

**CBCS SYLLABUS
FOR
THREE YEARS UNDER-GRADUATE COURSE
IN
GEOLOGY (HONOURS)
(w.e.f. 2017)**



**BANKURA UNIVERSITY
BANKURA, WEST BENGAL, PIN 722155**



1. Introduction.....	4
2. Scheme for CBCS Curriculum	5
2.1 Credit Distribution across Courses	5
2.2 CBCS Curriculum for B.sc Honours in Geology	5
2.3 Choices for Discipline Specific Elect.....	9
2.4 Choices for Skill Enhancement Courses	9
2.5 Choices for Generic Electives (To be opted by the honours students of other discipline).....	9
3. Core Subjects Syllabus	10
3.1 Core T1 – Earth System Science	10
3.2 Core P1 – Earth System Science Lab	11
3.3 Core T2 – Mineral Science	11
3.4 Core P2 – Mineral Science Lab	12
3.5 Core T3 – Elements of Geochemistry	13
3.6 Core P3 – Elements of Geochemistry Lab	13
3.7 Core T4 - Structural Geology	14
3.8 Core P4 – Structural Geology Lab	15
3.9 Core T5 - Igneous Petrology	15
3.10 Core P5 – Igneous Petrology– Lab	16
3.11 Core T6 – Sedimentology	17
3.12 Core P6 – Sedimentology Lab	17
3.13 Core T7 - Paleontology	18
3.14 Core P7 – Paleontology Lab	19
3.15 Core T8 - Metamorphic Petrology	19
3.16 Core P8 – Metamorphic Petrology Lab.....	20
3.17 Core T9 - Principles of Stratigraphy and Precambrian Stratigraphy of India.....	20
3.18 Core P9 –Principles of Stratigraphy and Preca mbrian Stratigraphy of India Lab.....	21
3.19 Core T10 - Phanerozoic Stratigraphy of India	21
3.20 Core P10 – Phanerozoic Stratigraphy of India Lab	22
3.21 Core T11 - Hydrogeology	22
3.22 Core P11 – Hydrogeology Lab	23
3.23 Core T12 - Economic Geology	23
3.24 Core P12 – Economic Geology Lab	24
3.25 Core T13 – Geomorphology, Remote Sensing and GIS.....	24
3.26 Core P13 – Geomorphology, Remote Sensing and GIS Lab	26
3.27 Core T14 - Engineering Geology	26
3.28 Core P14 – Engineering Geology Lab.....	27
4. Department Specific Electives Subjects Syllabus	27
4.1 DSE T1 - Earth and Climate	27
4.2 DSE P1 – Earth and Climate Lab.....	28
4.3 DSE T2 – Introduction to Geophysics	29
4.4 DSE P2 – Introduction to Geophysics Lab.....	30
4.5 DSE T3 - Fuel Geology	30
4.6 DSE P3 – Fuel Geology Lab.....	31



4.7	DSE T4 - Exploration Geology	31
4.8	DSE P4 –Exploration Geology Lab	32
4.9	DSE T5 - Evolution of Life through Time	32
4.11	DSE T6 - River Science	33
4.12	DSE P6 – River Science Lab	33
4.13	DSE T7 – Oceanography and Marine Science	34
4.14	DSE P7 – Oceanography and Marine Science Lab	35
4.15	DSE T8 – Urban Geology	35
4.16	DSE P8 – Urban Geology Lab	36
4.17	DSE T9 –Geodynamics	36
4.18	DSE P9 –Geodynamics Lab	37
5.	Skill Enhancement Course.....	37
5.1	SEC T1 – Field Geology I.....	37
5.2	SEC T2 - Field Geology II.....	38
5.3	SEC T3 – Field Geology III.....	38
5.4	SEC T4 - Field Geology IV.....	38
6.	Generic Elective	39
6.1	GE T1 - Essentials of Geology	39
6.2	GE P1 – Essentials of Geology Lab	39
6.3	GE T2- Rocks and Minerals	40
6.4	GE P2 – Rocks and Minerals Lab	40
6.5	GE T3 - Earth Surface Processes.....	41
6.6	GE P3 – Earth Surface Processes Lab	41
6.7	GE T4 - Natural Hazards and Disaster Management.....	42
6.8	GE T5 - Physics and Chemistry of Earth	42
6.9	GE P5 – Physics and Chemistry of Earth Lab	43
6.10	GE T6 - Fossils and Their Applications	43
6.11	GE P6 – Fossils and Their Applications Lab	44
6.12	GE T7 - Soils: Present and Past.....	44
6.13	GE P7 – Soils: Present and Past Lab	46
6.14	GE T8 - Nuclear Waste Management	46
6.15	GE P8 – Nuclear Waste Management Lab	47
6.16	GE T9 – Earth Resources.....	47
6.17	GE P9 – Earth Resources Lab.....	48



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 understanding of the subject and new techniques of mapping.

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. Thus, 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.

Abbreviations Used:

SH= Science Honours, GEL= Geology, ACSHP= Arts Commerce Science Honours Pass, AECC= Ability Enhancement Compulsory Course, C= Core Course, DSE= Discipline Specific Elective, ESE= End-Semester Examination, GE= Generic Elective, IA= Internal Assessment, Lec.= Lecture, Prc.=Practical, SEC= Skill Enhancement Course, and Tu.= Tutorial



2. Scheme for CBCS Curriculum

2.1 Credit distribution across courses

Course Type	Total Papers	Credits	
		Theory + Practical	Theory + Tutorial ⁺
Core Courses (CC)	14	14*4 = 56 + 14*2 = 28	14*5 = 70 14*1 = 14
Discipline Specific Elective (DSE)	4	4*4 = 16 + 4*2 = 8	4*5 = 20 4*1 = 4
Generic Elective (GE)	4	4*4 = 16 + 4*2 = 8	4*5 = 20 4*1 = 4
Ability Enhancement Course (AECC)	1	1*4 = 4	1*4 = 4
	1	1*2 = 2	1*2 = 2
Skill Enhancement Course (SEC)	4	2*2 = 4	2*2 = 4
Total	26	142	142

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

2.2 CBCS Curriculum for B. Sc. Honours in Geology

(A) Generalised Semester-wise course structure

YEAR	SEMESTER	CORE COURSE (CC) (14)	ABILITY ENHANCEMENT COURSE (AECC) (2)	SKILL ENHANCEMENT COURSE (SEC) (2)	DISCIPLINE SPECIFIC ELECTIVE (DSE) (4)	GENERIC ELECTIVE (GE) (4)
FIRST YEAR	I	1. EARTH SYSTEM SCIENCE 2. MINERAL SCIENCE	ENVIRONMENTAL STUDIES			GE-1
	II	3. ELEMENTS OF GEOCHEMISTRY 4. STRUCTURAL GEOLOGY	COMMUNICATIVE ENGLISH/HINDI/MIL			GE-2
SECOND YEAR	III	5. IGNEOUS PETROLOGY 6. SEDIMENTOLOGY		SEC-I (Field Geology)		GE-3
	IV	7. PALEONTOLOGY 8. METAMORPHIC PETROLOGY 9. PRINCIPLES OF STRATIGRAPHY AND PRECAMBRIAN STRATIGRAPHY OF INDIA 10. PHANEROZOIC STRATIGRAPHY OF INDIA		SEC-II (Field Geology)		GE-4
THIRD YEAR	V	11. HYDROGEOLOGY 12. ECONOMIC GEOLOGY			DSE - 1 DSE - 2	
	VI	13. GEOMORPHO-LOGY, REMOTE SENSING & GIS 14. ENGINEERING GEOLOGY			DSE - 3 DSE - 4	

**(B) Detail course structure****SEMESTER-I**

COURSE CODE	COURSE TITLE	CREDIT	MARKS			No. of hours		
			IA	ESE	TOTAL	Lec	Tu	Pr
SH/GEL/101/C-T1 & SH /GEL/101/C-P1	Earth System Science	4	10	25	35	4	0	0
	Earth System Science Lab	2	0	15	15	0	0	4
SH /GEL/102/C-T2 & SH /GEL/102/C-P2	Mineral Science	4	10	25	35	4	0	0
	Mineral Science Lab	2	0	15	15	0	0	4
* SH /GEL/103/GE-T1 & * SH /GEL/103/GE-P1	Essentials of geology/ Soil: present and past	4	10	25	35	4	0	0
	Essentials of geology Lab/ Soil: present and past Lab	2	0	15	15	0	0	4
ACSHP104/AECC-1	Environmental Studies	4	10	40	50	4	0	0
Total in Semester- I		22	40	160	200			

* To be opted by the honours students of other discipline

SEMESTER-II

COURSE CODE	COURSE TITLE	CREDIT	MARKS			No. of hours		
			IA	ESE	TOTAL	Lec	Tu	Pr
SH /GEL/201/C-T3 & SH /GEL/201/C-P3	Elements of Geochemistry	4	10	25	35	4	0	0
	Elements of Geochem. Lab	2	0	15	15	0	0	4
SH /GEL/202/C-T4 & SH /GEL/202/C-P4	Structural Geology	4	10	25	35	4	0	0
	Structural Geology Lab	2	0	15	15	0	0	4
* SH /GEL/203/GE-T2 & * SH /GEL/203/GE-P2	Rocks and minerals/ Fossils and their applications	4	10	25	35	4	0	0
	Rocks and minerals Lab/Fossils and their applications Lab	2	0	15	15	0	0	4
ACSHP/204/AECC-2	English/Hind/MIL	2	10	40	50	2	0	0
Total in Semester- II		20	40	160	200			

* To be opted by the honours students of other discipline

**SEMESTER-III**

COURSE CODE	COURSE TITLE	CREDIT	MARKS			No. of hours		
			IA	ESE	TOTAL	Lec	Tu	Pr
SH /GEL/301/C-T5 & SH / GEL /301/C-P5	Igneous Petrology	4	10	25	35	4	0	0
	Igneous Petrology Lab	2	0	15	15	0	0	4
SH / GEL /302/C-T6 & SH / GEL /302/C-P6	Sedimentology	4	10	25	35	4	0	0
	Sedimentology Lab	2	0	15	15	0	0	4
SH / GEL /303/C-T7 & SH / GEL /303/C-P7	Palaeontology	4	10	25	35	4	0	0
	Palaeontology Lab	2	0	15	15	0	0	4
* SH / GEL /304/GE-T3 & * SH / GEL /304/GE-P3	Earth surface processes/Physics and chemistry of earth	4	10	25	35	4	0	0
	Earth surface processes Lab /Physics and chemistry of earth Lab	2	0	15	15	0	0	4
SH / GEL /305/SEC-1	Field Geology	2	10	40	50	0	0	4
Total		26	50	200	250			

* To be opted by the honours students of other discipline

SEMESTER-IV

COURSE CODE	COURSE TITLE	CREDIT	MARKS			No. of hours		
			IA	ESE	TOTAL	Lec	Tu	Pr
SH /GEL/401/C-T8 & SH /GEL/401/C-P8	Metamorphic Petrology	4	10	25	35	4	0	0
	Metamorphic Petrology Lab	2	0	15	15	0	0	4
SH /GEL/402/C-T9 & SH /GEL/402/C-P9	Principles of Stratigraphy and Precambrian Stratigraphy of India	4	10	25	35	4	0	0
	Prin. Strat.& Precam. Strat. India Lab	2	0	15	15	0	0	4
SH /GEL/403/C-T10 & SH /GEL/403/C-P10	Phanerozoic Stratigraphy of India	4	10	25	35	4	0	0
	Phan. Strat. of India Lab	2	0	15	15	0	0	4
* SH /GEL/404/GE-T4 & * SH /GEL/404/GE-P4	Earth resources/Natural hazards and disaster management	4	10	25	35	4	0	0
	Earth resources Lab/Natural hazards and disaster management Lab	2	0	15	15	0	0	4
SH /GEL/405/SEC-2	Field Geology	2	10	40	50	0	0	4
Total		26	50	200	250			

* To be opted by the honours students of other discipline

**SEMESTER-V**

COURSE CODE	COURSE TITLE	CREDIT	MARKS			No. of hours		
			IA	ESE	TOTAL	Lec	Tu	Pr
SH /GEL/501/C-T11 & SH /GEL/501/C-P11	Hydrogeology	4	10	25	35	4	0	0
	Hydrogeology Lab	2	0	15	15	0	0	4
SH /GEL/502/C-T12 & SH /GEL/502/C-P12	Economic Geology	4	10	25	35	4	0	0
	Economic Geology Lab	2	0	15	15	0	0	4
SH /GEL/503/DSE-T1 & SH /GEL/503/DSE-P1	Fuel geology/Introduction to geophysics	4	10	25	35	4	0	0
	Fuel geology Lab / Introduction to geophysics Lab	2	0	15	15	0	0	4
SH /GEL/504/DSE-T2 & SH /GEL/504/DSE-P2	Exploration geology/Earth and climate	4	10	25	35	4	0	0
	Exploration geology Lab/Earth and climate Lab	2	0	15	15	0	0	4
Total		24	40	160	200			

SEMESTER-VI

COURSE NAME (CODE)	COURSE TITLE	CREDIT	MARKS			No. of hours		
			IA	ESE	TOTAL	Lec	Tu	Pr
SH /GEL/601/C-T13 & SH /GEL/601/C-P13	Geomorphology, Remote Sensing and GIS	4	10	25	35	4	0	0
	Geomorphology, Remote Sensing and GIS	2	0	15	15	0	0	4
SH /GEL/602/C-T14 & SH /GEL/602/C-P14	Engineering Geology	4	10	25	35	4	0	0
	Engineering Geology Lab	2	0	15	15	0	0	4
SH /GEL/603/DSE-T3 & SH /GEL/603/DSE-P3	River science/ Oceanography and marine science	4	10	25	35	4	0	0
	River science Lab/ Oceanography and marine science Lab	2	0	15	15	0	0	4
SH /GEL/604/DSE-T4 & SH /GEL/604/DSE-P4	Geodynamics/Urban geology	4	10	25	35	4	0	0
	Geodynamics Lab/Urban geology Lab	2	0	15	15	0	0	4
Total		24	40	160	200			
TOTAL OF ALL SEMESTERS		142	260	1040	1300			



2.3 Choices for Discipline Specific Electives

Discipline Specific Elective (to be chosen 4 subjects out of the following)			
Fuel Geology	Introduction to Geophysics	Exploration Geology	Earth and Climate
River Science	Oceanography and Marine Science	Geodynamics	Urban Geology

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

2.5 Choices for Generic Electives (To be opted by the honours students of other discipline)

Generic Elective (to be chosen 4 subjects out of the following)			
Essentials of geology	Soil: present and past	Rocks and minerals	Fossils and their applications
Earth surface processes	Physics and chemistry of earth	Earth resources	Natural hazards and disaster management



3. Core Subjects Syllabus

3.1 Core T1 – 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. Earthquake and earthquake belts: Seismic waves and internal constitution of the Earth- crust, mantle, core lithosphere, asthenosphere, mesosphere and centrosphere
2. Volcanoes and volcanism, distribution of volcanoes
4. Concept of isostasy
5. Convection in Earth's core and production of its magnetic field
6. 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

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

1. Weathering, erosion, 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: concept of uniformitarianism, 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.
5. 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. Distribution of cratons, mobile belts and major sedimentary basins in India

3.3 Core T2 – Mineral Science

Mineral Science

4 Credits

Unit 1: Crystallography

1. Concept of crystalline and amorphous matter. Definition of crystal
2. Crystal structure, Elementary ideas about crystal morphology in relation to internal structures
3. Crystal parameters and Miller indices, form and zone
4. Stereographic projection of crystal faces, crystal symmetry, classification of crystals into systems and point groups. Hermann Mauguin notation, crystal lattice and concept of space group.

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 physical properties (density, cleavage, fracture, parting, habit, hardness, streak, tenacity, elasticity, magnetism., radioactivity, fluorescence, piezoelectricity and pyroelectricity)
2. Classification of minerals (based on structures and chemical parameters) with examples of common silicates, oxides, carbonates, sulphides, sulphates and phosphates.
4. Major rock forming mineral groups (viz., quartz, feldspar, feldspathoids, olivine, pyroxene, amphibole, mica and garnet) – (a) structural formula, (b) members of the mineral groups, and (c) paragenesis

Unit 4: Crystal Optics

1. Optical behaviour of crystals - isotropic and anisotropic minerals, nicol prism and its principle of construction, polaroid, refractive index of minerals, uniaxial and biaxial minerals, birefringence, interference colour and use of interference colour chart, relation between crystallography and optical axes of crystals, pleochroism and pleochroic scheme, extinction, optical indicatrix, study of interference figure, optic sign of uniaxial and biaxial minerals, relation between optical and chemical properties (in case of feldspar and pyroxene groups).
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. Study of physical properties of minerals in hand specimen - (a) Quartz, Feldspar, Olivine, Pyroxene, Hornblende-Actinolite, Tremolite, Muscovite, Biotite, Garnet, Andalusite, Sillimanite, Kyanite, Staurolite, Beryl, Tourmaline, Serpentine, Talc, Nepheline, Zeolite Asbestos,
(b) Chert, Chalcedony, Agate, Jasper, Amethyst, Rock crystal
(c) 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 earth, continental and oceanic crust, depleted and enriched mantle and core
2. Isotope geology: Isotopic and elemental fractionation
3. Radiogenic and stable isotopes in earth materials. Radiometric dating of rocks and minerals: U-Pb, Pb-Pb, K-Ar, Rb-Sr, Sm-Nd methods. Dating igneous and sedimentary rocks.

Unit 3: Element transport

1. Advection and diffusion
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 (bivariate and trivariate) based on major elements and their interpretations: Harker variation diagram, AFM diagram, MgO diagram, Alkali-lime index, Iron enrichment index, and Aluminium saturation index

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 structures 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

Unit 4: 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

Unit 5: Fractures and faults

1. Geometric and genetic classification of fractures, joint 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. Solution of true dip and apparent dip problems, 3 point problems, fold problems, fault problems through graphical methods
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
6. Interpretation of Geological maps with unconformity, fault, fold and igneous bodies
Construction of structural cross section

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, their emplacement and evolution
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

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, Hatch, Wells & Wells and IUGS. TAS diagram for volcanic rocks
2. Composition and texture of important igneous rocks: Granitoids, Pegmatite, Syenite, Monzonite, Diorite, Norite, Gabbro, Anrothosite, Dolerite, Pyroxenites, Peridotite, Lamprophyres, Carbonatite, Rhyolite, Andesite, Dacite, Basalt, Komatiite

Unit 5: Phase Diagrams and igneous processes

1. 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, diopside-forsterite-silica and nepheline - kalsilite – silica.

2. Process of diversification of igneous rocks: magmatic differentiation, assimilation, partial melting, magma mixing
3. Concept of petrographic province and igneous rock series; Graphical analyses of compositional variations in igneous rock suites
4. Bowen's reaction series

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, 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 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, dunite, peridotite, 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 - Sedimentology

Sedimentology

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 –Sedimentology Lab

Sedimentology Lab

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 – sandstone (arkose, quartz arenite, greywacke) and limestone in 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 angiosperm and gymnosperm
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. Functional adaptation in trilobites and ammonoids
3. Origin of vertebrates and major steps in vertebrate 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

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 with special emphasis on ammonoidea and plant fossils
- 2.-Study of functional morphological characters of different groups (Bivalvia, Echinodermata). Study of morphological features of gastropod and Gondwana flora.
4. Identification of feeding habits from vertebrate (horse, elephants) teeth
5. Hard part morphology and identification of common Brachiopoda, Anthozoa, 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

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 Petrology Lab

Metamorphic Petrology

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: schists, gneisses, amphibolites, charnockite, khondalite, mafic granulites, eclogite, marble,
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.
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 and 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 of 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 – Principles of Stratigraphy and Precambrian Stratigraphy of India Lab

Principles of Stratigraphy and Precambrian Stratigraphy of India

2 Credits

List of Practical

1. Study of geological map of India and identification of major stratigraphic units
2. Major features of Precambrian paleogeographic maps

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 succession of Spiti, (b) Jurassic of Kutch, (c) Triassic and Jurassic non-marine successions of peninsular India (Upper Gondwana Formations and relevant Formations of Rajasthan basin), (d.) Cretaceous succession of Cauvery basin (e) Lameta and Jabalpur Formations of Narmada Basins.
4. Cenozoic stratigraphy of India: (a) Kutch basin, (b) Siwalik successions, (c) Assam, Arakan and Bengal 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. Pangaea reconstruction

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)

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
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 specimen 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

1. 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.

Unit 8: GIS and GPS

1. Datum, Coordinate systems and Projection systems.
2. Introduction to DEM analysis.
3. Concepts of GPS.
4. Concepts of GIS.
5. Applications in earth system sciences.

Reference Books

- Robert S. Anderson and Suzanne 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.

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

1. Concept, Mechanism and Significance of: a) Rock Structure Rating (RSR), b) Rock Mass Rating (RMR), c) Tunnelling Quality Index (Q)
2. Geological, Geotechnical and Environmental considerations for Dams and Reservoirs

Unit 6

Tunnels and Tunnelling Methods

Unit 7

Landslides and mass wasting: 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.

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

Definition and scope of 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, grade and rank of coal
2. Basic classification of coal based on Rank
3. Fundamentals of Coal Petrology - Introduction to litho types, microlitho types and macerals in coal
4. Proximate and Ultimate analyses
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

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. 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. Study of drainage pattern and palaeohydraulics

4.13 DSE T7 – Oceanography and Marine Science**Oceanography and Marine Science****4 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 T7 – Oceanography and Marine Science Lab**Credit 2**

1. Study of land-ocean distribution, sea floor features, plate boundaries, sea floor spreading, distribution of marine sediments and distribution of marine life
2. Preparation and study of T-S diagrams, Oxygen & carbon dioxide in sea water
3. Study of global winds and ocean currents, divergence and convergence zones in the oceans

4.15 DSE T8 – Urban Geology**Urban Geology****4 Credits****Unit 1: 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.

Unit 2: Geology and Urban Agriculture

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

Unit 3: 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

**Unit 4: 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.

Unit 5: 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.

Unit 6: GIS in Urban Geology

Introduction, Application in Urban development, landuse and GW Exploration.

Unit 7: 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

4.16 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

4.17 DSE T9 –Geodynamics**Geodynamics****4 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: Plate Motion

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.

4.18 DSE P9 –Geodynamics Lab

2 Credits

1. Position of Indian sub-continent during different geological times between break-up of Gondwanaland and formation of the Himalayas.
2. Different stages of Red sea formation with respect to continental rift system.
3. Different stages of Atlantic Ocean formation with respect to continental rift system.
4. Distribution of volcanoes along Ring of Fire in Pacific Ocean.
5. Schematic drawings of different stages of ocean-continent collision and continent-continent collision.

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. Generic Elective

6.1 GE T1 - Essentials of Geology

Essentials of Geology

4 Credits

Unit 1: Introduction

1. 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 processes: 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, 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. 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

Unit 4

1. 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 1991Globe Geomorphology Prentice Hall.
- Wllcock, 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



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, landslide, 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.

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, Pergamon 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, 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 O₂ and CO₂, 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.

Unit 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: Present and Past Lab**Soils: Present and Past****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