GOA UNIVERSITY
TALEIGAO PLATEAU-GOA

Course Structure of BSc Geology Honours Degree Programme w.e.f. 2017-18

Year	Sem-ester	Core Course	DSE	SEC	GE
Credits		**6 credits each**	**6 credits each**	**4 credits**	**4 credits**
First Year	**I**	GCC-1: Fundamental of Mineral Science GCC-2: Physical Geology GCC-3: Economic Geology			GGE1
	II	GCC-4: Introduction to Petrology GCC-5: Mineralogy GCC-6: Field Geology			GGE2
Second Year	**III**	GCC-7: Earth's Dynamics & Structural Geology GCC-8: Crystallography & Optical Mineralogy GCC-9: Sedimentary Petrology		SEC1	GGE3
	IV	GCC-10: Principles of Stratigraphy and Palaeontology GCC-11: Structural Geology GCC-12: Metamorphic Petrology		SEC2	GGE4
Third Year	**V**	GCC-13: Igneous Petrology	GDSE-1: Engineering Geology GDSE-2: Hydrogeology GDSE-3: Mining Geology GDSE-4: Environmental Geology	SEC3	
	VI	GCC-14: Indian Stratigraphy	GDSE-5: Geomorphology GDSE-6: Remote Sensing and Photogeology GDSE-7: Coal and Petroleum Geology GDSE-8: Gemology	SEC4	

Note: Project work will be in lieu of one GDSE of 6 credits running in both Vth and VIth semesters. Project and field work workload of the guiding/accompanying teachers will be computed as per the stipulated guidelines from time to time. Field training duration in FY, SY and TY BSc Geology is integrated in the practical components of the relevant courses. The field training programs will be preferably conducted in the intervening period between the semesters. The field training programs are compulsory components and the evaluation of the performance will be carried out during and after the field trainings.

GOA UNIVERSITY
TALEIGAO PLATEAU-GOA

Course Structure of B.Sc. Earth Science General Degree programme w.e.f. 2017-18

Year	Semester	CC	DSE	SEC	GE
Credits		**6 credits each**	**6 credits each**	**4 credits**	**4 credits**
First Year	**I**	GCC-1: Fundamentals of Mineral Science			
	II	GCC-4: Introduction to Petrology			
Second Year	**III**	GCC-7: Earth's Dynamics & Structural Geology			GGE-1
	IV	GCC-10: Principles of Stratigraphy and Palaeontology			GGE-2
Third Year	**V**		GDSE-1: Engineering Geology GDSE-2: Hydrogeology GDSE-3: Mining Geology GDSE-4: Environmental Geology	SEC1	
	VI		GDSE-5: Geomorphology GDSE-6: Remote Sensing and Photogeology GDSE-7: Coal and Petroleum Geology GDSE-8: Gemology	SEC1	

Note: Project work will be in lieu of one GDSE of 6 credits running in both Vth and VIth semesters. Project and field work workload of the guiding/accompanying teachers will be computed as per the stipulated guidelines from time to time. Field training duration in FY, SY and TY BSc Geology is integrated in the practical components of the relevant courses. The field training programs will be preferably conducted in the intervening period between the semesters. The field training programs are compulsory components and the evaluation of the performance will be carried out during and after the field trainings.

CBCS SYLLABUS of B.Sc. GEOLOGY: (AY 2017-18 onwards)

CORE COURSE: GEOLOGY
Paper-GCC1: Fundamentals of Mineral Science
(Credits: Theory-4; Practical-2)

THEORY:

Introduction to Geology, Earth in the Solar system- origin, size, shape and its age. Internal structure of the Earth.

Mineralogy: Elemental and Oxide composition of the Earth's Crust; Definition of a mineral;

Important and abundant mineral groups: Silicates, Sulphides, Sulphates, Carbonates, Oxides, Halides, Native metals with examples.

Physical Properties of Minerals: Colour, Streak, Luster, Transparency, Habit (Imitative form), Cleavage, Hardness, Fracture, Specific Gravity, luminescence. (15L)

Classification of Silicates according to Structure: Orthosilicates: Olivine Group; Inosilicates: Pyroxene and Amphibole groups;

Tectosilicates: Silica and Feldspar Groups; Phyllosilicates: Mica Group.

Mineralogy of Carbonate, Sulphides, Phosphates, Oxide and hydroxide groups, sulphides.
(15L)

Crystallography: Definition of a crystal; crystalline state and amorphous state; Atomic arrangement in crystalline matter; Types of Bonds. Three-dimensional order and repetitions in crystal space lattice and unit cell; Bravais lattices as building blocks for the crystal system. (15L)

Crystallographic axes and classification of crystals into Crystal systems and 32 point groups; Symmetry in crystals: Planes, Axes and Centre of Symmetry; Interfacial angle and Contact Goniometer; Parameters and Indices; Polymorphism, Isomorphism and Pseudo-morphism. (15L)

PRACTICAL:

Study of minimum 30 Crystal models representing all the crystal systems. (15P)

Identification and Description of the Physical Properties, Composition, Occurrences and Uses of minimum 30 common rock forming minerals. (15P)

Books:

1. Rutley's Elements of Mineralogy by H. H. Reed (Twenty-sixth Ed) (CBS Publishers & distributors)
2. Dana's textbook of Mineralogy by W. E. Ford (Fourth Ed)
3. Dexter and Perkins: Mineralogy
4. Putnis Andrew: Introduction to Mineral science, Cambridge Uni. Press

CORE COURSE: GEOLOGY
Paper-GCC2: Physical Geology
(Credits: Theory-4; Practical-2)

THEORY:

Scope and Importance of Physical Geology, Major Relief features of the Earth, Hypsographic Curve; Morphological features of the ocean floor;

Characteristic features of Mountains, Plateaus, and Plains: a) Mountains: Volcanic, Residual, Block, Tectonic; b) Plains: Erosional and depositional; c) Plateaus

Geological Work of the following natural agencies:

Rivers: Erosion, transportation [suspended and bed load] and deposition; *Erosional features:* Potholes, Canyons, Gorges, Waterfalls, V-shaped valleys with examples; *Depositional features:* Channel deposits (Point bars, Ox-bow lakes, Braided streams), Alluvial fans/cones, Deltas, Flood – plains with examples, River discharge, (15L)

Oceans and Seas: -Waves and breakers; erosion, transportation & deposition; *Erosional landforms:* Sea-cliffs, wave-cut platform, sea-arches, sea-caves, sea-stacks with examples; *Depositional landforms*: Shallow - water deposits: beaches, spits, bars, wave-built terraces, tombolos with examples; *Coral reefs:* Atolls, Fringing and Barrier reefs with examples. (15L)

Wind: -Wind erosion (abrasion & deflation), Transportation (suspension, saltation & surface creep) & Deposition ; *Erosional features :-* Deflation hollow, deflation armour, ventifacts, rock columns & pinnacles, mushroom / pedestal rock, yardangs, desert pavements with examples; *Depositional landforms :-* Sand dunes (transverse, longitudinal, parabolic, barchans), Loess deposits with examples. (15L)

Glaciers: - Definition, Snow-line, Firn / Neve, Types of Glaciers (valley, piedmont, continental) with examples; Crevasses; *Erosional features:* Roche moutonnées, fluted surfaces, cirques, arêtes, horns, glacial valleys (U-shaped, hanging valleys, fjords); *Depositional landforms:* (a) *Unstratified drift*: Moraines (lateral, medial, terminal), till, erratics & perched rocks, drumlins; (b) *Stratified deposits*: Out-wash plains, kettles, Kames, Varves, Eskers with examples.

Geological work of groundwater: erosional and depositional features (caves, caverns, stalactites, stalagmites) with examples. (15L)

PRACTICAL:

Laboratory work

Description and Drawing of Vertical sections of minimum 8 Geological Maps involving a Single Series of Horizontal, Dipping strata with vertical intrusive.
(15P)

Graphical Solution of Structural Geology Problems involving a) Strike, True Dip and Apparent Dip, b) Thickness and width of outcrop. Conversion of Fore and back bearings. (15P)

BOOKS:

1. A textbook of Geology by P. K. Mukherjee (World Press)
2. A Textbook of Engineering and General Geology (Seventh Ed) by Parbin Singh
3. Holmes' Principles of Physical Geology by Arthur Holmes (Third Ed) (ELBS)
4. Holmes' Principles of Physical Geology edited by P. McL. D. Duff (ELBS)
5. Physical Geology by Charles C. Plummer and David McGeary(Wm. C. Brown Publishers)
6. Physical Geology by C. W. Montgomery (Second Ed) (Wm C. Brown Publishers)
7. Understanding the Earth (Fourth Ed) by Press, Siever, Grotzinger& Jordan
8. The Changing Earth: Exploring Geology and Evolution (Third Ed) by Monroe &Wicander
9. Field Geology by Lahee, F.H
10, Field Geology by Compton
11. Structural geology by M. P. Billings

CORE COURSE: GEOLOGY
Paper-GCC3: Economic Geology
(Credits: Theory-4; Practical-2)

THEORY:

Definition of ore, gangue, grade of ore/ tenor, assaying, Classification of mineral deposits. Processes of ore formation and ore genesis. Hypogene, Supergene, Epigenetic and Syngenetic mineral deposits. (15L)

Magmatic, sublimation, contact metasomatic (skarn), hydrothermal,
Volcanic exhalative, residual (bauxite, iron and manganese)
Mechanical concentration. Oxidation and supergene enrichment. (15L)

Geology, mode of occurrence, distribution and origin of the following ore/mineral deposits in India: iron, manganese, aluminum, chromium, copper, lead-zinc, gold, coal and petroleum deposits (15L)

Industrial Minerals: Iron & steel, Cement, Ceramics, Fertilizers,
Abrasives, Refractories, Atomic energy. (15L)

PRACTICAL:

Identification and Description of the Physical Properties, Composition, Occurrences and Uses of minimum 30 economic minerals. (15P)

Description and Drawing of Vertical sections of minimum 8 Geological Maps involving Single Series of Folded (Non-plunging) strata with vertical faults and dykes. (15P)

Books:

1.Jensen M.L. and Bateman A.M. Economic Mineral Deposits John Wiley and Sons
2. Park C.F. and MacDiarmid R. A. Ore Deposits, Freeman and Co.
3. Gokhale G. V. G.K. and . C. Ore Deposits of India CBS Pub nadDistr
4. Krishnaswamy: Indian Mineral Resources Oxford IBH
5. Economic Geology by Ajay kumar Sen and P.K. Guha.
6. Anthony Evans; An introduction to ore geology.ELBS Books.
7. John M. Golbert and Charles Park: The geology of Ore deposits. W. H. Freeman & Co.
8. Santon, L.: Ore Petrology
9. Structural geology by M. P. Billings
10. Introduction to Economic geology by Anthony Evans

CORE COURSE: GEOLOGY
Paper-GCC4: Introduction to Petrology
(Credits: Theory-4; Practical-2)

THEORY:

Rocks; Classification of rocks into three classes: Igneous, Sedimentary and Metamorphic. Rock cycle.

Igneous Petrology: Definition, Magma, Properties of Magmas, Types of magmas, Plutonic, Hypabyssal and Volcanic Types.

Mode of Occurrence of Igneous rocks: Intrusive (major, minor), Extrusive, Dykes (Radiating, Arcuate, Ring dykes, and cone-sheets), Sills, Laccoliths, Phacoliths, Volcanic necks, Lopoliths, Batholiths (stocks, bosses, plugs), lava flows, puys, volcanic cones, stratovolcanoes, composite volcanoes and cinder cones.

Structures: Vesicular and Amygdaloidal, Sheet, Platy and Columnar, Block lava, Ropy lava, Pillow and Flow structures;

Textures: Degree of crystallization [Crystallinity]; Absolute sizes of crystal grains [Granularity], Shapes of crystals and Mutual relations of crystals – Equigranular (allotriomorphic, hypidiomorphic, &panidiomorphic), Inequigranular (Porphyritic) intergrowth (graphic, perthite), directive(trachytic) (15L)

Classification of igneous rocks based on Colour Index, Grain size & Mineral composition into the following groups – Felsic, Intermediate, Mafic, Ultramafic; Plutonic, Hypabyssal, Volcanic, Bowen's reaction series. Study of mineral composition, textures and mode of occurrence of following rocks: Granite, Syenite, Gabbro, Dolerite, Basalt, Dunite. (15L)

Sedimentary petrology: Weathering of Rocks; Types and products of weathering; Sedimentation and Diagenesis; Primary Structures, Textures and composition,

Classification based on Grain size and Mode of formation; Sedimentary depositional environments: marine, lacustrine, aeolian, glacial. Study of following rocks in brief: Conglomerate, breccia, sandstone, shale, limestone, coal and laterite. (15L)

Metamorphic petrology: Definition, Agents of metamorphism, Types of metamorphism, Index Minerals; Structures and Textures of metamorphic rocks; Metasomatic Processes: Hydrothermal, Pneumatolysis,

Classification based on types of metamorphism and composition; Nomenclature of metamorphic rocks. Introduction to facies concept. Study of following metamorphic rocks: slate, schist, gneiss, marble, quartzite, (15L)

PRACTICAL:

Laboratory work (30 hours/ 15P)

Identification, megascopic description and classification of 40 common rocks (Igneous-20, Sedimentary-10, Metamorphic-10. (15P)

Field Training (30 hours/ Four days) –(Compulsory module for 25 marks)

Orientation of Topographic sheet in field, marking location on toposheet, Bearing (Fore andback). Concepts of map reading, Distance, height and pace approximation. Identification of rock types in field; structures and texture of rocks, Use of hand lens. Basic field measurement techniques: Bedding dip and strike, Reading contours and topography. Field applications of GPS. (To be assessed in field by conducting Viva for 10 marks and in laboratory – field report and viva for 15 marks)

Books for study and reference:

1. The Principles of Petrology by G. W. Tyrell (B. I. Publications Pvt Ltd.)
2. A Textbook of Engineering and General Geology (Seventh Ed) by Parbin Singh
3. Understanding the Earth (Fourth Ed) by Press, Siever, Grotzinger& Jordan
4. The Changing Earth: Exploring Geology and Evolution (Third Ed) by Monroe &Wicanter
5. A textbook of Geology by P. K. Mukherjee (World Press)
6. A textbook of Geology by G. B. Mahapatra (CBS)
7. Essentials of Geology by WicanderReed and Monroe, J.S.
8. Field geology by Lahee
9. Igneous and metamorphic petrology by Winkler
10. Sedimentary petrology by Pettijohn.

CORE COURSE: GEOLOGY
Paper-GCC5: Mineralogy
(Credits: Theory-4; Practical-2)

THEORY:

Geochemistry- Introduction to geochemistry, Goldschmidth's geochemical classification of elements, Abundance of elements in Earth, trace elements, System (open, close, isolated system), phase rule, phase components, variance (degree of freedom)
Binary systems- with eutectic (diopside-anorthite) and with solid solution (albite-anorthite).
Radius Ratio, Ionic radius, Co-ordination Number, Types of Co-ordinations; (15L)

Description of following mineral groups with respect to chemical composition, structure, physical properties, optical properties and paragenesis:
Olivine, Pyroxenes, Amphiboles, Micas (15L)

Description of following mineral groups with respect to chemical composition, structure, physical properties, optical properties and paragenesis:
Feldspars, Silica, Felspathoids, Garnet, Sulphides (Cu, Pb, Zn),oxides, hydroxides (Fe,Mn,Cr,Ti), Zeolites (15L)

Hydroxides of aluminium (Bauxite), Phosphates, Carbonates (Ca, Mg, Fe), Sulphates Metamorphic minerals (garnet, staurolite, chlorite, andalusite-kyanite-sillimanite)
(15L)

PRACTICAL:

Identification and Description of the Physical Properties, Composition, Occurrences and Uses of minimum 30 common minerals (15P)

Calculations of Mineral formula: End member calculations, Structural formula. (15P)

Books:

1. Berry and Mason : Mineralogy CBS Publ. and Distr.
2. Phillips: Optical Mineralogy CBS Publ and Distr.
3. Kerr, P.: Optical Mineralogy McGraw Hill
4. Deer W. A. Howie R.A. Zussman J.: Rock forming minerals
5. Conrad Kruskeuf : Introduction to geochemistry
6. Dexter Parkins: Mineralogy
7. Dana's Textbook of Mineralogy by Dana, E.S. and Ford, W.E.

8. Brian Mason: Geochemistry
9. Geochemistry by Conline White
10. Mineralogy by Ness

CORE COURSE: GEOLOGY
Paper-GCC6: Field Geology
(Credits: Theory-4; Practical-2)

THEORY:

Introduction to Field Geology,

Toposheets:numbering, various features of toposheets, Scale: definition, Latitude and longitude.

Geological map: definition, various components of a geological map including scale, legend, contours, bedding junctions, structures, etc. (15L)

Field work and sampling: geological items to be carried to the field, use of clinometer compass, Brunton compass, Strike and dip measurements of planar and linear geological features. Sampling and oriented sample, their significance. (15L)

Geological mapping procedures: Plotting of location on map using latitude and longitude, geological mapping of igneous, sedimentary and metamorphic rocks with special reference to Goa. (15L)

Techniques of surveying and leveling; Plane table and dumpy level. (15L)

PRACTICAL:

Toposheet reading, conversion of scale, enlargement and reduction of maps, use of clinometer, brunton compass. Plane table survey, Dumpy level. Mapping of geological formations in field (30P)

Books:

1. Field Geology by Lahee
2. Field Geology by Compton
3. Holmes' Principles of Physical Geology by Arthur Holmes (Third Ed) (ELBS)
4. Understanding the Earth by Gass, Smith and Wilson
5. The Dynamic Earth by P. I. Wyllie

CORE COURSE: GEOLOGY
Paper-GCC7: Earth's Dynamics & Structural Geology
(Credits: Theory-4; Practical-2)

THEORY:

Earth as a planet, holistic understanding of Earth, General characteristics.

Origin of Solar System (Planetisimal hypothesis) and formation of a layered Earth; Earth's interior: Crust, Mantle and Core. Atmosphere, Hydrosphere. Seismic exploration of Earth's interior.

Earth's Gravity: acceleration due to gravity, change with latitude and altitude, mass and density; Isostasy.

Earth's Magnetism: Earth as a magnet, lines of force, inclination and declination, geomagnetic axis and geographic axis. Convection in the Earth's core and production of its magnetic field (15L)

Theory of continental drift: Geographical and geological evidences pointing to the continental drift. Introduction to Plate tectonics, Lithospheric plates, Plate boundaries and associated activities.

Earthquakes: Seismic waves, Magnitude (Mercalli Scale), Intensity (Richter Scale), Types of Earthquakes (shallow, intermediate, deep); Tsunamis;

Volcanoes: Types and distribution, Ring of fire. (15L)

Topography: high-grounds, plains, valleys, major topographic features on continents (mountains, hills, ridges, plateaus, plains, deserts, bad-lands, permafrost regions, etc) and oceans (continental shelf, slope, rise, abyssal plains, mid-oceanic ridges, trenches, islands, reefs, etc).

Contours, contour reading and contour patterns; Scale and compass bearing, Stratification, Strike, Dip (true and apparent dip), Strike and Dip symbols

Clinometer compass: construction, working and uses; Outcrop patterns of Horizontal, Inclined and Vertical strata on various types of ground surfaces; Rule of 'V's' (15L)

Folds: Causes and types of folds: symmetrical, asymmetrical, overturned, recumbent, isoclinal, fan, chevron, monocline, structural terrace, open and closed, plunging; importance of folds

Joints: Geometric classification, importance;

Faults: general characteristics, geometric classification and importance, Horst, Graben and Thrust faults;

Unconformities: Stages of development, types and importance of unconformities; Off-lap and Overlap, Outliers, Inliers, (15L)

PRACTICAL:

Description and Drawing of Vertical sections of minimum 10 Geological Maps involving a Single Series of Horizontal, Dipping strata with vertical intrusive. Graphical Solution of Structural Geology Problems involving a) Strike, True Dip and Apparent Dip, b) Thickness and width of outcrop. Clinometer compass- Fore and back bearings. (30P)

Reference Books:

1. A textbook of Geology by P. K. Mukherjee (World Press)
2. A Textbook of Engineering and General Geology (Seventh Ed) by Parbin Singh
3. Understanding the Earth (Fourth Ed) by Press, Siever, Grotzinger& Jordan
4. The Changing Earth: Exploring Geology and Evolution (Third Ed) by Monroe &Wicanter
5. Holmes' Principles of Physical Geology by Arthur Holmes (Third Ed) (ELBS)
6. Holmes' Principles of Physical Geology edited by P. McL. D. Duff (ELBS)
7. Physical Geology by C. W. Montgomery (Second Ed) (Wm C. Brown Publishers)
8. Structural Geology by M. P. Billings (Prentice Hall)
9. Manual of Structural Geology by Pradeep Rao Mathur, University Press.
10. Structural Geology- A Practical manual by Ramashri Prasad Singh, GanacauveryPubl

CORE COURSE: GEOLOGY
Paper-GCC8: Crystallography & Optical Mineralogy
(Credits: Theory-4; Practical-2)

THEORY:

Crystallography- imperfections in crystals – lattice defects- internal imperfections, carved surfaces, interfacial angle. Crystalline aggregates and twinning, types of twins (contact, penetration) multiple. (15L)

Introduction to stereographic projections. Derivation of 32 classes of symmetry. Miller indices. Forms in all crystal systems. (15L)

Optical Mineralogy: nature of light, polarized light, polarizing microscope. Properties in plain polarized light and between cross polars: colour, pleochroism, relief, twinkling, birefringence, interference colours, twinning, zoning, extinction, inclusions. (15L)

Properties under conoscopic light and its applications in the study of uniaxial and biaxial minerals. Uniaxial and Biaxial indicatrix. Accessory plates: Mica, Quartz, Gypsum, 2v, 2e. (15L)

PRACTICAL:

Determining & describing the symmetry in crystal models of normal and lower classes of all the systems. Plotting of crystal symmetry of normal and lower classes on stereonet (Cubic, Tetragonal, Orthorhombic, 2 models each). Calculation of axial ratios (Orthorhombic & Tetragonal system), Crystal drawings including clinographic projection (15P).

Microscopic identification of minimum 20 mineral thin-sections. Optical methods: (Determination of order of polarization, birefringence, sign of elongation, optic sign, An-content). Calculation of 2v (15P)

Books:

1. Berry and Mason : Mineralogy CBS Publ. and Distr.
2. Phillips, W. R and Griften, D.T: Optical Mineralogy CBS Publ and Distr.
3. Kerr, P. : Optical Mineralogy McGraw Hill
4. Deer W. A. Howie R.A. Zussman J.:Rock forming minerals, Longman
5. Gribble Colin D. and Hall Allan J.: Optical Mineralogy- Principles and practice
6. Michael Railh, Peter Raese and Jurgen Reinhardt: Guide to Thin section microscopy
7. Dana’s Mineralogy

CORE COURSE: GEOLOGY
Paper-GCC9: Sedimentary Petrology
(Credits: Theory-4; Practical-2)

THEORY:

Introduction, sedimentary processes weathering, (types and products), erosion and transportation, deposition, compaction and lithification. Diagenesis.

Textures in Sedimentary rocks: grain size (Udden-Wentworth scale), size frequency distribution, causal factors. Grain size and depositional processes, shape of grains: sphericity and roundness, fabric and framework geometry, porosity and permeability,
Fabrics in gravels, sands and clays, carbonate rocks and organic sedimentary rocks. (15L)

Classification of sedimentary rocks, textures, composition and distribution and diagenesis of various groups of sedimentary rocks: clastic, (rudaceous, arenaceous, argillaceous rocks);
Non-clastic: chemical (limestones, dolomites, ferruginous, silicious and phosphatic sediments and evaporarites, (15L)

Organic (limestones, silicious and calcareous oozes, phosphatic rocks, bog ores and coal;
Residual: laterite, bauxite and soil. Primary sedimentary structures: depositional, erosional. Secondary structures: chemical, biogenic. Heavy minerals, authigenic, allogenic minerals and provenance. (15L)

Basins of deposition – structural, morphological and tectonic basins, geosynclines. Depositional environments: physical, chemical, organic factors. Characteristics of flysch and molasses sediments. (15L)

PRACTICAL:

Megascopic identification of 15 sedimentary rocks. Exercises on sorting, sphericity & roundness
Microscopic identification of 10 sedimentary rocks in thin-sections. (30P)

Books:

1. Pettijohn, F.G.: Sedimentary Rocks, CBS Publ and Distr
2. Tucker: Sedimentary petology
3. Petrology of Sedimentary rocks: Greensmith
4. Sedimentary structures by Collinson and Thompson
5. Origin of Sedimentary Rocks by Blott, H., Middletin and Murray, R.
6. Procedures in sedimentary petrology by Carver, R. C.

7. Sedimentology processes and products: Leader, M.R.
8. Sam Boggs: Sedimentary Petrology

CORE COURSE: GEOLOGY
Paper-GCC10: Principles of Stratigraphy &Palaeontology
(Credits: Theory-4; Practical-2)

THEORY:

Stratigraphy: scope and importance; *Principles of Stratigraphy:* Laws of uniformitarianism, original horizontality, order of superposition, faunal succession, cross-cutting relationship, inclusions;

Correlation and methods of correlation: Structural relations (tectonic criteria), Lithological similarity (Marker horizon or key bed), Paleontological criteria (Index fossils),

Standard Stratigraphic timescale; Indian stratigraphic timescale; Geological Time Units: - Eon, Era, Period, Epoch, Age, Phase. Chronostratigraphic Units: - Erathem, System, Series, Stage and Zone. Lithostratigraphic Units: - Group, Formation, Member, Bed and laminae. (15L)

Age of the Earth; Radiometric Dating principles with suitable examples; Palaeogeographic configuration of the earth; Pangea, Laurasia, Gondwanaland. Present geographical configuration, Major physiographic features of the Earth (major mountain ranges, plateaus, plains, deserts)

Physiographic subdivisions of India and their distinctive characters; Brief account of major geological formations of India and their economic mineral wealth. (15L)

Fossils: Definition and types: Mega fossils (dinosaurs), Microfossils, Ichnofossils; Conditions for fossilization; Modes of preservation of organic remains: Biologic, mechanical and chemical destruction; Factors limiting distribution of organisms: sunlight, depth of water, oxygen, seawater temperature, salinity, substratum & food;

Modes of fossilization; Derived fossils; transported fossils; Index fossils and Endemic fossils; Uses of fossils; Introduction to taxonomy and species concept. (15L)

Study of general characteristics, morphology, habitats and geological history of the following Phylla with their biostratigraphic significance: Phylum *Mollusca*: Pelecypoda, Gastropoda, Cephalopoda (Classes Nautiloidea, Ammonoidea, Belemnoidea) with Indian examples, if any; Significance of ammonites.

Phylum *Brachiopoda*: Articulata, Inarticulata; Phylum *Echinodermata*: Echinoidea, Crinoidea; Phylum *Arthropoda*: Trilobita; Phylum *Protozoa*: Foraminifera with examples.

Origin of Vertebrates and major steps in vertebrate evolution, Mesozoic reptiles with special reference to diversity and extinction of Dinosaurs with Indian examples. Human evolution. Gondwana flora. (15L)

PRACTICAL:

Laboratory work (30 hours/15P)

Plotting of major geological formations on outline map of India. Identification, Classification, Description and Geological Time Range of minimum 30 Fossils. (15P)

Field Training (30 hours/Four days)- Compulsory module for 25 marks

Geological mapping: Basic concepts of outcrop mapping, geological mapping, mapping of structural features and stratigraphy. Mapping a mineral deposit /open cast mine. Mapping of igneous/metamorphic rocks terrain.

(To be assessed in field by conducting Viva for 10 marks and in laboratory – field report and viva for 15 marks)

Books:

1. The Elements of Palaeontology by Rhona Black (Cambridge University Press, 1972)
2. Invertebrate Paleontology and Evolution by E.N.K.Clarkson.(Second Ed) (ELBS/Allen & Unwin)
3. Introduction to Invertebrate Palaeontology by Koregave
4. Simon & Schuster's Guide of Fossils by Paolo Arduini& Giorgio Teruzzi (Simon & Schuster Inc., New York)
5. A Textbook of Engineering and General Geology (Seventh Ed) by Parbin Singh
6. Understanding the Earth (Fourth Ed) by Press, Siever, Grotzinger& Jordan
7. The Changing Earth: Exploring Geology and Evolution (Third Ed) by Monroe &Wicanter
8. Basic concepts of Historical Geology by E. W. Spencer (Oxford Hill)
9. Fundamentals of Historical Geology and Stratigraphy of India by Ravindrakumar (Wiley Eastern Ltd.)
10. Geology of India and Burma by M.S. Krishnan (Sixth Ed) (CBS)
11. Physical Geology by C. W. Montgomery (Second Ed) (Wm C. Brown Publishers)
12. Invertebrate Paleontology by Woods Henry
13. Principles of Stratigraphy by Marvin Weller

CORE COURSE: GEOLOGY
Paper-GCC11: Structural Geology
(Credits: Theory-4; Practical-2)

THEORY:

Concept of rock deformation, Stress and strain in rocks, Principles of mechanical behaviour of rocks, factors controlling their behaviour.
Planar and linear features, concept of strike and dip,
Folds: recognition, types and causes of folding. Genetic classification of folds.
Determination of top of beds with the help of primary and secondary features. (15L)

Joints:- principles of failure by rupture, genetic classification of joints.
Faults:- Effects on disrupted strata, separation, genetic classification, Criteria for faulting, types of faults (normal, strike-slip, reverse, thrust, overthrust) (15L)

Foliation and lineation: Cleavage and schistosity, description and origin, relationship with major structures, significance.
Unconformities: types of unconformities, recognition and distinction from faults and intrusive contacts. Effects of topography on structural features, Outcrop patterns of different structures. (15L)

Introduction to Plate Tectonics and sea floor spreading: Lithosphere, Asthenosphere, Mesosphere, Lithospheric plates, Types of Plate boundaries and associated major activities. Orogenic and epeirogenic movements. (15L)

PRACTICAL:

Description and drawing of cross-sections of 10 structural maps involving two series, inclined faults, folds and intrusives and 5 completion of outcrops. Graphical solutions of structural problems. (30P)

Books:

1. Billings: Structural Geology Oxford CBS
2. Hobbs: Outline of Structural Geology Prentice Hall
3. Condie: Plate Tectonics and Crustal Evolution, Pergamon Press
4. The Evolving Continents by B. F. Vindley
5. Structural Tectonic Principles by P. G. Badgley

CORE COURSE: GEOLOGY
Paper- GCC12: Metamorphic Petrology
(Credits: Theory-4; Practical-2)

THEORY:

Definition of metamorphism. Factors responsible for metamorphism: temperature (radioactive, magmatic, tectonic heat), geothermal gradient (in different crustal regions); pressure (P) (directed and load pressure); composition of the parent rock (*X)* ; fluids (H 2O and CO2). (*X*f).
Metamorphism in relation to the plate tectonic environments: divergent and convergent boundary environments. (15L)

Types of metamorphism: Local – contact metamorphism and cataclastic metamorphism; Regional- burial metamorphism and dynamothermal metamorphism, other types of metamorphism: ocean floor metamorphism, hydrothermal metamorphism, dislocation metamorphism, impact metamorphism and their relationship with the major types of metamorphism. Contact metamorphism its characteristics and products (e.g. hornfels, skarns). Regional metamorphism its characteristics and products (e.g. slates, schists, genisses and granulites). (15L)

Fabric of metamorphic rocks: definition (size and shape, and mutual relationship between and with adjacent minerals). Fabric types: relict fabric-primary features such bedding, fossil outlines, grain boundaries). Isotropic fabric, anisotropic fabric (imposed) foliation such as slaty cleavage, schistocity, gneissic banding, flaser and augen fabric;
Lineation (crenulation, mineral lineation, etc) appearance in field and in handspecimen. Origin of fabric of metamorphic rocks. Porphyroblasts-definition and examples.Idioblastic series.
Classification of metamorphic rocks based on mineralogy and fabric. Protoliths (metapelites, metabasites, metagreywackes etc.) (15L)

Field characters of metamorphic rocks: variations in mineralogy and fabric. Concept of depth zones and index minerals, their significance in mapping and understanding tectonic history. ACF and AFM diagrams their advantages and limitations. Facies concept after Golschmidt and Eskola.
Facies of contact metamorphism and characteristic mineral assemblages in shales and limestone. Facies of regional metamorphism and their characteristics: zonation in mineralogy, Barrovian- (relatively higher P) and Buchan- (relatively lower P) series, and their significance.
Products of regional metamorphism- rocks and characteristic minerals in different facies in different kinds of rocks such as shales, limestones and basalts. (15L)

PRACTICAL:

Megascopic identification of 20 metamorphic rocks. ACF & AFM diagrams. Microscopic identification of 10 metamorphic rocks in thin-sections, (30P)

Books:

1. Turner F.J.: Metamorphic rocks field mineralogical & tectonic aspects Longman
2. Raymond, Loren: Igneous and Metamorphic Petrology,John Wiley Sons
3. Winter John: Igneous and metamorphic petrology
4. Bhaskar Rao: Metamorphic petrology
5. Buchan and Grapes; Petrology of metamorphic rocks
6. Best M. G.: Igneous and metamorphic petrology.
7. Yardly, V.M.; An introduction to Metamorphic Petrology
8. Philpots, A.R. Principles of Igneous and Metamorphic Petrology.
9. Wood, B.J. and Fraser, D.G.: Elementary Thermodynamics for Geologists.

CORE COURSE: GEOLOGY
Paper-GCC13: Igneous Petrology
(Credits: Theory-4; Practical-2)

THEORY:

Igneous activity in relation to plate margins and plate interiors. Magmas, their nature, temperature, density, viscosity, chemical composition and role of volatiles.
Mode of occurrence, Kindred and suite, structures, (15L)

Classification (IUGS), and textures of igneous rocks. Generation and ascent of magma. Magmatic evolution (differentiation, magma mixing and assimilation), (15L)

Crystallization trend of Di-Ab-An system and Ne-Ka-Si system, Study of following suite (clans) of rocks: granites, syenites, gabbroic and ultramafic. (15L)

Study of lamprophyres, anorthosites, carbonatites, kimberlites. Geology of layered igneous intrusions with examples. Flood basalts and large igneous provinces. (15L)

PRACTICAL:

Megascopic identification of 25 igneous rocks. Normative analysis of igneous rocks. Microscopic identification of 15 Igneous rock thin-sections. (30P)

Books:

1. Middlemost E.A.K. Magmas and Magmatic Rocks, Longman
2. Best M.: Igneous and Metamorphic rocks CBS
3. Barker D.S. Igneous Petrology,Prentice Hall
4. Raymond, Loren : Igneous and Metamorphic Petrology,John Wiley Sons
5. Winter John: Igneous and metamorphic petrology
6. Bose Mihir: Igneous Petrology
7. G. W. Tyrell: The Principal of Petrology
8. Anthony Hall: Igneous petrology

CORE COURSE: GEOLOGY
Paper-GCC14: Indian Stratigraphy
(Credits: Theory-4; Practical-2)

THEORY:

Tectonic and Physiographic divisions of India – their characters and peculiarities with respect to geo-tectonics, stratigraphy and physiography.

Stratigraphy of Peninsular India: Dharwar Supergroup and Peninsular Gneissic Complex with their distribution , lithology, stratigraphic sequence, structures and economics. (15L)

Proterozoics of Peninsular India: Cuddapah Supergroup, Vindhyan Supergroup and Kaladgi Supergroup; their distribution lithology, stratigraphic sequence, structure and economics. (15L)

Palaeozoic succession of India: marine palaeozoic formation, Palaeozoic succession of Spiti and Kashmir, Mesozoic succession: Triassic, Jurassic, and Cretaceous formations of Extra peninsula (Spiti and Kashmir regions), marine Mesozoics of Peninsular India: Jurassic of Kutch, Cretaceous of Trichinopoly. Gondwana Supergroup. Ancient Gondwanaland, climatic changes during Gondwanas. Distribution, classification, tectonic relations, origin of Gondwana rocks and their economic importance. (15L)

Cenozoic Era: Palaeogeography of World, Life during Cenozoic, Tertiary formations in India (Gujarat, Assam & Tamil Nadu).

Deccan Basalt Group (Traps): distribution and age, inter-trappean and infra-trappean beds. Siwalik Group: structure, classification, lithology, climate, fossils.

Pleistocene glaciation. Ice age, Pleistocene ice age in India, evidences of ice age, Rise of Himalayas. (15L)

PRACTICAL:

Field training (60 hours/Eight days) (60 hours of field work is equal to 30 practical sessions of two hours each which is equal to 2 credits)

Observation and recording of primary and secondary planar and linear features in the rocks such as bedding planes, schistosity, cleavage, lineation and their measurements. Mapping of tectonic and stratigraphic features, stratigraphic correlation. Study of igneous/sedimentary/ metamorphic rock exposures. Preparation and submission of Geological report.

Field transect in a Precambrian/ Phenerozoic terrain of India. Field study of a horizontal/ incline/ folded/ faulted sedimentary succession. Preparation and submission of Geological report.

(To be assessed in field by conducting Viva for 20 marks and in laboratory – field report and viva for 30 marks)

Books:

1. Krishnan, M. S. : Geology of India and Burma CBS Publ and Distrib.
2. Wadia D. N.: Geology of India Oxford IBH
3. Ravindrakumar: Fundamentals of Historical Geology & Stratigraphy of India Oxford IBH
4. Geology of India ,GSI Volumes: Ramakrishnan, M and Vaidyanathan, R.
5. Dunbars and Rodgers: Principles of Stratigraphy

DISCIPLINE SPECIFIC ELECTIVE in GEOLOGY

Paper-GDSE1: Engineering Geology
(Credits: Theory-4; Practical-2)

THEORY:

Engineering properties of rocks-Rock as material for construction, rock as site for construction. Geotechnical Projects: Geological Investigations, methods of investigation (geophysical) and the role of geologists. (15L)

Dams and reservoirs: types of dams, site selection, stability and failure of dams. Foundation geology, induced seismicity related to dams and environmental impact. (15L)

Tunnels; stress conditions in tunnels, influence of geological conditions, changes in water table. Buildings (types of foundations), Bridges (types), Roads (construction in different geological terrains), canals: stability and problems. (15L)

Improvement in sites: Grouting, backfilling, soil stabilization.
RQD and slope stability study. (15L)

PRACTICAL:

Exercises and problems in engineering geology with respect.to tunnel alignment and dam locations. RQD problems (30P)

Books:

1. Valdiya K. S. : Environmental Geology Indian Context TMH
2. Tank: Environmental Geology CBS
3. Keller: Environmental Geology CBS
4. Priscu: Earthquake engineering for large dams CBS
5. Blyth and De Freitas: Geology for Engineers, ELBS Arnold
6. Engineering geology by Parbin Singh
7. Engineering Geology by Kesavulu

Paper-GDSE2: Hydrogeology
(Credits: Theory-4; Practical-2)

THEORY:

Introduction and basic concepts. Scope of hydrogeology and its societal relevance, Hydrological cycle and its components, precipitation, evaporation, transpiration, evapo-transpiration.
Infiltration and percolation, instruments for measurement.Surface runoff and its measurements.
Concepts of watershed, drainage network and their relation to surface runoff and infiltration. (15L)

Definition of subsurface water and groundwater, saturated and unsaturated zones, water in the unsaturated zone, vertical distribution of surface water, types of groundwater such as juvenile, connate, magmatic water, meteoric water.
Definition of an aquifer, types of aquifers, confining layers and types with examples. anisotropy and heterogeneity of aquifers.
Aquifer parameters: porosity, permeability, specific retention, specific yield, transmissivity, storativity, hydraulic conductivity and methods of determination (pumping tests). (15L)
Groundwater exploration methods: Remote sensing, geophysical methods (electrical, magnetic, seismic, VLF), Groundwater distribution in India. (15L)
Groundwater chemistry: Physical and chemical properties of water and water quality, parameters of water quality; physical, chemical and biological, major, minor and trace constituents, ISI standards for drinking water.

Introduction to methods of interpreting groundwater quality data using standard graphical plots.Sea water intrusion in coastal aquifers. (15L)

PRACTICAL:

Preparation and interpretation of water level contour maps (flow-nets) and depth to water level maps, Study, preparation and analysis of hydrographs for differing groundwater conditions. Graphical representation of chemical quality data and water classification. (30P)

Books:

1. Raghunath, N.M.: Groundwater, Wiley Eastern
2. Todd, D.K. 2006. Groundwater Hydrology, 2nd Ed., John Wiley & Sons, N.Y.
3. Davis, S.N. and De Weist, R.J.M. 1966. Hydrogeology, John Wiley & Sons Inc., N.Y.
4. Karanth K.R., 1987, Groundwater: Assessment, Development and Management, Tata McGraw-Hill Pub. Co. Ltd.
5. Fetter, C.W. 2001. Applied Hydrogeology, Prentice Hall Inc., N.J., U.S.A.

6. Regional groundwater quality by Alley, W.M. VNR, NY

8. Geophysical prospecting for Groundwater by Shankar Kumar Nath, H.P. Patra and S. Shahid

Paper-GDSE3: Mining Geology
(Credits: Theory-4; Practical-2)

THEORY:

Mining: Introduction to Mining, Mining methods (open cast, underground), Overview of Mining Industry(Exploration stage, planning stage, mining stage, ore processing, exports)

Role of a geologist, Mineral exploration, Geological mapping, drilling, drilling equipment and accessories, sampling, borehole logging, core, sludge. (15L)

Estimation of ore reserves, categorization of reserves based on UNFC, Grades of Ore,
Rules and regulations, Regulating agencies (15L)

Mine Planning, Mining machinery, Mining below water table and mine drainage, quality control.
Mineral beneficiation (dry, wet) (15L)

Environmental impact due to mining. Environmental Impact Assessment (EIA), Environmental Management in Mining (EMP). Utilisation and conservation of mineral resources. Case studies. (15L)

PRACTICAL:

Preparation of lithologs from core data, drawing of cross-section and longitudinal sections based on borehole data. Reserve calculations, mine development plan. Environmental management plans (afforestation, mine drainage, dust suppresion), key plans (demarcation of core and buffer zones). (30P)

Books:

1. Arogyaswami, R.N.P.: Courses in Mining Geology, III Edition, Oxford and IBH publication Co.
2. McKinstry H.F.; Mining Geology, Prentice Hill Inc.
3. Babu S.K. and Sinha D.K. Practical Manual of Exploration and prospecting. CBS Publishers and Engineers.

Paper-GDSE4: Environmental Geology
(Credits: Theory-4; Practical-2)

THEORY:

Fundamental concepts of Environmental geology- scope, objectives and aims.
Earths's thermal environment and Climates.
Global warming. Green house effect. Ozone depletion- Ice sheets and fluctuation in sea levels. Concepts of ecosystem, Earth's major ecosystems- terrestrial and aquatic. (15L)

Water, Land and Air pollution, solid waste disposal. ISI standards for water and air quality, Environmental health hazards.
Natural hazards: Earthquakes, landslides, Tsunamis, volcanoes, floods. Identification of hazard prone areas, risk evaluation, mitigation. (15L)

Environmental impact due to mining. Environmental Impact Assessment (EIA). Environmental Management in Mining (EMP), Environmental impact due to oil exploration. (15L)

Baseline parameters with respect to air, water, land and noise pollution. Quality Parameters, equipment. Case studies of air, water and land pollution in India. Floods and droughts and their impacts. (15L)

PRACTICAL:

Delineation of core and buffer zones around mining lease. Preparation of Key plan, EMP, Rose Calculation of Mean Rainfall, Study of hazard zoning maps. Analysis of basic parameters of soil and water, Visit to STP/ water purification plant, Preparation of Indian pollution maps with regards to F, As and nitrates. Flood prone area map, natural hazards map. (30P)

Books:

1. Valdiya K. S. : Environmental Geology Indian Context TMH, McGraw Hill Publ.
2. Tank: Environmental Geology CBS
3. Keller, E.C., Bell and Howell: Environmental Geology CBS
4. Priscu: Earthquake engineering for large dams CBS
5. Blyth and De Freitas: Geology for Engineers, ELBS Arnold
6. Bennett, M.R.B., and Doyle, p. 1997. Environmental Geology. John Wiley and Sons, NY.
7. Environmental Assessment Source Book, 1991, Vol. I, II, III. Environment Department, The World Bank, Washington DC.

Paper-GDSE5: Geomorphology
(Credits: Theory-4; Practical-2)

THEORY:

Geomorphology: Definition and fundamental concepts of Geomorphology, Geomorphic processes, Exogenic processes- gradation, degration and aggradation; Endogenic processes- diastrophism and volcanism.

Geoid, Topography, Hypsometry, Global Hypsometry, Major morphological features- Large scale topography of Ocean basins, Large scale mountain ranges (with emphasis on Himalaya). (15L)

Surfacial Processes and geomorphology,

Weathering- physical, chemical and differential weathering; and associated landforms.Formation of soil, soil profile and mass wasting. (15L)

Glacial, Periglacial processes and landforms, Fluvial cycle: streams and valleys, drainage patterns and their significance, stream erosion and deposition, processes and landforms. Peneplain concept of Paleosurfaces.

Aeolian Processes and landforms, Coastal Processes and landforms, Groundwater cycle and landforms. Karst topography, Effects of rocks on relief, Landforms associated with igneous activities. 15L)

Drainage basin morphometry, Linear, Areal and Slope aspects and their implications. Hortons laws of drainage basin composition.

Principles of Isostasy, Endogenic- Exogenic interactions, Rates of uplift and denudation, Tectonics and drainage development, Sea-level change, Long-term landscape development.(15L)

PRACTICAL:

Reading toposheets, Preparation of a topographic profile, Preparation of longitudinal profile of a river. Delineation of watershed boundary on toposheets. Morphometry of a drainage basin. Calculating different morphometric parameters. Preparation of geomorphic map and profiles. Preparation of land use and land cover maps. (30P)

Books:

1. Sparks: Geomorphology
2. Analysis of landforms by Twidale, C.R.
3. Principles of Geomorphology by Thornbury, W.D.
4. Geomorphology by Arthur Bloome.

5. Principles of Physical geology by Arthur Holms
6. Geomorphology by Lobeck, A.K.

Paper-GDSE6: Remote Sensing & GIS
(Credits: Theory-4; Practical-2)

THEORY:

Remote Sensing: Definition, methods, scope and limitations. Electromagnetic radiation (EMR) Interaction of EMR with atmosphere earth and surface.

Remote Sensing Platforms: Active and passive systems, High level and low level satellites, geosynchronous and sunsynchronous satellites, types of sensors, date types and products. (15L)

Resolutions: spatial, spectral, radiometric, temporal resolutions. Global and Indian space missions. Introduction to Image processing (stretching, band ratio). (15L)

Photogeology: definition, scope and objectives.Aerial photographs (AP) and their types-advantages and disadvantages.

Flight procedure overlap, drift and crab, spectral characteristics of APs.

Terminology and geometry of vertical AP. Scale of AP. Stereopairs and mosaics, Radial displacement due to relief and its controlling factors.

Stereoscopic viewing of AP; the instruments used: pocket stereoscope, mirror stereoscope and single prism stereoscope.

Study and interpretation of APs for geological information. Introduction and description of photoelements.

Identification of different landforms, Interpretation of structure and lithology from APs. (15L)

GIS: Introduction to GIS and GPS. Nature of geographic information, data representation, coordinate systems, spatial data models, vector and raster, TIN, linking attribute data to spatial data, data analysis. Integrating GPS data with GIS. Applications in Earth system sciences.

PRACTICAL:

Visual interpretation of at least 10 aerial stereo-pairs/satellite imageries. Preparation of various maps using google earth, georeferencing and digitisation in GIS. (30P)

Books:

1. Rees: Physical Principals of remote sensing Cambridge University Press
2. Lillesand T. M. and Kiefer R.W.: Remote Sensing and Image Interpretation. John Wiley and Sons
3. Image Interpretation by lender
4. Pande: Principals and Applications of Photogeology IBH
5. Photogeology by Miller and Miller
6. Photogrammetry by Moffitt, F.H. and Mikhail, E.M

Paper-GDSE7: Coal and Petroleum Geology
(Credits: Theory-4; Practical-2)
THEORY:

Coal: Definition and origin of Coal, Classification of coal.
Introduction to lithotypes, microlithotypes and macerals in coal, Coal as a fuel.
Global and Indian scenario. Distribution in India and its relation to geology. (15L)

Petroleum: Chemical composition and physical properties of crudes in nature,
Origin of petroleum. Maturation of kerogen; Biogenic and Thermal effect.
Petroleum Reservoirs and Traps, Reservoir rocks: general attributes and petrophysical properties.
Classification of reservoir rocks - clastic and chemical. (15L)

Hydrocarbon traps: definition, anticlinal theory and trap theory, Classification of hydrocarbon traps - structural, stratigraphic and combination, Time of trap formation and time of hydrocarbon accumulation. Cap rocks - definition and general properties.
(15L)

Plate tectonics and global distribution of hydrocarbon reserves, Geology of important Indian reserves (15L)

PRACTICALS:
Section correlation and identification of hydrocarbon prospect. Panel and Fence diagrams. Plotting of coal and petroleum deposits on outline map of India. Graphical solution of three point problems. (30P)

Books:
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.
5.Text Book of Coal (Indian context) by Chandra, D., singh, R.M. and singh, M.P., Tara Book Agency, Varanasi.
6. Petroleum Geology by JinGluvas and Richard Swarbrick, Blackwell Publishers.
7. Elements of Petroleum Geology by Richard C. Selley, Academy Press.
8. Petroleum Geology by North, F.K.

Paper-GDSE8: Gemmology
(Credits: Theory-4; Practical-2)

THEORY:

Nature of gem material: quality necessary in gems-beauty, rarity, durability. Formation of gem materials. Distinction between crystalline, amorphous and metamict materials. Crystal form and habit. Classification of gem stones. Observations with hand lens (10x)-importance and uses. Units of measurement: metric scale, carat, pearl and grain. Physical properties: hardness its applications in gemmology and limitations. Cleavage and parting their importance in gemology and lapidary work.Specific gravity-utility and determination by hydrostatic weighing, heavy liquids, floation and pycnometer.Inclusions and other features of gemstones. (15L)

Optical properties: the electromagnetic spectrum, reflection and its importance in gemology-lustre, aventurescence, sheen, chatoyancy, asterism. Refraction, refractive index, total reflection- in design of refractometer. Construction and use of refractometer. (15L)

Polariscope-construction and use in gemmology. Colour, causes responsible for colour in gem materials, idiochromatism, allochromatism, pseudochromatism, colour centres, charge transfer, organic material, floating electrons, dispersion, scattering, interference, diffraction. Variations in colour, pleochroism. Dichroscope-construction and use. Chelsea colour filter. Spectroscopy. Absorption spectra. Construction and use of spectroscope. Magnetic, electrical and thermal properties. Luminescence. Ultraviolet lamp its applications to gem testing. (15L)

Enhancement and treatments- enhancement methods -coloured and colourless impregnation, dyeing, bleaching and its identification. Methods of treatment – laser drilling, irradiation, heat treatment, surface modifications, diffusion treatment and its identification. Composites - types, classification and identification. (15L)

PRACTICAL:

Determination of refractive indices, optic figure, pleochroism, absorption spectrum, luminescence, SG of gemstones, using refractometer, polariscope, dichroscope, spectroscope, UV lamp, visual observation of gemstones.
Description & Identification of cuts in gemstones. Identification of gemstones- natural, synthetic gemstones and organic products. (30P)

Books:

1. Read: Gemmology
2. Liddicoat: Handbook of gem identification

3. Sinkankas: Mineralogy, Oxford
4. Karanth R.V. Gem and Gem Industry, Oxford IBH
5. Babu T.M.: Diamonds in India

GENERIC ELECTIVE

Paper-GGE1: Essentials of Geology
(Credits: Theory-3; Practical-1)

THEORY:

Introduction to geology, scope, sub-disciplines and relationship with other branches of sciences
Earth in the solar system, origin
Earth's size, shape, mass, density, rotational and evolutional parameters
Solar System- Introduction to Various planets - Terrestrial Planets
Solar System- Introduction to Various planets - Jovian Planets
Internal constitution of the earth - core, mantle and crust
Convections in the earth's core and production of magnetic field
Composition of earth in comparison to other bodies in the solar system
Origin and composition of hydrosphere and atmosphere
Origin of biosphere
Origin of oceans, continents and mountains
Age of the earth; Radioactivity and its application in determining the age of the Earth, rocks, Minerals and fossils

PRACTICALS:

1. Study of major geomorphic features and their relationships with outcrops through physiographic models.
2. Detailed 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

SUGGESTED READINGS:

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.

Paper-GGE2: Remote Sensing & GIS
(Credits: Theory-3; Practical-1)

THEORY:

Remote Sensing: Definition, methods, scope and limitations. Electromagnetic radiation (EMR) Interaction of EMR with atmosphere earth and surface.

Remote Sensing Platforms: Active and passive systems, High level and low level satellites, geosynchronous and sunsynchronous satellites, types of sensors, date types and products. (15L)

Resolutions: spatial, spectral, radiometric, temporal resolutions. Global and Indian space missions. Introduction to Image processing (stretching, band ratio). (15L)

GIS: Introduction to GIS and GPS. Nature of geographic information, data representation, coordinate systems, spatial data models, vector and raster, TIN, linking attribute data to spatial data, data analysis. Integrating GPS data with GIS. Applications in Earth system sciences. (15L)

PRACTICAL:

Visual interpretation of at least 5 aerial stereo-pairs/satellite imageries. Preparation of various maps using google earth and GIS. . (15P)

Books:

1. Rees: Physical Principals of remote sensing Cambridge University Press
2. Lillesand T. M. and Kiefer R.W.: Remote Sensing and Image Interpretation. John Wiley and Sons
3. Image Interpretation by lender
4. Pande: Principals and Applications of Photogeology IBH
5. Photogeology by Miller and Miller
6. Photogrammetry by Moffitt, F.H. and Mikhail, E.M

Paper-GGE3: Physical Geology
(Credits: Theory-3; Practical-1)

THEORY:

Scope and Importance of Physical Geology, Major Relief features of the Earth, Hypsographic Curve; Morphological features of the ocean floor;

Characteristic features of Mountains, Plateaus, and Plains: a) Mountains: Volcanic, Residual, Block, Tectonic; b) Plains: Erosional and depositional; c) Plateaus

Geological Work of the following natural agencies:

Rivers: Erosion, transportation [suspended and bed load] and deposition; *Erosional features:* Potholes, Canyons, Gorges, Waterfalls, V-shaped valleys with examples; *Depositional features:* Channel deposits (Point bars, Ox-bow lakes, Braided streams), Alluvial fans/cones, Deltas, Flood – plains with examples, River discharge, (15L)

Oceans and Seas: -Waves and breakers; erosion, transportation & deposition; *Erosional landforms:* Sea-cliffs, wave-cut platform, sea-arches, sea-caves, sea-stacks with examples; *Depositional landforms*: Shallow - water deposits: beaches, spits, bars, wave-built terraces, tombolos with examples; *Coral reefs:* Atolls, Fringing and Barrier reefs with examples. (15L)

Wind: -Wind erosion (abrasion & deflation), Transportation (suspension, saltation & surface creep) & Deposition ; *Erosional features :-* Deflation hollow, deflation armour, ventifacts, rock columns & pinnacles, mushroom / pedestal rock, yardangs, desert pavements with examples; *Depositional landforms :-* Sand dunes (transverse, longitudinal, parabolic, barchans), Loess deposits with examples. Geological work of groundwater: erosional and depositional features (caves, caverns, stalactites, stalagmites) with examples. (15L)

PRACTICAL:

Laboratory work

Description and Drawing of Vertical sections of minimum 4 Geological Maps involving a Single Series of Horizontal, Dipping strata with vertical intrusive. Visit to some geological landforms. (15P)

BOOKS:

1. A textbook of Geology by P. K. Mukherjee (World Press)
2. A Textbook of Engineering and General Geology (Seventh Ed) by Parbin Singh
3. Holmes' Principles of Physical Geology by Arthur Holmes (Third Ed) (ELBS)
4. Holmes' Principles of Physical Geology edited by P. McL. D. Duff (ELBS)
5. Physical Geology by Charles C. Plummer and David McGeary(Wm. C. Brown Publishers)

6. Physical Geology by C. W. Montgomery (Second Ed) (Wm C. Brown Publishers)
7. Understanding the Earth (Fourth Ed) by Press, Siever, Grotzinger& Jordan
8. The Changing Earth: Exploring Geology and Evolution (Third Ed) by Monroe &Wicander
9. Field Geology by Lahee, F.H
10, Field Geology by Compton
11. Structural geology by M. P. Billings

Paper-GGE4: Minerals and Rocks
(Credits: Theory-3; Practical-1)

THEORY:

Minerals-Definitions, Physical properties of minerals
Mineralogical structure of earth, planetary minerals and native elements
Mineral structures
Mineralogy of the Earth's crust, mantle and core
An overview of environmental and radiation mineralogy, biomineralisation and gemology.
Rocks- Definitions and types, Basics of rock formation.
Igneous rock- magma generation and differentiation
Sedimentary rocks- surface processes and sedimentary environments
Metamorphic rocks- chemical system and types of metamorphism
Rock cycle-interactions between plate tectonics and climate systems

PRACTICALS:

1. Study of physical properties of minerals
2. Study of physical properties of rocks
3. Understanding crystal symmetry via wooden models

SUGGESTED READINGS:

I. 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.

Paper-GGE5: Environmental Geology
(Credits: Theory-3; Practical-1)

THEORY:

Fundamental concepts of Environmental geology- scope, objectives and aims.
Earths's thermal environment and Climates.
Global warming. Green house effect. Ozone depletion- Ice sheets and fluctuation in sea levels. Concepts of ecosystem, Earth's major ecosystems- terrestrial and aquatic. (15L)

Water, Land and Air pollution, solid waste disposal. ISI standards for water and air quality, Environmental health hazards.
Natural hazards: Earthquakes, landslides, Tsunamis, volcanoes, floods. Identification of hazard prone areas, risk evaluation, mitigation. (15L)

Baseline parameters with respect to air, water, land and noise pollution. Quality Parameters, equipment. Case studies of air, water and land pollution in India. Floods and droughts and their impacts. (15L)

PRACTICAL:

Calculation of Mean Rainfall, Study of hazard zoning maps. Analysis of basic parameters of soil and water, Preparation of Indian pollution maps with regards to F, As and nitrates. Flood prone area map, natural hazards map. (15P)

Books:

1. Valdiya K. S. : Environmental Geology Indian Context TMH, McGraw Hill Publ.
2. Tank: Environmental Geology CBS
3. Keller, E.C., Bell and Howell: Environmental Geology CBS
4. Priscu: Earthquake engineering for large dams CBS
5. Blyth and De Freitas: Geology for Engineers, ELBS Arnold
6. Bennett, M.R.B., and Doyle, p. 1997. Environmental Geology. John Wiley and Sons, NY.
7. Environmental Assessment Source Book, 1991, Vol. I, II, III. Environment Department, The World Bank, Washington DC.