LEARNING OUTCOMES BASED CURRICULUM FRAMEWORK (LOCF)
FOR
SIX SEMESTER B. Sc. (GEOLOGY HONOURS)
UNDER
CHOICE-BASED CREDIT SYSTEM (CBCS)

(*w.e.f. A.Y. 2022-2023*)

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1. Introduction

One of the major initiatives of University Grants Commission (UGC) for quality improvement in higher education system is the curriculum revision. The curriculum also requires to be updated more often keeping in view with the latest developments in the society as well as to address the societies needs from time to time. In a discussion on the *UGC-notified Quality Mandate* in a conference (26-28 July, 2018) of the VCs and Directors of HEIs (Higher Education Institutes), it has been resolved to revise the curriculum based on Learning Outcome Curriculum Framework (LOCF) under the Choice-Based Credit System (CBCS).

The LOCF aims to equip students with knowledge, skills, values, attitudes, leadership readiness/qualities and lifelong learning. The fundamental premise of LOCF is to specify what graduates completing a particular programme of study are expected to know, understand and be able to do at the end of their programme of study. Thus, LOCF makes the undergraduate educations student-centric, interactive and outcome-oriented with well-defined aims, objectives and goals to achieve.

Geology as a discipline falls within the special category of science with a multidisciplinary approach. The syllabus for geology at undergraduate level using LOCF under the CBCS has been framed in compliance with model syllabus given by UGC. The goal of the syllabus is to equip students with the fundamental knowledge of the diverse fields of earth science. In addition, it is critical that students learn to think like a scientist and to apply the scientific method in their coursework and in their lives. The geology programs integrate field trips with classroom learning to give the hands-on experience, which is often required to succeed. These opportunities develop the technical skills using measuring instruments and laboratory equipment. The ultimate goal of the syllabus is that the students at the end are able to secure very good opportunities for higher studies and job.

In teaching and learning pedagogy, there should be a shift from domain or conclusions-based approach to the experiential or process-based approach. The learning should be on a proportionate scale of 20:30:50 principle, where lectures (listening/hearing) constitute 20 percent of the delivery; laboratory (scientific analysis and experiments) 30 percent of the learning methods and field-based (collecting/participating) 50 percent.

Abbreviations Used:

AECC= Ability Enhancement Compulsory Course, C= Core Course, DSE= Discipline Specific Elective, ESE= End-Semester Examination, GE= Generic Elective, GEL= Geology, 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	1*4 = 4 1*2 = 2	1*4 = 4 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 SCINCE 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 7. PALEONTOLOGY		SEC-I (Field Geology)		GE-3
	IV	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
UG/GEL/101/C-T1 & UG/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
UG/GEL/102/C-T2 & UG/GEL/102/C-P2	Mineral Science	4	10	25	35	4	0	0
	Mineral Science Lab	2	0	15	15	0	0	4
*UG/GEL/103/GE-T1 & *UG/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
UG/104/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
UG/GEL/201/C-T3 & UG/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
UG/GEL/202/C-T4 & UG/GEL/202/C-P4	Structural Geology	4	10	25	35	4	0	0
	Structural Geology Lab	2	0	15	15	0	0	4
*UG/GEL/203/GE-T2 & *UG/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
UG/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
UG/GEL/301/C-T5 & UG/ GEL /301/C-P5	Igneous Petrology	4	10	25	35	4	0	0
	Igneous Petrology Lab	2	0	15	15	0	0	4
UG/ GEL /302/C-T6 & UG/ GEL /302/C-P6	Sedimentology	4	10	25	35	4	0	0
	Sedimentology Lab	2	0	15	15	0	0	4
UG/ GEL /303/C-T7 & UG/ GEL /303/C-P7	Palaeontology	4	10	25	35	4	0	0
	Palaeontology Lab	2	0	15	15	0	0	4
*UG/ GEL /304/GE-T3 & *UG/ 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
UG/ 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
UG/GEL/401/C-T8 & UG/GEL/401/C-P8	Metamorphic Petrology	4	10	25	35	4	0	0
	Metamorphic Petrology Lab	2	0	15	15	0	0	4
UG/GEL/402/C-T9 & UG/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
UG/GEL/403/C-T10 & UG/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
*UG/GEL/404/GE-T4 & *UG/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
UG/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
UG/GEL/501/C-T11 & UG/GEL/501/C-P11	Hydrogeology	4	10	25	35	4	0	0
	Hydrogeology Lab	2	0	15	15	0	0	4
UG/GEL/502/C-T12 & UG/GEL/502/C-P12	Economic Geology	4	10	25	35	4	0	0
	Economic Geology Lab	2	0	15	15	0	0	4
UG/GEL/503/DSE-T1 & UG/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
UG/GEL/504/DSE-T2 & UG/GEL/504/DSE-P2	Mineral Exploration and Mining/Earth and climate	4	10	25	35	4	0	0
	Mineral Exploration and Mining 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
UG/GEL/601/C-T13 & UG/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
UG/GEL/602/C-T14 & UG/GEL/602/C-P14	Engineering Geology	4	10	25	35	4	0	0
	Engineering Geology Lab	2	0	15	15	0	0	4
UG/GEL/603/DSE-T3 & UG/GEL/603/DSE-P3	Oceanography and marine science/Medical Geology	4	10	25	35	4	0	0
	Oceanography and marine science Lab/ Medical Geology Lab	2	0	15	15	0	0	4
UG/GEL/604/DSE-T4 & UG/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 in Semester-V (to be chosen 02 subjects out of the following 04)		**Discipline Specific Elective in Semester-VI (to be chosen 02 subjects out of the following 04)**	
Fuel Geology	Introduction to Geophysics	Oceanography and Marine Science	Medical Geology
Mineral exploration and Mining	Earth and Climate	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 Courses

3.1 Core T1 – Earth System Science 4 Credits

(i) Course objectives:

This course aims to explore, understand, communicate, and teach the Earth as a planet, its complex processes, past and future evolution and interactions with the society. The main objective is to study the atmosphere, hydrosphere, and lithosphere, including their interaction and interrelationships with the biosphere.

(ii) Course learning outcomes:

Upon completion of this course the students will be able to (a) analyse the interactions between biological, chemical, and physical processes that shape and define the earth system; (b) correlate between the past Earth's evolution and its current changes; and (c) develop effective communication skills to help diffusing major current environmental problems.

(iii) Content of the course:

Unit 1: Earth as a planet

1. Branches of Earth Sciences.
2. Objectives and applications of earth sciences. Understanding of earth through geology, astronomy, oceanography and meteorology.
3. General characteristics and origin of the Universe, Solar System and its planets. The terrestrial and Jovian planets.
4. Mass and density of other planetary bodies and their origin. Elemental abundance in solar system.
5. Role of meteorites and asteroids in earth sciences.
6. Earth in the solar system - origin, size, shape, mass, density, rotational and revolution parameters.

Unit 2: Solid Earth, Hydrosphere, Atmosphere and Biosphere

1. Seismic waves and internal constitution of the Earth- crust, mantle and core.
2. Mechanical layering of the earth- lithosphere, asthenosphere, mesosphere and centrosphere.
3. Formation of hydrosphere, atmosphere and biosphere.
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: Plate Tectonics

1. Historical development of the concept of continental drift, sea-floor spreading and plate tectonics.
2. Plates and Plate boundaries.
3. Geodynamic elements of Earth: Mid Oceanic Ridges, trenches, transform faults and island arcs.
4. Origin of mountain belts and rift valleys.
5. Earthquake and earthquake belts.

6. Volcanoes- types, products and their distribution.

Unit 4: Surface Processes

1. Weathering and erosion.
2. Geological action of river, wind and glacier.
3. Soils: types, soil profile, processes of formation of soil.

Unit 5: Understanding the past from Stratigraphic records

1. Nature of stratigraphic records.
2. History of development in concepts of catastrophism and neptunism. Fundamental laws of stratigraphy: concept of uniformitarianism, laws of superposition and faunal succession.
3. Absolute and relative time in Geology; Geological time scale.
4. Concept of geochronology and its application in geological studies.
5. A brief introduction to geoheritage and geoarchaeology sites of India.

Suggested Readings

- 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 **2 Credits**

List of Practical

1. Study of major geomorphic features and their relationships with outcrops through physiographic models.
2. Detailed study of topographic sheets and preparation of physiographic description of an area.
3. Study of soil profile of any specific area.
4. Study of distribution of major lithostratigraphic units on the map of India.
5. Distribution of cratons, mobile belts and major sedimentary basins in India.
6. Study of seismic profile of a specific area and its interpretation.
7. Study of major ocean currents of the World.

3.3 Core T2 – Mineral Science **4 Credits**

(i) <u>Course objectives</u>:

This course helps to understand the fundamentals of crystallography and structural chemistry of minerals along with descriptive mineralogy. The students will be able to learn the optical and crystallographic properties of the minerals and their occurrences. The

course provides better understanding of crystallography, mineralogy and optical mineralogy and their application involved during the origin and evolution of the rocks.

(ii) Course learning outcomes:

After studying the course, the students will be able to (a) describe and recognize various physical properties of minerals, including lustre, cleavage, hardness, density etc. as well as optical properties; and (b) explain different symmetry elements of the crystals and how these relate to crystal systems.

(iii) Content of the course:

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, Miller indices, Form and Zone
4. Stereographic projection of crystal faces, Crystal symmetry, Classification of crystals into crystal systems and classes, 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.

Unit 3: Rock forming minerals

1. Minerals: definition, physical and other 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.
3. Silicate structures and its classification.
4. Major rock forming mineral groups (viz., feldspar, feldspathoids, olivine, pyroxene, amphibole, mica and garnet) – (a) structural formula, (b) members of the mineral groups, and (c) paragenesis.

Unit 4: Mineral 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 crystallographic and optical axes of crystals, pleochroism and pleochroic scheme, extinction angle, optical indicatrix, study of interference figure, optic sign of uniaxial and biaxial minerals, Variation of optical and physical properties with chemical composition of mineral groups.
2. Introduction to petrological microscope

Suggested Readings

- 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 2 Credits

List of Practical

1. Study of the symmetry of crystals. Stereographic projection of normal classes.
2. Study of physical properties of minerals in hand specimen - (a) Quartz, Feldspar, Olivine, Pyroxene, Hornblende-Actinolite, Tremolite, Muscovite, Biotite, Garnet, Andalusite, SilIimanite, 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
3. Study of optical properties of common rock-forming minerals: quartz, orthoclase, microcline, plagioclase, perthite, antiperthite, nepheline, olivine, orthopyroxene, clinopyroxene, hornblende, staurolite, garnet, muscovite, biotite, calcite, kyanite, sillimanite and andalusite.

3.5 Core T3 – Elements of Geochemistry 4 Credits

(i) Course objectives:

The Elements of Geochemistry aims to give an introduction to how chemical principles are used to explain the formation of the elements and solar system, the Earth's geochemical composition and differentiation into different reservoirs, the age of rocks, the surface environment, and the chemical traces of early life.

(ii) Course learning outcomes:

The students will be able to (a) demonstrate the behaviour of elements in geochemical context and relate this to how elements redistribute within the earth; (b) establish the Earth's chemistry in terms of interactions between reservoirs; (c) analyse the major processes operating in the Earth's crust and mantle., and (d) use isotopes to trace geological processes and age date specific events.

(iii) Content of the course:

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. Cosmic abundance of elements; the formation of the solar system; the Earth and Meteorites in the solar system.
4. Geochemical classification of elements.

Unit 2: Layered structure of Earth and geochemistry

1. Composition of the bulk silicate Earth; Composition of crust: continental and oceanic crust; Composition of mantle: depleted and enriched mantle; composition of core.
2. Isotope geology: radiogenic and stable isotopes in Earth materials; Isotopic and elemental fractionation.
3. Concept of Geochronology; Radiometric dating of rocks and minerals; principles of radioactive dating for Rb-Sr, K-Ar, Sm-Nd, U-Pb, Pb-Pb methods.

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.

Unit 4: Geochemistry of solid Earth

1. Geochemical variability of magma and its products.
2. Geochemical substitutions for elements; Concept of partition coefficient (K_d); compatible and incompatible elements.

Unit 5: Geochemical behaviour of selected elements

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

Suggested Readings

- 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 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, and Aluminium saturation index.

3.7 Core T4 - Structural Geology 4 Credits

(i) <u>Course objectives</u>:

The objectives of this course are to make students able to understand (a) the concepts of stress, strain and deformation, significance of brittle, plastic and ductile deformation and their products, (b) origin and mechanisms of faults, fractures, and folds, (c) processes and

fabrics that occur in shear zones and their kinematic significance, and (d) deriving tectonic histories from analysis of geological maps.

(ii) Course learning outcomes:

This course enables the students to (a) understand the structure of the rocks in the earth's crust and mantle, (b) determine the deformational history based on fabrics and geometric relationships, and (c) quantitatively describe stress and strain transformation.

(iv) Content of the course:

Unit 1: Basic structural elements

1. Diastrophic and non-diastrophic structures.
2. Penetrative and nonpenetrative planar and linear structures, Spatial orientation of planes and lines: concept of strike, dip, trend, plunge and pitch.
3. Uses of primary sedimentary and igneous structures in structural geology. Unconformity and its recognition.
4. Concept of scale in structural geology.
5. Topographic maps. Outcrop patterns of different structures.

Unit 2: Stress and strain in rocks

1. Concept of rock deformation: Concept of Stress.
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. Concept of Rock deformation: Brittle and ductile deformation.

Unit 3: Folds

1. Morphology and classification.
2. Characteristic features of buckling, bending, flexural slip and flow folding.

Unit 4: Foliation and lineation

1. Description and origin of foliations: axial plane cleavage and its tectonic significance.
2. 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.
2. Geologic/geomorphic criteria for recognition of faults and fault plane solutions.

Suggested Readings

- 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 2 Credits

List of Practical

1. Basic idea of topographic maps, topographic sheets of various scales.
2. Interpretation of topographic maps.
3. Stereographic projections of planes and lines.
4. True dip and apparent dip problems, 3-point problems, fold problems, fault problems through graphical methods.
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 4 Credits

(i) Course objectives:

Igneous petrology in the field of geology, the objective of the study to gain an appreciation for how the final appearance of characteristics of igneous rocks is controlled by chemical and physical properties of magmas and their surroundings.

(ii) Course learning outcomes:

Study of igneous rocks is a key component of geology curriculum (because these rocks not only abundant throughout the crust of the Earth, but, dominate some crustal and upper mantle environments). Students apply the knowledges of melt generation and crystallization mechanisms, diverse rock types and their link to tectonic settings in different earth processes.

(iii) Content of the course:

Unit 1: Introduction to Igneous petrology

1. Definition of igneous rocks and their formation; magma, its emplacement and evolution; volcanic, hypabyssal and plutonic igneous rock.
2. Physical properties of magma - temperature, viscosity, density and volatile content.

Unit 2: Forms of Igneous rock bodies

1. Mode of occurrences of igneous rocks
2. Forms and structures 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 and 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 – Hatch, Wells & Wells and IUGS.
2. Composition and texture of important igneous rocks: Granitoids, Pegmatite, Syenite, Monzonite, Diorite, Norite, Gabbro, Anorthosite, Dolerite, Pyroxenites, Peridotite, Dunite, Lamprophyres, Carbonatite, Rhyolite, Andesite, Dacite, Basalt and 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, and nepheline - kalsilite – silica.
2. Process of diversification of igneous rocks: magmatic differentiation, assimilation, partial melting and 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 and anorthosite.

Suggested Readings

- Tyrrel, G. W., (1926). Principles of Petrology, Springer
- 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 2 Credits

List of Practical

1. Study of important igneous rocks in hand specimen and thin section: granite, granodiorite, diorite, syenite, nepheline syenite, gabbro, dolerite, anorthosites, dunite, peridotite, basalt and andesite.
2. Plotting of mode in IUGS classification of plutonic rocks (Streckeisen's diagram)

3.11 Core T6 – Sedimentology 4 Credits

(i) Course objectives:

Sedimentary rocks are storehouse of many necessities of modern civilization viz. water, hydrocarbon etc. Major objective of the course is to make students understand fundamentals of sedimentary processes and their products, formation, and filling history of sedimentary basins in different tectonic backdrop. Nuances of both clastic and chemical sedimentation processes will be covered.

(ii) Course learning outcomes:

This course enable students to (a) describe scales of sedimentary grain size measurement and statistical analysis of data to interpret provenance, transportation history or depositional environment; (b) determine the texture and structure of clastic sedimentary rocks, procedure and importance of paleocurrent analysis; (c) recognize how sediments become sedimentary rocks, how porosity forms and evolves and how they can interpret the diagenetic evolution of ancient sedimentary rocks; and (d) comprehend concept of sedimentary environment and description of processes and products of different sedimentary environments viz. continental, marginal marine and marine.

(iii) Content of the course:

Unit 1: Introduction to Sedimentology

1. Outline of sedimentation process: Definition of sediment; origin of sediments: mechanical and chemical weathering; source rock or provenance, soils and paleosols.

Unit 2: Granulometry and Sedimentary textures

1. Grain size scale, particle size distribution, environmental connotation; particle shape and fabric; sorting and roundness.

Unit 3: Basic hydraulics, Sedimentary structures and environment

1. Fluid flow: 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; bedform stability diagram.
2. Mass flow: types, mechanisms and deposits.
3. Sedimentary structure: Primary, penecontemporaneous deformation structures and biogenic structures.
4. Paleocurrent analysis and its importance in sedimentology.
5. Brief introduction to sedimentary environments.

Unit 4: Types of Sedimentary rocks

1. Siliciclastic rocks: Components and classification(s) of conglomerates and sandstones; General introduction to Mudrocks, BIF and Chert.
2. Carbonate rocks: controlling factors of carbonate deposition; siliciclastic vs. carbonate sedimentation; 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.

Suggested Readings

- Pettijohn, F.J., 2019. *Sedimentary Rocks*. 3rd e-book Edition. CBS Publishers and Distributers, New Delhi.
- 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 2 Credits

List of Practical

1. Identification of sedimentary structures in hand specimen; Exercises on sedimentary structures and diagenetic features
2. Particle size distribution and statistical analysis
3. Paleocurrent analysis: Data acquisition, methodology and interpretation
4. Petrographic study of sedimentary rocks – sandstone (quartz arenite, arkose, lithic arenite and greywacke) and limestone in hand specimens and thin sections

3.13 Core T7 – Palaeontology 4 credits

(i) Course objectives:

The major objectives of this course are to understand the fossilised ancient invertebrate, vertebrate and micro-organisms in the light of their morphology, adaptation, ecology, and evolution. The present course will also throw light on the evidences and records of the earliest life on the earth and major events in the course of evolution of life through the Geological time**.**

(ii) Course learning outcomes:

The students will be able to (a) identify older life forms with their external and internal features; (b) deduction of ecology with the application of morphological modifications, and (c) apply principles of speciation and evolution.

(iii) Content of the course:

Unit 1: Fossilization and fossil record

1. Fossilization: definition of fossil, fossilization processes and modes of preservation, nature and importance of fossil record.
2. Taphonomy: definition, different types of taphonomic filters.

Unit 2: Taxonomy and Systematics

1. Taxonomy: concept of taxonomy and taxonomic hierarchy.
2. Species concept with special reference to palaeontology.

Unit 3: Evolution and History of Life

1. Theory of organic Evolution interpreted from fossil record: theory, concept of adaptation and variation, Natural Selection; Precambrian – doubtful organic traces of

life during the Precambrian, Ediacaran fauna; Palaeozoic – Cambrian Explosion of life. Episodes of mass extinction; Plants- Appearance of angiosperm and gymnosperm; and appearance of fish, amphibia, reptiles, birds, mammals and humans.

2. 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, Cephalopoda, Brachiopoda) and their functional aspects.
2. Brief introduction to Trilobites and Echinodermata.
3. Origin of vertebrates and major steps in vertebrate evolution; Evolution of horse; Human evolution.

Unit 5: Introduction to Palaeobotany, Gondwana Flora and Ichnology.

1. Introduction to Palaeobotany; Gondwana Flora
2. Introduction to Ichnology

Unit 6: Application of fossils in Stratigraphy

1. Biostratigraphy: Biozones, index fossils, stratigraphic correlation; significance of ammonites in Mesozoic biostratigraphy and their paleobiogeographic implications
2. Role of fossils in paleoenvironmental analysis, palaeoclimatology and sequence stratigraphy.
3. Paleoecology: biotic interactions, abiotic controlling factors; application of trace fossils in palaeoecology

Suggested Readings

- 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 – Palaeontology Lab 2 Credits

List of Practical

1. Study of fossils showing various modes of preservation.
2. Hard part morphology and identification of common invertebrates (Bivalvia, Gastropoda, Cephalopoda).
3. Identification of feeding habits from vertebrate (horse, elephants) teeth.
4. Identification and study of Gondwana flora..

3.15 Core T8 - Metamorphic Petrology 4 Credits

(i) Course objectives:

Dynamic nature of lithosphere leads to solid state transformations of rocks which hold clue to the past processes which are not possible to reconstruct by other means. This course aims

to enable students to identify critical data as well as provide theoretical basis for interpreting this data for past geodynamic processes, especially the orogenic events.

(ii) Course learning outcomes:

Identifying equilibrium mineral assemblages through textural and mineralogical observations Plotting the quantitative as well as qualitative mineral and mineral assemblage data to interpret the discontinuous reactions and to infer the nature of continuous reactions Apply the basics of Schreinemakers geometric plots for a set of reactions

(iii) Content of the course:

Unit 1: Metamorphism: controls and types.

1. Definition of metamorphism as per IUGS-SCMR. Factors controlling metamorphism, Types of metamorphism – contact, regional, fault zone metamorphism, impact metamorphism.
2. Causes of metamorphism.

Unit 2: Metamorphic Facies and Grades, Structure and Texture

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. Chemographic diagrams: ACF and AKF diagrams and their uses.
5. Metamorphic products of pelitic and mafic igneous rocks.

Unit 3: Metamorphic reactions 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

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

Suggested Readings

- 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 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

4 Credits

(i) Course objectives:

Objective of this course is to perform lithostratigraphic correlation, construct rank charts for lithostratigraphy, biostratigraphy and chronostratigraphy and to have an idea about different Precambrian stratigraphic successions of India.

(ii) Course learning outcomes:

On successful completion of the course, the student will be able to: (a) analyse basic principles of stratigraphy, different types of stratigraphic units and how they are named., and (b) use the fossil record in establishing age of the rock unit and correlation with other area, (c) give an account of criteria of stratigraphic correlation, and (c) appreciate how plate tectonic movements separated India from contiguous landmasses and shaped the depositional basins of the Indian Phanerozoic, and what were their effects on climate and life.

(iii) Content of the course:

Unit 1: Principles of stratigraphy

1. Fundamental laws of stratigraphy: concept of uniformitarianism, laws of superposition and faunal succession and their validity.
2. Fundamentals of lithostratigraphy, biostratigraphy and chronostratigraphy.
3. Introduction to concepts of dynamic stratigraphy (chemostratigraphy, seismic stratigraphy, sequence stratigraphy, magnetostratigraphy).
4. Relevance of type section.
5. Principles of stratigraphic correlation.

Unit 2: Code of stratigraphic nomenclature

a. International Stratigraphic Code – development of a standardized stratigraphic nomenclature.
b. Concepts of Stratotypes; Global Stratotype Section and Point (GSSP).

Unit 3: Facies concept in stratigraphy

1. Introduction to sedimentary Facies; 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. Study of Proterozoic supercontinent reconstructions; evolution of Indian sub-continent.
2. Geologic evolution with emphasis on sedimetation, lithology, magmatism, structure, metamorphism, mineral deposit and geochronology of Dharwar, Aravalli, Bundelkhand, Bastar and Singhbhum.
3. Proterozoic basins of India: Vindhyan, Cudappah and Chattisgarh basins.

Suggested Readings

- 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
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. Palaeogeographic reconstruction of Proterozoic Supercontinents and evolution of Indian sub-continent.
4. Scenario of Eustatic and Relative Sea level rise and fall.
5. Basic concepts of Sequence Stratigraphy.

3.19 Core T10 - Phanerozoic Stratigraphy of India **4 Credits**

(i) <u>Course objectives</u>:

The main objective is to enable the students to gather knowledge about different Phanerozoic stratigraphy of India and to know Precambrian-Cambrian boundary, Permian-Triassic boundary, and Cretaceous-Tertiary boundary in India.

(ii) Course learning outcomes:

On successful completion of the course the students can identify different Phanerozoic stratigraphic units and can correlate with the respective fossil assemblages.

(iii) Content of the course:

Unit 1: Stratigraphic boundaries

1. Phanerozoic time scale
2. Important Stratigraphic boundaries during Phanerozoic time in India – a. Permian-Triassic boundary, and b. Cretaceous-Tertiary boundary.

Unit 2: Important Phanerozoic successions in India

1. Important Palaeozoic successions in India with emphasis on succession, lithology, flora and fauna, correlation and palaeoenvironment of (a) Kashmir and its correlatives from Spiti and Zanskar in extrapeninsular India; and (b) Stratigraphy, Structure and hydrocarbon potential of different Gondwana basins in peninsular India.
2. Mesozoic stratigraphy of India, such as (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 and Cretaceous succession of Narmada Basins: Bagh and Lameta Formations.
3. Cenozoic stratigraphy of India: (a) Kutch basin, (b) Siwalik successions, (c) Assam, Arakan and Bengal basins.
4. Stratigraphy and structure of Krishna-Godavari basin, Cauvery basin, Bombay offshore basin, Kutch and Saurashtra basins and their potential for hydrocarbon exploration.

Unit 3: Volcanic provinces of India and the intertrappeans

1. Deccan, Rajmahal and Sylhet Trap

Unit 4: Quaternary Geology

1. Definition
2. Principles of sub-division of Quaternary succession in India.

Suggested Readings

- 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.

3.20 Core P10 – Phanerozoic Stratigraphy of India Lab 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. Drawing of various paleogeographic maps of Phanerozoic time.
4. Study of rocks in hand specimens from known Indian Phanerozoic stratigraphic horizons.

3.21 Core T11 – Hydrogeology 4 Credits

(i) Course objectives:

Water is a basic life supporting system. The rise in global population and the quest for better living standard has greatly stressed the water resources. The course content primarily focuses on groundwater, which being easily available is amenable to greater exploitation. Thus, this course aims to enable students to acquire knowledge about the physical and chemical attributes, occurrence, movement, and exploration of the groundwater resources.

(ii) Course learning outcomes:

The students will have a clear idea about the occurrence of groundwater, water bearing properties of formations, aquifer types and aquifer parameters. They can develop an idea about construction, design and development of water wells, aquifer parameter estimation and the science of groundwater flow under different conditions. They will also be able to use the concepts of groundwater exploration.

(iii) Content of the course:

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.

Suggested Readings

- 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 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 4 Credits

(i) Course objectives:

The objectives of this course are to: (a) familiarize with common ore minerals and their identifying criteria at various scales of study; (b) demonstrate knowledge of the variety of ore-forming processes; (c) understand the genetic controls exerted by physical and chemical processes on ore formation in various geologic settings; (d) differentiate between resources and reserves and how to estimate them.

(ii) Course learning outcomes:

On completion of this course, students will develop skills in different areas related to economic mineral deposits. They will recognise common ore minerals in hand samples and under microscope. They will be able to acquire knowledge about a wide range of ore deposits, the geometry of ore bodies, alteration patterns and assemblage of ore and gangue minerals. The students will also be aware about distribution of mineral deposits in India.

(iii) Content of the course:

Unit 1: Ores and gangues

1. Ores, protor, gangue minerals, tenor, grade and lodes.
2. Hypogene and supergene ore deposits, epigenetic and syngenetic mineral deposits; mineral beneficiation.
3. 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.
5. Role of plate tectonics in ore mineralization

Unit 3: Structure and texture of ore deposits

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

Unit 4: 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; and Uranium of Singhbhum.
2. Non-metallic and industrial rocks and minerals in India.
3. Atomic minerals in India.
4. Introduction to gemstones.

Unit 5: Ore grade and Reserve

1. Assessment of ore grade and reserve, reserve estimation.

Unit 6: 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.

Suggested Readings

- 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 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 4 Credits

(i) Course objectives:

The course provides an overview of landforms, land forming processes, and landscape evolution. In particular, it aims to shed light on various land forming processes and how these depend on climate and tectonic regimes, and time. Remote Sensing provides exposure to students in gaining knowledge on concepts and applications leading to modelling of earth resources management, to acquire skills in storing, managing digital data for planning and development, to acquire skills in advance techniques such as hyper spectral, thermal and LiDAR scanning for mapping, modelling and monitoring.

(ii) Course learning outcomes:

Students will be able to analyse how variations in climate, tectonics and environment affect the development of landforms, assess how different scales of time and space affect geomorphological processes and explain and apply geomorphological methods used in research today.

Students will also recognize and explain at a basic level, fundamental physical principles of remote sensing, including the electromagnetic spectrum; the emission, scattering, reflection, and absorption of electromagnetic (EM) radiation They will also know how EM radiation interactions vary across a limited number of substances, geometries, and temperatures; and geometric properties of photographs and imagery.

(iii) Content of the course:

Unit 1: Introduction to Geomorphology

1. Relationship between the landforms and the properties of earth material and different kind of processes: 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.
2. Lanforms produced by Glacial, Periglacial processes, Fluvial processes, Aeolian Processes and Coastal Processes.
3. Landforms associated with igneous Activities.

Unit 4

1. Endogenic-exogenic interactions; rates of uplift and denudation; tectonics and drainage development; sea-level change and 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 and Image classification.

Unit 8: GIS and GPS

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

Suggested Readings

- 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 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.

3.27 Core T14 - Engineering Geology 4 Credits

(i) Course objectives:

The objectives of the course are to study and identify different types natural materials like rocks & minerals and soil, to understand the various natural dynamic processes their influence on the surficial features, natural material and their consequences and to know the physical properties of rocks & minerals.

(ii) Course learning outcomes:

This course will develop ability of the students to categorize rocks and minerals by their origin and engineering properties. They will be able to apply geological principles to rock masses and discontinuities for use in engineering design e.g. rock slopes, foundation.

(iii) Content of the course:

Unit 1

1. Role of Engineering geologists in planning, designing and construction of major man-made structural features.

Unit 2

1. Site investigation and characterization.
2. Foundation treatment; Grouting, Rock Bolting and other support mechanisms.
3. Rock aggregates; Significance as Construction Material.

Unit 3

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

Unit 4

1. Tunnels and Tunnelling Methods.

Unit 7

1. Landslides and mass wasting: Causes, Factors and corrective/Preventive measures.

Unit 8

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

Unit 9

1. Case histories related to Indian Civil Engineering Projects.

Suggested Readings

- 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 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 RSR, RMR, RQD and 'Q'.

4. Department Specific Electives

4.1 DSE T1 Fuel Geology 4 Credits

(i) Course objectives:

To impart knowledge of formation and utilization of fossil fuels and nuclear fuels and to train students about the exploration techniques of fuels and estimation of their reserves.

(ii) Course learning outcomes:

Upon successful completion of course the students would be able to (a) understand the basic concept of occurrences, distribution and exploration of coal, petroleum and nuclear fuels.

(iii) Content of the course:

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. Classification of reservoir rocks - clastic and chemical.
3. Cap Rocks: definition and general properties; anticline theory and trap theory.
4. Hydrocarbon traps: definition, Classification of hydrocarbon traps - structural, stratigraphic and combination.
5. Time of trap formation and time of hydrocarbon accumulation.
6. Plate tectonics and global distribution of hydrocarbon reserves.
7. Petroliferous basins of India.

Unit 6: Other fuels

1. Nuclear Fuel and Gas Hydrate

Suggested Readings

- 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.

4.2 DSE P1 – Fuel Geology Lab **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
5. Study of different types of well logs in petroleum exploration

4.3 DSE T2 Introduction to Geophysics 4 Credits

(i) **Course objectives:**

The main objectives of the course are (a) to impart knowledge of geophysics and applications of physics in geology, and (b) to enhance knowledge and applications of geophysics in exploration of earth resources.

(ii) **Course learning outcomes:**

Upon successful completion of course the students would be able to (a) understand the basic concept of gravity, gravity corrections and interpretation of gravity data for mineral exploration., (b) understand concepts of magnetism related to genesis and exploration, (c) understand fundamentals resistivity and its applications in geology (d) understand the basic principles of seismic survey.

(iii) **Content of the course:**

Unit 1: Geology and Geophysics

1. 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
3. Scales of survey.
4. 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

1. Ambiguities in geophysical interpretation, planning and execution of geophysical surveys

Suggested Readings

- 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 **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- Mineral Exploration and Mining **4 Credits**

(i) Course objectives:

The course provides the essential and basic concepts of mineral exploration techniques and the art and science of mining mineral resources.

(ii) Course learning outcomes:

The course envisages to expose the students to the topics such as geology in mining industry, methods of exploration, sampling principle, methods, estimation of reserves, ore dressing and beneficiation.

Thus, this course tries to impart skills related to Geology in mining and enable him/her to perform duties of a geologist at the mining site.

(iii) Content of the course:

Unit 1: Mineral Resources

1. 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

1. Statistical analyses 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.

Unit 5: Elements of Mining

a. Classification of mining methods, factors influencing choice of mining method, open cast mining, underground mining, coal mining methods, ore dressing or beneficiation,

b. Brief outline of Mining Acts and Regulations in India, Conservation of mineral resources.

Suggested Readings

- 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.

4.6 DSE P3 –Mineral Exploration and Mining Lab 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

4.7 DSE T4 - Earth and Climate 4 Credits

(i) Course objectives:

The objectives of the course are to study the Earth's climate system, the climate change and the related different factors.

(ii) Course learning outcomes:

The students will learn the general characteristics of the Earth's climate system. It will also include interaction of the climate with the biosphere, the cyclicity of the climate and factors related with the monsoon.

(iii) Content of the course:

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: 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 3: Response of biosphere to Earth's climate

1. Climate Change: natural vs. anthropogenic causes.
2. Future perspectives.
3. Brief introduction to archives of climate change.
4. Brief introduction to palaeoclimate.
5. Paleoclimate data from India.

Unit 4: 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 5: Monsoon

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

Suggested Readings

- 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.

4.8 DSE P4 – 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

4.9 DSE T5 – Oceanography and Marine Science 4 Credits

(i) Course objectives:

To provide essential concepts of oceanography and to study the tectonics, geology, economic resources with respect to the oceans.

(ii) Course learning outcomes:

A student will understand and learn about the basic concepts of oceanography and marine geology with respect to geology as to enable them to work as a marine researcher. The students will equip himself with knowledge and skills related to dealing with the physical and chemical components and phenomena related to oceanography and marine geology.

(iii) Content of the course:

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.

Suggested Readings

- 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.

4.10 DSE P5 – Oceanography and Marine Science Lab 2 Credits

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

4.11 DSE T6 - Medical Geology 4 Credits

(i) Course objectives:

The course is designed to include the basic concepts of Medical Geology, interaction between abundances of elements and isotopes and the health of humans and plants. Thus, the course provides a basic understanding or geogenic and anthropogenic distribution of trace elements, their toxic effects on human health and that of flora and fauna

(ii) Course learning outcomes:

On completion of the course the student will be able to understand the distribution of trace elements and its cyclic movement through the abiotic-biotic environment and their influence on human health, flora and fauna.

(iii) Content of the course:

Unit-1

1. History of medical geology; subject matters and theoretical concepts of medical geology; goal, task, and significance of medical geology.

Unit 2

1. Basic features of geological environments; characteristics of geological factors and their influence on human health; interaction between abundances of elements and isotopes and the health of humans and plants, biogeochemical interactions and nutrient anomalies, anthropogenic degradation of geological environments.

Unit 3

1. The public health effects of Earth materials and geological processes.

2. Water and health: medical impacts of water quality, drinking water contamination through occurrences of arsenic, radionuclides (uranium) and other contaminants and pollutants; potential correlation between human diseases and the hardness of drinking water.
3. Mineral matters and health: global dust flux and respiratory problems, impacts of radon-arsenic-selenium-mercury-iodine, uranium on physiological function, carcinogenic associations with coal and fibrous minerals, geological effects on animal health, and geophagy (human ingestion of soil materials as a dietary supplement)
4. Health hazards associated with volcanic eruptions.

Unit 4

1. Application of geochemistry to environmental health issues, geospatial analysis as a tool in epidemiology.

Unit 5

1. Medicinal use of geological materials.

Unit 6

1. Use of knowledge of medical geology in forensic sciences.

Suggested Readings

- Dissanayake, C. B. and Chandrajith, R. (2009) Introduction to Medical Geology, Springer-Verlag Berlin Heidelberg
- Miomir Komatina (2004) Medical Geology, Volume 2, Effects of Geological Environments on Human Health, Elsevier Science
- Selinus, O., Brian., A et. al. (2005) Introduction to Medical Geology, Springer, 808 pp.
- Proceedings 'Workshop on Medical Geology' IGCP 454, 3-4th February, 2004 Special Publication No: 83 Geological Survey of India
- Eisenbud, M. and T. Gesell. (1997) Environmental radioactivity from natural, industrial, and military sources, Academic Press.
- Suryanarayana C. and Grant, M.N. (1998) X-Ray Diffraction: A Practical Approach. Plenum Press, New York.
- Bish, D.L., and Post, J.E., eds., (1989) Modern Powder Diffraction, Min. Soc. America Reviews in Mineralogy Vol. 20, 369 p.

4.12 DSE P9 – Medical Geology Lab **2 Credits**

a. Water quality analysis
b. Instrumental methods for analysis of geological materials
c. Mineralogical investigations using X-rays– Identification of X-ray pattern

4.13 DSE T7 –Geodynamics **4 Credits**

(iv) Course objective:

To impart knowledge about Geodynamic Processes, and to train the students about the Crustal evolution

(v) Course learning iutcome:

Upon successful completion of course the students would be able to understand the origin and evolution of early earth systems, continental drift, sea floor spreading and plate tectonics, origin and evolution of continental crust

(vi) Content of the course:

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: 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 on the Earth.
4. Plates: Physical character of plates. Macro and micro plates.
5. Plate boundaries: types, character, Identification of boundaries. Movement of plates along boundaries. Plate velocities.
6. Volcanic arcs, island arcs, trenches, accretionary prisms, oceanic ridges, transform faults. Magmatism in oceanic ridges and in subduction zones.

Unit 3: 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.

Suggested Readings

- Condie, K.C., 1982. *Plate Tectonics and Crustal Evolution.* 2nd Edition, Pergamon Press.
- Brown, G.C. and Mussett, A.E., 1993. *The Inaccessible Earth*. 2nd Edition, Chapman & Hall, London.
- Moores, E.M. and Twiss, R.J., 1995. *Tectonics.* W.H. Freeman
- 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.

4.14 DSE P7 –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.

4.15 DSE T8 – Urban Geology 4 Credits

(i) Course objectives:

The major objective is to focus the geology related to urban areas.

(ii) Course learning outcomes:

The students will learn urban agriculture, urban land use, urban water, waste and its treatment and urban planning.,

(iii) Content of the course:

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

1. 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 land use, Geological problems in construction of underground structures in urban areas.
2. Urban Tunnelling: Tunnelling for road and rail in urban areas, Method, Equipment, 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

1. 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

1. Introduction, Application in Urban development, land use 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.

Suggested Readings

- 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 2 Credits

List of Practical

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

5. Skill Enhancement Courses

5.1 SEC P1 – Field Geology I - Basic Field Training 2 Credits

(i) Course objectives:

Students will understand how preliminary surveys are carried out especially in mining and natural resource bearing areas. They would be trained to work independently in the field of geological mapping and sampling.

(ii) Course learning outcomes:

This course is devised to provide basic knowledge of geological mapping and surveying techniques. It also will upgrade and relate the theoretical knowledge of geological aspects to field observations.

(iii) Content of the course:

Unit 1

a. Topographic sheet: Methods of naming. Features, scale. Map reading. Clinometer and Brunton compass: Use of the instruments in measuring geological data in field.

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

a. Identification of rock types.
b. Identification of sedimentary and tectonic structures in field.

Unit 4

1. Techniques of measurement of orientation data in field.
2. Litholog preparation

Unit 5

1. Recording field data in maps and notebooks.
2. Report writing.

5.2 SEC P2 - Field Geology II - Geological Mapping and Structural Geology Field 2 Credits

(i) Course objectives:

Students will be expected to do the geological mapping with structural details.

(ii) Course learning outcomes:

This course is devised to provide details of structural mapping. It also will upgrade and relate the theoretical knowledge of geological aspects to field observations.

(iii) Content of the course:

Unit 1

1. Preparation of a geological map of a small area with homoclinal or gently folded beds.

Unit 2

1. Stereographic plots of orientation data and their interpretation.

5.3 SEC P3 – Field Geology III - Stratigraphy and Palaeontology-related field 2 Credits

(i) Course objectives:

Students will be expected to do the geological mapping i8n relation to stratigraphy and palaeontology

(ii) Course learning outcomes:

This course is devised to provide knowledge of geological mapping stratigraphy and palaeontology.

(iii) Content of the course

1. Study of primary sedimentary structures,
2. Study of taphonomic features,
3. Preparation of stratigraphic column of an area, etc.

5.4 SEC P4 - Field Geology IV- Himalayan Geology Field/ Mine visit

2 Credits

(i) Course objectives:

Students will be expected to do the geological mapping in Himalayan area or a mine visit

(ii) Course learning outcomes:

This course is devised to gather knowledge on Himalayan geology and economic geology.

(iii) Content of the course

Preparation of a geological transect map in the Himalayas

Or

Visit to an underground or Open cast mine; Underground mapping/Bench mapping Study

Or

Geological mapping of a project site (Dam sites, tunnel, etc).; Identification of environmental problems of a project site and remedial measures to be taken.

6. Generic Electives

6.1 GE T1 - Essentials of Geology

4 Credits

(i) Course objectives:

This course gives an overall introduction to Geology. The course presents an understanding of the processes in action on the earth's surface and their impact on man and his institutions

(ii) Course learning outcomes:

The study of this paper strengthens students' knowledge with respect to understanding the essentials of the structural dynamics of the earth. The students will understand the origin of our solar system and planets, including earth. The students are exposed to the Geological time scale and be able to appreciate the dynamics of earth evolution through time.

(iii) Content of the course:

Unit 1: Introduction

a. 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 evolutional 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

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

Suggested Readings

- 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 **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 Indi.a
4. Study of important rocks, minerals and fossils (the items may be fixed by the department concern).

6.3 GE T2 - Soils: Present and Past **4 Credits**

(i) <u>Course objectives</u>:

The major objective of the course is to focus on different aspects of recent soil and paaeosol.

(ii) Course learning outcomes:

The students will be able to understand soil forming processes, general soil regime, modern soils and key pedo features, soil taxonomy, geological records of fossil soils. etc.

(iii) Content of the course:

Unit 1:

1. Soil forming processes: Chemical weathering, major buffer maintaining ocean/atmosphere/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:

1. General soil forming regimes: Gleization; podzolization; lessivage; ferrallitizatin; calcification; salinization.

Unit 3:

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

Unit 4:

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

Unit 5:

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

Unit 6:

1. Introduction to soil taxonomy and paleosol taxonomy.

Unit 7:

1. Micromorphology: Thin section analysis of paleosols.

Unit 8:

1. Geochemistry: molecular rations; chemical weathering indices.

Units 9:

1. Stable isotope geochemistry: carbon13 and oxygen18 system for vegetation, temperature, pCO_2.

Unit 10:

1. Diagenetic overprinting in fossil soils: compaction; oxidation of organic matter; cementation; illitization .

Unit 11:

1. Geological record of fossil soils- Precambrian paleosols- evolution of paleoatmospheric conditions.

Unit 12:

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

Unit 13:

1. 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:

1. Pleistocene-Holocene paleosols- human impact on landscape and soils, climate change, neotectonics.

Unit 15:

1. Paleosols and non-marine sequence stratigraphy based on paleopedology and sedimentology of fluvial successions.

Suggested Readings

- 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.

6.4 GE P2 – Soils: Present and Past Lab **2 Credits**

List of Practical

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

6.5 GE T3- Rocks and Minerals **4 Credits**

(i) <u>Course objectives</u>:

Studying the basics of mineralogy and petrology helps in understanding and building the overall knowledge in Geology

(ii) Course learning outcomes:

The students will be able to identify common rock-forming minerals in hand specimens as well as in thin sections. Besides, they will familiarise themselves with Bavarias crystal lattice and crystal; systems. The course deals with the study of minerals, their chemistry and identification in hand specimen. Further, it also deals with the study of crystals with respect to their morphology, symmetry and the normal crystal classes.

(iii) Content of the course:

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.

Suggested Readings

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

6.6 GE P3 – Rocks and Minerals Lab 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.

6.7 GE T4 - Fossils and their Applications 4 Credits

(i) Course objectives:

The major objectives of this course are to understand the invertebrate, vertebrate and micropaleontology in the light of their morphology, adaptation, ecology, and Evolution. The present course will also teach on the evidences and records of the earliest life on the earth.

(ii) Course learning outcomes:

The students will be able to (a) identify older life forms with their external and internal features; (b) deduction of ecology with the application of morphological modifications, and (c) apply principles of speciation and evolution.

(iii) Content of the course:

Unit 1: Introduction to Fossils

1. 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

1. 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

1. Brief introduction of important fossils groups: invertebrate, vertebrate, microfossils, spore, pollens and plant fossils.
2. Important age-diagnostic.
3. Fossiliferous horizons of India.

Unit 4: Application of fossils

1. Principles and methods of paleoecology, application of fossils in the study of paleoecology, paleobiogeography and paleoclimate.

Unit 5: Economic importance of fossils

1. 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.

Suggested Readings

- Schoch, R.M. 1989. Stratigraphy, Principles and Methods.VanNostrand Reinhold.
- Clarkson, E.N.K.1998. Invertebrate Paleontology and Evolution George AlIen&Unwin
- Prothero, D.R. 1998. Bringing fossils to life - An introduction to Paleobiology, McGraw Hill.

- Benton, M.J. 2005. Vertebrate paleontology (3rd edition). Blackwell Scientific, Oxford.
- Colbert's Evolution of the Vertebrates: A History of the Backboned Animals Through Time, EdwinH. Colbert, Michael Morales, Eli C. Minkoff, John Wiley & Sons, 1991.

6.8 GE P4 – Fossils and their Applications Lab **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).

6.9 GE T5 - Earth Surface Processes **4 Credits**

(i) Course objectives:

The objective of the course is to study mainly various endogenous and exogenous processes and surface process related natural hazards.

(ii) Course learning outcomes:

The students will gather good idea about different surface processes, soil formation and natural Hazards.

(iii) Content of the course:

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.

Suggested Readings

- Alien, P.A., 1997. Earth Surface Processes, Blackwell publishing.
- Bloom, A.L., 1998. Geomorphology: A Systematic Analysis of Late Cenozoic Landforms, Pearson Education.
- Bridge, J.S. and Demicco, R.V., 2008. Earth Surface Processes, Landforms and Sediment Deposits,
- Cambridge University Press.
- Esterbrook, D.J., 1992. Surface Processes and Landforms, MacMillan Publ.
- Kale, V.S. and Gupta A 2001 1ntoduction to Geomorphology, Orient Longman Ltd.
- Leeder, M. and Perez-Arlucea M 2005 Physical processes in earth and environmental sciences, Blackwell' publishing.
- Summerfield M A 1991Globle Geomorphology Prentice Hall.
- Wllcock, P.R., Iverson R M (2003) Prediction in geomorphology ' AGU Publication.

6.10 GE P5 – Earth Surface Processes Lab 2 Credits

List of Practical

1. Study and interpretations of different landform maps

6.11 GE T6 - Physics and Chemistry of Earth 4 Credits

(i) Course objectives:

The objective of the courses is to gather information about the Earth's interior in relation to the geophysics and geochemistry.

(ii) Course learning outcomes:

The students will be acquainted with the earth's interior, Earth's magnetic field, environmental geochemistry, isostasy, nucleosynthesis etc.

(iii) Content of the course:

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

Suggested Readings

- 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

6.12 GE P6 – Physics and Chemistry of Earth Lab **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

6.13 GE T7 – Earth Resources **4 Credits**

(i) Course objectives:

The objectives of this course are to: (a) familiarize with common energy resources of the earth and mineral deposits.

(ii) Course learning outcomes:

On completion of this course, students will develop skills in different areas related to earth' resources and economic mineral deposits.

(iii) Content of the course:

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.

Suggested Readings

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

6.14 GE P7– Earth Resources Lab **2 Credits**

List of Practical

1. Study of coal in 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.

6.15 GE T8 - Natural Hazards and Disaster Management 6 Credits

(i) Course objectives:

The objective of the course is to provide ideas about natural hazards and their management

(ii) Course learning outcomes:

Students will have very good knowledge about various natural hazards and disaster management, hazard zonation mapping. They will have good ideas about remote-sensing and GIS applications in real time disaster monitoring prevention and rehabilitation

(iii) Content of the course:

Unit 1

1. Natural Hazards: Concept and 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.

Suggested Readings

- 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

6.16 Core P8-Natural Hazards and Disaster Management Lab 2 Credits

List of Practical

1. Study of seismic profile of a specific area and its interpretation.
2. Plotting of earthquake prone zone on map of India.
3. Exercise on Hazard Zonation Mapping.

7. Programme Outcome:

A. **Graduate Attributes**: The quality and feature or characteristics of an individual, including the knowledge, skills, attitudes, and values that are expected to be acquired by a graduate through studies at the higher education institution.

Some of the characteristic attributes that a graduate should demonstrate:
i) Disciplinary knowledge
ii) Communication Skills
iii) Critical thinking
iv) Problem solving
v) Analytical reasoning
vi) Research-related skills vii) Cooperation/Teamwork viii) Scientific reasoning
ix) Reflective thinking
x) Information/digital literacy xi) Self-directed learning
xii) Multicultural competence
xiii) Moral and ethical awareness/reasoning
xiv) Leadership readiness/qualities
xv) Lifelong learning

B. **Qualification descriptors:** The generic outcomes and attributes expected for the award of a particular type of qualification (for e.g. a bachelor's degree or a bachelor's degree with honours).

Qualification descriptors for a bachelor's degree with honours

(a) Demonstrate (i) a systematic, extensive and coherent knowledge and understanding of an academic field of study as a whole and its applications, and links to related disciplinary areas/subjects of study; including a critical understanding of the established theories, principles and concepts, and of a number of advanced and emerging issues in the field of study; (ii) procedural knowledge that creates different types of professionals related to the disciplinary/subject area of study, including research and development, teaching and government and public service; (iii) skills in areas related to one's specialization and current developments in the academic field of study, including a critical understanding of the latest developments in the area of specialization, and an ability to use established techniques of analysis and enquiry within the area of specialization.

(b) Demonstrate comprehensive knowledge about materials, including current research, scholarly, and/or professional literature, relating to essential and advanced learning areas pertaining to the chosen disciplinary areas (s) and field of study, and techniques and skills

required for identifying problems and issues relating to the disciplinary area and field of study.

(c) Demonstrate skills in identifying information needs, collection of relevant quantitative and/or qualitative data drawing on a wide range of sources, analysis and interpretation of data using methodologies as appropriate to the subject(s) for formulating evidence-based solutions and arguments.

(d) Use knowledge, understanding and skills for critical assessment of a wide range of ideas and complex problems and issues relating to the chosen field of study.

(e) Communicate the results of studies undertaken in an academic field accurately in a range of different contexts using the main concepts, constructs and techniques of the subject(s) of study.

(f) Address one's own learning needs relating to current and emerging areas of study, making use of research, development, and professional materials as appropriate, including those related to new frontiers of knowledge.

(g) Apply one's disciplinary knowledge and transferable skills to new/unfamiliar contexts and to identify and analyze problems and issues and seek solutions to real-life problems.

(h) Demonstrate subject-related and transferable skills that are relevant to some of the job trades and employment opportunities.

8. **Programme Specific Outcome**:

The student graduating with the Degree B. Sc. (Honours) Geology should be able to

A) Acquire

i. a fundamental/systematic or coherent understanding of the academic field of Geology, its different learning areas and applications in basic Geology like Mineralogy, Petrology, Stratigraphy, Palaeontology, Economic geology, Hydrogeology, etc. and its linkages with related interdisciplinary areas/subjects like Geography, Environmental sciences, Physics, Chemistry, Mathematics, Life sciences, Atmospheric sciences, Remote Sensing, Computer science, Information Technology;

ii. procedural knowledge that creates different types of professionals related to the disciplinary/subject area of Geology, including professionals engaged in research and development, teaching and government/public service.

iii. skills in areas related to one's specialization area within the disciplinary/subject area of Geology and current and emerging developments in the field of Geosciences.

(B) Demonstrate the ability to use skills in Geology and its related areas of technology for formulating and tackling geosciences-related problems and identifying and applying appropriate geological principles and methodologies to solve a wide range of problems associated with geosciences.

(C) Recognize the importance of RS&GIS, mathematical modeling simulation and computing, and the role of approximation and mathematical approaches to describing the physical world.

(D) Plan and execute Geology-related experiments or investigations, analyze and interpret data/information collected using appropriate methods, including the use of appropriate software such as programming languages and purpose-written packages, and report accurately the findings of the experiment/investigations while relating the conclusions/findings to relevant theories in Geology.

Demonstrate relevant generic skills and global competencies such as

i. problem-solving skills that are required to solve different types of geoscience-related problems with well-defined solutions and tackle open-ended problems that belong to the disciplinary area boundaries; b) investigative skills, including skills of independent investigation of geoscience-related issues and problems.
ii. communication skills involving the ability to listen carefully, to read texts and research papers analytically and to present complex information in a concise manner to different groups/audiences of technical or popular nature; d) analytical skills involving paying attention to detail and ability to construct logical arguments using correct technical language related to Geology and ability to translate them with popular language when needed; e) ICT skills; f) personal skills such as the ability to work both independently and in Teams

Demonstrate professional behaviour such as being objective, unbiased, and truthful in all aspects of work and avoiding unethical, irrational behaviour such as fabricating, falsifying or misrepresenting data or committing plagiarism; b) the ability to identify the potential ethical issues in work-related situations; c) appreciation of intellectual property, environmental and sustainability issues; and d) promoting safe learning and working environment.