, and depth of exploration

DISCIPLINE SPECIFIC ELECTIVE 2 (GLD 5.22(b))
INTRODUCTION TO GEOPHYSICS
Practical Credit: 2
1. Anomaly and background- Graphical method
2. Study and interpretation of seismic reflector geometry
3. Problems on gravity anomaly

Recommended Books and References:
1. Outlines of Geophysical Prospecting - A manual for geologists by Ramachandra Rao,M.B., Prasaranga, University of Mysore, Mysore, 1975.
2. Exploration Geophysics - An Outline by Bhimasarikaram V.L.S., Association of Exploration Geophysicists, Osmania University, Hyderabad, 1990.
3. Dobrin, M.B. (1984) An introduction to Geophysical Prospecting. McGraw-Hill, New Delhi.
4. Telford, W. M., Geldart, L. P., & Sheriff, R. E. (1990). *Applied geophysics* (Vol. 1). Cambridge university press.
5. Lowrie, W. (2007). Fundamentals of geophysics. Cambridge University Press.

SEMESTER – VI

CORE 13 (GLC 6.11)
ENGINEERING GEOLOGY

Theory Credit: 4

UNIT I
Role of Geology in Engineering. Site investigation and characterization (relief, lithology, structures, ground water conditions). Engineering properties of rocks.

UNIT II
Foundation treatment: Grouting, Rock Bolting and other support mechanisms. Rock aggregates: significance as construction material.

UNIT III
Concept, Mechanism and Significance of: Rock Structure Rating (RSR), Rock Mass Rating (RMR) and Tunneling Quality Index (TQI).

UNIT IV
Geological considerations in the constructions of Dams and Reservoir. Tunnels and Tunnelling methods.

UNIT V
Geological considerations in the constructions of Highways and Bridges. Landslides: causes and corrective/preventive measures.

CORE 13 (GLC 6.12)
ENGINEERING GEOLOGY

Practical Credit: 2

1. Computation of reservoir area, catchment area, reservoir capacity and reservoir life.
2. Merits, demerits & remedial measures based upon geological cross sections of project sites.
3. Computation of Index properties of rocks.
4. Computation of RQD, RSR, RMR and 'Q'

Recommended Books and References:
1. Krynin, D.P. and Judd W.R. 1957. Principles of Engineering Geology and Geotechnique, McGraw Hill (CBS Publ).
2. Johnson, R.B. and De Graf, J.V. 1988. Principles of Engineering Geology, John Wiley.
3. Goodman, R.E., 1993. Engineering Geology: Rock in Engineering constructions. John Wiley &Sons, N.Y.
4. Waltham, T., 2009. Foundations of Engineering Geology (3rd Edn.) Taylor & Francis.
5. Bell: F.G-, 2006. Basic Environmental and Engineering Geology Whittles Publishing.
6. Bell, .F.G, 2007. *Engineering Geology,* Butterworth-Heineman

CORE 14 (GLC 6.21)
REMOTE SENSING AND GIS

Theory Credit: 4

UNIT I
Concepts in Remote Sensing. Photogeology: Types and acquisition of aerial photographs. Scale and resolution. Principles of stereoscopy, relief displacement, vertical exaggeration and distortion.

UNIT II
Elements of air photo interpretation. Identification of sedimentary, igneous and metamorphic rocks. Sensors and scanners. Satellites and their characteristics.

UNIT III
Digital image processing, Pre-processing: Radiometric correction, Geometric correction, Image processing systems. Image Enhancement, Filtering, Image Rationing.

UNIT IV
GIS: Definition, Datum, Coordinate systems and Projection systems. Spatial data models. Application of GIS in resource mapping.

UNIT V
GPS: Introduction and working principle of GPS. Components of GPS. GPS satellite constellations. GPS signal. Applications in geosciences.

CORE 14 (GLC 6.22)
REMOTE SENSING AND GIS

Practical Credit: 2

1. Aerial Photo interpretation, identification of sedimentary, igneous and metamorphic rocks and various aeolian, glacial, fluvial and marine landforms
2. Introduction to DIP software. Digital Image Processing exercises including analysis of satellite data in different bands and interpretation of various objects on the basis of their spectral signatures Creating a FCC from raw data, registration of satellite data with a toposheet of the area
3. Enhancing the satellite images; Generating NDVI images and other image ratio and its interpretation
4. GIS: Introduction to basic GIS software and demonstration.

Recommended Books and References:
1. Demers, M.N., 1997. *Fundamentals of Geographic Information System*, John Wiley & sons. Inc.
2. Hoffmann-Wellenhof, B., Lichtenegger, H. and Collins, J., 2001. *GPS: Theory & Practice*,

Springer Wien New York.
3. Jensen, J.R., 1996. *Introductory Digital Image Processing: A Remote Sensing Perspective*, Springer- Verlag.
4. Lillesand, T. M. & Kiefer, R.W., 2007. *Remote Sensing and Image Interpretation*, Wiley.
5. Richards, J.A. and Jia, X., 1999. *Remote Sensing Digital Image Analysis*, Springer-Verlag.
6. Stephen R Galati. Geographic Information System Demystified.

DISCIPLINE SPECIFIC ELECTIVE 3 (GLD 6.11(a))
FUEL GEOLOGY

Theory Credit: 4

UNIT I
Definition and origin of Coal. Basic classification of coal. Introduction to lithotypes, micro lithotypes and macerals in coal, Proximate and Ultimate analysis.

UNIT II
Coal Bed Methane (CBM): Introduction, fundamentals of coal bed methane production. Underground coal gasification and Coal liquefaction.

UNIT III
Origin of crude oil. Chemical composition and physical properties of crude oil. Migration of crude oil and its types.

UNIT IV
Reservoir rocks - clastic and chemical, hydrocarbon traps - structural, stratigraphic and combination, Cap rocks - definition and general properties.

UNIT V
Gas Hydrates. Radioactive minerals: Occurrence and origin of Uranium and Thorium bearing minerals, reserves in India. Nuclear waste disposal.

DISCIPLINE SPECIFIC ELECTIVE 3 (GLD 6.12(a))
FUEL GEOLOGY

Practical Credit: 2

1. Study of hand specimens of coal
2. Reserve estimation of coal
3. Plot the different sedimentary basins and nuclear minerals on the outline map of India.
4. Prepare structural contour maps
5. Reserve estimation of crude oil

Recommended Books and References:

1. Chandra D. (2007). Chandra's Textbook on applied coal petrology. Jijnasa Publishing House.
2. Shelly R. C. (2014). Elements of Petroleum geology: Third Edition, Academic Press
3. Bjorlykke, K. (1989). Sedimentology and petroleum geology. Springer-Verlag.
4. Bastia, R., & Radhakrishna, M. (2012). Basin evolution and petroleum prospectivity of the continental margins of India (Vol. 59). Newnes.

DISCIPLINE SPECIFIC ELECTIVE 3 (GLD 6.11(b))
URBAN GEOLOGY

Theory Credit: 4

UNIT I

Geology in Urban Constructions. Geotechnical feature and mapping for subsurface in Metropolitan areas. Building materials, Excavation and cutting in urban areas.

UNIT II

Soil studies, Chemistry and geochemistry of soil in relation to ground water and fertilizer. Effect of pollutants on vegetable contamination.

UNIT III

Geotechnical site characterization, Geotechnical and land use mapping, Decision making in urban land use, Geological problems in construction of underground structures in urban areas.

UNIT IV

Water lagging in built-up areas, Source of water, Standards for various uses of water. Sources of contamination. Waste waters: Sources and its disinfection and treatment.

UNIT V

Geotechnical characterization for waste sites, Domestic waste, Industrial waste, Need for special purpose mapping for selection of waste disposal sites.

DISCIPLINE SPECIFIC ELECTIVE 3 (GLD 6.12(b)
URBAN GEOLOGY

Practical Credit: 2

1. Map Reading
2. Ground water flow direction estimation
3. Case studies of Urban flood; Flood hydrographs
4. Case studies of urban planning

Recommended Books and References:

1. Huggenberger, P. and Eptin, J. 2011 Urban Geology: Process-Oriented Concepts for Adaptive and Integrated Resource Management. Springer
2. Lollino, G. et al. (Ed.), Engineering Geology for Society and Territory. Springer

DISCIPLINE SPECIFIC ELECTIVE 4 (GLD 6.21(a))
FIELD WORK II

Credit: 4

Field training along Precambrian/Tertiary terrain/Economic geology field, etc. Documentation of stratigraphic details in the field. Collection of sedimentological, stratigraphic and structural details. Basic techniques of surveying, concept of outcrop mapping

DISCIPLINE SPECIFIC ELECTIVE 4 (GLD 6.22(a))
SEMINAR

Credit: 2

Seminar

DISCIPLINE SPECIFIC ELECTIVE 4 (GLD 6.21(b))
EARTH AND CLIMATE

Theory Credit: 4

UNIT I

Components of the climate system. Climate forcing, Climate controlling factors. Climate system response, response rates and interactions within the climate system.

UNIT II

Incoming solar radiation, receipt and storage of heat. Heat transformation. Earth's heat budget. Interactions amongst various sources of earth's heat.

UNIT III
Layering of atmosphere and atmospheric Circulation. Atmosphere and ocean interaction and its effect on climate. Heat transfer in ocean. Global oceanic conveyor belt and its control on earth's climate.

UNIT IV
Climate Change: natural vs. anthropogenic effects. Humans and climate change. Brief introduction to archives of climate change.

UNIT V
Milankovitch cycles and variability in the climate. Glacial-interglacial stages. Pleistocene Glacial-Interglacial cycles. Marine isotope stages.

UNIT VI
Mechanism of monsoon. Monsoonal variation through time. Factors associated with monsoonal intensity. Effects of monsoon.

DISCIPLINE SPECIFIC ELECTIVE 4 (GLD 6.22(b))
EARTH AND CLIMATE

Practical Credit: 2

1. Study of distribution of major climatic regimes of India on map
2. Distribution of major wind patterns on World map
3. Preparation of paleogeographic maps (distribution of land and sea) of India during specific geological time intervals
4. Numerical exercises on interpretation of proxy records for paleoclimate

Recommended Books and References:
1. Rudiman, W.F., 2001. Earth's climate: past and future. Edition 2, Freeman Publisher.
2. Rohli, R.V., and Vega, A.J., 2007. Climatology. Jones and Barlatt
3. Lutgens, F., Tarbuck, E., and Tasa, D., 2009. The Atmosphere: An Introduction toMeteorology. Pearson Publisher
4. Aguado, E., and Burt, J., 2009. Understanding weather

GENERIC ELECTIVE
GEOLOGY

SEMESTER	COURSE	COURSE NAME	COURSE CODE	CREDIT
I	Generic Elective 1	Essentials Of Geology (Theory) OR Earth Surface Processes (Theory)	GLG 1.11(a) GLG 1.11(b)	4
		Essentials Of Geology (Practical) OR Earth Surface Processes (Practical)	GLG 1.12(a) GLG 1.12(b)	2
II	Generic Elective 2	Rocks And Minerals (Theory) OR Soils: Present And Past (Theory)	GLG 2.11(a) GLG 2.11(b)	4
		Rocks And Minerals (Practical) OR Soils: Present And Past (Practical)	GLG 2.12(a) GLG 2.12(b)	2
III	Generic Elective 3	Fossils And Their Applications (Theory) OR Earth Resources (Theory)	GLG 3.11(a) GLG 3.11(b)	4
		Fossils And Their Applications (Practical) OR Earth Resources(Practical)	GLG 3.12(a) GLG 3.12(b)	2
IV	Generic Elective 4	Natural Hazards And Disaster Management (Theory) OR Nuclear Waste Management (Theory)	GLG 4.11(a) GLG 4.11(b)	4
		Natural Hazards And Disaster Management (Practical) OR Nuclear Waste Management (Practical)	GLG 4.12(a) GLG 4.12(b)	2
				24

SEMESTER I

GENERIC ELECTIVE 1 (GLG 1.11(a))
ESSENTIALS OF GEOLOGY

Theory Credit: 4

UNIT I
Introduction to geology, scope and its relationship with other branches of sciences
Solar System- Introduction to Various planets - Terrestrial Planets and Jovian Planets
Origin of the earth: Nebular, planetesimal and tidal hypothesis
Earth's size, shape, mass, density, rotational and revolutional parameters

UNIT II
Atmosphere: composition and structure. Hydrosphere, Composition of sea water. Lithosphere: Composition and internal structure.

UNIT III
Concept of Plate tectonics: Continental drift and Seafloor spreading. Origin of mountains, oceans and continents.

UNIT IV
Earthquakes: causes and kinds of seismic waves, Richter and Mercalli scale. Volcanoes- types, products and their distribution. Convection in Earth's core and production of its magnetic field

UNIT V
Age of the earth; sedimentation method, rate of cooling of the earth, Varved sediment method. Radioactivity and its application in determining the age of the Earth. Geological time scale.

GENERIC ELECTIVE (GLG 1.12(a))
ESSENTIALS OF GEOLOGY

Practical Credit: 2
1. Study of major geomorphic features and their relationships with outcrops through physiographic models.
2. Study of topographic sheets and preparation of physiographic description of an area
3. Study of distribution of major dams on map of India and their impact on river systems
4. Study of major ocean currents of the World
5. Study of seismic zone maps

Recommended Books and References:
1. Holmes' Principles of Physical Geology. 1992. Chapman & Hall.
2. Emiliani, C, 1992. Planet Earth, Cosmology, Geology and the Evolution of Life and Environment. Cambridge University Press.
3. Gross, M.G., 1977. *Oceanography: A view of the Earth*, Prentice Hall.

GENERIC ELECTIVE (GLG 1.11(b))
EARTH SURFACE RESOURCES

Theory Credit: 4

UNIT I
Historical development in concepts, terrestrial relief, scales in geomorphology.

UNIT II
Weathering and formation of soils, karst and speleology, slope and catchment erosion processes, fluvial, aeolian, glacial, peri-glacial and coastal processes and resultant landforms, , Water and sediment flux in river systems, Morphometric analysis of drainage basin and geomorphology-hydrology relationship.

UNIT III
Techniques for measuring rates of processes: sediment budgeting, rock magnetism, isotope geochemical tracers, cosmogenic nuclides, OSL & C-14 dating.

UNIT IV
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.

UNIT V
Spatial & temporal scales, geomorphic system, connectivity, buffering, magnitude frequency concept, time lag, sensitivity, equilibrium, threshold, non-linearity & complexities. Mega geomorphology and process interrelationship. Surface processes and natural hazards; Applied aspects of geomorphology; Introduction to planetary geomorphology.

GENERIC ELECTIVE (GEOL 1.12(b))
EARTH SURFACE RESOURCES

Practical Credit: 2

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

Recommended Books and References:
1. Alien, P.A., 1997. *Earth Surface Processes,* Blackwell publishing.
2. Bloom, A.L., 1998. *Geomorphology: A Systematic Analysis of Late Cenozoic Landforms,*PearsonEducation.
3. Bridge, J.S. and Demicco, R.V., 2008. *Earth Surface Processes, Landforms and Sediment Deposits,*Cambridge University Press.

4. Esterbrook, D.J., 1992. *Surface Processes and Landforms,* MacMillan Publ.
5. Kale, V.S. and Gupta A 2001 *1ntoduction 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 1991Globle *Geomorphology* Prentice Hall.
8. Wilcock, P.R., Iverson R M (2003) Prediction in geomorphology ' AGU Publication.

SEMESTER II

GENERIC ELECTIVE (GLG 2.11(a))
ROCKS AND MINERALS

Theory Credit: 4

UNIT I
Minerals-Definitions, Physical properties of minerals: Color, Lustre, transparency and translucency, form, hardness, fracture, streak, cleavage, specific gravity.

UNIT II
Study of petrological microscope, nature of light, Isotropic and Anisotropic substances, Refractive Index, Interference color, Extinction, Pleochroism absorption, twinning.

UNIT III
Igneous rocks: nature and origin. Magma differentiation and assimilation. Classification of igneous rocks.

UNIT IV
Sedimentary rocks: sedimentary processes- physical, chemical and biological weathering, transportation, diagenesis. Classification of sedimentary rocks.

UNIT V
Metamorphic rocks- agents, types of metamorphism. Textures and structures of metamorphic rocks.

GENERIC ELECTIVE (GLG 2.12(a))
ROCKS AND MINERALS

Practical Credit: 2
1. Study of physical properties of minerals
2. Study of optical properties of minerals
3. Study of physical properties of rocks
4. Study of optical properties of rock under thin sections

Recommended Books and References:
1. Earth Materials- Introduction to Mineralogy and Petrology, Cornelis Klein and Anthony Philpotts, Cambridge University Press, 2013.
2. Understanding Earth (Sixth Edition), John Grotzinger and Thomas H. Jordan, 2010, W.H. Freeman and company, New York.

GENERIC ELECTIVE (GLG 2.11(b))
SOILS: PRESENT AND PAST

Theory Credit: 4

UNIT I
Soil forming processes: Physical weathering, loosening and particle size reduction; pressure release; thermal expansion; growth of foreign crystal.

UNIT II
Soil structures; horizons; roots; Fe-Mn mottles and concretions; pedogenic carbonate.
Introduction to paleopedology and paleosols; role of factors controlling paleosol formation- parent material, climate, vegetation, topography, time.

UNIT III
Introduction to soil taxonomy and paleosol taxonomy. Micromorphology: Thin section analysis of paleosols. Geochemistry: molecular rations; chemical weathering indices.

UNIT IV
Diagenetic overprinting in fossil soils: compaction; oxidation of organic matter; cementation; Illitization. Geological record of fossil soils.

UNIT V
Pleistocene-Holocene paleosols- human impact on landscape and soils, climate change, neotectonics. Paleosols and non-marine sequence stratigraphy based on paleopedology and sedimentology of fluvial successions.

GENERIC ELECTIVE (GLG 2.12(B))
SOILS: PRESENT AND PAST

Practical Credit: 2
1. Micromorphic detailing of the paleosols- structure, horizonation, color, rhizocretions, Pedogenic carbonate etc.
2. Particle size analysis and clay mineral analysis of the paleosols
3. Micromorphological analysis- thin section preparation, description, and interpretation
4. Geochemical analysis- bulk geochemistry, molecular rations and weathering indices
5. Field trip to examine modern and fossil soils- field characterization and sampling procedures

Recommended Books and References:
1. Retallack, G.J. (2001) *Soils of the Past: An Introduction to Paleopedology* (2nd edition): Oxford, Blackwell Science, Ltd., 416 p.
2. Birkeland, P.W. (1999) Soil and Geomorphology. Oxford University Press (430 pp.). reconstruction using paleosols. Earth-Science Reviews 95, 1–52.
5. Stoops, G. (2003) Guidelines for analysis and distribution of soil and regolith thin sections. SoilSci. Soc. Am., Madison, Wisconsin, 184 pp.
7. Bhattacharyya T., Sarkar, D., Pal, D. K. (Eds.) Soil Survey Manual. NBSSLUP Publication No

SEMESTER III

GENERIC ELECTIVE (GLG 3.11(a))
FOSSILS AND THEIR APPLICATION

Theory Credit: 4

UNIT I
Definition of fossil, Types, fossilization processes (taphonomy), modes of fossil preservation, fossils sampling techniques, uses of fossils

UNIT II
Definition of species, speciation, methods of description and naming of fossils, code of systematic nomenclature

UNIT III
Brief introduction of important fossils groups: invertebrate, vertebrate, microfossils, spore, pollens and plant fossils. Important age-diagnostic fossiliferous horizons of India

UNIT IV
Principles and methods of paleoecology, application of fossils in the study of paleoecology, paleobiogeography and paleoclimate

UNIT V
Morphological study and geological distribution of the following classes: brachiopoda, lamellibranchia, gastropoda and cephalopoda.

GENERIC ELECTIVE (GLG 3.12(a))
FOSSILS AND THEIR APPLICATIONS

Practical Credit: 2

1. Study of fossils showing various modes of fossilization
2. Distribution of age diagnostic fossils in India
3. Biostratigraphic correlation

Recommended Books and References:
1. Schoch, R.M. 1989. Stratigraphy, Principles and Methods.VanNostrand Reinhold.
2. Clarkson, E.N.K.1998. Invertebrate Paleontology and Evolution George AlIen&Unwin
3. Prothero, D.R. 1998. Bringing fossils to life - An introduction to Paleobiology, McGraw Hill.
4. Benton, M.J. 2005. Vertebrate paleontology (3rd edition). Blackwell Scientific, Oxford.
5. Colbert's Evolution of the Vertebrates: A History of the Backboned Animals Through Time,EdwinH. Colbert, Michael Morales, Eli C. Minkoff, John Wiley & Sons, 1991.

GENERIC ELECTIVE (GLG 3.11(B))
EARTH RESOURCES

Theory Credit: 4

UNIT I
Resource and reserve definitions. Mineral, energy and water resources in industries. A brief overview of classification of mineral deposits.

UNIT II
Definition of Energy: Primary and Secondary Energy. Difference between Energy, Power and Electricity. Renewable and Non-Renewable Sources of Energy.

UNIT III
Major Types and Sources of Energy: Natural Oil and Gas, Coal and Nuclear Minerals. Potential of Hydroelectric Power, Solar Energy, Wind, Wave and Biomass based power and energy.

UNIT IV
Vertical distribution of groundwater. Ground water resources and its role in economic development of a country. Impact of urbanization on groundwater. Potential of Hydroelectric Power.

UNIT V
Metallic and non-metallic mineral deposits.
Metallic deposits: Precious metals, ferrous, non-ferrous mineral deposits
Non metallic: Gemstones, building material, industrial, fertilizer mineral deposits.

GENERIC ELECTIVE (GLG 3.12(b))
EARTH RESOURCES

Practical Credit: 2

1. Plotting of major Indian oil fields on map of India
2. Problems related to hydroelectric power generation
3. Problems related to bio fuel
4. Problems related to metallic and non-metallic mineral deposits
5. Problems related to nuclear minerals

Recommended Books and References:
1. Energy and the Environment by Fowler, J.M 1984. McGraw-Hill
2. Global Energy Perspectives by Nebojsa Nakicenovic 1998, Cambridge University Press.
3. Energy Resources and Systems: Fundamentals and Non-Renewable Resources by Tushar K. Ghosh and M. A. Prelas. 2009, Springer

SEMESTER IV

GENERIC ELECTIVE (GLG 4.11(a))
NATURAL HAZARDS AND DISASTER MANAGEMENT

Theory Credit: 4

UNIT I
Introduction to natural hazards and disaster management.
Atmospheric Hazards, Hydrosphere and Related Hazards
Types of disaster: natural and manmade- cyclone, flood and tsunami

UNIT II
The Lithosphere and Related Hazards
Types of disaster: natural and manmade- land slide, land subsidence, fire and earthquake and volcanic eruption

UNIT III
Disaster management, mitigation, and preparedness, Techniques of monitoring and design against the disasters, Management issues related to disaster

UNIT IV
Risk, Vulnerability and Hazard, Mitigation through capacity building, Pre-disaster risk & vulnerability reduction, Post disaster recovery & rehabilitation

UNIT V
Prevention and rehabilitation: Emergency alert System, Management, Bhopal Gas leak disaster. Disaster related infrastructure development

GENERIC ELECTIVE (GLG 4.12(a))
NATURAL HAZARDS AND DISASTER MANAGEMENT

Practical Credit: 2

Trainings in first aid, relief, rescue and mock drill.
The course will also include discussions on topics assigned to students based on their interest.

Recommended Books and References:
1. Bell, F.G., 1999. Geological Hazards, Routledge, London.
2. Bryant, E., 1985. Natural Hazards, Cambridge University Press.
3. Smith, K., 1992. Environmental Hazards. Routledge, London.
4. Subramaniam, V., 2001. Textbook in Environmental Science, Narosa International

GENERIC ELECTIVE (GLG 4.11(b))
NUCLEAR WASTE

Theory Credit: 4

UNIT I
Nuclear reactors and generation of nuclear waste, nuclear fuel cycle.

UNIT II
Basic concepts about nuclear waste management. Classification, composition and types of nuclear waste, their sources and characteristics.

UNIT III
Introduction to immobilization and vitrification processes. Nuclear waste forms and containments. Immobilization of nuclear waste in synthetic glasses and natural glass/rocks (acidic: obsidian, rhyolite and basic: nephilinite and basaltic).

UNIT IV
Glass/rock characterization and its long-term performance assessment. Geochemistry of glass/rock-water interaction-solution and neoformed mineral chemistry.

UNIT V
Nuclear waste confinement and safe disposal in deep geological repository. Application of clays as natural barrier.

GENERIC ELECTIVE (GLG 4.12(b))
NUCLEAR WASTE

Practical Credit: 2
1. Determination of physical properties such as hardness, durability, melting and pouring temperatures.
2. Chemical characterization of synthetic and natural glass.
3. Mathematical modeling and extrapolation of synthetic glass alterations.
4. Determination of rate of alteration and recognition of neo-formed minerals.
5. Calculation of retention coefficient for glass residue.

Recommended Books and References:
1. Saling, J. (2001). Radioactive waste management. CRC Press.
2. Ojovan, M. I., & Lee, W. E. (2013). An introduction to nuclear waste immobilisation. Newnes.
3. Bethke, C. M. (2007). Geochemical and biogeochemical reaction modeling. Cambridge University Press.