# UNIVERSITY OF CALCUTTA

Dr. MILAN KUMAR PAL, M.Sc., Ph.D.
O.S.D.
UNIVERSITY OF CALCUTTA.

SENATE HOUSE
87/1, College Street, Kolkata-700073
Phone : **2257-3376,** 2241-0071-74,
2241-4984-86,2241-4989-90,
2241-2850-51,2241-2859
Fax : 91-033-2241-3222
E-mail : u.g.councilsc.u@gmail.com
Website : www.caluniv.ac.in

Ref No. CUS/ 399(Cir.) / 17
Dated the 11th December, 2017

**To**
**The Principals/T.I.C.**
**of all the Undergraduate Colleges**
**offering B.Sc. (Honours and General ) in Geology**
**affiliated to the University of Calcutta**

Sir/Madam,

The undersigned is to inform you that the proposed **revised semesterised draft Syllabus for Geology (Honours and General)** Courses of Studies under **CBCS has been uploaded in the Calcutta University website (www.caluniv.ac.in).**

The said syllabus has been prepared by the **U.G. Board of Studies in Geology, C.U.**, suppose to be implemented from the academic session 2018-2019

You are requested kindly to go through it and send your feedback within 31st December, 2017.

In this regard you may send your observation/ suggestion to the **Department of U.G. Councils, C.U**. or through email (u.g.councilsc.u@gmail.com), and you also may contact **Prof. Rajib Kar,** Department of Geology through e-mail **(rajib_kar@yahoo.com).**

Your cooperation in this regard will be highly appreciated. Kindly treat the matter as urgent.

Thanking you,

Yours faithfully,
11.12.17

**(Milan Kr. Pal)**
**O.S.D., C.U.**

Dr. Milan Kumar Pal
O.S.D.
University of Calcutta

# UNIVERSITY OF CALCUTTA

# Syllabus for B.Sc.(Hons.) Geology

## Six Semester Course Under

## Choice Based Credit System

| YEAR | SEMESTER | CORE COURSE(14) | ABILITY ENHANCEMENT COURSE ( A C E ) (2) | SKILL ENHANCEMENT COURSE ( S E C ) (3) | DISCIPLINE SPECIFIC ELECTIVE (DSE)(4) | GENERIC ELECTIVE (GE)(4) |
|---|---|---|---|---|---|---|
| 1st Year | I | i)EARTHSYSTEM SCIENCE [CC1]<br>ii) MINERAL SCIENCE [CC2] | COMMUNICATIVE ENGLISH [AEC1] | | | GE-1 |
| | II | iii)ELEMENTSOF GEOCHEMISTRY [CC3]<br>iv)STRUCTURAL GEOLOGY [CC4] | **BENGALI** [AEC2] | | | GE-2 |
| 2nd Year | III | v)IGNEOUS PETROLOGY [CC5]<br>vi)SEDIMENTARY PETROLOGY [CC6]<br>vii)PALEONTOLOGY [CC7] | | FieldWork-I<br>[SEC1] | | GE-3 |
| | IV | viii)METAMORPHIC PETROLOGY [CC8]<br>ix)STRATIGRAPHIC PRINCIPLESAND INDIAN STRATIGRAPHY [CC9]<br>x) PHANEROZOIC STRATIGRAPHY OF INDIA [CC10] | | FieldWork-II<br>[SEC2] | | GE-4 |
| 3rd Year | V | xi)ECONOMIC GEOLOGY [CC11]<br>xii) ENGINEERING GEOLOGY [CC12] | ENVIRONMENAL SCIENCE [AEC3] | | DSE1<br>DSE2 | |
| | VI | xiii) HYDROGEOLGOY [CC13]<br>xiv) GEOMORPHOLOGY, REMOTESENSING ANDGIS [CC14] | ENVIRONMENAL SCIENCE [AEC4] | | DSE3<br>DSE4 | |

| YEAR | SEMESTER | PAPER | COURSE NAMES WITH CODE | CREDIT POINTS | EQUIVALENT MARKS | | | | | TOTAL CREDIT POINTS |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Theory | Practical | Internal Assessment | Attendance | TOTAL | |
| 1ST YEAR | I | CC1 | CCT1: EARTH SYSTEM SCIENCE | 4 | 50 | | 10 | 10 | 100 | 20 |
| | | | CCP1: EARTH SYSTEM SCIENCE | 2 | | 30 | | | | |
| | | CC2 | CCT2: MINERAL SCIENCE | 4 | 50 | | 10 | 10 | 100 | |
| | | | CCP2: MINERAL SCIENCE | 2 | | 30 | | | | |
| | | AEC1 | AEC1: COMMUNICATIVE ENGLISH | 2 | 50 | | | | 50 | |
| | | GE1 | GET1: ESSENTIALS OF GEOLOGY | 4 | 50 | | 10 | 10 | 100 | |
| | | | GEP1: ESSENTIALS OF GEOLOGY | 2 | | 30 | | | | |
| | II | CC3 | CCT3: ELEMENTS OF GEOCHEMISTRY | 4 | 50 | | 10 | 10 | 100 | 20 |
| | | | CCP3: ELEMENTS OF GEOCHEMISTRY | 2 | | 30 | | | | |
| | | CC4 | CCT4: STRUCTURAL GEOLOGY | 4 | 50 | | 10 | 10 | 100 | |
| | | | CCP4: STRUCTURAL GEOLOGY | 2 | | 30 | | | | |
| | | AEC2 | AEC2: BENGALI | 2 | 50 | | | | 50 | |
| | | GE2 | GET2: ROCKS AND MINERALS | 4 | 50 | | 10 | 10 | 100 | |
| | | | GEP2: ROCKS AND MINERALS | 2 | | 30 | | | | |
| 2ND SEMESTER | III | CC5 | CCT5: IGNEOUS PETROLOGY | 4 | 50 | | 10 | 10 | 100 | 26 |
| | | | CCP5: IGNEOUS PETROLOGY | 2 | | 30 | | | | |
| | | CC6 | CCT6: SEDIMENTARY PETROLOGY | 4 | 50 | | 10 | 10 | 100 | |
| | | | CCP6: SEDIMENTARY PETROLOGY | 2 | | 30 | | | | |
| | | CC7 | CCT7: PALEONTOLOGY | 4 | 50 | | 10 | 10 | 100 | |
| | | | CCP7: PALEONTOLOGY | 2 | | 30 | | | | |
| | | GE3 | GET3: PHYSICS AND CHEMISTRY OF EARTH | 4 | 50 | | 10 | 10 | 100 | |
| | | | GEP3: PHYSICS AND CHEMISTRY OF EARTH | 2 | | 30 | | | | |
| | | SEC1 | SEC1: Field Work-I | 2 | | 30 | 10 | 10 | 50 | |
| | IV | CC8 | CCT8: METAMORPHIC PETROLOGY | 4 | 50 | | 10 | 10 | 100 | 26 |
| | | | CCP8: METAMORPHIC PETROLOGY | 2 | | 30 | | | | |
| | | CC9 | CCT9: STRATIGRAPHIC PRINCIPLES AND INDIAN STRATIGRAPHY | 4 | 50 | | 10 | 10 | 100 | |
| | | | CCP9: STRATIGRAPHIC PRINCIPLES AND INDIAN STRATIGRAPHY | 2 | | 30 | | | | |
| | | CC10 | CCT10: PHANEROZOIC STRATIGRAPHY OF INDIA | 4 | 50 | | 10 | 10 | 100 | |
| | | | CCP10: PHANEROZOIC STRATIGRAPHY OF INDIA | 2 | | 30 | | | | |
| | | SEC2 | SEC2: Field Work-II | 2 | | 30 | 10 | 10 | 50 | |
| | | GE4 | GET4: FOSSILS AND THEIR APPLICATIONS | 4 | 50 | | 10 | 10 | 100 | |
| | | | GEP4: FOSSILS AND THEIR APPLICATIONS | 2 | | 30 | | | | |

| YEAR | SEMESTER | PAPER | COURSE NAMES WITH CODE | CREDIT POINTS | EQUIVALENT MARKS | | | | | TOTAL CREDIT POINTS |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Theory | Practical | Internal Assessment | Attendance | TOTAL | |
| 3RD SEMESTER | V | CC11 | CCT11: ECONOMIC GEOLOGY | 4 | 50 | | 10 | 10 | 100 | 24 |
| | | | CCP11: ECONOMIC GEOLOGY | 2 | | 30 | | | | |
| | | CC12 | CCT12: ENGINEERING GEOLOGY | 4 | 50 | | 10 | 10 | 100 | |
| | | | CCP12: ENGINEERING GEOLOGY | 2 | | 30 | | | | |
| | | DSE1 | DSET1: TECTONICS | 4 | 50 | | 10 | 10 | 100 | |
| | | | DSEP1: TECTONICS | 2 | | 30 | | | | |
| | | DSE2 | DSET2: FUEL GEOLOGY | 4 | 50 | | 10 | 10 | 100 | |
| | | | DSEP2: FUEL GEOLOGY | 2 | | 30 | | | | |
| | | AEC3 | AEC3:ENVIRONMENTAL STUDIES | 2 | 50 | | | | 50 | |
| | VI | CC13 | CCT13: HYDROGEOLOGY | 4 | 50 | | 10 | 10 | 100 | 24 |
| | | | CCP13: HYDROGEOLOGY | 2 | | 30 | | | | |
| | | CC14 | CCT14: GEOMORPHOLOGY, REMOTE SENSING AND GIS | 4 | 50 | | 10 | 10 | 100 | |
| | | | CCP14: GEOMORPHOLOGY, REMOTE SENSING AND GIS | 2 | | 30 | | | | |
| | | DSE3 | DSET3: EARTH AND CLIMATE | 4 | 50 | | 10 | 10 | 100 | |
| | | | DSEP3: EARTH AND CLIMATE | 2 | | 30 | | | | |
| | | DSE4 | DSET4: FIELD GEOLOGY AND GRAND VIVA | 4 | 50 | | 10 | 10 | 100 | |
| | | | DSEP4: FIELD GEOLOGY AND GRAND VIVA | 2 | | 30 | | | | |
| | | AEC4 | AEC4:ENVIRONMENTAL STUDIES | 2 | 50 | | | | | |
| | | | | | TOTAL | | | | 2300 + 200 | 140 |

Note

1. AEC courses are not included in the gradation
2. Geology Hons Students are not eligible to take the GE courses. They should opt for GE courses of other Discipline of equivalent credit.
3. At least 50 lectures of an hour duration should be allotted for 4 credit theoretical course and 2 credit practical course.

**CORE COURSE: GEOLOGY**
**Paper –CC1**
EARTH SYSTEM SCIENCE

**THEORY LECTURES CCT1 [4 CREDITS]**

## Unit 1: Earth as a Planet

Branches of Earth Sciences.
General characteristics and origin of the Universe, Solar System and its planets. The terrestrial and jovian planets.
Meteorites and Asteroids.
Earth in the solar system - origin, size, shape, mass, density, rotational and revolution parameters.
Origin of atmosphere, ocean and life.

## Unit 2: Solid Earth, Hydrosphere, Atmosphere and Biosphere

Mechanical layering of the Earth: lithosphere, asthenosphere, mantle and core.
Earthquake and earthquake belts: seismic waves and internal constitution of the Earth.
Volcanoes and volcanism, distribution of volcanoes.
Concept of isostasy.
Formation of core, mantle, crust, atmosphere, hydrosphere and biosphere.
Convection in Earth's core and production of its magnetic field.
Geothermal gradient and internal heat of the Earth.

## Unit 3: Cosmic abundance of elements

Distribution of elements in solar system and in Earth.
Composition of the Earth. General concepts about geochemical cycles.
Properties of common elements in Earth.
Concepts of geochemical cycles.

## Unit 4: Hydrosphere and Atmosphere

Oceanic current system and effect of Coriolis force.
Concepts of eustasy.
Land-sea interaction: Wave erosion and beach processes.
Atmospheric circulation.
Weather and climatic changes.

## Unit 5: Plate Tectonics

Historical development of the concept of continental drift and plate tectonics.
Plates and plate boundaries.
Geodynamic elements of Earth: mid oceanic ridges, trenches, transform faults and island arcs.
Plate tectonics: mountain belts and rift valleys.

## Unit 6: Soil

Soils: types, soil profile, processes of formation of soil.

## Unit 7: Understanding the past from Stratigraphic records

Nature of stratigraphic records.
Fundamental laws of stratigraphy: laws of superposition and faunal succession.

Absolute and relative time in Geology. Concept of time and geological time scale
Concept of radiometric dating. Radiometric dating of rocks and minerals: U-Pb, Pb-Pb, K-Ar, Rb-Sr, Sm-Nd methods. Dating igneous and sedimentary rocks.
Concepts of neptunism, plutonism, uniformitarianism, and catastrophism.
Geological time scale.

**PRACTICAL LECTURES CCP1 [2 CREDITS]**

Study of major geomorphic features and their relationships with outcrops through maps and physiographic models.
Detailed study of topographic sheets and preparation of physiographic description of an area.
Study of soil profile of a specific area.
Distribution of major lithostratigraphic units of India.
Global distribution of cratons, mobile belts and major sedimentary basins. Distribution of cratons, mobile belts and major sedimentary basins in India
Calculation of Richter magnitude from P and S wave interval data.
Study of minerals in hand specimens (Silicates: olivine, garnet, andalusite, sillimanite, kyanite, staurolite, beryl, tourmaline, pyroxene, tremolite, hornblende-actinolite, serpentine, talc, muscovite, biotite, quartz, feldspar, nepheline, zeolite, asbestos; Quartz varieties: chert, chalcedony, agate, jasper, amethyst, rock crystal.
Other minerals: pyrite, chalcopyrite, galena, sphalerite, barite and gypsum, magnetite, haematite, pyrolusite and psilomelane, corundum, ilmenite, chromite, bauxite; fluorite, calcite, dolomite, apatite, graphite)
Study of rocks in hand specimens

## Suggested Readings

Duff, P. M. D. and Duff, D. (Eds.) (1993). Holmes' principles of physical geology. Taylor and Francis.
Emiliani, C. (1992). Planet Earth: cosmology, geology, and the evolution of life and environment. Cambridge University Press.
Gross, M. G. (1977). Oceanography: A view of the earth.
Tarback, E. J. and Lutgens, F.K. (2006). Earth Science. Pearson Prentice Hall, New Jersey.
Grotzinger, J., Jordan, T.H., Press, F and Siever, R. (2007) Understanding Earth (Fifth Edition). W. H. Freeman and company, New York.

**CORE COURSE: GEOLOGY**
**Paper –CC2**
MINERAL SCIENCE

**THEORY LECTURES CCT2 [4 CREDITS]**

### Unit 1: **Crystallography**

Concept of crystal and crystalline matter. Internal order in crystal.
Crystal structure; elementary ideas about crystal morphology in relation to internal structures.
Crystal parameters and indices; form and zone.
Stereographic projection of crystal faces, Crystal symmetry, classification of crystals into systems. Lattice theory and 32 point groups. International symbol of point groups.

**Unit 2: Atomic arrangements and Mineral structure**
Atomic arrangements: unit cell, CCP, FCC and HCP.
Ionic radius and coordination, Pauling's rules. Solid Solution, polymorphism, pseudomorphism.
Atomic structure of silicate minerals.

**Unit 3: Rock forming minerals**
Minerals - definition and classification, physical and chemical properties.
Chemical classification of minerals.
Composition of common oxides, carbonates, sulphides and sulphates, phosphates.

Composition of common rock-forming minerals – internal atomic structure, pyroxene, amphibole, and mica groups.

**Unit 4: Crystal Optics**
Nature of light and optical behaviour of crystals.
Introduction to petrological microscope.
Theory of light propagation in isotropic, uniaxial, and biaxial crystals.
Principles of orthoscopic and conoscopic studies of minerals under optical microscope.

**PRACTICAL LECTURES CCP2 [2 CREDITS]**

Study of the symmetry of crystals. Stereographic projection of crystals.
Derivation of structural formulae based on composition.
Study of optical properties of common rock-forming minerals: quartz, orthoclase, microcline, plagioclase, perthite, nepheline, olivine, orthopyroxene, clinopyroxene, hornblende, staurolite, garnet, muscovite, biotite, calcite, chlorite, epidote, kyanite, sillimanite, tourmaline, zirocon, sphene, zoisite, apatite.
Determination of scheme of pleochroism and extinction angles of hornblende

## Suggested Readings

Klein, C., Dutrow, B., Dwight, J., and Klein, C. (2007). The 23rd Edition of the Manual of Mineral Science (after James D. Dana). J. Wiley and Sons.
Verma, P. K. (2010). Optical Mineralogy (Four Colour). Ane Books Pvt Ltd.
Deer, W. A., Howie, R. A., and Zussman, J. (1996). An Introduction to Rock-Forming Minerals. Prentice Hall.
Nesse, W. D. (2011). Introduction to Optical Mineralogy (Fourth Edition). Oxford University Press.
Putnis, A. (1992). Introduction to Mineral Sciences. Cambridge University Press.

**CORE COURSE: GEOLOGY**
**Paper –CC3**
ELEMENTS OF GEOCHEMISTRY

**THEORY LECTURES CCT3 [4 CREDITS]**

## Unit 1: Basic Concepts

The periodic table.
Chemical bonding, states of matter and atomic environment of elements.
Geochemical classification of elements.
Cosmic abundance of elements in earth and meteorites.

## Unit 2: Layered Structure of Earth and Geochemistry

Composition of crust: Continental and Oceanic.
Composition of mantle: depleted mantle and enriched mantle.
Composition of core.
Bulk chemical Composition of the Earth.
Isotope geology – radiogenic and stable isotopes in Earth materials.
Principles of radioactive dating(Rb-Sr method).

## Unit 3: Element transport

Abundance of elements in river and ocean water
Constancy of elemental composition of ocean water
Concept of ionic and redox potential and pH

Aqueous geochemistry- basic concepts and speciation in solutions, Eh, pH relations.
Factors controlling chemical sedimentation.

### Unit 4: Geochemistry of solid Earth

Geochemical variability of magma and its products. Melting processes.

### Unit 5: Geochemical behaviour of selected Elements during Magmatic Fractionation

Si, Al, K, Na, Ca, Fe, Mg, Ti.

**CORE COURSE: GEOLOGY**
**Paper –CC3**
ELEMENTS OF GEOCHEMISTRY

**PRACTICAL LECTURES CCP3 [2 CREDITS]**

Geochemical variation diagrams and its interpretations: bivariate and trivariate plots to delineate the control of different compositional variables: Harker variation diagram, AFM diagram, MgO diagram. Chemical variation diagrams based on major elements: the alkali-lime index, iron enrichment index, aluminum saturation index and alkalinity index diagrams.

### Reference Books

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

**CORE COURSE: GEOLOGY**
**Paper –CC4**
**STRUCTURAL GEOLOGY**

**THEORY LECTURES CCT4 [4 CREDITS]**

### Unit 1: Basic Structural Elements

Diastrophic and non-diastrophic structures.
Structural elements: planar and linear structures, concept of strike and dip, trend and plunge, rake/pitch.
Application of primary sedimentary and igneous structure in structural geology. Unconformity and its types, recognition of unconformity.
Concept of scale of observation of structures.
Topographic maps. Outcrop patterns of different structures.

### Unit 2: Stress and Strain in Rocks

Basic concept of rock deformation. Concept of Stress. Concept of strain: Homogeneous and inhomogeneous strain, Rotational and irrotational strain in rocks. Strain ellipsoids of different types and their geological significance. Flinn and Ramsay's diagram.
Concept of brittle and ductile deformation.

### Unit 3: Folds

Fold morphology; Geometric classification of folds; elementary idea on mechanism of folding-buckling, bending, flexural slip and flow folding. Relation of foliation and lineation with folds.

### Unit 4: Foliation and Lineation

Morphological features of foliations and lineations. Tectonic significance of foliation and lineation. Brief idea of origin of foliation.

### Unit 5: Fractures and faults

Basic idea of shear zone. Faults and joints.
Geometric classification of faults. Anderson's dynamic analysis of faulting.
Effects of faulting on the outcrops.
Criteria for recognition of faults. Geometry of pinch and swell and boudin structure.

**CORE COURSE: GEOLOGY**
**Paper –CC4**
STRUCTURAL GEOLOGY

**PRACTICAL LECTURES CCP4 [2 CREDITS]**

Basic idea of topographic maps. Topographic sheets of various scales. Interpretation of topographic maps.
Interpretation of geological maps with unconformity, fault, fold and igneous bodies. Construction of structural cross section.
Stereographic projections of planes and lines.
True dip and apparent dip problems, 3-point problems, fold problems, fault problems and their solutions through stereographic projection methods.

### Reference Books


Davis, G. R. (1984). Structural Geology of Rocks and Region. John Wiley
Billings, M. P. (1987). Structural Geology, 4th edition. Prentice-Hall.
Ragan, D. M. (2009). Structural Geology: an introduction to geometrical techniques (4th Ed). Cambridge University Press (For Practical)
Twiss, R. J. and Moores, E. M. (2007) Structural Geology. Second Edition. W. H. Freeman and Company.
Fossen, H. (2010). Structural Geology. Cambridge University Press.
Marshak, S. and Mitra, G. (1988). Basic Methods in Structural Geology. Prentice Hall.


**CORE COURSE: GEOLOGY**
**Paper –CC5**
IGNEOUS PETROLOGY

**THEORY LECTURES CCT5 [4 CREDITS]**

### Unit 1: Introduction to Igneous Petrology

Modes of magma generation in the crust and upper mantle.
Physical properties of magma - temperature, viscosity, density and volatile content. Modes of emplacement of igneous rocks: volcanic, hypabyssal, plutonic.

### Unit 2: Forms of Igneous rock bodies

Mode of occurrence of Igneous rocks.
Forms of igneous rocks.

### Unit 3: Texture and Microstructure of Igneous rocks

Crystallinity, granularity, shapes and mutual relations of grains; nucleation and growth of igneous minerals. Description of the following textures and microstructures with their occurrence in different rocks - panidiomorphic, hypidiomorphic, allotriomorphic, porphyritic, vitrophyric, poikilitic, ophitic, sub-ophitic, intergranular, intersertal, pilotaxitic, trachytic, graphic, granophyric, rapakivi, orbicular, corona, perthitic, myrmekitic, variolitic, speherulitic and spinifex, vesicular, amygdaloidal.

### Unit 4: Classification of Igneous rocks

Bases of classification of igneous rocks: mineralogical, textural, chemical, chemico-mineralogical and associational. Norm and mode. Standard classification schemes – Shand, Hatch and Wells, and IUGS. TAS diagram for volcanic rocks. Outline of CIPW classification.
Composition and texture of important igneous rocks: granitoids, pegmatite, syenite, monzonite, diorite, norite, gabbro, anthrothosite, dolerite, pyroxenites, peridotite, lamprophyres, carbonatite, rhyolite, andesite, dacite, basalt, komatiite.

### Unit 5: Phase Diagrams

Phase rule and its application to eutectic, peritectic and solid solution system. Phase equilibria in the following binary and ternary systems, and their petrogenetic significance: diopside – anorthite, forsterite – silica, albite – anorthite, albite – orthoclase, diopside – albite – anorthite, forsterite – diopside – silica and nepheline - kalsilite – silica.

### Unit 6: Petrogenesis of Igneous rocks

Magmatic processes; crystal settling in magma, magma convection, crystal mush theory, igneous cumulates, diversity of igneous rocks
Petrogenesis of felsic and mafic igneous rocks: granitoids, basalt, anorthosite, alkaline rocks, ultramafic rocks.

### Unit 7: Magmatism in different tectonic settings

Fundamental ideas of magmatism in different tectonics settings.

**CORE COURSE: GEOLOGY**
**Paper –CC5**
IGNEOUS PETROLOGY

**PRACTICAL LECTURES CCP5 [2 CREDITS]**

Study of important igneous rocks in thin sections: granite, granodiorite, diorite, syenite, nepheline syenite, gabbro, anorthosite, peridotite, pyroxenite, basalt, andesite, trachyte, rhyolite, dacite.
Norm calculation of silica saturated igneous rocks.
Plotting of mode in IUGS classification of plutonic rocks (Streckeisen diagram).

### Reference Books

Philpotts, A. and Ague, J. (2009). Principles of igneous and metamorphic petrology. Cambridge University Press.
Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson.Rollinson, H. R. (2014). Using geochemical data: evaluation, presentation, interpretation. Routledge.
Raymond, L. A. (2002). Petrology: the study of igneous, sedimentary, and metamorphic rocks. McGraw-Hill Science Engineering.
Myron G. Best (2001). Igneous and Metamorphic Petrology.
Cox, K. G. and Bell. J. D. (1979). The Interpretation of Igneous Rocks. Springer/Chapman and Hall.

Bose M. K. (1997). Igneous Petrology.
Frost B. R. and Frost C. D (2014). Essentials of Igneous and Metamorphic Petrology. Cambridge University Press.

**CORE COURSE: GEOLOGY**
**Paper –CC6**
SEDIMENTARY PETROLOGY

**THEORY LECTURES CCT6 [4 CREDITS]**

### Unit 1: Introduction to Sedimentology
Scope of sedimentology, origin of sediments, classification of sedimentary rocks based on composition and texture.

### Unit 2: Granulometry: Textural parameters of clastic sediments
Grain size: concept and size scale; particle shape and fabric; sedimentary textures. grain size analyses and environmental connotation

### Unit 3: Basic Hydraulics and Sedimentary Structures: sediment transport mechanism
Fluid flow: flow rheology, fluid gravity flow, sediment gravity flow, flow regime, laminar and turbulent flow, particle entrainment in fluid flow.
Mass flow: types and deposits
Sedimentary structure: primary and penecontemporaneous deformation structures, biogenic structures.
Paleocurrent analysis: data acquisition, methodology, different palaeocurrent patterns.

### Unit 4: Sedimentary rocks
Siliciclastic rocks: components and classification(s) of conglomerates, sandstones, mudrocks.
General introduction to carbonate rocks, BIF, chert;
Components and classifications of limestone, dolomites and dolomitisation.

### Unit 5: Sedimentary environments
Classification, sedimentary facies.
Facies models for glacier, meandering, fluvial, deltaic, and shelf depositional settings

### Unit 6: Diagenesis
Concepts of diagenesis
Stages of diagenesis: diagenetic changes in sand and carbonate deposits, lithification.

**CORE COURSE: GEOLOGY**
**Paper –CC6**
SEDIMENTARY PETROLOGY

**PRACTICAL LECTURES CCP6 [2 CREDITS]**

Identification of sedimentary structures in hand specimens.
Statistical analysis of particle size distribution.
Paleocurrent analysis.
Petrographic study of clastic and non-clastic rocks in thin sections.

### Reference Books

Allen, J.R.L. (1985). Principles of Physical Sedimentology. George Allen and Unwin, London.
Prothero, D. R. and Schwab, F. (2004). Sedimentary geology. Macmillan.
Tucker, M. E. (2001). Sedimenary Petrology, Third Edition Blackwell Science.

Collinson, J. D. and Thompson, D. B. (1988). Sedimentary structures. Unwin- Hyman, London.
Nichols, G. (2009). Sedimentology and Stratigraphy. Second Edition. Wiley Blackwell.
Folk, R. L. (1974). Petrology of Sedimentary Rock. Hemphill Publishing Company, Austin, Texas.

**CORE COURSE: GEOLOGY**
**Paper –CC7**
PALEONTOLOGY

**THEORY LECTURES CCT7 [4 CREDITS]**

**Unit 1: Fossilization and fossil record**
Nature and importance of fossil record; Fossilization processes and modes of preservation

**Unit 2: Taxonomy and Species concept**
Species concept with special reference to paleontology, Taxonomic hierarchy Theory of organic evolution interpreted from fossil record

**Unit 3: Invertebrates**
Brief introduction to important invertebrate groups (Mollusca and Brachiopoda) and their biostratigraphic significance
Significance of ammonites in Mesozoic biostratigraphy and their paleobiogeographic implications
Functional adaptation in trilobites and ammonoids.
Origin of invertebrates and major steps in their evolution.

**Unit 4: Vertebrates**
Origin of vertebrates and major steps in vertebrate evolution.
Mesozoic reptiles with special reference to origin diversity and extinction of dinosaurs
Evolution of horse and intercontinental migrations.
Human evolution.

**Unit 5. Introduction to Paleobotany, Gondwana Flora**
Introduction to Ichnology.

**Unit 6: Application of fossils in Stratigraphy**
Biozones, index fossils, correlation
Role of fossils in sequence stratigraphy
Fossils and paleoenvironmental analysis
Fossils and paleobiogeography, biogeographic provinces, dispersals and barriers
Paleoecology – fossils as a window to the evolution of ecosystems

**CORE COURSE: GEOLOGY**
**Paper –CC7**
PALEONTOLOGY

**PRACTICAL LECTURES CCP7 [2 CREDITS]**

Study of fossils showing various modes of preservation
Study of morphological characters of various invertebrates, vertebrates and plant fossils
Elementary exercise on functional morphology of bivalves

**Reference Books**

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

**CORE COURSE: GEOLOGY**
**Paper –CC8**
METAMORPHIC PETROLOGY
**THEORY LECTURES CCT8 [4 CREDITS]**

### Unit 1: Metamorphism: Controls and Types

Definition of metamorphism. Factors controlling metamorphism, Types of metamorphism – contact, regional, fault zone metamorphism, impact metamorphism.
Causes of metamorphism and concept of metamorphic P-T-t paths.

### Unit 2: Metamorphic Facies and Grades. Metamorphic Structures and Textures

Index minerals, metamorphic zones and isograds. Structure and textures of metamorphic rocks.
Concept of metamorphic facies and grade.
Mineralogical phase rule of closed and open system.
Composition-paragenesis diagrams. ACF, AKF and AFM diagrams.
Metamorphic products of pelitic, carbonate and mafic igneous rocks.

### Unit 3: Metamorphic reactions. Metamorphism and deformation.

Progressive and retrogressive metamorphism.
Prograde and retrograde metamorphic minerals reactions.
Relationship between metamorphism and deformation.

### Unit 4: Migmatites and their origin

Metasomatism and role of fluids in metamorphism.
Brief idea of crustal anatexis. Migmatites and its origin.
Metamorphic differentiation.

### Unit 5: Metamorphic rock associations and Plate Tectonic settings

Regional occurrence and tectonic significance of metamorphic rocks: metamorphism along convergent plate margins, in continent-continent collisions, in rifting terrains and sea floor metamorphism.
Metamorphic belts of India.

**CORE COURSE: GEOLOGY**
**Paper –CC8**
METAMORPHIC PETROLOGY

**PRACTICAL LECTURES CCP8 [2 CREDITS]**

Hand specimen study of following metamorphic rocks: slate, phyllite, schist, gneiss, amphibolite, charnockite, khondalite, mafic granulite, marble.

Textural and mineralogical study of following metamorphic rocks in thin sections: slate, varieties of schists, gneiss, amphibolite, charnockite, khondalite, mafic granulite, eclogite, marble, high Mg-Al granulites.
Graphical plots of metamorphic mineral assemblages using chemographic diagrams (ACF and AKF) in greenschist and amphibolite facies.

## Reference Books


Philpotts, A. and Ague, J. (2009). Principles of igneous and metamorphic petrology. Cambridge University Press.
Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson.
Rollinson, H. R. (2014). Using geochemical data: evaluation, presentation, interpretation. Routledge.
Raymond, L. A. (2002). Petrology: the study of igneous, sedimentary, and metamorphic rocks. McGraw-Hill Science Engineering.
Yardley, B. W. D. (1989). An introduction to metamorphic petrology. Longman Scientific and Technical, London.
Spear F. S. (1993). Metamorphic phase equilibria and Pressure-Temperature-Time paths. Mineralogical Society of America. Monograph.


**CORE COURSE: GEOLOGY**
**Paper –CC9**
STRATIGRAPHIC PRINCIPLESAND INDIAN STRATIGRAPHY

**THEORY LECTURES CCT9 [4 CREDITS]**

### Unit 1: Principles of stratigraphy
Fundamentals of litho-, bio- and chrono-stratigraphy
Introduction to concepts of dynamic stratigraphy (chemostratigraphy, seismic stratigraphy, sequencestratigraphy, magnetostratigraphy)

### Unit 2: Code of stratigraphic nomenclature
International Stratigraphic Code – development of a standardized stratigraphic nomenclature.
Concepts of Stratotypes. Global Stratotype Section and Point (GSSP).
Principles of stratigraphy and principles of Precambrian stratigraphy

### Unit 3: Facies concept in stratigraphy
Walther's Law of Facies.

### Unit 4: Paleogeography
Concept of paleogeographic reconstruction

### Unit 5: Physiographic and tectonic subdivisions of India
Brief introduction to the physiographic and tectonic subdivisions of India.

### Unit 6: Precambrian Stratigraphy
Introduction to Indian Shield
Concept of Archean nucleus: Dharwar and Singhbhum
Introduction to Proterozoic basins of India.
Geology of Vindhyan and Cudappah basins of India

**CORE COURSE: GEOLOGY**
**Paper –CC9**
STRATIGRAPHIC PRINCIPLESAND INDIAN STRATIGRAPHY

**PRACTICAL LECTURES CCP9 [2 CREDITS]**

Study of geological map of India and identification of major Precambrian stratigraphic units.
Drawing of various paleogeographic maps of Precambrian time
Study of different Proterozoic and Pangea supercontinent reconstructions.

**Reference Books**

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

**CORE COURSE: GEOLOGY**
**Paper –CC10**
PHANEROZOIC STRATIGRAPHY OF INDIA

**THEORY LECTURES CCT10 [4 CREDITS]**

**Unit 1: Phanerozoic Stratigraphy of India**

Paleozoic Succession of Kashmir and its correlatives from Spiti Stratigraphy
Structure of Gondwana basins.
Mesozoic stratigraphy of India: Triassic successions of Spiti, Jurassic of Kutch, Cretaceous successions of Cauvery basins
Cenozoic stratigraphy of India: Kutch basin, Siwalik successions, Assam and Andaman basins.
Stratigraphy and structure of Krishna-Godavari basin, Cauvery basin, Bombay offshore basin, Kutch and Saurashtra basins

**Unit 2: Volcanic provinces of India**

Deccan, Rajmahal, Sylhet Trap

**Unit 3: Stratigraphic boundaries**

Important Stratigraphic boundaries in India: Precambrian-Cambrian boundary, Permian-Triassic boundary, Cretaceous-Paleogene boundary

**CORE COURSE: GEOLOGY**
**Paper –CC10**
PHANEROZOIC STRATIGRAPHY OF INDIA

**PRACTICAL LECTURES CCP10 [2 CREDITS]**

Study of geological map of India and identification of major Phanerozoic stratigraphic units.
Drawing of various paleogeographic maps of Phanerozoic time
Stratigraphic correlation of Phanerozoic stratigraphic units in geological map of India.

**Reference Books**

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

**CORE COURSE: GEOLOGY**
**Paper –CC11**
ECONOMIC GEOLOGY

**THEORY LECTURES CCT11 [4 CREDITS]**

## Unit 1: Ores and Gangues

Ores, protor, gangue minerals, tenor, grade and lodes. Hypogene and supergene ore deposits, epigenetic and syngenetic mineral deposits; mineral beneficiation
Resources and reserves- economic and academic definitions.

## Unit 2: Mineral deposits and Classical concepts of Ore formation

Mineral occurrence, mineral deposit and ore deposit.
Historical concepts of ore genesis: Man's earliest vocation- mining.
Mineral deposits and their litho-tectonic environments.
Metallogenic provinces and epochs.

## Unit 3: Structure and texture of ore deposits

Concordant and discordant ore bodies.
Endogenous processes: magmatic concentration, skarns, greisens, and hydrothermal deposits.
Exogenous processes: weathering products and residual deposits, oxidation and supergene enrichment, placer deposits.

## Unit 4: Ore grade and Reserve

Assessment of ore grade and reserve, reserve estimation.

## Unit 5: Metallic and Nonmetallic ores

Important deposits of India including atomic minerals: study of geologic set up, mode of occurrence, mineralogy and genesis of the following ore deposits in India: iron ore in Singhbhum and Karnataka, Manganese of Central India, copper of Malanjkhand, lead-zinc of Zawar area, uranium of Singhbhum.
Non-metallic and industrial rocks and minerals in India.
Introduction to gemstones.

**CORE COURSE: GEOLOGY**
**Paper –CC11**
ECONOMIC GEOLOGY

**PRACTICAL LECTURES CCP11 [2 CREDITS]**

Hand sample identification of important ores and nonmetallic minerals.
Study of microscopic properties of ore forming minerals (oxides and sulphides).
Preparation of maps: distribution of important ores and other economic minerals in India.

## Reference Books

Guilbert, J.M. and Park Jr. C.F. (1986). The Geology of Ore deposits. Freeman and Co.
Bateman, A.M. and Jensen, M.L. (1990). Economic Mineral Deposits. John Wiley.
Evans, A.M. (1993). Ore Geology and Industrial minerals. An Introduction. (Third Edition). Blackwell Publishing.
Robb, L. J. (2005). Introduction to ore forming processes. Wiley.
Deb, S. (1980). Industrial minerals and rocks of India. Allied Publishers.
Sarkar, S.C. and Gupta, A. (2014). Crustal Evolution and Metallogeny in India. Cambridge Publications.
Mookherjee A. (1999). Ore Genesis A Holistic approach. Allied Publishers Pvt. Ltd.
Stanton, R. L. (1972). Ore Petrology. Mcgraw_Hill Book company.

**CORE COURSE: GEOLOGY**
**Paper –CC12**
ENGINEERING GEOLOGY

## THEORY LECTURES CCT12 [4 CREDITS]

**Unit 1:Introduction**
RoleofEngineeringgeologists in planning,design andconstruction ofmajor man-madestructuralfeatures.

**Unit 2: Siteinvestigation**
Site investigationandcharacterization.

**Unit 3: Foundation**
Foundation treatment;Grouting,RockBoltingandother supportmechanisms.

**Unit 4: Intact Rock and Rock Massproperties**
Rockaggregates;significanceas construction material.

**Unit 5: Rock Quality Designation (RQD)**
Concept, mechanism and significance of: Rock Structure Rating(RSR) Rock Mass Rating(RMR)Tunneling Quality Index (Q) Geological, Geotechnical and Environmental considerations for dams and reservoirs.

**Unit 6: Tunnels**
Tunneling methods.

**Unit 7: Landslides**
Causes, factors and corrective/preventive measures.

**Unit 8: Earthquakes**
Corrective/preventive measures. Mitigating the damage caused by earthquake.

**CORE COURSE: GEOLOGY**
**Paper –CC12**
ENGINEERING GEOLOGY

## PRACTICAL LECTURES CCP12 [2 CREDITS]

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

**Reference Books**

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

**CORE COURSE: GEOLOGY**
**Paper –CC13**
HYDROGEOLGOY
**THEORY LECTURES CCT13 [4 CREDITS]**

**Unit 1: Introduction and basic concepts**
Scope of hydrogeology and its societal relevance
Hydrologic cycle: precipitation, evapo-transpiration, run-off, infiltration and subsurface movement of water.
Rock properties affecting groundwater, Vertical distribution of subsurface water
Types of aquifer, aquifer parameters, anisotropy and heterogeneity of aquifers

**Unit 2: Groundwater flow**
Darcy's law and its validity
Intrinsic permeability and hydraulic conductivity
Groundwater flow rates and flow direction
Laminar and turbulent groundwater flow

**Unit 3: Groundwater provinces**
Groundwater provinces of India and West Bengal

**Unit 4: Groundwater chemistry**
Physical and chemical properties of water and water quality
Sea water intrusion in coastal aquifers

**Unit 5: Groundwater management**
Surface and subsurface water interaction
Groundwater level fluctuations
Basic concepts of water balance studies, recharge and discharge
Rainwater harvesting and artificial recharge of groundwater

**CORE COURSE: GEOLOGY**
**Paper –CC13**
HYDROGEOLGOY

**PRACTICAL LECTURES CCP13 [2 CREDITS]**

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,

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

**CORE COURSE: GEOLOGY**
**Paper –CC14**
GEOMORPHOLOGY, REMOTESENSING ANDGIS

**THEORY LECTURES CCT14 [4 CREDITS]**

## Unit 1: Introduction
Introduction to geomorphology; relationship between the landforms and the properties of earth material and different kind of processes.
Endogenic and exogenic processes.

## Unit 2
Geoid, topography, hypsometry, major morphological features of the earth surface.
Large scale topography - plate tectonics overview, large scale mountain ranges (with emphasis on Himalayas).

## Unit 3
Surficial processes and geomorphology; weathering and associated landforms.
Landforms produced by glacial, periglacial processes, fluvial processes, aeolian processes, coastal processes.
Landforms associated with igneous activities.

## Unit 4
Endogenic-exogenic interactions; rates of uplift and denudation; tectonics and drainage development; sea-level change; long-term landscape development.
Landform dating techniques.

## Unit 5: Photogeology
Types and acquisition of aerial photographs; scale and resolution; principles of stereoscopy, relief displacement, vertical exaggeration and distortion.
Elements of air photo interpretation.
Identification of sedimentary, igneous and metamorphic rocks and various aeolian, glacial, fluvial and marine landforms.

## Unit 6: Remote Sensing
Concepts in Remote Sensing.
Sensors and scanners.
Satellites and their characteristics.
Data formats- Raster and Vector.

## Unit 7: Digital Image Processing
Image classification

## Unit 8: GIS and GPS
Datum, Coordinate systems and projection systems.
Concepts of GPS.
Integrating GPS data with GIS.
Applications of GPS in earth system sciences.

**CORE COURSE: GEOLOGY**
**Paper –CC14**
GEOMORPHOLOGY, REMOTESENSING ANDGIS

## PRACTICAL LECTURES CCP14 [2 CREDITS]

Reading topographic maps. Preparation of topographic profile.
Preparation of longitudinal profile of a river. Calculating stream length gradient index.
Morphometry of a drainage basin. Interpretation of geomorphic processes from the geomorphology of the area.
Aerial photo interpretation: identification of sedimentary, igneous and metamorphic rocks and various aeolian, glacial, fluvial and marine landforms.

**Reference Books**

Roberts S. Anderson and Suzzane P. Anderson (2010). Geomorphology – The Mechanism and Chemistry of landscapes. Cambridge University Press.
M. A. Summerfield (1991). Global Geomorphology. Willey and Sons.
R G Huggett. Fundamentals of Geomorphology (3rd ed.). Routledge.
Demers, M.N., 1997. *Fundamentals of Geographic Information System*, John Wiley & sons. Inc.
Hoffmann-Wellenhof, B., Lichtenegger, H. and Collins, J., 2001. *GPS: Theory & Practice*, Springer Wien New York.
Jensen, J.R., 1996. *Introductory Digital Image Processing: A Remote Sensing Perspective*, Springer- Verlag.
Lillesand, T. M. & Kiefer, R.W., 2007. *Remote Sensing and Image Interpretation*, Wiley.
Richards, J.A. and Jia, X., 1999. *Remote Sensing Digital Image Analysis*, Springer-Verlag.

## DISCIPLINE SPECIFIC ELECTIVE
## Paper – DSE 1
TECTONICS

**THEORY LECTURES DSET1 [4 CREDITS]**

### Unit 1: Introduction
Continents and oceans. Continental and oceanic crust. Internal processes of earth. Ophiolites. Palaeomagnetism. Concept of lithosphere and asthenosphere. Physical character of lithosphere and asthenosphere. Concept of plate. Plate tectonic system.
Concept of hot spot and plumes.

### Unit 2: Historical Perspective: Continental Drift, Sea Floor Spreading and Plate Tectonics
Wegener's Continental drift hypothesis and its evidences. Continental position in the past.
Sea-floor spreading theory and its evidences. Magnetic time scale. Palaeomagnetism and motion of plates.

### Unit 3: Plate and Plate boundaries
Plates: physical character of plates. Macro and micro plates.
Plate boundaries: types, character, Identification of boundaries. Motion along plate boundaries. Triple points. Kinematics of plate motion. Rate of plate motion.
Volcanic arcs, island arcs, trenches, accretionary prisms, oceanic ridges, transform faults. Magmatism in oceanic ridges and in subduction zones.

### Unit 4: Plate Tectonics: Past and Present
Plate tectonics model and its evidences. Distribution of plates in the Earth. Reconstruction of plates - supercontinent. Supercontinents and their breakup and assembly. Assembly and breakup of Pangaea. Wilson cycle.
Driving mechanisms of plates. Plate tectonics and mantle convection.

## DISCIPLINE SPECIFIC ELECTIVE
## Paper – DSE 1
TECTONICS

**PRACTICAL LECTURES DSEP1 [2 CREDITS]**

Geometry of plate tectonics: Vector solutions in 2D and 3D of plate movements
Problems of plate movements - Rotations on sphere

### Reference Books

Kearey, p., Klepeis, K. A., and Vine, F. J. (2009). Global Tectonics. Third edition. Wiley-Blackwell, Oxford.
Condie, K.C. (1997). Plate Tectonics and Crustal Evolution. Fourth edition. Butterworth-Heinemann.
Moores, E. M. and Twiss, R. J. (1995). Tectonics. W. H. Freeman, New York.

## DISCIPLINE SPECIFIC ELECTIVE
## Paper – DSE 2
FUEL GEOLOGY

**THEORY LECTURES DSET2 [4 CREDITS]**

**Unit 1: Coal**
Definition and origin of Coal
Basic classification of coal
Fundamentals of Coal Petrology - Introduction to lithotypes, microlithotypes and macerals in coal
Proximate and Ultimate analysis

**Unit 2: Coal as a fuel**
Coal Bed Methane (CBM): global and Indian scenario

**Unit 3: Petroleum**
Chemical composition and physical properties of crudes in nature
Origin of petroleum

**Unit 4: Petroleum Reservoirs and Traps**
Reservoir rocks: general attributes
Classification of reservoir rocks - clastic and chemical.
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.

**Unit 5: Other fuels**
Gas Hydrate
Nuclear Fuel

## DISCIPLINE SPECIFIC ELECTIVE
## Paper – DSE 2
FUEL GEOLOGY

**PRACTICAL LECTURES DSEP2 [2 CREDITS]**

Study of hand specimens of coal
Reserve estimation of coal

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

## DISCIPLINE SPECIFIC ELECTIVE
## Paper – DSE 3
EARTH AND CLIMATE

**THEORY LECTURES DSET3 [4 CREDITS]**

**Unit 1: Climate system: Forcing and Responses**

Components of the climate system.
Climate forcing, Climate controlling factors.
Feedbacks in climate system (positive and negative).

### Unit 2: **Heat budget of Earth**
Incoming solar radiation, receipt and storage of heat transformation.
Earth's heat budget. Interactions amongst various sources of earth's heat.

### Unit 3: **Atmosphere – Hydrosphere**
Layering of atmosphere and atmospheric Circulation.
Atmosphere and ocean interaction and its effect on climate.
Surface and deep circulation.
Sea ice and glacial ice.

### **Unit 4:Response of biosphere to Earth's climate**
Climate change: natural vs. anthropogenic effects.
Future perspectives.
Brief introduction to archives of climate change.
Brief introduction to palaeoclimate.
Palaeoclimate data from India.

### Unit 5: **Orbital cyclicity and climate**
Milankovitch cycles and variability in the climate.
Glacial-interglacial stages
The last glacial maximum (LGM)
Pleistocene Glacial-Interglacial cycles.

### **Unit 6: Monsoon**
Mechanism of monsoon.
Monsoonal variation through time.
Factors associated with monsoonal intensity.
Effects of monsoon.

## DISCIPLINE SPECIFIC ELECTIVE
## Paper – DSE 3
EARTH AND CLIMATE

**PRACTICAL LECTURES DSEP3 [2 CREDITS]**

Study of distribution of major climatic regimes of India on map
Distribution of major wind patterns on World map
Numerical exercises on interpretation of proxy records for palaeoclimate

### Reference Books

Rudiman, W.F., 2001. Earth's climate: past and future. Edition 2, Freeman Publisher.
Rohli, R.V., and Vega, A.J., 2007. Climatology. Jones and Barlatt
Lutgens, F., Tarbuck, E., and Tasa, D., 2009. The Atmosphere: An Introduction to Meteorology. Pearson Publisher
Aguado, E., and Burt, J., 2009. Understanding weather and Climate. 5th Edition, Pearson Publisher

Dorothy Merritts, Kirsten Menking and Andrew deWet, 2014. Environmental Geology: An Earth Systems Science Approach. Edition 2, W.H.Freeman and Co Ltd

## DISCIPLINE SPECIFIC ELECTIVE
## Paper – DSE 4
FIELD GEOLOGY AND GRAND VIVA

**THEORY LECTURES DSET4 [4 CREDITS]**

**Unit 1: Grand viva**
Viva-voce on all topics covered under six semester course curricula

## DISCIPLINE SPECIFIC ELECTIVE
## Paper – DSE 4
FIELD GEOLOGY AND GRAND VIVA

**PRACTICAL LECTURES DSEP4 [2 CREDITS]**

**7-day fieldwork**
Preparation of a Geological map of a small area with folded/faulted beds.
Interrelation between different structural elements and their interpretations.
Visit to one underground/open crust mine: mining operation, surface geological expression of mining site Visit to dam site
Report writing.

## DISCIPLINE SPECIFIC ELECTIVE
## Paper – DSE 5
EXPLORATION GEOLOGY

**THEORY LECTURES DSET5 [4 CREDITS]**

**Unit 1: Mineral Resources**
Resource reserve definitions, Mineral resources in industries – historical perspective and present, A brief overview of classification of mineral deposits with respect to processes of formation in relation to exploration strategies.

**Unit 2: Prospecting and Exploration**
Principles of mineral exploration, Prospecting and exploration- conceptualization, methodology and stages, Sampling, subsurface sampling including pitting, trenching and drilling, Geochemical exploration.

**Unit 3: Evaluation of data**
Evaluation of sampling data
Mean, mode, median, standard deviation and variance

**Unit 4: Drilling and Logging**
Core and non-core drilling
Planning of bore holes and location of boreholes on ground

Core-logging

**Unit 5: 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)
Regular and irregular grid patterns, statistics and error estimation

## DISCIPLINE SPECIFIC ELECTIVE
## Paper – DSE 5
EXPLORATION GEOLOGY

**PRACTICAL LECTURES DSEP5 [2 CREDITS]**

Identification of anomaly
Concept of weighted average in anomaly detection
Geological cross-section
Models of reserve estimation

**Reference Books**
Clark, G.B. 1967. Elements of Mining. 3rd Ed. John Wiley & Sons.
Arogyaswami, R.P.N. 1996 Courses in Mining Geology. 4th Ed. Oxford-IBH.
Moon, C.J., Whateley, M.K.G., Evans, A.M., 2006, Introduction to Mineral Exploration, Blackwell Publishing.

## DISCIPLINE SPECIFIC ELECTIVE
## Paper – DSE 6
INTRODUCTION TO GEOPHYSICS

**THEORY LECTURES DSET6 [4 CREDITS]**

**Unit 1: Geology and Geophysics**
Interrelationship between geology and geophysics, Role of geological and geophysical data in explaining geodynamical features of the earth.

Unit 2: General and Exploration geophysics
Different types of geophysical methods - gravity, magnetic, electrical and seismic; their principles and applications
Concepts and Usage of corrections in geophysical data

**Unit 3: Geophysical field operations**
Different types of surveys, grid and route surveys, profiling and sounding techniques
Scales of survey, Presentation of geophysical data

Unit 4: Application of Geophysical methods
Regional geophysics, oil and gas geophysics, ore geophysics, groundwater geophysics, engineering geophysics

**Unit 5: Geophysical anomalies**
Correction to measured quantities, geophysical, anomaly, regional and residual (local) anomalies, factors controlling anomaly, and depth of exploration

Unit 6: Integrated geophysical methods
Ambiguities in geophysical interpretation, planning and execution of geophysical surveys

## DISCIPLINE SPECIFIC ELECTIVE
## Paper – DSE 6
INTRODUCTION TO GEOPHYSICS

**PRACTICAL LECTURES DSEP6 [2 CREDITS]**

Anomaly and background- Graphical method
Study and interpretation of seismic reflector geometry
Problems on gravity anomaly

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

## DISCIPLINE SPECIFIC ELECTIVE
## Paper – DSE 7
EVOLUTION OF LIFE THROUGH TIME

**THEORY LECTURES DSET7 [4 CREDITS]**

**Unit 1: Life through ages**
Fossils and chemical remains of ancient life.
Geological Time Scale with emphasis on major bio-events.
Fossilization processes and modes of fossil preservation.
Exceptional preservation sites- age and fauna

**Unit 2: Geobiology**
Biosphere as a system, processes and products
Biogeochemical cycles
Abundance and diversity of microbes, extremophiles

Microbes-mineral interactions, microbial mats

**Unit 3: Origin of life**
Possible life sustaining sites in the solar system, life sustaining elements and isotope records
Archean life: Earth's oldest life, Transition from Archean to Proterozoic, the oxygen revolution and radiation of life
Precambrian macrofossils – The garden of Ediacara
The Snow Ball Earth Hypothesis

**Unit 4: Paleozoic Life**
The Cambrian Explosion.
Biomineralization and skeletalization
Origin of vertebrates and radiation of fishes
Origin of tetrapods - Life out of water
Early land plants and impact of land vegetation

**Unit 5: Mesozoic Life**
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

**Unit 6: Cenozoic Life**
Aftermath of end Cretaceous mass extinction – radiation of placental mammals
Evolution of modern grasslands and co-evolution of hoofed grazers
Rise of modern plants and vegetation
Back to water – Evolution of Whales

**Unit 7: The age of humans**
Hominid dispersals and climate setting
Climate Change during the Phanerozoic - continental break-ups and collisions
Plate tectonics and its effects on climate and life
Effects of life on climate and geology

## DISCIPLINE SPECIFIC ELECTIVE
## Paper – DSE 7
EVOLUTION OF LIFE THROUGH TIME

**PRACTICAL LECTURES DSEP7 [2 CREDITS]**

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

**Reference Books**
Stanley, S.M., 2008 Earth System History
Jonathan I. Lumine W.H.Freeman Earth-Evolution of a Habitable World, Cambridge University Press.
Canfield, D.E. & Konhauser, K.O., 2012 Fundamentals of Geobiology Blackwell
Cowen, R., 2000 History of Life, Blackwell

## SKILL ENHANCEMENT COURSE
## Paper - SEC 1[2 CREDITS]
FieldWork-I

**7-days fieldwork**
Topographic sheet: methods of naming. Features, scale. Map reading.
Use of topographic sheets in field. Marking location in topographic sheet using physical features and bearing.
Identification of rock types in field.
Identification of primary and secondary structures in field.
Clinometer and Brunton compass: use of the instruments in measuring geological data in field. Techniques of measurement of orientation data in field.
Litholog measurement
Recording field data in maps and notebooks.
Report writing.

## SKILL ENHANCEMENT COURSE
## Paper - SEC 2 [2 CREDITS]
FieldWork-II

**7-day fieldwork**
Map reading and geological mapping
stratigraphic and biogeographic correlation using fossils
Preparation of a geological map of a small area with homoclinal or gently folded beds.
Stereographic plots of orientation data and their interpretation.
Report writing.

## SKILL ENHANCEMENT COURSE
## Paper - SEC 3 [2 CREDITS]
FieldWork-III

**7-days fieldwork**
Visit to any mineral deposit
Mode occurrence of ore, Ore mineralogy
Ore-Host rock interrelation
Ore formation process
Basic techniques of surveying, concept of outcrop mapping
Report writing.

## SKILL ENHANCEMENT COURSE
## Paper - SEC 4 [2 CREDITS]
FieldWork-IV

**7-day fieldwork**
Identification and characterization of major structural boundaries in Himalaya viz. MBT, MFT etc.,
OR
Field along any suitable transect of Himalayan foreland,
OR
Field transect in Siwalik
OR
Identification of Himalayan and pre-Himalayan elements
Report writing.

## SKILL ENHANCEMENT COURSE
## Paper - SEC 5 [2 CREDITS]
FieldWork-V

**7-day fieldwork**
Field transect in any Precambrian terrain
Study of craton ensemble including basic intrusive suites
Precambrian sedimentary basin
Basement-Cover relation in: a. fold belts, b. sedimentary successions
Report writing.

## SKILL ENHANCEMENT COURSE
## Paper - SEC 6[2 CREDITS]
FieldWork-VI

**7-day fieldwork**
Field training along Phanerozoic basin of India
Documentation of stratigraphic details in the field
Collection of sedimentological, stratigraphic and paleontological details and their representation
Facies concept and its spatio-temporal relation (Walther's Law) and concept of facies distribution atbasinal-scale
Fossils sampling techniques and their descriptions
Report writing.

## SKILL ENHANCEMENT COURSE
## Paper - SEC 7 [2 CREDITS]
FieldWork-VI

**7-day fieldwork**
Geological mapping of a project site (Dam sites, Tunnel alignments etc)
On site visit & to study various geotechnical aspects related to the project site.
Identification of geotechnical problems of a project site and remedial measures to be taken.
Identification of environmental problems of a project site and remedial measures to be taken.
Computation of rock mass Properties (RQD, RSR, RMR & Q) in the field.
Identification of potential suspected/probable sites of Natural Disaster and suggestions about corrective/preventive measures.

## SKILL ENHANCEMENT COURSE
## Paper - SEC 8[2 CREDITS]
ProjectWork

Preparation of seminar presentation on topics not directly covered in regular course curriculum
Seminar Report writing.

## GENERIC ELECTIVE
## Paper – GE 1
ESSENTIALS OF GEOLOGY

**THEORY LECTURES GET1 [4 CREDITS]**

Unit 1: Introduction to geology, scope, sub-disciplines and relationship with other branches of sciences

Unit 2: 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

Unit 3: Convections in the earth's core and production of magnetic field
Composition of earth in comparison to other bodies in the solar system

Unit 4: Origin and composition of hydrosphere and atmosphere
Origin of biosphere
Origin of oceans, continents and mountains

Unit 5: Age of the earth; Radioactivity and its application in determining the age of the Earth, rocks, minerals and fossils

## GENERIC ELECTIVE
## Paper – GE 1
ESSENTIALS OF GEOLOGY

**PRACTICAL LECTURES GEP1 [2 CREDITS]**

Study of major geomorphic features and their relationships with outcrops through physiographic models.
Detailed study of topographic sheets and preparation of physiographic description of an area
Study of soil profile of any specific area
Study of distribution of major lithostratigraphic units on the map of India
Study of distribution of major dams on map of India and their impact on river systems
Study of major ocean currents of the World
Study of seismic profile of a specific area and its interpretation

**Reference Books**

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

## GENERIC ELECTIVE
## Paper – GE 2
ROCKS AND MINERALS

**THEORY LECTURES GET2 [4 CREDITS]**

**Unit 1:** Minerals-Definitions, Physical properties of minerals
Mineralogical structure of earth, planetary minerals and native elements

Unit 2: Mineral structures
Mineralogy of the Earth's crust, mantle and core

Unit 3: Nature of light and principles of optical mineralogy
Optical classification of minerals.
An overview of environmental and radiation mineralogy, biomineralisation and gemology.

Unit 4: 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

## GENERIC ELECTIVE
## Paper – GE 2
ESSENTIALS OF GEOLOGY

**PRACTICAL LECTURES GEP2 [2 CREDITS]**

Study of physical properties of minerals
Introduction to optical microscopy
Study of optical properties of minerals
Study of physical properties of rocks
Study of optical properties of rock under thin sections
Understanding crystal symmetry via wodden models
Stereographic projection of mineral faces
Mineral formula calculation
Crystal chemical calculation
Introduction to analytical techniques for rock and mineral study.

**Reference Books**

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

## GENERIC ELECTIVE
## Paper – GE 3
PHYSICS AND CHEMISTRY OF EARTH

**THEORY LECTURES GET3 [4 CREDITS]**

Unit 1: Earth: surface features
Continents, continental margins, oceans

Unit 2: Earth's interior - variation of physical quantities and seismic wave velocity inside the earth, major
sub divisions and discontinuities.
Concepts of Isostasy; Airy and Pratt Model
Core: Seismological and other geophysical constraints
The geodynamo - Convection in the mantle

Unit 3: Elements of earth's magnetism.
Secular variation and westward drift
Solar activity and magnetic disturbance

Unit 4: Elements: Origin of elements/nucleosynthesis.
Abundance of the elements in the solar system / planet earth
Geochemical classification of elements.
Earth accretion and early differentiation
Isotopes and their applications in understanding Earth processes.
Stable isotopes: Stable isotope fractionation. Oxygen isotopes
Sublithospheric Mantle (Mineralogy/phase transitions)

Unit 5: Environmental geochemistry
Geological disposal of nuclear waste
Lead in environment and effect of lead on human health

## GENERIC ELECTIVE
## Paper – GE 3
ESSENTIALS OF GEOLOGY

**PRACTICAL LECTURES GEP3 [2 CREDITS]**

Projection of major elements on binary and triangular diagrams for rock classification
Projection of major element data on Harker's diagram to characterize magmatic differentiation
Study of trace elements through a) Projection of chondrite/primitive normalized trace elements to characterize sources b) Projection of trace elements on tectonic discrimination diagrams
Understanding Earth structure through behavior of seismic wave propagation
Problems on isostasy

**Reference Books**

Holmes, A., Principles of Physical Geology, 1992, Chapman and Hall
Condie, K.C. Plate Tectonics and Crustal Evolution, Pargamon Press, 1989.
Krauskopf, K. B., & Dennis, K. Bird, 1995, Introduction to Geochemistry. McGraw-Hill
Faure, G. Principles and Applications of Geochemistry, 2/e (1998), Prentice Hall, 600 pp.
Anderson, G. M. (1996). Thermodynamics of natural systems. John Wiley & Sons Inc.
Steiner, E. (2008). The chemistry maths book. Oxford University Press.
Yates, P. (2007) Chemical calculations. 2nd Ed. CRC Press.

## GENERIC ELECTIVE
## Paper – GE 4
EARTH RESOURCES
**THEORY LECTURES GET4 [4 CREDITS]**

Unit 1: Earth Resources
Resource reserve definitions; mineral, energy and water resources in industries
Historical perspective and present
A brief overview of classification of mineral deposits with respect to processes of formation in relation to exploration strategies

Unit 2: Definition of Energy: Primary and Secondary Energy
Difference between Energy, Power and Electricity
Renewable and Non-Renewable Sources of Energy
The concept and significance of Renewability: Social, Economic, Political and Environmental Dimension of Energy

Unit 3: Major Types and Sources of Energy
Resources of Natural Oil and Gas
Coal and Nuclear Minerals
Potential of Hydroelectric Power, Solar Energy, Wind, Wave and Biomass Based power and Energy

Unit 4: Energy Sources and Power Generation: Nuclear, Hydroelectric, Solar, Wind and Wave- General Principles.
Ground water resources and its role in economic development of a country
Current Scenario and Future Prospects of Solar Power, Hydrogen Power and Fuel Cells.

## GENERIC ELECTIVE
## Paper – GE 4
EARTH RESOURCES
**PRACTICAL LECTURES GEP4 [2 CREDITS]**

Plotting of major Indian oil fields on map of India
2. Problems related to hydroelectric power generation
3. Problems related to assessment of possible oil exploration site from geological maps
Problems related to energy demand projection of India and possible mitigation pathways
Problems related to biofuel

**Reference Books**

Energy and the Environment by Fowler, J.M 1984. McGraw-Hill
Global Energy Perspectives by Nebojsa Nakicenovic 1998, Cambridge University Press.
Energy Resources and Systems: Fundamentals and Non-Renewable Resources by Tushar K. Ghosh and M. A. Prelas. 2009, Springer
Introduction to Wind Energy Systems: Hermann-Josef Wagner and Jyotirmay Mathur. 2009, Springer.
Renewable Energy Conversion, Transmission and Storage. Bent Sorensen, 2007, Springer.

## GENERIC ELECTIVE
## Paper – GE 5
NATURAL HAZARDS AND DISASTER MANAGEMENT
**THEORY LECTURES GET5 [4 CREDITS]**

Unit 1: The Lithosphere and Related Hazards
Atmospheric Hazards, Hydrosphere and Related Hazards

Unit 2: Concepts of disaster
Types of disaster: natural and manmade - cyclone, flood, land slide, land subsidence, fire and earthquake, tsunami and volcanic eruption

Unit 3: Tectonics and Climate, Meteorite Impacts
Issues and concern for various causes of disasters
Disaster management, mitigation, and preparedness
Techniques of monitoring and design against the disasters
Management issues related to disaster

Unit 4: Disaster Management in India
Risk, Vulnerability and Hazard
Mitigation through capacity building
Legislative responsibilities of disaster management; disaster mapping, assessment
Pre-disaster risk & vulnerability reduction
Post disaster recovery & rehabilitation
Disaster related infrastructure development

Unit 5: Hazard Zonation Mapping
Remote-sensing and GIS applications in real time disaster monitoring
Prevention and rehabilitation

## GENERIC ELECTIVE
## Paper – GE 5
NATURAL HAZARDS AND DISASTER MANAGEMENT

**PRACTICAL LECTURES GEP5 [2 CREDITS]**

The course will also include discussions on topics determined by students in Tutorial. There would be 2 student presentations apart from the lectures. The topics would be assigned to students based on their interest.

**Reference Books**

Bell, F.G., 1999. Geological Hazards, Routledge, London.
Bryant, E., 1985. Natural Hazards, Cambridge University Press.
Smith, K., 1992. Environmental Hazards. Routledge, London.
Subramaniam, V., 2001. Textbook in Environmental Science, Narosa International

## GENERIC ELECTIVE
## Paper – GE 6
EARTH SURFACE PROCESSES

**THEORY LECTURES GET6 [4 CREDITS]**

Unit 1: Introduction to earth surface processes
Historical development in concepts, terrestrial relief, scales in geomorphology,

Unit 2: Energy flow and relative energy of surface processes.
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 3: Rates and changes in surface processes
Techniques for measuring rates of processes: sediment budgeting, rock magnetism, isotope geochemical tracers, cosmogenic nuclides, OSL & C-14 dating

Unit 4: 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 5: Geomorphic concepts in cause-effect relationship
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
## Paper – GE 6
EARTH SURFACE PROCESSES

**PRACTICAL LECTURES GEP6 [2 CREDITS]**

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

**Reference Books**

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

Bloom, A.L., 1998. *Geomorphology: A Systematic Analysis of Late Cenozoic Landforms,* Pearson Education.
Bridge, J.S. and Demicco, R.V., 2008. *Earth Surface Processes, Landforms and Sediment Deposits,* Cambridge University Press.
Esterbrook, D.J., 1992. *Surface Processes and Landforms,* MacMillan Publ.
Kale, V.S. and Gupta A 2001 *1ntoduction to Geomorphology,* Orient Longman Ltd.
Leeder, M. and Perez-Arlucea M 2005 Physical processes in earth and environmental sciences, Blackwell' publishing.
Summerfield M A 1991Globle *Geomorphology* Prentice Hall.
Wllcock, P.R., Iverson R M (2003) Prediction in geomorphology ' AGU Publication.

## GENERIC ELECTIVE
## Paper – GE 7
INTRODUCTION TO SUSTAINABILITY

**THEORY LECTURES GET7 [4 CREDITS]**

Unit 1: Introduction to Sustainability; basic concepts
Human Population – Past and Future trends

Unit 2: Ecosystems
Extinctions and Tragedy of Commons
Climate and Energy
Water Resources and Agriculture

Unit 3: National Resources Accounting
Environmental Economics and Policy
Measuring Sustainability
Systems interconnectivity among Primary Sustainability challenges
Sustainability Solutions: Some examples

## GENERIC ELECTIVE
## Paper – GE 7
INTRODUCTION TO SUSTAINABILITY

**PRACTICAL LECTURES GEP7 [2 CREDITS]**

The course will also include discussions on topics determined by students in Tutorial. There would be12 student presentations apart from the lectures. The topics would be assigned to students based ontheir interest.

**Reference Books**

Rogers, P.P., K. F. Jalal, and J.A. Boyd. 2007. An Introduction to Sustainable Development. Earthscan Publishers, 416 pp.
Brown, L. 2009. Plan B 4.0. Norton Publishers, New York. (The entire book is available in pdf format: http://www.earthpolicy.org/images/uploads/book_files/pb4book.pdf)

## GENERIC ELECTIVE
## Paper – GE 8
FOSSILS AND THEIR APPLICATIONS

**THEORY LECTURES GET8 [4 CREDITS]**

Unit 1: Introduction to fossils
Definition of fossil, fossilization processes (taphonomy), taphonomic attributes and its implications, modes of fossil preservation, role of fossils in development of geological time scale and fossils sampling techniques.

Unit 2: Species concept
Definition of species, species problem in paleontology, speciation, methods of description and naming of fossils, code of systematic nomenclature

Unit 3: Introduction to various fossils groups
Brief introduction of important fossils groups: invertebrate, vertebrate, microfossils, spore, pollens and plant fossils. Important age-diagnostic fossiliferous horizons of India

Unit 4: Application of fossils
Principles and methods of paleoecology, application of fossils in the study of paleoecology, paleobiogeography and paleoclimate

Unit 5: Societal importance of fossils
Implication of larger benthic and micropaleontology in hydrocarbon exploration: identification of reservoirs and their correlation. Application of spore and pollens in correlation of coal seams, spore and pollens as indicator of thermal maturity of hydrocarbons reservoirs, fossils associated with mineral deposits, fossils as an indicator of pollution.

## GENERIC ELECTIVE
## Paper – GE 8
FOSSILS AND THEIR APPLICATIONS

**PRACTICAL LECTURES GEP8 [2 CREDITS]**

Study of fossils showing various modes of fossilization
Distribution of age diagnostic fossils in India
Biostratigraphic correlation

**Reference Books**

Schoch, R.M. 1989. Stratigraphy, Principles and Methods.VanNostrand Reinhold.
Clarkson, E.N.K.1998. Invertebrate Paleontology and Evolution George AlIen&Unwin
Prothero, D.R. 1998. Bringing fossils to life - An introduction to Paleobiology, McGraw Hill.
Benton, M.J. 2005. Vertebrate paleontology (3rd edition). Blackwell Scientific, Oxford.
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
## Paper – GE 9
MARTIAN GEOLOGY

**THEORY LECTURES GET9 [4 CREDITS]**

Unit 1: MARS – OUR POTENTIAL HOME?
History of the exploration of Mars; The Journey of Mangalyaan
Evolution of Mars

Unit 2: The characteristics of Mars and its interior
The Martian atmosphere and hydrosphere.

Unit 3: Surface provinces of Mars
Surface processes on Mars and its evidences from Earth-based analogs – Impact structures, Volcanic features on Mars, Layered deposits, Eolian dunes, Debris flow, Martian outflow channels, Glacial Origin of Fretted Terrains on Mars, Mountain building

Unit 4: Geochemical analogs and Martian meteorites
Martian History Epochs of change: what went "wrong" and why?

Unit 5: Life in Mars
Is there evidence for life on Mars?
Physical and chemical conditions supportive of permanent Mars occupation; Terraforming of Mars and its challenges
New Trends for Human Missions to Mars and Human colonization of Mars

## GENERIC ELECTIVE
## Paper – GE 9
MARTIAN GEOLOGY

**PRACTICAL LECTURES GEP9 [2 CREDITS]**

The course will also include discussions on topics determined by students in Tutorial. There would be 12 student presentations apart from the lectures. The topics would be assigned to students based on their interest.

**Reference Books**

Sagan, C. (1973). Planetary Engineering on Mars, Icarus, 20, 513.
Fairen, A.G., Mars: Evolution, Geology and Exploration. Nova Publishers, ISBN: 978-1-62618-102-1
Chapman, M. (Ed.). (2007). *The geology of Mars: evidence from earth-based analogs* (Vol. 5). Cambridge University Press.
Ahrens, P. (2007). The Terraformation of Worlds.Nexial Quest, 22 p.
Gerstell, M. F.; Francisco, J. S.; Yung, Y. L.; Boxe, C.; Aaltonee, E. T. (2001). Keeping Mars warm with new super greenhouse gases. Proceedings of the National Academy of Sciences 98 (5): 2154-2157. doi:10.1073/pnas.05151159.
Beech, M. (2009).The Terraforming of Mars. Terraforming, 125-173.

## GENERIC ELECTIVE
## Paper – GE 10
SOILS: PRESENT AND PAST

**THEORY LECTURES GET10 [4 CREDITS]**

Unit 1: Soil forming processes: Chemical weathering, major buffer maintaining ocean/atm/biosphere $O_2$ and $CO_2$, new compounds/minerals of greater volume and lower density; Oxidation; Carbonation; Hydrolysis; Hydration; Base Exchange; Chelation; Microbial weathering

Unit 2: General soil forming regimes: Gleization; podzolization; lessivage; ferrallitizatin; calcification; salinization

Unit 3: Soil forming processes: Physical weathering, loosening and particle size reduction; pressure release; thermal expansion; growth of foreign crystal.

Unit 4: Modern soils and key pedofeatures: Soil structures; horizons; roots; Fe-Mn mottles and concretions; pedogenic carbonate

Unit 5: Introduction to paleopedology and paleosols; role of factors controlling paleosol formation- parent material, climate, vegetation, topography, time.

Units 6: Introduction to soil taxonomy and paleosol taxonomy

Unit 7: Micromorphology: Thin section analysis of paleosols

Unit 8: Geochemistry: molecular rations; chemical weathering indices

Units 9: Stable isotope geochemistry: carbon$_{13}$ and oxygen$_{18}$ system for vegetation, temperature, $pCO_2$

Unit 10: Diagenetic overprinting in fossil soils: compaction; oxidation of organic matter; cementation; illitization

Unit 11: Geological record of fossil soils- Precambrian paleosols- evolution of paleoatmospheric conditions

Unit 12: Geological record of fossil soils- Paleozoic paleosols- evolution of land animals and plants, coal, Permian-Triassic transition paleosols and extinction events

Unit 13: Geological record of fossil soils- Mesozoic-Cenozoic paleosols- fossil soils at K-T extinction event, Paleogene fossil soils at green house to ice house transition, evolution of Asian monsoon system.

Unit 14: Pleistocene-Holocene paleosols- human impact on landscape and soils, climate change, neotectonics.

Unit 15: paleosols and non-marine sequence stratigraphy based on paleopedology and sedimentology of fluvial successions.

## GENERIC ELECTIVE
## Paper – GE 10
SOILS: PRESENT AND PAST

**PRACTICAL LECTURES GEP10 [2 CREDITS]**

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

**Reference Books**

Retallack, G.J. (2001) *Soils of the Past: An Introduction to Paleopedology* (2nd edition): Oxford, Blackwell Science, Ltd., 416 p.
Birkeland, P.W. (1999) Soil and Geomorphology. Oxford University Press (430 pp.).
Bullock, P., Fedoroff, N., Jongeroius, A., Stoops, G., Tursina, T. (1985) Handbook of Soil Thin Section Description. Waine Research Publication, Wolverhampton (152 pp.).
Sheldon, N.D., Tabor, N.J. (2009) Quantitative paleoenvironmental and paleoclimatic reconstruction using paleosols. Earth-Science Reviews 95, 1–52.
Stoops, G. (2003) Guidelines for analysis and distribution of soil and regolith thin sections. Soil Sci. Soc. Am., Madison, Wisconsin, 184 pp.
Soil Survey Staff, (2006) Key to Soil Taxonomy, 10th ed. USDA Natural Resources Conservation Service, Washington D.C.(341 pp.)
Bhattacharyya T., Sarkar, D., Pal, D. K. (Eds.) Soil Survey Manual.NBSSLUP Publication No 146.

## GENERIC ELECTIVE
## Paper – GE 11
STUDIES ON CRYOSPHERE

**THEORY LECTURES GET11 [4 CREDITS]**

Unit 1: Introduction to Cryosphere
Cryosphere, Distribution and its components, Terrestrial and Marine cryosphere, Role of cryosphere in the climate system, Remote sensing of cryosphere and its applications.

Unit 2: Terrestrial Cryosphere
Snow formation, Snowfall and Snow cover, Metamorphism of snow, Snow and Remote sensing, Snowmelt modeling, Glacier Characteristics, Types of Glaciers, Erosional and Depositional features of Glaciers, Glacier mass balance, Surging Glaciers, Glacier hydrology, Glacier and remote sensing, Avalanches and its Characteristics, Ice caps and Ice sheets, Greenland or Antarctic Ice sheets, Sea level changes and Ice sheet, Permafrost and its features, Lake and River ice. Terrestrial Cryosphere in the present, past and future.

Unit 3: Marine Cryosphere
Ice shelves, Ice bergs, Sea ice characteristics, Ice islands, Ice streams, Mass balance of Sea ice, Ice drift and ocean circulation. Marine Cryosphere in the present, past and future

## GENERIC ELECTIVE
## Paper – GE 11
STUDIES ON CRYOSPHERE

**PRACTICAL LECTURES GEP11 [2 CREDITS]**

Remote sensing
1. Linear and non-linear regression algorithms to estimate SWE (snow water equivalent) from remote sensed data (mainly microwave data)
2. Estimation of precipitation from remote sensed data

Snowmelt run-off modeling
1. Empirical (Snow cover to spring snowmelt relation)
2. One of the non-empirical model (Degree-day, modified degree-day or energy balance methods)

**Reference Books**

The Global Cryosphere by Roger Berry and Thian Yew Gan
Cambridge University Press
Web inputs from sites sources such as TRMM and SMMR (Scanning Multichannel Microwave Radiometer) sites

## GENERIC ELECTIVE
## Paper – GE 12
NUCLEAR WASTE MANAGEMENT

**THEORY LECTURES GET12 [4 CREDITS]**

Nuclear reactors and generation of nuclear waste, nuclear fuel cycle, basic concepts about nuclear waste management. Classification, composition and types of nuclear waste, their sources and characteristics. Introduction to immobilization and vitrification processes. Nuclear waste forms and containments. Immobilization of nuclear waste in synthetic (AVS,BBS,SON 68 and R7T7) glasses and natural glass/rocks (acidic:obsidian, rhyolite and basic: nephiliniite and basaltic). Glass/rock characterization and its long-term performance assessment. Geochemistry of glass/rock-water interaction-solution and neoformed mineral chemistry.
Glass/rock alteration studies by mathematical modeling using EQ3/6 and GWB. Nuclear waste confinement and safe disposal in deep geological repository.Application of clays as natural barrier.

## GENERIC ELECTIVE
## Paper – GE 12
NUCLEAR WASTE MANAGEMENT

**PRACTICAL LECTURES GEP12 [2 CREDITS]**

Determination of physical properties such as hardness, durability, melting and pouring temperatures.
Chemical characterization of synthetic and natural glass.
mathematical modeling and extrapolation of synthetic glass alterations.
Mathematical modelling and extrapolation of natural acidic (obsidian, rhyolite) and basic (nephilinite and basaltic) glasses.

Determination of rate of alteration and recognition of neo-formed minerals.
Calculation of retention coefficient for glass residue.

**Reference Books**

Saling, J. (2001). Radioactive waste management. CRC Press.
Ojovan, M. I., & Lee, W. E. (2013). An introduction to nuclear waste immobilisation. Newnes.
T. G. Wolery: reaction path modeling of aqueous geochemical systems.
Bethke, C. M. (2007). Geochemical and biogeochemical reaction modeling. Cambridge University Press.

# UNIVERSITY OF CALCUTTA

# Syllabus for B.Sc.(General) Geology

## Six Semester Course Under

## Choice Based Credit System

| YEAR | SEMESTER | PAPER | COURSE NAMES WITH CODE | CREDIT POINTS | EQUIVALENT MARKS | | | | | TOTAL CREDIT POINTS |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Theory | Practical | Internal Assessment | Attendance | TOTAL | |
| 1ST YEAR | I | CC1 | CCT1: PHYSICAL and STRUCTURAL GEOOGY | 4 | 50 | | 10 | 10 | 100 | 8 |
| | | | CCP1: : PHYSICAL and STRUCTURAL GEOOGY | 2 | | 30 | | | | |
| | | AEC1 | AEC1: COMMUNICATIVE ENGLISH | 2 | 50 | | | | 50 | |
| | II | CC2 | CCT2: CRYSTALLOGRAPHY and MINERALOGY | 4 | 50 | | 10 | 10 | 100 | 8 |
| | | | CCP2: CRYSTALLOGRAPHY and MINERALOGY | 2 | | 30 | | | | |
| | | AEC2 | AEC2: BENGALI | 2 | 50 | | | | 50 | |
| 2ND YEAR | III | CC3 | CCT3: PETROLOGY | 4 | 50 | | 10 | 10 | 100 | 8 |
| | | | CCP3: PETROLOGY | 2 | | 30 | | | | |
| | | SEC1 | SEC1: GEOMORPHOLOGY and GEOTECTONICS | 2 | | 30 | 10 | 10 | 50 | |
| | IV | SEC2 | SEC2: FIELD GEOLOGY | 2 | | 30 | 10 | 10 | 50 | 8 |
| | | DSE1 | DSET1: ECONOMIC GEOLOGY and HYDROLOGY | 4 | 50 | | 10 | 10 | 100 | |
| | | | DSEP1: ECONOMIC GEOLOGY and HYDROLOGY | 2 | | 30 | | | | |
| 3RD YEAR | V | CC4 | CCT4: STRATIGRAPHY and PALAEONTOLOGY | 4 | 50 | | 10 | 10 | 100 | 10 |
| | | | CCP4: STRATIGRAPHY and PALAEONTOLOGY | 2 | | 30 | | | | |
| | | SEC3 | SECT3: GEOCHEMISTRY | 2 | 30 | | 10 | 10 | 50 | |
| | | AEC3 | AEC3:ENVIRONMENTAL STUDIES | 2 | 50 | | | | 50 | |
| | VI | SEC4 | SEC4: PHOTOGEOLOGY and REMOTE SENSING | 2 | 30 | | 10 | 10 | 50 | 10 |
| | | DSE2 | DSET2: ELEMENTS OF APPLIED GEOLOGY | 4 | 50 | | 10 | 10 | 100 | |
| | | | DSEP2: ELEMENTS OF APPLIED GEOLOGY | 2 | | 30 | | | | |
| | | AEC4 | AEC4:ENVIRONMENTAL STUDIES | 2 | 50 | | | | | |
| | | | | | TOTAL | | | | 800 + 200 | 52 |

Note:

1. AEC courses are not included in the gradation
2. At least 50 lectures of an hour duration should be allotted for 4 credit theoretical course and 2 credit practical course.

| YEAR | SEMESTER | CORE COURSE (CC) | ABILITY ENHANCEMENT COMPULSORY COURSE (AECC) | SKILL ENHANCEMENT COURSE (SEC) | DISCIPLINE SPECIFIC ELECTIVE (DSE) |
|---|---|---|---|---|---|
| 1ST | I | PHYSICAL and STRUCTURAL GEOLOGY | COMMUNICTIVE ENGLISH | -- | -- |
| | II | CRYSTALLOGRAPHY and MINERALOGY | ENVIRONMENT SCIENCE | -- | -- |
| 2ND | III | PETROLOGY | -- | GEOMORPHOLOGY And GEOTECTONICS | -- |
| | IV | -- | -- | FIELD GEOLOGY | ECONOMIC GEOLOGY and HYDROLOGY |
| 3RD | V | STRATIGRAPHY and PALAEONTOLOGY | -- | GEOCHEMISTRY | -- |
| | VI | -- | -- | PHOTO GEOLOGY And REMOTE SENSING | ELEMENTS OF APPLIED GEOLOGY |

**CC-1**

**PHYSICAL and STRUCTURAL GEOLOGY (THEORY) (04 credits)**

**Unit-I**: Introduction to geology and its scope, Earth and solar system: origin, size, shape, mass, density and its atmosphere.

**Unit-II**: A brief account of various theories regarding the origin and age of the earth; Brief idea of interior of earth and its composition.

**Unit-III**: Weathering and erosion: factors, types and their effects;

**Unit-IV**: Earthquakes: nature of seismic waves, their intensity and magnitude scale; Origin of earthquake; Volcanoes: types, products and causes of volcanism;.

**Unit-V**: Introduction to Structural Geology; contours, topographic and geological maps; Elementary idea of bed, dip and strike; Outcrop, effects of various structures on outcrop. Clinometer/Brunton compass and its use.

**Unit-VI**: Elementary idea of types of deformation; Folds: nomenclature and types of folds;

**Unit-VII**: Faults: nomenclature, geometrical and genetic classifications, normal, thrust and slip faults;

**Unit-VIII**: definition, kinds and significance of joints and unconformity.

**PRACTICALS (02 Credits)**

• **Physical Geology:**

Study of important geomorphological models; Reading topographical maps of the Survey of India; Identification of geomorphic features.

• **Structural Geology:**

Study of clinometers/Brunton compass; Identification of different types of folds/faults from block models; Exercises on structural problems: preparation of cross section profile from a geological map.

**Books Recommended**:

1. Arthur Holmes, 1992. Principles of Physical Geology. Chapman and Hall, London.
2. Miller, 1949. An Introduction to Physical Geology. East West Press Ltd.
3. Spencer, E.V., 1962. Basic concepts of Physical Geology. Oxford & IBH.
4. Mahapatra, G.B., 1994. A text book of Physical geology. CBS Publishers.
5. Billings, M.P., 1972. Structural Geology. Prentice Hall.
6. Davis, G.R., 1984. Structural Geology of Rocks and Region. John Wiley
7. Hills, E.S., 1963. Elements of Structural Geology. Farrold and Sons, London.
8. Singh, R. P., 1995. Structural Geology, A Practical Approach. Ganga Kaveri Publ., Varanasi.

**CC-2**

**CRYSTALLOGRAPHY and MINERALOGY (THEORY) (04 credits)**

**Unit-I**: Crystals and their characters:

**Unit-II**: Crystal form, face, edge, solid angle; Interfacial angle and their measurements; Crystallographic axes and angles.

**Unit-III**: Crystal parameters, Weiss and Miller system of notations;

**Unit-IV**: Symmetry elements and description of normal class of Isometric, Tetragonal,

Hexagonal, Trigonal, Orthorhombic, Monoclinic and Triclinic systems.
**Unit-V**: Introduction to Mineralogy, Definition and characters of mineral;
**Unit-VI**: Common physical properties of minerals; Chemical composition and diagnostic physical properties of minerals such as: Quartz, Orthoclase, Microcline, Hypersthene, Hornblende, Garnet, Muscovite, Biotite, Chlorite, Olivine, Epidote, Calcite.
**Unit-VII**: Polarizing microscope, its parts and functioning; Ordinary and polarized lights; Common optical properties observed under ordinary, polarized lights and crossed nicols.
**Unit-VIII**: Optical properties of some common rock forming minerals (Quartz, Orthoclase, Microcline, Olivine, Augite, Hornblende, Muscovite, Biotite, Garnet, Calcite).

**PRACTICALS (02 Credits)**

• **Crystallography:**
Study of symmetry elements of normal class of Isometric, Tetragonal, Hexagonal, Trigonal, Orthorhombic, Monoclinic and Triclinic systems.

• **Mineralogy:**
Study of physical properties of minerals mentioned in theory course. Use of polarizing microscope; Study of optical properties of common rock forming minerals mentioned in theory course.

**Books Recommended**:

1. Dana, E.S. and Ford, W.E., 2002. A textbook of Mineralogy (Reprints).
2. Flint, Y., 1975. Essential of crystallography, Mir Publishers.
3. Phillips, F.C., 1963. An introduction to crystallography. Wiley, New York.
4. Berry, L.G., Mason, B. and Dietrich, R.V., 1982. Mineralogy. CBS Publ.
5. Nesse, D.W., 1986. Optical Mineralogy. McGraw Hill.
6. Read, H.H., 1968. Rutley's Element of Mineralogy (Rev. Ed.). Thomas Murby and Co.
7. Berry and Mason, 1961. Mineralogy. W.H. Freeman & Co.
8. Kerr, B.F., 1995. Optical Mineralogy 5th Ed. Mc Graw Hill, New York.

**CC-3**
**PETROLOGY (THEORY) (04 Credits)**

**Igneous Petrology**
**Unit-I:** Magma: definition, composition, types and origin; Forms of igneous rocks; textures of igneous rocks.
**Unit-II**: Reaction principle; Differentiation and Assimilation; Crystallization of unicomponent and bicomponent (mix-crystals); Bowen's reaction series.
**Unit-III**: Mineralogical and chemical classification of igneous rocks:.
**Unit-IV**: Detailed petrographic description of Granite, Granodiorite, Rhyolite, Syenite, Phonolite, Diorite, Gabbro.
**Sedimentary Petrology**
**Unit-V:** Processes of formation of sedimentary rocks; Classification, textures and structures of sedimentary rocks;
**Unit-VI:** Petrographic details of important siliciclastic and carbonate rocks such as -

conglomerate, breccia, sandstone, greywacke, shale, limestones.

**Metamorphic Petrology**

**Unit-VII:** Process and products of. metamorphism; Type of metamorphism. Factors, zones and grade of metamorphism; Textures, structures and classification of metamorphic rocks.

**Unit-VIII**: Petrographic details of some important metamorphic rocks such as - slate, , schists, gneiss, quartzite, marble.

**PRACTICALS (02 Credits)**

• **Igneous Petrology:**

Identification of rocks: On the basis of their physical properties in hand specimen; and optical properties in thin sections.

• **Sedimentary and metamorphic Petrology:**

Identification of sedimentary and metamorphic rocks both in hand specimen and thin sections.

**Books Recommended**:

1. Turner, F.J. & Verhoogen, J., 1960, Igneous & Metamorphic petrology. McGraw Hill Co.
2. Bose, M.K., 1997. Igneous petrology. World press
3. Tyrell, G. W., 1989. Principles of Petrology. Methuren and Co (Students ed.).
4. Ehlers, WG, and Blatt, H., 1987. Petrology, Igneous, Sedimentary and Metamorphic rocks, CBS Publishers
5. Moorhouse, WW., 1969. The study of rocks in thin sections. Harper and sons.
6. Friedman & Sanders, 1978. Principles of Sedimentology. John Wiley and sons.
7. Pettijohn, F.J., 1975. Sedimentary rocks, Harper & Bros. 3rd Ed.
8. Prasad, C., 1980. A text book of sedimentology.
9. Sengupta. S., 1997. Introduction to sedimentology. Oxford-IBH.
10. Turner, F.J., 1980. Metamorphic petrology. McGraw Hill.
11. Mason, R., 1978. Petrology of Metamorphic Rocks. CBS Publ.
12. Winkler, H.G.C., 1967. Petrogenesis of Metamorphic Rocks. Narosa Publ.

**CC-4**

**STRAIGRAPHY and PALAEONTOLOGY (THEORY) (04 Credits)**

**Unit I:** Definition, Principle of stratigraphy; Geological Time Scale and stratigraphic classification; Physiographic division of India.

**Unit II**: Study of following Precambrian succession: Dharwar, Cuddapha, Vindhyan and Delhi Supergroups; Brief idea of Palaeozoic succession of northwestern Himalaya; Triassic of Spiti; Mesozoic type seccession of Kutch and Rajasthan; Cretaceous of Tiruchirapalli;

**Unit III:** Study of following type localities: Gondwana and Deccan Trap.

**Unit IV:** Palaeogene-Neogene sequences of northwest Himalaya and Assam.

**Unit-V**: Palaeontology: definition, Fossils: definition, characters, binomial nomenclature in taxonomy, mode of preservation, condition of fossilization and significance of fossils;.

**Unit VI:** Morphology and geological distribution of brachiopods, pelecypods, cephalopods.

**Unit VII:** Morphology and geological distribution of trilobite, echinoidea.

**Unit VIII:** Evolutionary history of horse; Morphology, distribution and significance of Gondwana flora.

**Practicals (02 Credits)**

I. Morphological characters, systematic position and age of fossil genera pertaining to brachiopods, pelecypods, cephalopods, trilobite and Echinacea.

II. Preparation of lithostratigraphic maps of India showing distribution of important geological formations.

**Books Recommended:**

1. Wadia, D., 1973. Geology of India. Mc Graw Hill Book co.
2. Krishnan, M.S., 1982. Geology of India and Burma, 6th Edition. CBS Publ.
3. Ravindra Kumar, 1985. Fundamentals of Historical Geology & Stratigraphy of India. Wiley Eastern.
4. Shrock, R.R. & Twenhoffel, W.H., 1952. Principles of Invertebrate Paleontology. CBS Publ.
5. Swinerton, HH., 1961. Outlines of Paleontology. Edward Arnold Publishers
6. Jain, P.C. & Anantharaman, M.S., 1983. Paleontology: Evolution & Animal Distribution. Vishal Publ.
7. Lehmann, U., 1983. Fossil Invertebrate. Cambridge Univ. Press.
8. Rastogi, 1988. Organic evolution. Kedrnath and Ramnath Publ.

**SEC-1**

**GEOMORPHOLOGY and GEOTECTONICS (02 Credits)**

**Unit-I:** Basic principles of Geomorphology, geomorphological cycles, weathering and erosion; Geomorphic mapping- tools and techniques.

**Unit-II:** Epigene/exogenic processes: degradation and aggradation. Hypogene/endogenic processes; Diastrophism and volcanism, Extraterrestrial processes; Geological work of wind, glacier, river, underground water and ocean.

**Unit-III**: Earth as a dynamic system. Elementary idea of continental drift, sea-floor spreading and mid-oceanic ridges. Paleomagnetism and its application.

**Unit-IV:** Plate Tectonics: the concept, plate margins, orogeny, deep sea trenches, island arcs and volcanic arcs.

**Books Recommended:**

1. Allen, P., 1997. Earth Surface Processes. Blackwell
2. Bloom, A.L., 1998. Geomorphology: A systematic Analysis of Late Cenozoic Landforms (3rd Edition). Pearson Education, Inc.
3. Keary, P. and Vine, F.J., 1997. Global Tectonics. Blackwell and crustal evolution. Butterworth-Heinemann.
4. Kale, V.S. and Gupta, A., 2001. Introduction to Geomorphology. Orient Longman Ltd.
5. Moores, E and Twiss. R.J., 1995. Tectonics. Freeman.
6. Patwardhan, A. M., 1999. The Dynamic Earth System. Prentice Hall.
7. Summerfied, M.A., 2000. Geomorphology and Global tectonic. Springer Verlag.
8. Valdia, K.S., 1988. Dynamic Himalaya. Universities Press, Hyderabad.
9. WD Thornbury, 2002. Principles of Geomorphology. CBS Publ. New Delhi.

**SEC-2**

**FIELD GEOLOGY (02 Credits)**

Students will be required to carry out 03 days field work in a suitable geological area to study the elementary aspects of field geology and submit a report thereon.

**SEC-3**

**GEOCHEMISTRY (02 Credits)**

Unit-I: Introduction to geochemistry: basic knowledge about crystal chemistry. Types of chemical bonds, coordination number; Colloids in geological systems, ion exchanges and geological evidence for earlier colloids; Elementary idea of Periodic Table.

Unit-II: Cosmic abundance of elements; Composition of the planets and meteorites; Geochemical evolution of the earth and geochemical cycles;

Unit-III: Gold Schmidt's geochemical classification of elements; Distribution of major, minor and trace elements in igneous, metamorphic and sedimentary rocks.

Unit-IV: Elements of geochemical thermodynamics; Isomorphism and polymorphism; Isotope geochemistry.

**Books Recommended:**

1. Hoefs, J., 1980. Stable Isotope Geochemistry. Springer-Verlag.
2. Klein, C. and Hurlbut, C.S., 1993. Manual of Mineralogy. John Viley and Sons, New York.
3. Krauskopf, K.B., 1967. Introduction to Geochemistry. McGraw Hill.
4. Mason, B. and Moore, C.B., 1991. Introduction to Geochemistry. Wiley Eastern.
5. Rollinson, H.R., 1993. Using geochemical data: Evaluation, Presentation, and Interpretation. Longman.

**SEC-4**

**PHOTO GEOLOGY and REMOTE SENSING (02 Credits)**

**Unit-I**: Elementary idea about photogeology: electro-magnetic spectrum, types & geometry of aerial photographs; factors affecting aerial photography; types of camera, film and filters; factors affecting scale;

**Unit-II**: Fundamentals of remote sensing; remote sensing systems; remote sensing sensors; signatures of rocks, minerals and soils. Application of remote sensing in geoscience and geomorphological studies.

**Unit-III**: Types of Indian and Foreign Remote Sensing Satellites, Digital image processing; fundamental steps in image processing; elements of pattern recognition and image classification.

**Unit-IV**: Introduction to Geographic Information System (GIS); components of GIS; product generation in GIS; tools for map analysis; integration of GIS with remote sensing.

**Books Recommended**:

1. Bhatta, B., 2008. Remote Sensing and GIS. Oxford, New Delhi.
2. Gupta, R.P., 1990. Remote Sensing Geology. Springer Verlag.
3. Lilleasand, T.M. and Kiffer, R.W., 1987. Remote Sensing and Image Interpretation. John Wiley.
4. Pandey, S.N., 1987. Principles and Application of Photogeology. Wiley Eastern, New Delhi.
5. Sabbins, F.F., 1985. Remote Sensing – Principles and Applications. Freeman.
6. Siegal, B.S. and Gillespie, A.R., 1980. Remote Sensing in Geology. John Wiley.
7. Rampal K.K. 1999. Hand book of aerial photography and interpretation. Concept publication.

**DSE-1**

**ECONOMIC GEOLOGY and HYDROLOGY (THEORY) (04 Credits)**

**Unit-I:** Concept of ore and ore deposits, ore minerals and gangue minerals; Tenor of ores; Metallic and non-metallic ore minerals; Strategic, Critical and essential minerals.

**Unit-II:** Processes of formation of ore deposits; Magmatic, contact metasomatic, hydrothermal, sedimentation,.
**Unit-III:** Study of important metallic (Cu, Pb, Zn Mn, Fe, Au, Al) and non-metallic (industrial) minerals (gypsum, magnesite, mica).
**Unit-IV:** Distribution of coal and petroleum in India;.
**Unit-V**: Definition of hydrogeology, Hydrological cycle;
**Unit-VI**:Hydrological parameters - Precipitation, evaporation, transpiration and infiltration.
**Unit-VII**: Origin of groundwater; Vertical distribution of groundwater; Types of aquifers; Water bearing properties of rocks - Porosity and Permeability; specific yield, specific retention.
**Unit-VIII**: Surface and subsurface geophysical and geological methods of ground water exploration; Groundwater provinces of India.

**PRACTICALS (02 Credits)**

**I) Economic Geology:**

Study of ore and economic minerals in hand specimen; Preparation of maps showing distribution of important metallic and non-metallic deposits and important coal and oil fields of India.

**II) Hydrology:**

Study of hydro-geological models, Estimation of porosity and permeability from the given data; Preparation and interpretation of water table maps.

**Books Recommended:**

1. Brown, C. and Dey, A.K.1955. Indian Mineral Wealth. Oxford Univ.
2. Gokhale, K.V.G.K. and Rao, T.C., 1983. Ore Deposits of India. East West Press Pvt. Ltd.
3. Jense, M.L. and Bateman A.M., 1981. Economic Mineral Deposits. John Wiley and Sons.
4. Krishnnaswamy, S., 1979. India's Minerals Resources. Oxford and IBH Publ.
5. Deb, S., 1980. Industrial minerals and Rocks of India. Allied Publishers Pvt. Ltd.
6. Umeshwar Prasad, 2003. Economic Geology. CBS Publishers and distributers.
7. Sharma, N.L. and Ram, K.V.S., 1972. Introduction to India's Economic Minerals, Dhanbad.
8. Karanth, K. R., 1989. Hydrogeology. Tata McGraw Hill Publ.
9. Raghunath, H. M., 1990. Groundwater. Wiley Eastern Ltd.
10. Subramaniam, V., 2000. Water-Kingston Publ. London.

**DSE-2**

**ELEMENTS OF APPLIED GEOLOGY (THEORY) (04 Credits)**

**Unit-I:** Engineering properties of rocks and Soils.
**Unit-II:** Soil and Soil groups of India.
**Unit-III**: Dam, Types and their geological and environmental considerations; Geological problem of reservoirs.
**Unit-IV:** Tunnels: geology, structure, seepage problem and role of water table;
**Unit-V:** Landslides: classification, causes and preventative measures.
**Unit-VI**: Mineral exploration: Elementary idea of geological and geophysical prospecting.
**Unit-VII:** Elementary idea of mining.
**Unit-VIII:** Environmental considerations for mining.

**PRACTICALS (02 Credits)**

Engineeringproperties and identification of building stones. Identification of various models of landslide, tunnel and dam. Study of soil profiles.

**Books Recommended**:


1. Valdiya, K.S., 1987. Environmental Geology – Indian Context. Tata McGraw Hill.
2. Rajendran S., 2007. Mineral Exploration : Recent Strategies.
3. Dobrin, M.B. & Savit, CH., 1988. Introduction to Geophysical Prospecting, McGraw-Hill.
4. Arogyaswamy, R.N.P., 1973. Courses in Mining Geology. Oxford and IBH Publ.
5. Parasins, D.S., 1997. Principles of applied geophysics. Chapman Hall.
6. Krynine D.P. and Judd W.R., 1957. Principles of Engineering Geology & Geotechnics. McGraw-Hill Book
7. Kesavulu, N.C., 2009. A text book of engineering geology. Macmillan P publishing India Ltd.
8. Crozier. M.J., 1989. Landslides: causes, consequences and environment. Academic Press.
9. Readman, J.H., 1979. Techniques in Mineral exploration. Applied Science Publishres.
10. Bell, F.G., 1983. Fundamentals of Engineering Geology. Butterworth and Co.