



Draft Syllabus Geology (Hons)

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1. Introduction

The syllabus for Geology at undergraduate level using the Choice Based Credit system has been framed in compliance with model syllabus given by UGC.

The main objective of framing this new syllabus is to give the students a holistic understanding of the subject giving substantial weightage to both the core content and techniques used in Geology.

The ultimate goal of the syllabus is that the students at the end are able to secure a job. Keeping in mind and in tune with the changing nature of the subject, adequate emphasis has been given on new techniques of mapping and understanding of the subject.

The syllabus has also been framed in such a way that the basic skills of subject are taught to the students, and everyone might not need to go for higher studies and the scope of securing a job after graduation will increase.

While the syllabus is in compliance with UGC model curriculum, some changes have been made to ensure all topics are covered and any of the subjects don't become difficult to be completed in one semester.

As Stratigraphy needs to be covered in detail for Geology students, it has been split into two core papers to be covered in 4th Semester. Also, papers on Geomorphology and Remote Sensing have related content and matters are relatively light in both papers, this they have been clubbed into one core paper to be covered in 6th semester

Also, new electives on "Geodynamics" has been introduced which an important subject that every Geology student should study, however the same was not proposed in the UGC syllabus. Similarly, a general elective on "Earth Resources" has also been introduced.

It is also suggested that three General Elective papers "Earth Surface Processes", "Natural Hazards and Disaster Management" and "Physics and Chemistry of Earth" may also be offered to Geology students for the larger benefit of the students.

2.Scheme for CBCS Curriculum

2.1 Credit Distribution across Courses

		Credits	
Course Type	Total Papers	Theory + Practical	Theory*
Core Courses	14	$14 \times 4 = 56$ $14 \times 2 = 28$	$14 \times 5 = 70$ $14 \times 1 = 14$
Discipline Specific Electives	4	$4 \times 4 = 16$ $4 \times 2 = 8$	$4 \times 5 = 20$ $4 \times 1 = 4$
Generic Electives	4	$4 \times 4 = 16$ $4 \times 2 = 8$	$4 \times 5 = 20$ $4 \times 1 = 4$
Ability Enhancement Language Courses	2	$2 \times 2 = 4$	$2 \times 2 = 4$
Skill Enhancement Courses	2	$2 \times 2 = 4$	$2 \times 2 = 4$
Totals	26	140	140

*Tutorials of 1 Credit will be conducted in case there is no practical component

2.2 Scheme for CBCS Curriculum

Semester	Course Name	Course Detail	Credits
I	Ability Enhancement Compulsory Course - I	English communication / Environmental Science	2
	Core course - I	Earth System Science	4
	Core course - I Practical	Earth System Science Lab	2
	Core course - II	Mineral Science	4
	Core course - II Practical	Mineral Science Lab	2
	Genetic Elective - 1	TBD	4
	Generic Elective - 1 Practical	TBD	2
II	Ability Enhancement Compulsory Course - II	English communication / Environmental Science	2
	Core course - III	Elements of Geochemistry	4
	Core course - III Practical	Elements of Geochemistry Lab	2
	Core course - IV	Structural Geology	4
	Core course - IV Practical	Structural Geology Lab	2
	Generic Elective - 2	TBD	4
	Generic Elective - 2 Practical	TBD	2
III	Core course - V	Igneous Petrology	6
	Core course - V Practical	Igneous Petrology Lab	-
	Core course - VI	Sedimentary Petrology	6
	Core course - VI Practical	Sedimentary Petrology Lab	-
	Core course - VII	Paleontology	4
	Core course - VII Practical	Paleontology Lab	2
	Skill Enhancement Course - 1	TBD	2

	Generic Elective - 3	TBD	4
	Generic Elective - 3 Practical	TBD	2
IV	Core course - VIII	Metamorphic Petrology	4
	Core course - VIII Practical	Metamorphic Petrology Lab	2
	Core course - IX	Stratigraphic Principles and Indian Stratigraphy	4
	Core course - IX Practical	Stratigraphic Principles and Indian Stratigraphy Lab	2
	Core course - X	Phanerozoic Stratigraphy of India	4
	Core course - X Practical	Phanerozoic Stratigraphy of India Lab	2
	Skill Enhancement Course-2	TBD	2
	Generic Elective - 4	TBD	4
	Generic Elective - 4 Practical	TBD	2
V	Core course - XI	Hydrogeology	4
	Core course - XI Practical	Hydrogeology lab	2
	Core course - XII	Economic Geology	4
	Core course - XII Practical	Economic Geology Lab	2
	Discipline Specific Elective - 1	TBD	4
	Discipline Specific Elective - 1 Practical	TBD	2
	Discipline Specific Elective - 2	TBD	4
	Discipline Specific Elective - 2 Practical	TBD	2
VI	Core course - XIII	Geomorphology, Remote Sensing & GIS	4
	Core course - XIII Practical	Geomorphology, Remote Sensing & GIS Lab	2
	Core course - XIV	Engineering Geology	4
	Core course - XIV Practical	Engineering Geology Lab	2
	Discipline Specific Elective - 3	TBD	4

	Discipline Specific Elective - 3 Practical	TBD	2
	Discipline Specific Elective - 4	TBD	4
	Discipline Specific Elective - 4 Practical	TBD	2

2.3 Choices for Discipline Specific Electives

Discipline Specific Elective - 1 to 4			
Earth and Climate	Introduction to Geophysics	Fuel Geology	Exploration Geology
Evolution of Life through time	River Science	Oceanography and Marine Science	Urban Geology
Geodynamics			

2.4 Choices for Skill Enhancement Courses

Skill Enhancement Course-1		Skill Enhancement Course-2	
Field Geology I	Field Geology II	Field Geology III	Field Geology IV

3. Core Subjects Syllabus

3.1 Core T1 - Earth System Science

Earth System Science	
	4 Credits
Unit 1: Earth as a planet	
1. Branches of Earth Sciences 2. General characteristics and origin of the Universe, Solar System and its planets The terrestrial and jovian planets 3. Meteorites and Asteroids 4. Earth in the solar system - origin, size, shape, mass, density, rotational and revolution parameters 5. Origin of atmosphere, ocean and life	
Unit 2: Solid Earth, Hydrosphere, Atmosphere and Biosphere	
1. Mechanical layering of the Earth: Lithosphere, asthenosphere, mantle and core 2. Earthquake and earthquake belts: Seismic waves and internal constitution of the Earth 3. Volcanoes and volcanism, distribution of volcanoes 4. Concept of isostasy 5. Formation of core, mantle, crust, atmosphere, Hydrosphere and Biosphere 6. Convection in Earth's core and production of its magnetic field 7. Geothermal gradient and internal heat of the Earth	
Unit 3: Cosmic abundance of elements	
1. Distribution of elements in solar system and in Earth 2. Composition of the Earth. General concepts about geochemical cycles 3. Properties of common elements in Earth 4. Concepts of geochemical cycles	
Unit 4: Hydrosphere and Atmosphere	
1. Oceanic current system and effect of Coriolis force 2. Concepts of eustasy	

3. Land-air-sea interaction: Wave erosion and beach processes Atmospheric circulation
4. Weather and climatic changes Earth's heat budget

Unit 5: Plate Tectonics

1. Historical development of the concept of continental drift and plate tectonics
2. Plates and Plate boundaries
3. Geodynamic elements of Earth: Mid Oceanic Ridges, trenches, transform faults and island arcs
4. 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

1. Nature of stratigraphic records
2. Fundamental laws of stratigraphy: Laws of superposition and faunal succession
3. Absolute and relative time in Geology. Concept of time and geological time scale
4. Concept of radiometric dating. Radiometric dating of rocks and minerals: U-Pb, Pb-Pb, K-Ar, Rb-Sr, Sm-Nd method. Dating igneous and sedimentary rocks
5. Concepts of neptunism, plutonism, uniformitarianism, and catastrophism
6. Geological Time Scale

Reference Books

- ▶ Duff, P. M. D., & Duff, D. (Eds.). (1993). Holmes' principles of physical geology. Taylor & 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.
- ▶ Environmental Science - Earth as a Living Planet. By - Daniel B. Botkin & Edward A. Keller, John Wiley & Sons.

3.2 Core P1 - Earth System Science Lab

Earth System Science	
	2 credits
List of Practical	
1. 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 2. Study of soil profile of any specific area 3. Study of distribution of major lithostratigraphic units on the map of India 4. Global distribution of cratons, mobile belts and major sedimentary basins. oDistribution of cratons, mobile belts and major sedimentary basins inIndia 5. Calculation of Richter magnitude from S-P wave interval data.	

3.3 Core T2 - Mineral Science

Mineral Science	
	4 Credits
Unit 1: Crystallography	
1. Concept of crystal and crystalline matter. Internal order in crystal. 2. Crystal structure, Elementary ideas about crystal morphology in relation to internal structures 3. Crystal parameters and indices, form and zone 4. Stereographic projection of crystal faces Crystal symmetry, classification of crystals into systems and point groups. International symbol of point groups	
Unit 2: Atomic arrangements and Mineralogical structure	
1. Atomic arrangements: Unit cell, CCP, FCC and HCP 2. Ionic radius and coordination, Pauling's rules. Solid Solution, Polymorphism, Pseudomorphism 3. Atomic structure of silicate minerals	
Unit 3: Rock forming minerals	
1. Minerals - definition and classification, physical and chemical properties 2. Chemical classification of minerals 3. Composition of common oxides, carbonated, sulphides and sulphates and phosphates 4. Composition of common rock-forming minerals	
Unit 4: Crystal Optics	
1. Nature of light and optical behaviour of crystals 2. Introduction to petrological microscope	
Reference Books	
▶ Klein, C., Dutrow, B., Dwight, J., & Klein, C. (2007). The 23rd Edition of the Manual of Mineral Science (after James D. Dana). J. Wiley & Sons. ▶ Verma, P. K. (2010). Optical Mineralogy (Four Colour). Ane Books Pvt Ltd. ▶ Deer, W. A., Howie, R. A., & Zussman, J. (1992). An introduction to the rock-forming minerals (Vol. 696). London: Longman.	

- ▶ Nesse, W. D. (2011). Introduction to Optical Mineralogy (Fourth Edition). Oxford University Press.
- ▶ Putnis, A. (1992): Introduction to Mineral Sciences. Cambridge University Press.

3.4 Core P2 - Mineral Science Lab

Mineral Science	
	2 Credits
List of Practical	
1. Study of the symmetry of crystals. Stereographic projection of crystals 2. Derivation of structural formulae based on composition 3. Study of physical properties of minerals in hand specimen - Silicates: Olivine, Garnet, Andalusite, Sillimanite, Kyanite, Staurolite, Beryl, Tourmaline, Pyroxene, Tremolite, Hornblende-Actinolite, Serpentine, Talc, Muscovite, Biotite, Quartz, Feldspar, Nepheline, Zeolite Asbestos 4. Quartz varieties: Chert, Chalcedony, Agate, Jasper, Amethyst, Rock crystal 5. Other minerals: Pyrite, Chalcopyrite, Galena, Sphalerite Barite and Gypsum; Magnetite, Haematite, Pyrolusite and Psilomelane, Corundum, Ilmenite, Chromite, Bauxite; Fluorite, Calcite, Dolomite, Apatite, Graphite 6. Study of optical properties of common rock-forming minerals: quartz, orthoclase, microcline, plagioclase, perthite, nepheline, olivine, orthopyroxene, clinopyroxene, hornblende, staurolite, garnet, muscovite, biotite, calcite	

3.5 Core T3 - Elements of Geochemistry

Elements of Geochemistry	
	4 Credits
Unit 1: Basic Concepts	
1. Introduction to properties of elements: The periodic table 2. Chemical bonding, states of matter and atomic environment of elements 3. Geochemical classification of elements	
Unit 2: Layered structure of Earth and geochemistry	
1. Composition of the bulk silicate Earth 2. Composition of core 3. Composition of mantle: depleted mantle and enriched mantle 4. Composition of crust: Continental and Oceanic 5. Isotope geology: Isotopic and elemental fractionation 6. Radiogenic and stable isotopes in Earth materials	
Unit 3: Element transport	
1. Advection and diffusion Chromatography 2. Aqueous geochemistry- basic concepts and speciation in solutions, Eh, pH relations 3. Elements of marine chemistry 4. Mineral reactions- diagenesis and hydrothermal reactions.	
Unit 4: Geochemistry of solid Earth	
1. Geochemical variability of magma and its products. Melting processes.	
Unit 5: Geochemical behaviour of selected elements	
Si, Al, K, Na, Ca, Fe, Mg, Ti.	
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 & Technical. ▶ Walther, J. V. (2009). Essentials of geochemistry. Jones & 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

3.6 Core P3 - Elements of Geochemistry Lab

Elements of Geochemistry	
	2 Credits
List of Practical	
1. Geochemical variation diagrams and its interpretations: a. Bivariate and trivariate plots to delineate the control of different compositional variables: i. Harker variation diagram ii. AFM diagram iii. MgO diagram b. Chemical variation diagrams based on major elements: i. Alkali-lime index ii. Iron enrichment index iii. Aluminium saturation index iv. Alkalinity index diagrams	

3.7 Core T4 - Structural Geology

Structural Geology	
	4 Credits
Unit 1: Basic structural elements	
1. Diastrophic and non- diastrophic structures 2. Structural elements: planar and linear structures, concept of strike and dip, trend and plunge, rake/pitch 3. Application of primary sedimentary and igneous structure in structural geology. Unconformity and its types; recognition of Unconformity 4. Concept of scale of observation of structures 5. Topographic maps. Outcrop patterns of different structures	
Unit 2: Stress and strain in rocks	
1. Concept of rock deformation: Concept of Stress. Basic idea of Shear zone 2. Concept of Strain: Homogeneous and inhomogeneous strain, Rotational and irrotational strain in rocks, 3. Strain ellipsoids of different types and their geological significance. 4. Flinn and Ramsay's diagram 5. Concept of Rock deformation: Brittle and ductile deformation.	
Unit 3: Folds	
1. Fold morphology 2. Geometric and genetic classification of folds 3. Introduction to the mechanics of folding: Buckling, Bending, Flexural slip and flow folding	
Foliation and lineation	
Description and origin of foliations: axial plane cleavage and its tectonic significance Description and origin of lineation and relationship with the major structures	
Fractures and faults	
1. Geometric and genetic classification of fractures and faults Effects of faulting on the outcrops	

2. Geologic/geomorphic criteria for recognition of faults and fault plane solutions

Reference Books

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

3.8 Core P4 - Structural Geology Lab

Structural Geology	
	2 Credits
List of Practical	
1. Basic idea of topographic maps, Topographic sheets of various scales 2. Interpretation of topographic maps 3. Interpretation of Geological maps with unconformity, fault, fold and igneous bodies Construction of structural cross section 4. Stereographic projections of planes and lines 5. True dip and apparent dip problems, 3-point problems, fold problems, fault problems and their solutions through stereographic projection methods	

3.9 Core T5 - Igneous Petrology

Igneous Petrology	
	4 Credits
Unit 1: Introduction to Igneous petrology	
1. Modes of magma formation in the crust and upper mantle 2. Physical properties of magma - temperature, viscosity, density and volatile content 3. Modes of emplacement of igneous rocks: volcanic, hypabyssal, plutonic	
Unit 2: Forms of Igneous rock bodies	
1. Mode of occurrence of Igneous rocks 2. Forms of igneous rocks	
Unit 3: Texture and microstructure of Igneous rocks	
1. Crystallinity, granularity, shapes and mutual relations of grains; nucleation and growth of igneous minerals 2. 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 & spinifex 3. Binary and Ternary Phase diagrams in understanding crystal-melt equilibrium in basaltic and granitic magmas 4. Magma generation in crust and mantle, their emplacement and evolution	
Unit 4: Classification of igneous rocks	
1. Bases of classification of igneous rocks: mineralogical, textural, chemical, chemico-mineralogical and associational; Norm and mode; Standard classification schemes - Niggli, Wells & Wells and IUGS. TAS diagram for volcanic rocks 2. 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

1. Magma generation in crust and mantle, their emplacement and evolution
2. Petrogenesis of Felsic and Mafic igneous rocks: Granitoids, Basalt, Gabbros, Anorthosite, Komatiites, Alkaline rocks, Kimberlites

Unit 7: Magmatism in different tectonic settings

1. Magmatism in the oceanic domains (MORB, OIB)
2. Magmatism along the subduction zones: Island arcs and continental arcs
3. Magmatism along continental rifts

Reference Books

- ▶ Philpotts, A., & 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,
- ▶ K. G. Cox, J. D. Bell. (1979). The Interpretation of Igneous Rocks. Springer/Chapman & Hall.
- ▶ Bose M.K. (1997). Igneous Petrology.
- ▶ Frost B. R. and Frost C. D (2014). Essentials of Igneous and Metamorphic Petrology. Cambridge University Press.

3.10 Core P5 - Igneous Petrology- II Lab

Igneous Petrology	
	2 Credits
List of Practical	
1. Study of important igneous rocks in hand specimens and thin sections: granite, granodiorite, diorite, syenite, nepheline syenite, gabbro, anorthosites, ultramafic rocks, basalts, andesites, trachyte, rhyolite, dacite 2. Norm calculation. Visual estimation of modes from thin sections 3. Plotting of mode in IUGS classification of plutonic rocks (Streckeisen diagram)	

3.11 Core T6 - Sedimentary Petrology

Sedimentary Petrology	
	4 Credits
Unit 1: Introduction to Sedimentology	
Outline of sedimentation process: Definition of sediment; origin of sediments: mechanical and chemical sediments; source rock or provenance	
Unit 2: Granulometry	
Grain size: concept and size scale, particle size distribution, environmental connotation; particle shape and fabric; Sedimentary textures	
Unit 3: Basic hydraulics and Sedimentary structures	
1. Fluid flow: Types of fluids, Laminar and turbulent flow, subcritical, critical and supercritical flows; concept of mean flow velocity, unit discharge and bed shear stress; flow profile and flow separation; particle entrainment, transport and deposition 2. Mass flow: types, mechanisms and controlling factors, process-product relationship 3. Penecontemporaneous deformation: mechanisms and controlling factors 4. Sedimentary structure: Primary and penecontemporaneous deformation structures 5. Bedform stability diagram 6. Paleocurrent analysis: Data acquisition, methodology, different palaeocurrent patterns	
Unit 4: Sedimentary rocks	
1. Siliciclastic rocks: Components and classification(s) of conglomerates and sandstones 2. Tectonic control on sandstone composition 3. General introduction to Mudrocks, Carbonate rocks; controlling factors of carbonate deposition; components and classifications of limestone; dolomite and dolomitisation	
Unit 5: Diagenesis	
1. Concepts of diagenesis 2. Stages of diagenesis: diagenetic changes in sand and carbonate deposits, lithification	
Reference Books	

- ▶ Prothero, D. R., & Schwab, F. (2004). Sedimentary geology. Macmillan.
- ▶ Tucker, M. E. (2006) Sedimentary Petrology, Blackwell Publishing.
- ▶ Collinson, J. D. & Thompson, D. B. (1988) Sedimentary structures, Unwin-Hyman, London.
- ▶ Nichols, G. (2009) Sedimentology and Stratigraphy Second Edition. Wiley Blackwell

3.12 Core P6 - Sedimentary Petrology Lab

Sedimentary Petrology	
	2 Credits
List of Practical	
1. Identification of sedimentary structures 2. Particle size distribution and statistical analysis 3. Paleocurrent analysis 4. Petrographic study of clastic and non-clastic rocks through hand specimens and thin sections	

3.13 Core T7 - Paleontology

Paleontology	
	4 Credits
Unit 1: Fossilization and fossil record	
1. Fossilization: definition of fossil, fossilization processes and modes of preservation, exceptional preservation 2. Taphonomy: definition, different types of taphonomic filters	
Unit 2: Taxonomy and Systematics	
1. Taxonomy: concept of taxonomy and taxonomic hierarchy 2. Biological and morphological species concept	
Unit 3: Evolution and History of Life	
1. Theory of organic Evolution: theory, concept of adaptation and variation, Natural Selection. Precambrian - doubtful organic traces of life during the Precambrian, Ediacaran fauna 2. Paleozoic - Cambrian Explosion of life. Episodes of mass extinction 3. Plants: Appearance of angiosperma and gymnosperma 4. Appearance of fish, amphibia, reptiles, birds, mammals and humans 5. Mass extinction: five major extinction episodes and their causes; effect of extinction	
Unit 4: Invertebrates and Vertebrates	
1. Brief introduction to important invertebrate groups (Bivalvia, Gastropoda, Brachiopoda) and their biostratigraphic significance 2. Significance of ammonites in Mesozoic biostratigraphy and their paleobiogeographic implications. Functional adaptation in trilobites and ammonoids 3. Origin of vertebrates and major steps in vertebrate evolution 4. Mesozoic reptiles with special reference to origin, diversity and extinction of dinosaurs 5. Evolution of horse and intercontinental migrations 6. Human evolution	
Unit 5: Introduction to Paleobotany, Gondwana Flora Introduction to Ichnology.	

1. Introduction to Paleobotany, Gondwana Flora, Plants as indicator of past climate
2. Ichnology and its application in paleoecology

Unit 6: Application of fossils in Stratigraphy

1. Definitions: Biozones, index fossils, stratigraphic correlation, examples - significance of ammonites in Mesozoic paleobiostratigraphy
2. Application of fossils in Paleoenvironmental analysis
3. Fossils and paleobiogeography, biogeographic provinces, dispersals and barriers. Paleoenvironmental analysis

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.
- ▶ Benton, M. J., Harper, D. A. T. (2010). Introduction to Paleobiology and the Fossil Record, Wiley-Blackwell.
- ▶ Shukla, A. C., & Misra, S. P. (1975). Essentials of paleobotany. Vikas Publisher

3.14 Core P7 - Paleontology Lab

Paleontology	
	2 Credits
List of Practical	
1. Study of fossils with various modes of preservation 2. Study of systematic position, stratigraphic position and age of various invertebrate, vertebrate and plant fossils 3. Study of functional morphological characters of different groups (Bivalvia, Gastropods, Brachiopoda, Echinodermata, Ammonoidea, Gondwana flora, vertebrates) 4. Identification of feeding habits from vertebrate (horse, elephants, Sus) teeth 5. Hard part morphology and identification of common Brachiopoda, Anthozoa, Trilobita, Echinoidea, Gastropoda. Identification of Gondwana flora	

3.15 Core T8 - Metamorphic Petrology

Metamorphic Petrology	
	4 Credits
Unit 1: Metamorphism: controls and types.	
1. Definition of metamorphism. Factors controlling metamorphism, Types of metamorphism - contact, regional, fault zone metamorphism, impact metamorphism 2. Causes of metamorphism and concept of metamorphic P-T-t paths	
Unit 2: Metamorphic Facies and Grades. Metamorphic Structures and Textures	
1. Index minerals, metamorphic zones and isograds. Structure and textures of metamorphic rocks 2. Concept of metamorphic facies and grade 3. Mineralogical phase rule of closed and open system 4. Composition-paragenesis diagrams. ACF, AKF and AFM diagrams 5. Metamorphic products of pelitic, carbonate and mafic igneous rocks	
Unit 3: Metamorphic reactions. Metamorphism and deformation.	
1. Progressive and retrogressive metamorphism 2. Prograde and retrograde metamorphic minerals reactions. 3. Relationship between metamorphism and deformation.	
Unit 4: Migmatites and their origin	
1. Metasomatism and role of fluids in metamorphism. 2. Brief idea of crustal anatexis. Migmatites and its origin.	
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.	
Reference Books	
► Philpotts, A., & 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. 799 p.

3.16 Core P8 - Metamorphic Paleontology Lab

Metamorphic Paleontology	
	2 Credits
List of Practical	
1. Hand specimen study of following metamorphic rocks: Slate, Phyllite, Schist, Gneiss, Amphibolite, Charnockite, Khondalite, Mafic granulite, Marble 2. 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 3. Graphical plots of metamorphic mineral assemblages using chemographic diagrams	

3.17 Core T9 - Principles of Stratigraphy and Precambrian Stratigraphy of India

Principles of Stratigraphy and Precambrian Stratigraphy of India	
	4 Credits
Unit 1: Principles of stratigraphy	
1. Fundamentals of lithostratigraphy, biostratigraphy and chronostratigraphy. 2. Introduction to concepts of dynamic stratigraphy (chemostratigraphy, seismic stratigraphy, sequence stratigraphy). 3. Relevance of Type section. 4. Principles of stratigraphic correlation.	
Unit 2: Code of stratigraphic nomenclature	
1. International Stratigraphic Code - development of a standardized stratigraphic nomenclature 2. Concepts of Stratotypes. Global Stratotype Section and Point (GSSP) 3. Brief introduction to the concepts of lithostratigraphy, biostratigraphy, chronostratigraphy, seismic stratigraphy, chemostratigraphy, magnetostratigraphy, sequence stratigraphy and their subdivisions with Indian examples	
Unit 3: Principles of stratigraphic analysis Facies concept in stratigraphy	
1. Walther's Law of Facies. 2. Concept of paleogeographic reconstruction	
Unit 4: Stratigraphic boundaries in India	
1. Archaean-Proterozoic boundary. 2. Precambrian-Cambrian boundary and their status in global perspective.	
Unit 5: Physiographic and tectonic subdivisions of India	
1. Brief introduction to the physiographic and tectonic subdivisions of India 2. Introduction to Indian Shield, Craton 3. Introduction to Indian Precambrian belts. 4. Introduction to Proterozoic basins of India	

Unit 6: Geologic evolution Important Precambrian terrains

1. Geologic evolution with emphasis on sedimentation, lithology, magmatism, structure, metamorphism and geochronology of: Singhbhum, Dharwar, Rajasthan, Central India and Eastern Ghats.
2. Vindhyan and Cudappah basins 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.

3.18 Core P9 - Stratigraphic Principles and Indian Stratigraphy Lab

Stratigraphic Principles And Indian Stratigraphy	
	2 Credits
List of Practical	
1. Study of geological map of India and identification of major stratigraphic units 2. Major features of paleogeographic maps - Precambrian	

3.19 Core T10 - Phanerozoic Stratigraphy of India

Phanerozoic Stratigraphy of India	
	4 Credits
Unit 1: Introduction	
1. Definition. 2. Important Stratigraphic boundaries during Phanerozoic time in India - a. Precambrian-Cambrian boundary, b. Permian-Triassic boundary, and c. Cretaceous-Tertiary boundary.	
Unit 2: Important Palaeozoic successions in India	
Important Palaeozoic successions in India with emphasis on succession, lithology, flora and fauna, correlation and palaeoenvironment of the following: 1. Paleozoic Succession of Kashmir 2. Stratigraphy Structure of Gondwana basins. 3. Mesozoic stratigraphy of India: a. Triassic successions of Spiti, b. Jurassic of Kutch, c. Triassic and Jurassic non marine successions of peninsular India (Upper Gondwana formations, relevant Formations of Rajasthan basin) d. Cretaceous, successions of Cauvery basins e. Lameta and Jabalpur Formations 4. Cenozoic stratigraphy of India: a. Kutch basin, b. Siwalik successions, c. Assam, Andaman and Arakan basins. 5. Stratigraphy and structure of Krishna-Godavari basin, Cauvery basin, Bombay offshore basin, Kutch and Saurashtra basins and their potential for hydrocarbon exploration	
Unit 3: Stratigraphy of the intertrappeans	
1. Deccan, 2. Rajmahal, 3. Sylhet Trap	
Unit 4: Quaternary Geology	

1. Definition
2. Principles of subdivision of Quaternary succession in India.

3.20 Core P10 - Phanerozoic Stratigraphy of India Lab

Phanerozoic Stratigraphy of India	
	2 Credits
List of Practical	
1. Study of geological map of India and identification of major Phanerozoic stratigraphic units. 2. Stratigraphic correlation of Phanerozoic stratigraphic units in geological map of India 3. Proterozoic supercontinent reconstructions	

3.21 Core T11 - Hydrogeology

Hydrogeology	
	4 Credits
Unit 1: Introduction and basic concepts	
1. Scope of hydrogeology and its societal relevance. Global and Indian distribution of water resource. 2. Hydrologic cycle: precipitation, evapo-transpiration, run-off, infiltration and groundwater flow. Basic concept of hydrographs Origin of groundwater, Vertical distribution of subsurface water, Genetic classification of groundwater. 3. Classification of rocks with respect to water bearing characteristics, geomorphic and geologic controls of groundwater, Types of aquifer- unconfined, confined and semi-confined. Water table and piezometric surface. Groundwater provinces in India and West Bengal. 4. Rock properties affecting groundwater: Porosity, void ratio, specific retention and Storage coefficient - specific yield, specific storage and storativity, Anisotropy and heterogeneity of aquifers	
Unit 2: Groundwater flow	
1. Darcy's law and its validity; Reynold's Number. Groundwater velocity. 2. Intrinsic permeability and hydraulic conductivity, Transmissivity, Measurement of hydraulic conductivity in laboratory - Constant Head Permeameter and Falling (Variable) Head Permeameter. Water Table and Piezometric surface contour maps and Groundwater flow direction, Laminar and turbulent groundwater flow	
Unit 3: Well hydraulics and Groundwater exploration	
1. Basic Concepts (drawdown; specific capacity etc) 2. Elementary concepts related to equilibrium and non-equilibrium (Steady and unsteady) conditions for groundwater flow to a well 3. Surface-based groundwater exploration methods Introduction to subsurface borehole logging methods	
Unit 4: Groundwater chemistry	
1. Physical, chemical and bacteriological properties of water and water quality	

2. Introduction to methods of interpreting groundwater quality data using standard graphical plots
3. Elementary concept on Groundwater pollution: Arsenic, Fluoride and Nitrate, Sea water intrusion in coastal aquifers -,Ghyben-Herzberg Relation

Unit 5: Groundwater management

1. Surface and subsurface water interaction. Recharge and discharge areas. Groundwater level fluctuations. Effects of Climate Change on Groundwater.
2. Basic concepts of water balance studies, issues related to groundwater resources development and management
3. Rainwater harvesting and artificial recharge of groundwater

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.
- ▶ Raghunath H, M. 2007, Groundwater, 3rd Ed. New Age International Publishers , New Delhi

3.22 Core P11 - Hydrogeology Lab

Hydrogeology	
	2 Credits
List of Practical	
1. Preparation and interpretation of depth to water level maps and water level contour maps. Study, preparation and analysis of hydrographs for differing groundwater conditions 2. Water potential zones of India (map study) 3. 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 and Groundwater flow	

3.23 Core T12 - Economic Geology

Economic Geology	
	4 Credits
Unit 1: Ores and gangues	
1. Ores, gangue minerals, tenor, grade and lodes 2. Resources and reserves- Economic and Academic definitions	
Unit 2: Mineral deposits and Classical concepts of Ore formation	
1. Mineral occurrence, Mineral deposit and Ore deposit 2. Historical concepts of ore genesis: Man's earliest vocation- Mining 3. Plutonist and Neptunist concepts of ore genesis 4. Metallogenic provinces and epochs	
Unit 3: Mineral exploration	
1. Exploration and exploitation techniques 2. Brief idea on: Remote Sensing, Geophysical and Geochemical Explorations 3. Geological mapping at different scales, drilling, borehole logs and transverse sections	
Unit 4: Structure and texture of ore deposits	
1. Concordant and discordant ore bodies 2. Endogenous processes: Magmatic concentration, skarns, greisens, and hydrothermal deposits 3. Exogenous processes: weathering products and residual deposits, oxidation and supergene enrichment, placer deposits,	
Unit 5: Ore grade and Reserve	
Assessment of ore grade and reserve, reserve estimation	
Unit 6: Metallic and Non-metallic ores	
1. 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.

2. Non-metallic and industrial rocks and minerals, in India.
3. Introduction to gemstones.

Reference Books

- ▶ Guilbert, J.M. and Park Jr., C.F. (1986) The Geology of Ore deposits. Freeman & Co.
- ▶ Bateman, A.M. and Jensen, M.L. (1990) Economic Mineral Deposits. John Wiley.
- ▶ Evans, A.M. (1993) Ore Geology and Industrial minerals. Wiley
- ▶ Laurence Robb. (2005) Introduction to ore forming processes. Wiley.
- ▶ Gokhale, K.V.G.K. and Rao, T.C. (1978) Ore deposits of India their distribution and processing, Tata-McGraw Hill, New Delhi.
- ▶ 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.

3.24 Core P12 - Economic Geology Lab

Economic Geology	
	2 Credits
List of Practical	
1. Hand sample identification of important ores and non-metallic minerals 2. Study of microscopic properties of ore forming minerals (Oxides and sulphides) 3. Preparation of maps: Distribution of important ores and other economic minerals in India	

3.25 Core T13 - Geomorphology, Remote Sensing and GIS

Geomorphology, Remote Sensing and GIS	
	4 Credits
Unit 1: Introduction to Geomorphology	
1. Introduction to Geomorphology 2. Relationship between the landforms and the properties of earth material and different kind of processes 3. Endogenic and Exogenic processes	
Unit 2	
1. Geoid, Topography, Hypsometry, Major Morphological features of the earth surface 2. Large Scale Topography - Plate tectonics overview. Large scale mountain ranges (with emphasis on Himalaya)	
Unit 3	
Surficial Processes and geomorphology, Weathering and associated landforms, Hill slopes Glacial, Periglacial processes and landforms, Fluvial processes and landforms, Aeolian Processes and landforms, Coastal Processes and landforms, Landforms associated with igneous activities	
Unit 4	
1. Endogenic- Exogenic interactions. Rates of uplift and denudation. Tectonics and drainage development, Sea-level change, Long-term landscape development. 2. Landform dating techniques.	
Unit 5: Photogeology	
1. Types and acquisition of aerial photographs; Scale and resolution; Principles of stereoscopy, relief displacement, vertical exaggeration and distortion 2. Elements of air photo interpretation 3. Identification of sedimentary, igneous and metamorphic rocks and various aeolian, glacial, fluvial and marine landforms	
Unit 6: Remote Sensing, Concepts in Remote Sensing	

1. Concepts in Remote Sensing.
2. Sensors and scanners.
3. Satellites and their characteristics.
4. Data formats- Raster and Vector.

Unit 7: Digital Image Processing

1. Image Errors, Rectification and Restoration, FCC, Image Enhancement, Filtering, Image Rationing.
2. Image classification and accuracy assessment.
3. GIS integration and Case studies-Indian Examples.

Unit 8: GIS and GPS

1. Datum, Coordinate systems and Projection systems.
2. Spatial data models and data editing.
3. Introduction to DEM analysis.
4. Concepts of GPS.
5. Integrating GPS data with GIS.
6. Applications in earth system sciences.

Reference Books

- ▶ Robert S. Anderson and Suzzane P. Anderson (2010): Geomorphology - The Mechanics and Chemistry of Landscapes. Cambridge University Press.
- ▶ M.A. Summerfield (1991) Global Geomorphology. Wiley & Sons.
- ▶ 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.

3.26 Core P13 - Geomorphology, Remote Sensing and GIS Lab

Geomorphology, Remote Sensing and GIS	
	2 Credits
List of Practical	
1. Reading topographic maps. Preparation of a topographic profile. 2. Preparation of longitudinal profile of a river. 3. Calculating Stream length gradient index 4. Morphometry of a drainage basin. 5. Interpretation of geomorphic processes from the geomorphology of the area. 6. Aerial Photo interpretation: Identification of sedimentary, igneous and metamorphic rocks and various aeolian, glacial, fluvial and marine landforms. 7. Introduction to DIP and GIS softwares. 8. Digital Image Processing exercises including analysis of satellite data in different bands and interpretation of various objects on the basis of their spectral signatures. 9. Registration of satellite data with a toposheet of the area. 10. DEM analysis: generating slope map, aspect map and drainage network map and its applications	

3.27 Core T14 - Engineering Geology

Engineering Geology	
	4 Credits
Unit 1	
Role of Engineering geologists in planning, design and construction of major man-made structural features	
Unit 2	
Site investigation and characterization	
Unit 3	
Foundation treatment; Grouting, Rock Bolting and other support mechanisms	
Unit 4	
Rock aggregates; Significance as Construction Material	
Unit 5	
Concept, Mechanism and Significance of: a) Rock Structure Rating (RSR) b) Rock Mass Rating (RMR) c) Tunnelling Quality Index (Q) Geological, Geotechnical and Environmental considerations for Dams and Reservoirs	
Unit 6	
Tunnels and Tunnelling Methods	
Unit 7	
Landslides: Causes, Factors and corrective/Preventive measures	

Unit 8

Earthquakes: Causes, Factors and corrective/Preventive measures. Mitigating the damage caused by Earthquake

Unit 9

Case histories related to Indian Civil Engineering Projects

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 & Sons, N.Y.
- ▶ Waltham, T., 2009. Foundations of Engineering Geology (3rd Edn.) Taylor & Francis.
- ▶ Bell: F.G-, 2006. Basic Environmental and Engineering Geology Whittles Publishing.
- ▶ Bell, .F.G, 2007. Engineering Geology, Butterworth-Heineman

3.28 Core P14 - Engineering Geology Lab

Engineering Geology	
	2 Credits
List of Practical	
1. Computation of reservoir area, catchment area, reservoir capacity and reservoir life. 2. Merits, demerits & remedial measures based upon geological cross sections of project sites. 3. Computation of Index properties of rocks. 4. Computation of RQD, RSR, RMR and 'Q'	
Reference Books	
▶ Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House. ▶ Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers ▶ A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal ▶ Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer	

4. Department Specific Electives Subjects Syllabus

4.1 DSE T1 - Earth and Climate

Earth and Climate	
	4 Credits
Unit 1: Climate system: Forcing and Responses	
1. Components of the climate system 2. Climate forcing, Climate controlling factors 3. Climate system response, response rates and interactions within the climate system 4. Feedbacks in climate system	
Unit 2: Heat budget of Earth	
1. Incoming solar radiation, receipt and storage of heat transformation 2. Earth's heat budget. Interactions amongst various sources of earth's heat	
Unit 3: Atmosphere - Hydrosphere	
1. Layering of atmosphere and atmospheric Circulation 2. Atmosphere and ocean interaction and its effect on climate 3. Heat transfer in ocean 4. Global oceanic conveyor belt and its control on earth's climate 5. Surface and deep circulation 6. Sea ice and glacial ice	
Unit 4: Response of biosphere to Earth's climate	
1. Climate Change: natural vs. anthropogenic effects 2. Humans and climate change 3. Future perspectives 4. Brief introduction to archives of climate change 5. Brief introduction to palaeoclimate 6. Paleoclimate data from India	

Unit 5: Orbital cyclicity and climate

1. Milankovitch cycles and variability in the climate
2. Glacial-interglacial stages
3. The Last Glacial maximum (LGM)
4. Pleistocene Glacial-Interglacial cycles
5. Younger Dryas
6. Isotope Palaeontology

Unit 6: Monsoon

1. Mechanism of monsoon
2. Monsoonal variation through time
3. Factors associated with monsoonal intensity
4. Effects of monsoon

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
- ▶ Environmental Geology - an Earth System Science Approach, By - Dorothy J. Merritts, Andrew De Wet & Kristen Menking, W.H. Freeman & Company, New York.

4.2 DSE P1 - Earth and Climate Lab

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

4.3 DSE T2 - Introduction to Geophysics

Introduction to Geophysics	
	4 Credits
Unit 1: Geology and Geophysics	
What is geophysics? Interrelationship between geology and geophysics	
Unit 2: General and Exploration geophysics	
1. Different types of geophysical methods - gravity, magnetic, electrical and seismic; Principles of different methods. Applications of different methods. Elements of well logging. 2. Corrections in geophysical data	
Unit 3: Geophysical field operations	
1. Data acquisition and Processing. Data reduction. Signal and noise 2. Different types of surveys, grid and route surveys, profiling and sounding techniques a. Scales of survey b. Presentation of geophysical data	
Unit 4: Application of Geophysical methods	
1. Regional geophysics, oil and gas geophysics, ore geophysics, groundwater geophysics, engineering geophysics 2. Geological interpretation of geophysical data	
Unit 5: Geophysical anomalies	
1. Correction to measured quantities, geophysical, anomaly, regional and residual (local) anomalies, factors controlling anomaly 2. Depth of exploration	
Unit 6: Integrated geophysical methods	

Ambiguities in geophysical interpretation, planning and execution of geophysical surveys

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.
- ▶ Mussett, A. E. and Khan, M. A. (2000). Looking into the Earth. Cambridge University Press.

4.4 DSE P2 - Introduction to Geophysics Lab

Introduction to Geophysics	
	2 Credits
List of Practical	
1. Anomaly and background- Graphical method 2. Study and interpretation of seismic reflector geometry 3. Gravity anomaly: Problems on gravity anomaly	

4.5 DSE T3 - Fuel Geology

Fuel Geology	
	4 Credits
Unit 1: Energy Resources	
1. Different Sources of energy: Global and Indian scenario	
Unit 2: Coal	
1. Definition and origin of Coal 2. Basic classification of coal. 3. Fundamentals of Coal Petrology - Introduction to lithotypes, microlithotypes and macerals in coal 4. Proximate and Ultimate 5. Major coal basins of India	
Unit 3: Coal as a fuel	
1. Concept of clean coal technology 2. Coal Bed Methane (CBM): global and Indian scenario 3. Underground coal gasification 4. Liquefaction of coal	
Unit 4: Petroleum	
1. Chemical composition and physical properties of crudes oil 2. Origin and migration of petroleum 3. Kerogen: Maturation of kerogen; Biogenic and Thermal effect	
Unit 5: Petroleum Reservoirs and Traps	
1. Reservoir rocks: general attributes and petrophysical properties. 2. Cap Rocks: definition and general properties 3. Hydrocarbon traps: definition, Classification of hydrocarbon traps - structural, stratigraphic and combination a. Time of trap formation and time of hydrocarbon accumulation.	

- b. Plate tectonics and global distribution of hydrocarbon reserves
- c. Petroliferous basins of India

Unit 6: Other fuels

- 1. Nuclear Fuel
- 2. Gas Hydrate

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 prospectively of the continental margins of India (Vol. 59). Newness.

4.6 DSE P3 - Fuel Geology Lab

Fuel Geology	
	2 Credits
List of Practical	
1. Study of hand specimens of coal 2. Reserve estimation of coal 3. Section correlation and identification of hydrocarbon prospect 4. Panel and Fence diagrams	

4.7 DSE T4 - Exploration Geology

Exploration Geology	
	4 Credits
Unit 1: Mineral Resources	
Resource: Definitions, Mineral resources in industries - historical perspective and present scenario, classification of mineral deposits with respect to processes of formation; exploration strategies.	
Unit 2: Prospecting and Exploration,	
1. Principles of mineral exploration 2. Prospecting and exploration: conceptualization, methodology and stages, Sampling, subsurface sampling including pitting, trenching and drilling 3. Geochemical exploration 4. Outline of exploration techniques for ferrous and non-ferrous metals, limestone and coal and petroleum	
Unit 3: Evaluation of data	
Evaluation of sampling data - Mean, mode, median, standard deviation and variance	
Unit 4: Drilling and Logging	
1. Core and non-core drilling 2. Planning of bore holes and location of boreholes on ground Core-logging	
Unit 5: Reserve estimations and Errors	
1. Principles of reserve estimation, Factors affecting reliability of reserve estimation 2. Reserve estimation based on geometrical models (square, rectangular, triangular and polygon blocks) 3. Regular and irregular grid patterns 4. Statistics and error 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.

4.8 DSE P4 -Exploration Geology Lab

Exploration Geology	
	2 Credits
List of Practical	
1. Identification of anomaly: Gravity and Magnetic 2. Concept of weighted average in anomaly detection 3. Geological cross-section 4. Models of reserve estimation	

4.9 DSE T5 - Evolution of Life through Time

Evolution of Life Through Time	
	6 Credits
Unit 1: Life through ages	
1. Fossils and chemical remains of ancient life. 2. Geological Time Scale with emphasis on major bio-events. 3. Biomineralization and skeletalization	
Unit 2: Principles of evolution	
1. Mechanism of evolution 2. Evolutionary lineages 3. Species as basic unit of lineage 4. Constraints in lineage reconstruction	
Unit 3: Geobiology	
1. Biosphere as a system, processes and products 2. Biogeochemical cycles 3. Abundance and diversity of microbes, extremophiles Microbes-mineral interactions, microbial mats	
Unit 4: Origin of life	
1. Possible life sustaining sites in the solar system, life sustaining elements and isotope records 2. Archean life: Earth's oldest life, Transition from Archean to Proterozoic, the oxygen revolution and radiation of life 3. Precambrian macrofossils - The garden of Ediacara The Snow Ball Earth Hypothesis	
Unit 5: Paleozoic Life	
1. The Cambrian Explosion. 2. Origin of vertebrates and radiation of fishes 3. Origin of tetrapods - Life out of water	

4. Early land plants and impact of land vegetation

Unit 6: Mesozoic Life

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

Unit 7: Cenozoic Life

1. Aftermath of end Cretaceous mass extinction - radiation of placental mammals Evolution of modern grasslands and co-evolution of hoofed grazers
2. Rise of modern plants and vegetation Back to water - Evolution of Whales

Unit 8: The age of humans

1. Hominid dispersals and climate setting
2. Climate Change during the Phanerozoic - continental break-ups and collisions Plate tectonics and its effects on climate and life.
3. Effects of life on climate and geology

Unit 9: Applications of Evolution

1. Biostratigraphy and Chrono stratigraphy in the context of organic evolution
2. Role of fossils in correlation
3. Basis of stage boundaries in the Phanerozoic

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

4.11 DSE T6 - River Science

River Science	
	4 Credits
Unit 1: Stream hydrology	
1. Basic stream hydrology 2. Physical properties of water, sediment and channel flow 3. River discharge, River hydrographs (UH, IUH, SUH, GIUH) and its application in hydrological analysis 4. Flood frequency analysis	
Unit 2: River basin	
1. Sediment source and catchment erosion processes Sediment load and sediment yield 2. Sediment transport processes in rivers 3. Erosion and sedimentation processes in channel.	
Unit 3: Drainage	
1. Drainage network 2. Quantitative analysis of network organization - morphometry, Random Topology (RT) model and fractal analysis 3. Role of drainage network in flux transfer 4. Evolution of drainage network in geological time scale.	
Unit 4: Rivers in time and space	
1. River diversity in space, Patterns of alluvial rivers - braided, meandering and anabranching channels, Dynamics of alluvial rivers 2. Channel patterns in stratigraphic sequences 3. Different classification approaches in fluvial geomorphology and its applications.	
Unit 5: Channels and Landscapes	
1. Bedrock channels, Bedrock incision process 2. River response to climate, tectonics and human disturbance	

3. Bedrock channel processes and evolution of fluvial landscapes.

Unit 6: Fluvial hazards

1. Integrated approach to stream management
2. Introduction to river ecology

Reference Books

- ▶ Davies, T. (2008) Fundamentals of hydrology. Routledge Publications.
- ▶ Knighton, D. (1998) Fluvial forms and processes: A new perspective. Arnold Pubs.
- ▶ Richards, K. (2004) Rivers: Forms and processes in alluvial channels. Balckburn Press.
- ▶ Bryirely and Fryirs (2005) Geomorphology and river management. Blackwell Pub.,
- ▶ Julien, P.Y. (2002) River Mechanics. Cambridge University Press.
- ▶ Robert, A. (2003) River Processes: An introduction to fluvial dynamics. Arnold Publications.
- ▶ Vanoni, V.A. (2006) Sedimentation Engineering. ASCE Manual, Published by American Society of Civil Engineering,
- ▶ Tinkler, K.J., Wohl, E.E. (eds.) 1998. Rivers over rock. American Geophysical Union Monograph, Washington, DC.

4.12 DSE P6 - River Science Lab

River Science	
	2 Credits
List of Practical	
1. Stream power calculation Longitudinal profile analysis 2. Hydrograph analysis and other related problems	

4.13 DSE T7 - Oceanography and Marine Science

Oceanography and Marine Science	
	6 Credits
Unit 1: Fundamentals of Ocean	
1. Concept of land and Ocean. Land-Ocean distribution 2. Marine Provinces 3. Plate Tectonics and Sea Floor spreading	
Unit 2: Chemical and Physical aspects of Ocean	
1. Ocean dynamics 2. Ocean Chemistry 3. Marine Sediments 4. Sea Water: Composition, Controls on sea water composition 5. Sea-Air Interaction	
Unit 3: Waves, Tides and Coasts	
1. Ocean Circulation 2. Waves and Water Dynamics 3. Ocean Energy 4. The Coast: Beaches and Shoreline 5. The Coastal Ocean - Migration for Coastal Erosion	
Unit 4: Life in the Ocean	
1. Marine Life and the Environment 2. Biologic Productivity and in Ocean 3. Animals of the Pelagic Environment and Life 4. Animals of the Benthic environment and Life	
Reference Books	
▶ Introductory Oceanography by Harold V. Thurman, Mt. San Antonio College ,Charles E.	

Merrill Publishing Company.

- ▶ Oceanography for Beginners, by Pronab K. Banerjee, Allied Publishers Pvt Limited
- ▶ Coastal Hydraulics, by A. M. Muir and C. A. Fleming 1981, The MacMillan Press Ltd, London.

4.14 DSE T8 - Urban Geology

Urban Geology	
	4 Credits
Geology and Society	
1. Necessity of Geology in Urban life. Geology in Urban Constructions 2. Geotechnical feature and mapping for subsurface in Metropolitan areas Building materials, Excavation and cutting in urban areas.	
Geology and Urban Agriculture	
Soil studies, Chemistry and geochemistry of soil in relation to ground water and fertilizer Effect of pollutants on vegetable contamination	
Urban land use	
1. Geotechnical site characterization, Geotechnical and land use mapping, Decision making in urban landuse, Geological problems in construction of underground structures in urban areas 2. Urban Tunneling: Tunneling for road and rail in urban areas, Method, Equipments, Importance of Geology	
Urban water	
1. Water lagging in built-up areas, Source of water, Standards for various uses of water Sources of contamination 2. Waste waters: Sources and its disinfection and treatment, Ground water surveys and resource development.	
Urban wastes and Treatment	
Urban wastes and Treatment, Geotechnical characterization for waste sites, Domestic waste, Industrial waste, Mine drainage, Power production waste, Radioactive waste, Need for special purpose mapping for selection of waste disposal sites.	
GIS in Urban Geology	

GIS-An introduction, Application in Urban development, Application in landuse, Application in GW Exploration.

Precaution from seismic hazard in Urban planning

1. Precaution from seismic hazard in Urban planning
2. Seismic Hazards: Micro-zonations of hazard based on engineering geological features, Urban-subservice network.

Reference Books

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

4.15 DSE P8 - Urban Geology Lab

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

4.16 DSE T9 -Geodynamics

Geodynamics	
	6 Credits
Unit 1: Introduction	
1. Definition. Continents and oceans. Continental and oceanic crust. Internal processes of earth 2. Concept of lithosphere and asthenosphere. Physical character of lithosphere and asthenosphere. Concept of plate. 3. Concept of hot spot and mantle plume. Ophiolites. Palaeomagnetism.	
Unit 2: Plate and Plate boundaries	
1. Plates: Physical character of plates. Macro and micro plates. 2. Plate boundaries: types, character, Identification of boundaries. Movement of plates along boundaries. Plate velocities. 3. Volcanic arcs, island arcs, trenches, accretionary prisms, oceanic ridges, transform faults. Magmatism in oceanic ridges and in subduction zones	
Unit 3: Continental Drift, Sea floor spreading and Plate tectonics	
1. Wegner Continental drifts hypothesis and its evidences. Continental position in the past 2. Sea-floor spreading process and its evidences. 3. Plate tectonics model and its evidences. Distribution of plates in the Earth	
Unit 4:	
1. Palaeomagnetism and motion of plates 2. Driving mechanisms of plates. Plate tectonics and mantle convection. 3. Supercontinents and their breakup and assembly. Wilson cycle	
Reference Books	
▶ Turcotte, D.L. and Schubert, G. Geodynamics. Second Edition. Cambridge ▶ Kearey, p., Klepeis, K. A., and Vine, F. J. (2009). Global Tectonics. Third edition. Wiley-Blackwell, Oxford.	

5.Skill Enhancement Course

5.1 SEC T1 - Field Geology I

Field Geology I - Basic Field Training	
	2 Credits
Unit 1	
Topographic sheet: Methods of naming. Features, scale. Map reading.	
Unit 2	
1. Use of topographic sheets in field. Marking location in topographic sheet using physical features and bearing. 2. Use of GPS in field. 3. Distance, height and pace approximation in field.	
Unit 3	
1. Identification of rock types. 2. Identification of sedimentary and tectonic structures in field.	
Unit 4	
1. Clinometer and Brunton compass: Use of the instruments in measuring geological data in field. Techniques of measurement of orientation data in field. 2. Litholog measurement	
Unit 5	
1. Recording field data in maps and notebooks. 2. Report writing.	

5.2 SEC T2 - Field Geology II

Field Geology II - Geological Mapping and Structural Geology Field	
	2 Credits
Unit 1	
Preparation of a geological map of a small area with homoclinal or gently folded beds.	
Unit 2	
Stereographic plots of orientation data and their interpretation.	

5.3 SEC T3 - Field Geology III

Field Geology III- Stratigraphy and Palaeontology-related field	
	2 Credits
List of Visits	
1. Preparation of a Geological map of a small area with folded/faulted beds. 2. Interrelation between different structural elements and their interpretations.	

5.4 SEC T4 - Field Geology IV

Field Geology IV - Himalayan Geology Field	
	2 Credits
List of Visits	
1. Field training in a sedimentary basin. Documentation of stratigraphic details in the field. 2. Collection of sedimentological, and stratigraphical and paleontological details and their representation.	
Or	
1. Preparation of a geological transect map in the Himalayas	
Or	
1. Visit to an underground or Open cast mine 2. Underground mapping/Bench mapping Study	
Or	
1. Geological mapping of a project site (Dam sites, tunnel, etc). 2. Identification of environmental problems of a project site and remedial measures to be taken.	

6. General Elective

6.1 GE T1 - Essentials of Geology

Essentials of Geology	
	4 Credits
Unit 1: Introduction	
Introduction to geology, scope, sub-disciplines and relationship with other branches of sciences	
Unit 2	
1. Earth in the solar system, origin 2. Earth's size, shape, mass, density, rotational and evolutionary parameters 3. Solar System- Introduction to Various planets - Terrestrial Planets Solar System- Introduction to Various planets - Jovian Planets	
Unit 3: Solid Earth, Hydrosphere, Atmosphere and Biosphere	
1. Mechanical layering of the Earth: Lithosphere, asthenosphere, mantle and core 2. Earthquake and earthquake belts: Seismic waves and internal constitution of the Earth 3. Volcanoes and volcanism, distribution of volcanoes 4. Concept of isostasy 5. Formation of core, mantle, crust, atmosphere, Hydrosphere and Biosphere. 6. Convection in Earth's core and production of its magnetic field 7. Geothermal gradient and internal heat of the Earth	
Unit 4: Plate Tectonics	
1. Fundamental Earth process: Plate tectonics. Plates and Plate boundaries. 2. Origin of oceans, continents, mountains and rift valleys	
Unit 5: Earth's Surface Processes	
1. Weathering and Erosion. 2. Landforms in deserts, glaciated region and river valleys	

Unit 6: Age of Earth

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

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.

6.2 GE P1 - Essentials of Geology Lab

Essentials of Geology	
	2 Credits
List of Practical	
1. Study of topographic sheets and description of physiographic features of an area. 2. Study of geological maps with simple outcrop patterns 3. Study of distribution of major lithostratigraphic units on the map of India 4. Study of important rocks, minerals and fossils (the items may be fixed by the department concern)	

6.3 GE T2- Rocks and Minerals

Rocks and Minerals	
	4 Credits
Unit 1	
1. Minerals-Definitions, Physical properties of minerals 2. Chemical classification of minerals. 3. Internal structure of minerals 4. Atomic structure of silicate minerals	
Unit 2	
1. Mineralogical Composition of common crustal rocks 2. Mineralogical Composition of mantle.	
Unit 3	
1. Nature of light and optical behaviour of crystals 2. Classification of minerals on the basis of optical character 3. Introduction to gemology	
Unit 4	
1. Rocks-Definitions and types, rock; Processes of formation of Igneous rocks, sedimentary rocks and metamorphic rocks 2. Classification of Igneous rocks (Hatch and Wells and IUGS), sedimentary rocks (Folk) and metamorphic rocks. Concept of grade in metamorphic rocks 3. Brief idea about the plate tectonic settings of the common rock types	
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.	

6.4 GE P2 - Rocks and Minerals Lab

Rocks and Minerals	
	2 Credits
List of Practical	
1. Study of physical properties of common rock forming minerals 2. Study of optical properties of common rock forming minerals 3. Study of common sedimentary, igneous and metamorphic rocks in hand samples 4. Study of common sedimentary, igneous and metamorphic rocks under microscope	

6.5 GE T3 - Earth Surface Processes

Earth Surface Processes	
	4 Credits
Unit 1	
1. Introduction to earth surface processes 2. Historical development in concepts, terrestrial relief, scales in geomorphology,	
Unit 2	
1. Energy flow and relative energy of surface processes. 2. Weathering and formation of soils, Processes of formation of important landforms on Earth. 3. Water and sediment flux in river systems, Morphometric analysis of drainage basin and geomorphology-hydrology relationship.	
Unit 3	
1. Rates and changes in surface processes 2. Techniques for measuring rates of processes: sediment budgeting, rock magnetism, isotope geochemical tracers, cosmogenic nuclides, OSL & C-14 dating	
Unit 4	
1. Controlling factors (tectonics, climate, sea level changes and anthropogenic) of surface processes 2. 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	
1. Geomorphic concepts in cause-effect relationship 2. Spatial & temporal scales, geomorphic system, connectivity, buffering, magnitude-frequency concept, time lag, sensitivity, equilibrium, threshold, non-linearity & complexities	

3. Mega geomorphology and process interrelationship
4. Surface processes and natural hazards; Applied aspects of geomorphology; Introduction to planetary geomorphology.

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 Introduction to Geomorphology, Orient Longman Ltd.
- ▶ Leeder, M. and Perez-Arlucea M 2005 Physical processes in earth and environmental sciences, Blackwell publishing.
- ▶ Summerfield M A 1991 Global Geomorphology Prentice Hall.
- ▶ Willcock, P.R., Iverson R M (2003) Prediction in geomorphology ' AGU Publication.

6.6 GE P3 - Earth Surface Processes Lab

Earth Surface Processes	
	2 Credits
List of Practical	
1. Study and interpretations of different landforms on maps 2. Exercises on hill slope development, fluvial channel, sediment erosion and transport, sediment budgeting, , drainage basin, drainage morphometry	

6.7 GE T4 - Natural Hazards and Disaster Management

Natural Hazards and Disaster Management	
	6 Credits
Unit 1	
Natural Hazards: Concept, Types of hazards	
Unit 2	
1. Concepts of disaster 2. Types of disaster: natural and manmade - cyclone, flood, land slide, land subsidence, fire and earthquake, tsunami and volcanic eruption 3. Issues and concern for various causes of disasters	
Unit 3	
1. Disaster management, mitigation, and preparedness 2. Techniques of monitoring and design against the disasters Management issues related to disaster	
Unit 4	
1. Disaster Management in India: Risk, Vulnerability and Hazard Mitigation through capacity building 2. Legislative responsibilities of disaster management; disaster mapping, assessment Pre-disaster risk & vulnerability reduction 3. Disaster preparation: Pre- disaster: reduction of risk & vulnerability; Syn-disaster and Post-disaster: recovery and rehabilitation	
Unit 5	
1. Hazard Zonation Mapping 2. Remote-sensing and GIS applications in real time disaster monitoring Prevention and rehabilitation	
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

6.8 GE T5 - Physics and Chemistry of Earth

Physics and Chemistry of Earth	
	4 Credits
Unit 1	
1. Continents, continental margins, oceans	
Unit 2	
1. Earth's interior - variation of physical quantities and seismic wave velocity inside the earth, major sub divisions and discontinuities. 2. Concepts of Isostasy; Airy and Pratt Model 3. Constitutions of Core and mantle: Seismological and other geophysical constraints 4. Convection in the mantle	
Unit 3	
1. Earth's magnetic field: Character and genesis. 2. Secular variation and westward drift 3. Solar activity and magnetic disturbance	
Unit 4	
1. Origin of elements/nucleosynthesis. Abundance of the elements in the solar system / planet earth geochemical classification of elements. 2. Earth accretion and early differentiation 3. Isotopes and their applications in understanding Earth processes. Stable isotopes: Stable isotope fractionation. Oxygen isotopes	
Unit 5	
1. Basic concept of environmental geochemistry 2. Geological disposal of nuclear waste 3. Lead and other heavy metals in environment and their effect on human health	
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.
- ▶ Turcotte, D. and Schubert, G. Geodynamic. Second Edition. Cambridge

6.9 GE P5 - Physics and Chemistry of Earth Lab

Physics and Chemistry of Earth	
	2 Credits
List of Practical	
1. Method of plotting in triangular diagrams 2. Projection of major element data on Harker's diagram to characterize magmatic differentiation 3. 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 4. Problems on isostasy	

6.10 GE T6 - Fossils and Their Applications

Fossils And Their Applications	
	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: Economic 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.	
Reference Books	
▶ Schoch, R.M. 1989. Stratigraphy, Principles and Methods. VanNostrand Reinhold. ▶ Clarkson, E.N.K. 1998. Invertebrate Paleontology and Evolution George Allen&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.

6.11 GE P6 - Fossils and Their Applications Lab

Fossils and Their Applications	
	2 Credits
List of Practical	
1. Study of fossils showing various modes of fossilization 2. Study of important fossils from India (list may be prepared by the department concern)	

6.12 GE T7 - Soils: Present and Past

Soils: Present and Past	
	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; ferrallitization; 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 ratios; chemical weathering indices

Units 9

Stable isotope geochemistry: carbon¹³ and oxygen¹⁸ system for vegetation, temperature, pCO₂

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.

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 Resources Conservation Service, Washington D.C. (341 pp.)
- ▶ Bhattacharyya T., Sarkar, D., Pal, D. K. (Eds.) Soil Survey Manual. NBSSLUP Publication No 146.

6.13 GE P7 - Soils Past and Present Lab

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

6.14 GE T8 - Nuclear Waste Management

Nuclear Waste Management	
	4 Credits
Theory and Concepts	
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.	
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.	

6.15 GE P8 - Nuclear Waste Management Lab

Nuclear Waste Management	
	2 Credits
List of Practical	
1. Determination of physical properties such as hardness, durability, melting and pouring temperatures 2. Chemical characterization of synthetic and natural glass 3. Mathematical modeling and extrapolation of synthetic glass alterations 4. Mathematical modelling and extrapolation of natural acidic (obsidian, rhyolite) and basic (nephilinite and basaltic) glasses 5. Determination of rate of alteration and recognition of neo-formed minerals 6. Calculation of retention coefficient for glass residue	

6.16 GE T9 - Earth Resources

Earth Resources	
	4 Credits
Unit 1: Earth Resources	
1. Resource reserve definitions; mineral, energy and water resources 2. A brief overview of classification of mineral deposits with respect to processes of formation	
Unit 2: Definition of Energy: Primary and Secondary Energy	
1. Difference between Energy, Power and Electricity 2. Renewable and Non-Renewable Sources of Energy 3. The concept and significance of Renewability: Social, Economic, Political and Environmental Dimension of Energy	
Unit 3: Major Types and Sources of Energy	
1. Resources of Natural Oil and Gas 2. Coal and Nuclear Minerals 3. Potential of Hydroelectric Power, Solar Energy, Wind, Wave and Biomass Based power and Energy	
Unit 4: Ground Water, Hydropower, Solar power	
1. Ground water resources in India and its role in economic development of the country 2. Current Scenario and Future Prospects of Solar Power, Hydrogen Power and Fuel Cells.	
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.

6.17 GE P9 - Earth Resources Lab

Earth Resources	
	2 Credits
List of Practical	
1. Study of coal and Hand specimen 2. Plotting of major Indian oil fields on map of India 3. Problems related to assessment of possible oil exploration site from geological maps and sections. 4. Construction of cross section of mineral deposits from maps and drill hole data. 5. Estimation of reserves. 6. Preparation and interpretation of depth to water level maps and water level contour maps	

7. Appendix I - Scheme for CBCS Curriculum for Pass Course

7.1 Credit Distribution across Courses

Credits				
Course Type		Total Papers	Theory + Practical	Theory*+Tutorials
Core Courses	4 papers each from 3 disciplines of choice	12	12*4 =48	12*5 =60
			12*2 =24	12*1=12
Elective Courses	2 papers each from 3 discipline of choice including interdisciplinary papers	6	6*4=24	6*5=30
			6*2=12	6*1=6
Ability Enhancement Language Courses		2	2*2=4	2*2=4
Skill Enhancement Courses		4	4*2=8	4*2=8
Totals		24	120	120

*Tutorials of 1 Credit will be conducted in case there is no practical component

- All Pass courses will have 3 subjects/disciplines of interest. Student will select 4 core courses each from discipline of choice including Geology as one of the disciplines. The details for core courses available in Geology have been detailed in Section 3 of this document
- Student will select 2 core courses each from discipline of choice including Geology as one of the disciplines. The details for elective courses available in Geology have been detailed in Section 4 of this document
- Student may also chose Skill Enhancement courses in Geology. The details for skill enhancement courses available in Geology have been detailed in Section 5 of this document

7.2 Scheme for CBCS Curriculum

Semester	Course Name	Course Detail	Credits
I	Ability Enhancement Compulsory Course-I	English communication / Environmental Science	2
	Core course-I	Core Course 1A from Geology	4
	Core course-I Practical	Core Course 1A Practical from Geology	2
	Core course-II	Core Course 2A from other chosen discipline	4
	Core course-II Practical	Core Course 2A Practical from other chosen discipline	2
	Core course - III	Core Course 3A from other chosen discipline	4
	Core course - III Practical	Core Course 3A Practical from other chosen discipline	2
II	Ability Enhancement Compulsory Course-II	English communication / Environmental Science	2
	Core course-IV	Core Course 1B from Geology	4
	Core course-IV Practical	Core Course 1B Practical from Geology	2
	Core course-V	Core Course 2B from other chosen discipline	4
	Core course- V Practical	Core Course 2B Practical from other chosen discipline	2
	Core course - VI	Core Course 3B from other chosen discipline	4
	Core course - VI Practical	Core Course 3B Practical from other chosen discipline	2
III	Core course VII	Core Course 1C from Geology	4
	Core course-VII Practical	Core Course 1C Practical from Geology	2
	Core course - VIII	Core Course 2C from other chosen discipline	4
	Core course - VIII Practical	Core Course 2C Practical from other chosen discipline	2
	Core course-IX	Core Course 3C from other chosen discipline	4
	Core course-IX Practical	Core Course 3C Practical from other chosen discipline	2
	Skill Enhancement Course-1	TBD	2

IV	Core course-X	Core Course 1D from Geology	4
	Core course - X Practical	Core Course 1D Practical from Geology	2
	Core course-XI	Core Course 2D from other chosen discipline	4
	Core course-XI Practical	Core Course 2D Practical from other chosen discipline	2
	Core course-XII	Core Course 3D from other chosen discipline	4
	Core course-XII Practical	Core Course 3D Practical from other chosen discipline	2
	Skill Enhancement Course-2	TBD	2
V	Skill Enhancement Course - 3	TBD	2
	Discipline Specific Elective 1	DSE 1A from Geology	4
	Discipline Specific Elective 1 Practical	DSE 1A Practical from Geology	2
	Discipline Specific Elective 2	DSE 2A from other chosen discipline	4
	Discipline Specific Elective 2 Practical	DSE 2A Practical from other chosen discipline	2
	Discipline Specific Elective 3	DSE 3A from other chosen discipline	4
	Discipline Specific Elective 3 Practical	DSE 3A Practical from other chosen discipline	2
VI	Skill Enhancement Course - 4	TBD	2
	Discipline Specific Elective 4	DSE 1B from Geology	4
	Discipline Specific Elective 4 Practical	DSE 1B Practical from Geology	2
	Discipline Specific Elective 5	DSE 2B from other chosen discipline	4
	Discipline Specific Elective 5 Practical	DSE 2B Practical from other chosen discipline	2
	Discipline Specific Elective 6	DSE 3B from other chosen discipline	4
	Discipline Specific Elective 6 Practical	DSE 3B Practical from other chosen discipline	2

