PRESCRIBED SYLLABUS

FOR CBCS

GEOLOGY HONOURS

SEMESTER-WISE COURSES

Submitted to

ডিব্রুগড় বিশ্ববিদ্যালয়
Dibrugarh University

Submitted by
Department of Applied Geology, Dibrugarh University

SEMWISE DISTRIBUTION OF COURSES IN B. Sc HONOURS IN GEOLOGY (CBCS)

Sem	Core Course (14)	AECC (2)	SEC (2)	DSE (4)	GE (4)
I	**C1** **C2**				**GE 1**
II	**C3** **C4**				**GE 2**
III	**C5** **C6** **C7**		**SEC 1**		**GE 3**
IV	**C8** **C9** **C10**		**SEC 2**		**GE 4**
V	**C11** **C12**			**DSE 1** **DSE 2**	
VI	**C13** **C14**			**DSE 3** **DSE 4**	

CORE COURSE (14c) General Structure:

Semester	PAPERS	Prescribed Core Course	Recommended by UGC
I	**C1**	Earth System Science	Earth System Science
	C2	Crystallography& Mineralogy	Mineral Science
II	**C3**	Geochemistry and Optical Mineralogy	Elements of Geochemistry
	C4	Structural Geology and Plate tectonics	Structural Geology
III	**C5**	Igneous Petrology	Igneous Petrology
	C6	Sedimentary Petrology	Sedimentary Petrology
	C7	Metamorphic Petrology	Palaeontology
IV	**C8**	Paleontology	Metamorphic Petrology
	C9	Stratigraphic Principles and Indian Stratigraphy	Stratigraphic Principles and Indian Stratigraphy
	C10	Hydrogeology & Oceanography	Hydrogeology
V	**C11**	Surveying & Engineering Geology	Economic Geology
	C12	Geomorphology	Geomorphology
VI	**C13**	Economic Geology, Coal and Petroleum	Engineering Geology
	C14	Remote Sensing and GIS	Remote Sensing and GIS

Skill Enhancement Course SEC (2c)General Structure: (As per recommendations)

Semester	Paper Structure	Papers available for selection
III	**SEC 1 (2c)**	• Basic field training) • Geological Mapping) • Economic Geology fieldwork • Himalayan Geology fieldwork
IV	**SEC 2 (2c)**	• Precambrian Geology fieldwork • Visit to Engineering Project sites) • Stratigraphy and Paleontology fieldwork PROJECT WORK –VIII

Elective Discipline Specific DSE (4c)General Structure:

Semester	Paper	Papers available for selection
V	**DSE – 1**	1. EXPLORATION GEOLOGY 2. FUEL GEOLOGY
	DSE – 2	3. RIVER SCIENCE 4. SURVEYING& MAPPING
VI	**DSE – 3**	5. INTRODUCTION TO GEOPHYSICS 6. GEOLOGY OF NORTH-EAST INDIA
	DSE – 4	7. EARTH AND CLIMATE 8. EVOLUTION OF LIFE THROUGH TIME

Elective Generic GE (4c)General Structure:

Semester	Paper	
I	**GE – 1**	1. ROCKS AND MINERALS 2. PHYSICS AND CHEMISTRY OF EARTH
II	**GE – 2**	3. EARTH RESOURCES 4. EARTH SURFACE PROCESSES
III	**GE – 3**	5. FOSSILS AND THEIR APPLICATIONS 6. MARTIAN GEOLOGY
IV	**GE – 4**	7. SOILS: PRESENT AND PAST 8. STUDIES ON CRYOSPHERE

SEMWISE DISTRIBUTION OF COURSES IN B. Sc HONOURS IN GEOLOGY (CBCS)

Sem	Core Course (14)	Course code	AECC (2)	Course code	SEC (2)	Course code	DSE (4)	Course code	GE (4)	Course code
1	C1		AECC1-2C						GE-1	
	C2		AECC2-2C							
2	C3		AECC3-4C						GE-2	
	C4									
3	C5				SEC 1				GE-3	
	C6									
	C7									
4	C8				SEC 2				GE4	
	C9									
	C10									
5	C11						DSE 1			
	C12						DSE 2			
6	C13						DSE3			
	C14						DSE4			

1st Sem

	Course	Paper code	Title of the Course	Credit			Marks Distribution				
				Th	Prac	Total	Theory		Practical		Total
							End Sem	In- Sem	End Sem	In-Sem	
1st Sem	C1	GEOH101T4	Earth System Science	4		6	48	12			100
		GEOH101P2			2				32	8	
	C2	GEOH102T4	Crystallography and Mineralogy	4		6	48	12			100
		GEOH102P2			2				32	8	
	GE 1(6C)	GEOH GE101AT4	Rocks and Minerals	4		6	48	12			100
		GEOH GE101AP2			2				32	8	
		GEOH GE101BT4	PHYSICS AND CHEMISTRY OF EARTH	4		6	48	12			100
		GEOH GE101BP2			2				32	8	
		Total				18					300

2nd Sem

	Course	Paper code	Title of the Course	Credit			Marks Distribution				
				Th	Prac	Total	Theory		Practical		Total
							End Sem	In- Sem	End Sem	In-Sem	
2nd Sem	C3	GEOH201T4	**Geochemistry & Optical Mineralogy**	4		6	48	12			100
		GEOH201P2			2				32	8	
	C4	GEOH202T4	**Structural Geology and Tectonics**	4		6	48	12			100
		GEOH202P2			2				32	8	
	GE2 (6C)	GEOH GE201AT4	EARTH RESOURCES	4		6	48	12			100
		GEOH GE201AP2			2				32	8	
		GEOH GE201BT4	EARTH SURFACE PROCESSES	4		6	48	12			100
		GEOH GE201BP2			2				32	8	
	Total					18					300

3rd Sem

	Course	Paper code	Title of the Course	Credit			Marks Distribution				
				Th	Prac	Total	Theory		Practical		Total
							End Sem	In- Sem	End Sem	In-Sem	
3rd Sem	C5	GEOH301T4	Igneous Petrology	4		6	48	12			100
		GEOH301P2			2				32	8	
	C6	GEOH302T4	Sedimentary petrology	4		6	48	12			100
		GEOH302P2			2				32	8	
	C7	GEOH302T4	Metamorphic petrology	4		6	48	12			100
		GEOH302P2			2				32	8	
	GE 3 (6 C)	GEOH GE301AT4	Fossils and their applications	4		6	48	12			100
		GEOH GE301AP2			2				32	8	
		GEOH GE301BT4	Martian Geology	4		6	48	12			100
		GEOH GE301BP2			2				32	8	
	SEC 1-2C	GEOHSEC301AT2	Basic Field Training	2		2	24	6			30
		GEOHSEC301BT2	Geological Mapping	2		2	24	6			30
		GEOHSEC301CT2	Economic Geology Fieldwork	2		2	24	6			30
		GEOHSEC301DT2	Himalayan Geology Fieldwork	2		2	24	6			30
	Total					26					430

4th Sem

	Course	Paper code	Title of the Course	Credit			Marks Distribution				
				Th	Prac	Total	Theory		Practical		Total
							End Sem	In- Sem	End Sem	In-Sem	
4th Sem	C8	GEOH401T4	Palaeontology	4		6	48	12			100
		GEOH401P2			2				32	8	
	C9	GEOH402T4	Stratigraphic principles and Indian stratigraphy	4		6	48	12			100
		GEOH402P2			2				32	8	
	C10	GEOH403T4	Hydrogeology and Oceanography	4		6	48	12			100
		GEOH403P2			2				32	8	
	GE4 (6C)	GEOH GE401AT4	Soils: Present and past	4		6	48	12			100
		GEOH GE401AP2			2				32	8	
		GEOH GE401BT4	Studies on Cryosphere	4		6	48	12			100
		GEOH GE401BP2			2				32	8	
	SEC 2-2C	GEOHSEC401AT2	Precambrian geology field work	2		2	24	6			30
		GEOHSEC401BT2	Visit to engineering project sites	2		2	24	6			30
		GEOHSEC401CT2	Stratigraphy and P alaeontology field work	2		2	24	6			30
		GEOHSEC401DT2	Project work	2		2	24	6			30
	Total					26					430

5th Semester

	Course	Paper code	Title of the Course	Credit			Marks Distribution				
				Th	Prac	Total	Theory		Practical		Total
							End Sem	In- Sem	End Sem	In-Sem	
5th Sem	C11	GEOH501T4	Surveying and engineering geology	4		6	48	12			100
		GEOH501P2			2				32	8	
	C12	GEOH502T4	Geomorphology	4		6	48	12			100
		GEOH502P2			2				32	8	
	DSE1 (6C)	GEOH DSE501AT4	Exploration Geology	4		6	48	12			100
		GEOH DSE501AP2			2				32	8	
		GEOH GE501BT4	Fuel Geology	4		6	48	12			100
		GEOH GE501BP2			2				32	8	
	DSE 2(6C)	GEOH GE502AT4	River Science	4		6	48	12			100
		GEOH GE502AP2			2				32	8	
		GEOH GE502BT4	Surveying and mapping	4		6	48	12			100
		GEOH GE502BP2			2				32	8	
	Total					24					400

6th Semester

	Course	Paper code	Title of the Course	Credit			Marks Distribution				
				Th	Prac	Total	Theory		Practical		Total
							End Sem	In- Sem	End Sem	In-Sem	
6th Sem	C13	GEOH601T4	Economic geology: coal and petroleum	4		6	48	12			100
		GEOH601P2			2				32	8	
	C14	GEOH602T4	Remote sensing , GIS and GPS	4		6	48	12			100
		GEOH602P2			2				32	8	
	DSE3 (6C)	GEOH DSE601AT4	Introduction to geophysics	4		6	48	12			100
		GEOH DSE601AP2			2				32	8	
		GEOH GE601BT4	Geology of north east India	4		6	48	12			100
		GEOH GE601BP2			2				32	8	
	DSE 4(6C)	GEOH GE602AT4	Earth and climate	4		6	48	12			100
		GEOH GE602AP2			2				32	8	
		GEOH GE602BT4	Evolution of life through time	4		6	48	12			100
		GEOH GE602BP2			2				32	8	
	Total					24					400

1st Semester
Core courses

GEOH101T4: Earth System Science
Course, C1 (THEORY) (End sem 48+ Insem 12) Marks: 60 48 Hours

Objectives: Earth system science programme aims to explore, understand, communicate and teach the earth as a planet, its complex processes, past and future evolution and interaction with society. In short language, it provides integrated understanding of the earth system. It also deals with complex interaction among lithosphere, biosphere and atmosphere.

Unit 1: Universe and Solar System (L: 4 T: 1) 5 classes (Marks: 10)

- Formation and evolution of the Universe, Galaxy, Milky Way, Sun and the Solar System, meteorites and asteroids

Unit 2: Earth System (L: 8 T: 2) 10classes (Marks: 20)

- Planet Earth, moon, planetary properties, orbital and rotational characteristics, physical characteristics, gravity, atmosphere, hydrosphere, lithosphere, biosphere, magnetic field, theories of origin, brief geological history and age of earth.
- Interior of the Earth: core, mantle and crust.

Unit 3: Introduction to Geology (L: 18 T: 2) 20classes (Marks: 30)

- Various branches of geology and relation to other branches of science, concept of seismology.
- Minerals and rocks: concept of native elements, mineraloids, rock forming minerals. Brief introduction to rocks: igneous, metamorphic and sedimentary rocks.
- Gradational processes: weathering, erosion by running water, wind, gravity, ice and sea waves. Soil: formation, soil profile and soil types. Brief idea about different geomorphic environments. Physiographic divisions of Indian subcontinent.
- Concept of plate tectonics, origin of oceans, continents, mountains and rift valleys. Earthquake and earthquake belts. Volcanoes- types, products and their distribution.
- Atmospheric and hydrological processes: difference between sea waves and oceanic current system, Coriolis Effect, concepts of eustasy, land-air-sea interactions, wave erosional activities. Atmospheric circulation, wind, weather and climatic changes, earth's heat budget.
- Stratigraphy and historical geology (understanding the past from stratigraphic records, nature of stratigraphic records, standard stratigraphic time scale and relationship between time and geology, introduction to geochronological methods and their application in geological studies, history of development in concepts of uniformitarianism, catastrophism, actualism and neptunism, laws of superposition and faunal succession). Introduction to the geology of India.

GEOH101P2 Earth System Science
Course, C1 (PRACTICAL) (End sem 32+ Insem 8) Marks: 40 24 Hours

Practical 1: Study of major geomorphic features from physiographical models.
Practical 2: Study of topographic sheets/contour maps and description of physiography.
Practical 3: Study of soil profile of any specific area.

Practical 4: Study of earthquake and volcanic belts of the world.
Practical 5: Study of major ocean currents of the World.

SUGGESTED READINGS:

1. Duff, P. M. D., & Duff, D. (Eds.). (1993). *Holmes' principles of physical geology*. Taylor &Francis.
2. Emiliani, C. (1992). *Planet earth: cosmology, geology, and the evolution of life and environment*. Cambridge University Press.
3. Gross, M. G. (1977). Oceanography: A view of the earth.

GEOH102T4: Crystallography and Mineralogy

Course, C2 (THEORY) (End Sem 48+ In Sem 12) Marks: 60 48 Hours

Objectives: Use and utility of mineral science in industry is learnt from this subject. In crystallography, one can find how to determine the arrangement of atoms in the crystalline solids and in mineralogy, one can know in detail about the minerals, the basic building blocks of earth material.

Unit 1: Crystallography (L: 23 T: 2) 15classes (Marks: 25)

- Introduction to crystallography, crystalline and non-crystalline matter, geometrical nature of crystal. Morphology of crystals; face, edge and solid angle. Laws of constancy of interfacial angles, axial systems and axial ratio.
- Crystal symmetry operations, direction and planes in crystal structures. Point group and space group symmetry. International system of symmetry notations. Classification of crystals into systems and classes.
- Study of crystal structure and forms, stereograms and examples of crystal/mineral of the important crystal classes.
- Crystal growth and twinning, different types of crystal twins, causes of twinning and twin laws.

Unit 2: Mineralogy (L: 32 T: 3) 20classes (Marks: 35)

- Introduction to mineralogy: composition of common rock-forming minerals, silicate and non-silicate structures; CCP and HCP structures.
- Significance of atomic structure in physical properties of minerals, Physical properties of minerals: colour, luster, streak, density, specific gravity and hardness - their definition and varieties with examples. Moh's hardness scale and determination of hardness of minerals. Cleavage, parting and fracture - their definition and mineral examples. Form and habit of minerals; types, examples and use in identification.
- Physical and chemical properties of some important silicates: Tectosilicates, Phyllosilicates, Inosilicates, Cyclosilicates, Sorosilicates and Orthosilicates; Non-Silicates: Native elements, Sulfides, Oxides, Halides, Sulfate and Phosphate families.

GEOH102P2 : Crystallography and Mineralogy

Course, C2 (PRACTICAL) (End sem 32+ Insem 8) Marks: 40 24 Hours

Practical 1: Identification of crystal models.
Practical 2: Study of crystals and symmetry elements of crystal-models.

Practical 3: Stereographic projections of crystal models of different systems.
Practical 4: Study and identification of minerals in hand specimen.

SUGGESTED READINGS:

1. 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.
2. Kerr, P. F. (1959). Optical Mineralogy. McGraw-Hill.
3. Verma, P. K. (2010). Optical Mineralogy (Four Colour). Ane Books Pvt Ltd.
4. Deer, W. A., Howie, R. A., & Zussman, J. (1992). An introduction to the rock-forming minerals (Vol. 696). London: Longman.

1st Semester
Generic Electives (GE)

GEOH GE101AT4 Rocks and Minerals (End sem 48+ Insem 12) Marks: 60 48 Hours
Course GE1

Objective: Deals with the study of the basics of rocks and minerals of the earth, its definition, properties, structure, composition, types and occurrences with basic knowledge of optical mineralogy and its classification and rock-cycle interactions (plate tectonics and climate)

Unit 1: Minerals-Definitions, Physical properties of minerals (L: 4 T:1) **5classes (Marks: 10)**
Mineralogical structure of earth, planetary minerals and native elements

Unit 2: Mineral structures (L: 4 T:1) **5classes (Marks: 10)**
Mineralogy of the Earth's crust, mantle and core

Unit 3: Nature of light and principles of optical mineralogy (L:13 T:2) **5classes (Marks: 15)**
Optical classification of minerals.
An overview of environmental and radiation mineralogy, biomineralisation and gemology.

Unit 4: Rocks- Definitions and types, Basics of rock formation. (L:18 T:2) **20classes (Marks: 25)**
Igneous rock- magma generation and differentiation
Sedimentary rocks- surface processes and sedimentary environments
Metamorphic rocks- chemical system and types of metamorphism
Rock cycle-interactions between plate tectonics and climate systems

GEOH GE101AP2: Rocks and Minerals
Course GE1 (End sem 32+ Insem 8) Marks: 40 24 Hours

1. Study of physical properties of minerals
2. Introduction to optical microscopy
3. Study of optical properties of minerals
4. Study of physical properties of rocks
5. Study of optical properties of rock under thin sections
6. Understanding crystal symmetry via wodden models

7. Stereographic projection of mineral faces
8. Mineral formula calculation
9. Crystal chemical calculation
10. Introduction to analytical techniques for rock and mineral study.

SUGGESTED READINGS:

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

GEOH GE101BT4:): PHYSICS AND CHEMISTRY OF EARTH
Course GE1 (End sem 48+ Insem 12) Marks: 60 48 Hours 35claases

Objective: Impart knowledge about the physical features of the earth surfaces and the physical properties of the earth's interior. Deals geochemistry of the earth with study of the elements of earth and solar system, element classification, abundance, application and its impact on environment.

Unit 1: Earth: surface features
Continents, continental margins, oceans (L: 3 T: 1) **4classes (Marks: 5)**

Unit 2: Earth's interior - variation of physical quantities and seismic wave velocity inside the earth, major sub divisions and discontinuities.
Concepts of Isostasy; Airy and Pratt Model
Core: Seismological and other geophysical constraints
The geodynamo - Convection in the mantle (L: 7 T: 1) **8classes (Marks: 15)**

Unit 3: Elements of earth's magnetism.
Secular variation and westward drift
Solar activity and magnetic disturbance (L: 5 T: 1) **6classes (Marks: 10)**

Unit 4: Elements: Origin of elements/nucleosynthesis.
Abundance of the elements in the solar system / planet earth
Geochemical classification of elements.
Earth accretion and early differentiation
Isotopes and their applications in understanding Earth processes.
Stable isotopes: Stable isotope fractionation. Oxygen isotopes
Sublithospheric Mantle (Mineralogy/phase transitions) (L: 9 T: 1)**10classes (Marks: 20)**

Unit 5: Environmental geochemistry
Geological disposal of nuclear waste
Lead in environment and effect of lead on human health (L: 6 T: 1)**7classes (Marks: 10)**

GEOH GE101BP2: PHYSICS AND CHEMISTRY OF EARTH: PRACTICAL
Course: GE1 (End sem 32+ Insem 8) Marks: 40 24 Hours

PRACTICALS

1. Projection of major elements on binary and triangular diagrams for rock classification
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. Understanding Earth structure through behavior of seismic wave propagation
5. Problems on isostasy

SUGGESTED READINGS:

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

2nd Semester
Core courses

GEOH201T4 : Geochemistry & Optical Mineralogy
Course, C3(THEORY) (End sem 48+ Insem 12) Marks: 60 48 Hours
35classes

Objectives: Geochemistry helps in understanding the compositional heterogeneity and geochemical processes that take place in the earth. It is the basic tool used in the geochemical exploration of economic mineral deposits. The knowledge of optical mineralogy is very important for identification of minerals and ores.

Unit 1: Concepts of Geochemistry (L: 4)4 classes (Marks: 10)

- Introduction to properties of elements: The periodic table. Chemical bonding, states of matter and atomic environment of elements. Geochemical classification of elements

Unit 2: Earth and Geochemistry (L: 4 T: 1) 5classes (Marks: 10)

- Composition of different Earth reservoirs and the nuclides and radioactivity. Conservation of mass, isotopic and elemental fractionation. Concept of radiogenic isotopes in geochronology and isotopic tracers
- The solid Earth – geochemical variability of magma and its products.

Unit 3: Element transport & Geochemical behavior of elements (L: 4) 4 classes (Marks: 10)

- Advection and diffusion, Chromatography, Aqueous geochemistry- basic concepts and speciation in solutions, Eh, pH relations, Elements of marine chemistry, Mineral reactions- diagenesis and hydrothermal reactions.
- Geochemical behaviours of selected elements like Si, Al, K, Na etc.

Unit 4: Nature of light and Optical Properties of Minerals (L: 10 T: 2) 12classes (Marks: 15)

Natural light, ordinary and polarized light, polarization of light and polaroids, refractive index and relief, becke line and its use, double refraction, birefringence, behavior of isotropic and anisotropic mineral, pleochroism and pleochroic scheme, interference colour, extinction, polarizing microscope, interference figure, optic sign and determination of optic sign.

Unit 5: Descriptive Mineralogy (L: 9 T: 1)10classes (Marks: 15)

Study of important rock forming groups/species, their classification, physical and optical characters and paragenesis : 1) Quartz 2) Feldspar 3) Mica 4) Amphibole 5) Pyroxene 6) Olivine 7) Garnet 8) Chlorite 9) Calcite 10) Feldspathoids.

GEOH201P2 : Geochemistry & Optical Mineralogy
Course, C3(PRACTICAL) (End sem 32+ Insem 8) Marks: 40 24 Hours

Practical 1: Identification and understanding of different parts of petrological microscope.
Practical 2: Identification of rock-forming minerals under petrological microscope.
Practical 3: Study of interference figure and determination of optic signs from minerals.

SUGGESTED READINGS:

1. Mason, B. (1986) Principles of Geochemistry. 3rd Edition, Wiley New York.
2. Walther, J. V. (2009). Essentials of geochemistry. Jones & Bartlett Publishers.
3. Faure, Gunter and Teresa M. Mensing (2004). Isotopes: Principles andApplications,Wiley India Pvt. Ltd
4. Klein, C., Dutrow, B., Dwight, J., & Klein, C. (2007). The 23rd Edition of the Manual of MineralScience (after James D. Dana). J. Wiley & Sons.
5. Kerr, P. F. (1959). Optical Mineralogy. McGraw-Hill.

GEOH202T4: Structural Geology and Tectonics
Course, C4 (THEORY) (End sem 48+ Insem 12) Marks: 60 48 Hours

Objectives: The primary goal of structural geology is to uncover the history of deformation in the rocks. The deformation of the lithospheric rocks by tectonic forces can be learnt through this subject. Structural geology also helps to understand the geodynamics of regional to global dimension. Structural control on ore localization and landscape evolution are learnt through this subject. Application of structural geology in the engineering geology project is enormous.

Unit 1: Geological Structures and Topography (L:2) 2classes (Marks: 5)

- Diastrophic and non-diastrophic. Relation of geological structures and topography. Outcrop patterns of different structures.

Unit 2: Stress& Strain (L:4 T:1) 5classes (Marks: 10)

- Stress: Definition, units and dimension; types of stress, stress ellipse and ellipsoid, traction Strain: Definition, units strain ellipse and ellipsoid, types of strain, elasticity, plasticity, rigidity in rocks; ductile and brittle behaviour of rocks; Stress-strain relationships. Geometric, kinematic and dynamic aspects of structural geology. Scale of geologic structures.

Unit 3: Deformational Structures (L:18 T:2) 20classes (Marks: 20)

- Planar and linear structures. Concept of dip and strike.

- Fold morphology; Geometric and genetic classification of folds. Introduction to the mechanics of folding: Buckling, Bending, Flexural slip and flow folding.
- Foliation and lineation: description and origin of foliations: axial plane cleavage and its tectonic significance. Description and origin of lineation and relationship with the major structures.
- Joint, fracture and fault: Geometric and genetic classification of fractures and faults. Effects of faulting on the outcrops. Geologic/geomorphic criteria for recognition of faults and fault plane solutions. Joints: Definition, classification and origin. Relation of joints with major geological structures.
- Unconformity: Definition and types of unconformity; criteria for recognition of unconformities.

Unit 4: Tectonics and geodynamics (L:6 T:2) 8classes(Marks: 25)

- Concept of Plate Tectonics, plate boundaries, triple junction, rift-valley, sea-floor spreading, Mid-Oceanic-Ridge, transform faults, mechanism of subduction, island arcs, volcanic-arc system, deep sea trenches. Relation of plate tectonics with volcanic and earthquake belts.
- Tectonic framework of Indian subcontinent with respect to its physiographic subdivisions. Structural settings of North East India.

GEOH202P2 : Structural Geology and Tectonics
Course, C4 (PRACTICAL) (End sem 32+ Insem 8) Marks: 40 24 Hours

Practical 1: Use of clinometer and Brunton compass for structural measurements.
Practical 2: Study of contour maps, structural maps and sub-surface graphical problems.
Practical 3: Three point structural problems and structural projections.
Practical 4: Reconstruction of structure from given profiles.

SUGGESTED READINGS:

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

2nd Semester
Generic Electives (GE)

GEOH GE201AT4: EARTH RESOURCES
Course GE2 (End sem 48+ Insem 12) Marks: 60 48 Hours

Objectives: Aims to study the various resources of the earth with its historical perspective and present status. Deals with the energy sources and types and power generation.

Unit 1: Earth Resources (L:5 T:1) 6 classes (Marks: 12)
Resource reserve definitions; mineral, energy and water resources in industries
Historical perspective and present
A brief overview of classification of mineral deposits with respect to processes of formation in relation to exploration strategies

Unit 2: Definition of Energy: Primary and Secondary Energy (L:7 T:1) 8 classes (Marks: 12)

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

Unit 3: Major Types and Sources of Energy (L:9 T:1) 10 classes (Marks: 18)

Resources of Natural Oil and Gas
Coal and Nuclear Minerals
Potential of Hydroelectric Power, Solar Energy, Wind, Wave and Biomass Based power and Energy

Unit 4: Energy Sources and Power Generation: (L:10 T:1) 11 classes (Marks: 18)

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

GEOH GE201AP2: EARTH RESOURCES: PRACTICAL
Course GE2 (End sem 32+ Insem 8) Marks: 40 24 Hours

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

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

GEOH GE201BT4: EARTH SURFACE PROCESSES

Course GE2 (End sem 48+ Insem 12) Marks: 60 48 Hours

Objectives: Study of various surfaces processes which shape the earth surface. Imparts knowledge about the flow and changes of the energy and interrelation of the various processes, its controlling factors and its cause and effect relationship.

Unit 1: Introduction to earth surface processes (L: 6 T: 1) 4 classes (Marks: 10)

Historical development in concepts, terrestrial relief, scales in geomorphology,

Unit 2: Energy flow and relative energy of surface processes. (L: 9 T: 1) 10 classes (Marks: 15)

Weathering and formation of soils, karst and speleology, slope and catchment erosion processes, fluvial, aeolian, glacial, peri-glacial and coastal processes and resultant landforms, , Water and sediment flux in river systems, Morphometric analysis of drainage basin and geomorphology-hydrology relationship.

Unit 3: Rates and changes in surface processes (L: 5 T: 1) 6 classes (Marks: 10)

Techniques for measuring rates of processes: sediment budgeting, rock magnetism, isotope geochemical tracers, cosmogenic nuclides, OSL & C-14 dating

Unit 4: Controlling factors (tectonics, climate, sea level changes and anthropogenic) and surface Processes (L:4 T:1) 5 classes (Marks: 10)

Climate change and geomorphic response of fluvial systems of arid and humid regions
Geomorphic response to tectonics, sea level/base level change, anthropogenic affects
Introduction to Anthropocene

Unit 5: Geomorphic concepts in cause-effect relationship (L:9 T:1) 10 classes (Marks: 15)
Spatial & temporal scales, geomorphic system, connectivity, buffering, magnitude-frequency concept, time lag, sensitivity, equilibrium, threshold, non-linearity & complexities
Mega geomorphology and process interrelationship
Surface processes and natural hazards; Applied aspects of geomorphology; Introduction to planetary geomorphology.

GEOH GE201BP2: EARTH SURFACE PROCESSES: PRACTICAL

Course GE2 (End sem 32+ Insem 8) Marks: 40 24 Hours

Mapping of different landforms and interpretation of surface processes
Exercises on hill slope development, fluvial channel, sediment erosion and transport, sediment budgeting, aggradation and degradation events, drainage basin, drainage morphometry
Basic exercises on computation of rate for different surface processes

SUGGESTED READINGS:

1. Alien, P.A., 1997. *Earth Surface Processes,* Blackwell publishing.
2. Bloom, A.L., 1998. *Geomorphology: A Systematic Analysis of Late Cenozoic Landforms,* Pearson Education.

3. Bridge, J.S. and Demicco, R.V., 2008. *Earth Surface Processes, Landforms and Sediment Deposits,* Cambridge University Press.
4. Esterbrook, D.J., 1992. *Surface Processes and Landforms,* MacMillan Publ.
5. Kale, V.S. and Gupta A 2001 *1ntoduction to Geomorphology,* Orient Longman Ltd.

3rd Semester
Core courses

GEOH301T4 : Igneous Petrology
Course, C5 (THEORY) (End sem 48+ In sem 12) Marks: 60 48 Hours

Objectives: The primary objective of learning igneous petrology is to understand the process of magma generation, evolution and volcanism. This subject also deals with interaction of plate tectonics, magma generation and ore localization.

36classes

Unit 1: Introduction to Igneous petrology (L: 3) 3classes (Marks: 6)

- General idea of igneous petrology, heat flow, geothermal gradients.

Unit 2: Magma & Lava (L: 4) 4classes (Marks: 10)

- Origin and generation of magma, physical properties, composition & chemical properties, primary and magma derivatives, types of lava flows, classification of magma and lava on the basis of physical and chemical contents.

Unit 3: Thermodynamic considerations (L:4 T:1) 6classes (Marks: 10)

- State functions, intensive & extensive variables, laws of thermodynamics, concept of component, phase and phase equilibrium, degrees of freedom, phase rule: general idea, phase rule for open and closed systems, phase diagrams: one, two and three component systems. Congruent and incongruent melting.

Unit 4: Evolution and Differentiation of Magma (L:7 T:1) 8classes (Marks: 14)

Reaction principles. Evolution of Magma, Magmatic differentiation, Mixing and Assimilation. Role of volatiles in magma. Rock association (consanguinity); Petrographic province and variation diagram. Igneous rocks and continental margins.

Unit 5: Igneous texture and structures (L:4 T:1) 5classes (Marks: 14)

- Textures, structures and mode of occurrences of igneous rocks. Petrographical significance of igneous rocks.

Unit 6: Igneous rocks and Petrogenesis (L:9 T:1) 10classes (Marks: 14)

- Classification of Igneous rocks on the basis of: chemical contents, modes of formation, colour index and modes of occurrence.

- IUGS Classification of igneous rocks: QAPF (volcanic and plutonic), Ol-Opx-Cpx (ultra-basic), pyroclastic rocks, carbonatite and melitic igneous rocks, TAS chemical classification.
- Magmatism in different tectonic settings: Magmatism in the oceanic domains (MORB, OIB), Magmatism along the plate margins (Island and continental arcs).
- Petrogenesis of Igneous rocks: Petrogenesis of Felsic and Mafic igneous rocks, Komatiites, Granite and Granitoides, Basalt, Gabbros, Alkaline rocks, kimberlites and lamprophites. Sylhet traps and Abor Volcanics.

GEOH301P2 : Igneous Petrology
Course, C5 (PRACTICAL) (End sem 32+ In sem 8) Marks: 40 24 Hours

Practical 1: Study of igneous rocks in hand specimens.
Practical 2: Study of igneous rocks in thin section.
Practical 3: Study of texture in thin sections and hand specimens.
Practical 4: Study of phase diagrams to understand melts composition and crystallization.

SUGGESTED READINGS:

1. Philpotts, A., & Ague, J. (2009). Principles of igneous and metamorphic petrology. Cambridge University Press.
2. Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson.
3. Rollinson, H. R. (2014). Using geochemical data: evaluation, presentation, interpretation. Routledge.
4. Raymond, L. A. (2002). Petrology: the study of igneous, sedimentary, and metamorphic rocks. McGraw-Hill Science Engineering.
5. McBirney, A. R. (1984). Igneous Petrology. San Francisco (Freeman, Cooper & Company) and Oxford (Oxford Univ. Press),
6. Myron G. Best (2001). Igneous and Metamorphic Petrology,
7. K. G. Cox, J. D. Bell. (1979). The Interpretation of Igneous Rocks. Springer/Chapman & Hall.
8. Bose M.K. (1997). Igneous Petrology.
9. G W Tyrrell. (1926). Principles of Petrology. Springer

GEOH302T4 : Sedimentary Petrology
Course, C6 (THEORY) (End sem 48+ In sem 12) Marks: 60 48 Hours

Objectives: The major objective of learning sedimentary petrology is to know the processes of formation of sediments and their transformation to sedimentary rock as well as their characteristics and classifications.

Unit 1: Origin of Sediments (L: 4 T: 1) 5classes (Marks: 10)

- Weathering and sedimentary flux: Physical and chemical weathering, soils and paleosols. Transportation of sediments by running water, wind, ice, gravity and sea waves. Provenance-Definition and concepts; Heavy minerals and their significance.

Unit 2: Properties of Sediments and Sedimentary Rocks (L:5 T:1) 6classes (Marks: 10)

- Grain size scale, particle size distribution, Environmental connotation; particle shape and fabric.

- Textural properties of sedimentary rocks - concept of size, grade scale, sphericity, roundness and fabric. Sedimentary textures, structures (lamination, ripples, cross stratification, stylolite, geode, nodule, concretion, verves) and sedimentary environment. Fluid flow, sediment transport and sedimentary structures: Types of fluids, laminar vs. turbulent flow, particle entrainment, transport and deposition.

Unit 3: Classifications (L: 3) 3classes (Marks: 10)

- Textural and genetic classification of clastic and non-clastic rocks.

Unit 4: Processes of formation of sedimentary rocks (L:9 T:1) 10classes (Marks: 20)

- Process of formation of sedimentary rocks- weathering, transportation and deposition.
- Diagenesis-compaction, cementation, lithifaciation, authigenesis, replacement and recrystallisation; physico-chemical factors of sedimentation.
- Concept of sedimentary facies, Walther's law.
- Depositional environments - Preliminary concepts of continental, marginal-margin and marine environments.
- Paleocurrent analysis- Paleocurrents for different sedimentary environments, Sedimentary structure- primary and syn-sedimentary structures.

Unit 5: Descriptive Sedimentary Petrology (L:9 T:1) 10 classes (Marks: 10)

- Petrogaphic description of the following rock types: Sandstones (Arenites and Wacke), siltstone, shale, limestone, dolomite, breccia, conglomerate and evaporites.

GEOH302P2: Sedimentary Petrology
Course, C6 (PRACTICAL) (End sem 32+ Insem 8) Marks: 40 24 Hours

Practical 1: Study of sedimentary rocks in hand specimens.
Practical 2: Study of sedimentary rocks in thin sections.
Practical 3: Study of texture in thin sections and hand specimens.
Practical 4: General overview on depositional conditions and provenance from the study of framework, cement and matrix of given sedimentary rock in thin sections.

SUGGESTED READINGS:

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

GEOH303T4: Metamorphic Petrology
Course, C7 (THEORY) (End sem 48+ Insem 12) Marks: 60 48 Hours

Objectives: Metamorphic petrology deals with the dynamic processes of the earth that has affected the pre existing rocks. This subject also helps us to understand ore localization and genesis.

Unit 1: Introduction of Metamorphism (L:5 T:1) 6classes (Marks: 15)

- Metamorphism: definition, controlling factors, types of metamorphism - contact, regional, fault zone metamorphism, impact metamorphism. Regional metamorphism of argillaceous, calcareous and basic rocks. Occurrence of metamorphic rocks.
- Index minerals, Chemographic projections, Metamorphic zones and isograde. Concept of metamorphic facies and grade.

Unit 2: Thermodynamic Considerations in Metamorphism (L:4 T:1) 5classes (Marks: 10)

- General idea about the thermodynamic consideration in metamorphic rock. Equilibrium in metamorphism. Mineralogical phase rule: Univariant and bivariant reactions and their significance. Mineralogical phase rule of closed and open systems.

Unit 3: Metamorphic Structure and Texture (L:9 T:1) 8 classes (Marks: 15)

- Structure and textures of metamorphic rocks.
- Relationship between metamorphism and deformation, Metamorphic mineral reactions (prograde and retrograde).

Unit 4: Metasomatism and Migmatites (L:7 T:1) 8 classes (Marks: 8)

- Metasomatism and role of fluids in metamorphism.
- Migmatites and their origin.

Unit 5: Descriptive Metamorphic Petrology (L:9 T:1) 10 classes (Marks: 12)

- Descriptive petrography of the following rocks: Slate, phyllite, schist, blue schists, gneiss, quartzite, marble, amphibolite, granulite, hornfels, eclogites, khasi greenstone, charnockite and khondalite**.**

GEOH303P2: Metamorphic Petrology
Course, C7 (PRACTICAL) (End sem 32+ Insem 8) Marks: 40 24 Hours

Practical 1: Study of metamorphic rocks in hand specimens.
Practical 2: Study of metamorphic rocks in thin sections.
Practical 3: Study of texture in thin section and hand specimens.
Practical 4: Study of metamorphic phase diagrams.

SUGGESTED READINGS:
1. Philpotts, A., & Ague, J. (2009). *Principles of igneous and metamorphic petrology*. Cambridge University Press.

2. Winter, J. D. (2014). *Principles of igneous and metamorphic petrology*. Pearson.
3. Rollinson, H. R. (2014). *Using geochemical data: evaluation, presentation, interpretation*. Routledge.
4. Raymond, L. A. (2002). *Petrology: the study of igneous, sedimentary, and metamorphic rocks*. McGraw-Hill Science Engineering.
5. Yardley, B. W., & Yardley, B. W. D. (1989). An introduction to metamorphic petrology. Longman Earth Science Series.

3rd Semester
Generic Electives (GE)

GEOH GE301AT4: FOSSILS AND THEIR APPLICATIONS
Course GE3 (End sem 48+ Insem 12) Marks: 60 48 Hours

Objectives: Aims to study the basics of the fossil, various fossil groups and species to be familiar with the past phenomenon of the earth environment and imparts the knowledge of its application and societal importance.

Unit 1: Introduction to fossils (L:5 T:1) (Marks: 10)

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

Unit 2: Species concept (L:5 T:1) (Marks: 10)

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 (L:10 T:2) (Marks: 15)
Brief introduction of important fossils groups: invertebrate, vertebrate, microfossils, spore, pollens and plant fossils. Important age-diagnostic fossiliferous horizons of India

Unit 4: Application of fossils (L: 6) (Marks: 15)
Principles and methods of paleoecology, application of fossils in the study of paleoecology, paleobiogeography and paleoclimate

Unit 5: Societal importance of fossils (L: 5) (Marks: 10)
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.

GEOH GE301AP2: FOSSILS AND THEIR APPLICATIONS
Course GE3 (PRACTICAL) (End sem 32+ Insem 8) Marks: 40 24 Hours

1. Study of fossils showing various modes of fossilization

2. Distribution of age diagnostic fossils in India
3.Biostratigraphic correlation

SUGGESTED READINGS:

1. Schoch, R.M. 1989. Stratigraphy, Principles and Methods.VanNostrand Reinhold.
2. Clarkson, E.N.K.1998. Invertebrate Paleontology and Evolution George AIlen&Unwin
3. Prothero, D.R. 1998. Bringing fossils to life - An introduction to Paleobiology, McGraw Hill.
4. Benton, M.J. 2005. Vertebrate paleontology (3rd edition). Blackwell Scientific, Oxford.
5. 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.

GEOH GE301BT4: Martian Geology

Course GE3 (End sem 48+ Insem 12) Marks: 60 48 Hours

Objectives: To study the geology of the Mars Planet, its history, evolution, characteristics, atmosphere, hydrosphere, surfacial processes and its similarity with earth's surface processes

Unit 1: MARS – OUR POTENTIAL HOME? **(L: 4) (Marks: 10)**
History of the exploration of Mars; The Journey of Mangalyaan
Evolution of Mars

Unit 2: The characteristics of Mars and its interior **(L: 6) (Marks: 10)**
The Martian atmosphere and hydrosphere.

Unit 3: Surface provinces of Mars **(L: 10 T: 2) (Marks: 15)**
Surface processes on Mars and its evidences from Earth-based analogs – Impact structures, Volcanic features on Mars, Layered deposits, Eolian dunes, Debris flow, Martian outflow channels, Glacial Origin of Fretted Terrains on Mars, Mountain building

Unit 4: Geochemical analogs and Martian meteorites **(L: 6) (Marks: 10)**
Martian History Epochs of change: what went "wrong" and why?

Unit 5: Life in Mars **(L:6 T:1) (Marks: 15)**
Is there evidence for life on Mars?
Physical and chemical conditions supportive of permanent Mars occupation; Terraforming of Mars and its challenges
New Trends for Human Missions to Mars and Human colonization of Mars

GEOH GE301BP2: Martian Geology

Course GE3 PRACTICAL (End sem 32+ Insem 8) Marks: 40 24 Hours

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

SUGGESTED READINGS:

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

3rd Sem
Skill Enhancement Courses (SEC)

GEOHSEC301AT2: Basic Field Training
Course, SEC1 **(End sem 24+ Insem 6) Marks: 30** **24 Hours**

Objectives: The purpose of basic field mapping is the skill enhancement to enable us the basic field techniques and procedures.

Unit 1: Orientation of Topographic sheet in field, marking location in toposheet, Bearing (Front andback). Concepts of map reading, Distance, height and pace approximation **(L: 4) (Marks: 6)**

Unit 2: Identification of rock types in field; structures and texture of rocks, Use of hand lense **(L: 6) (Marks: 10)**

Unit 3: Basic field measurement techniques: Bedding dip and strike, Litholog measurement **(L: 6) (Marks: 10)**

Unit 4: Reading contours and topography **(L: 2) (Marks: 4)**

SUGGESTED READINGS:

1. Lahee, F.H. 1916. Field Geology.
2. Compton, R.R, 1985. Geology in the Field.

GEOHSEC301BT2: Geological Mapping
Course, SEC1 **(End sem 24+ Insem 6) Marks: 30** **24 Hours**

Objectives: Geological mapping deals with use of the different instruments and techniques in the field and enhance the skill of understanding the earth through measurement, plotting, sketching, correlating etc.

Unit 1: Geological mapping, stratigraphic correlation **(L: 6) (Marks: 10)**

Unit 2: Primary (scalars and vectors) and secondary structures (linear and planar) **(L: 4) (Marks: 6)**

Unit 3: Trend, plunge, Rake/Pitch **(L: 4) (Marks: 6)**

Unit 4: Stereoplots of linear and planar structures, Orientation analyses **(L: 5) (Marks: 8)**

SUGGESTED READINGS:

1. Lahee, F.H. 1916. Field Geology.
2. Compton, R.R, 1985. Geology in the Field.
3. Barnes, J.W. 4th Edition, Basic Geological Mapping.

GEOHSEC301CT2: Economic Geology Fieldwork
Course, SEC1 (End sem 24+ Insem 6) Marks: 30 24 Hours

Objectives: Provides practical knowledge about different mineral deposits, formations, occurrences and their mining methods and enhance the skill of understanding the minerals deposits through mapping and surveying.

Module I

Unit 1: Visit to any mineral deposit **(L: 2) (Marks: 3)**
Unit 2: Mode occurrence of ore, Ore mineralogy **(L: 2) (Marks: 4)**
Unit 3: Ore-Host rock interrelation **(L: 2) (Marks:)**
Unit 4: Ore formation process **(L: 2) (Marks: 8)**
Unit 5: Basic techniques of surveying, concept of outcrop mapping **(L: 2) (Marks: 3)**

Module 2

Unit 1: Visit to underground or open cast mine **(L: 2) (Marks: 3)**
Unit 2: Practical experience of mining methods **(L: 2) (Marks: 3)**
Unit 3: Underground mapping/ Bench mapping **(L: 2) (Marks: 3)**
Unit 4: Isopach and Isochore maps **(L: 2) (Marks: 3)**

SUGGESTED READINGS:

1. Lahee, F.H. 1916, Field Geology.
2. Evans, A.M. 1993, Ore Geology and Industrial Minerals- An Introduction.

GEOHSEC301DT2: Himalayan Geology Fieldwork
Course, SEC1 (End sem 24+ In sem 6) Marks: 30 24 Hours

Objectives: Practical experience of complex terrane of the Himalaya through field traverse along the selected transect and enhance the skill of one to identify the different signatures to differentiate structural elements of the area.

Identification and characterization of major structural boundaries in Himalaya viz. MBT, MFT etc. **(L: 18)(Marks: 30)**

Or

Field along any suitable transect of Himalayan foreland **(L: 18) (Marks: 30)**

or

Field transect in Siwalik **(L: 18) (Marks: 30)**

or
Identification of Himalayan and pre-Himalayan elements **(L: 18) (Marks: 30)**

SUGGESTED READINGS:

1. Kumar, G. 1997, Geology of Arunachal Pradesh.
2. Lahee, F.H. 1916, Field Geology.

4th Sem
Core Courses

GEOH401T4: Paleontology
Course, C8 (THEORY) **(End sem 48+ Insem 12) Marks: 60** **48 Hours**

Objectives: Paleontology deals with identification, classification and taxonomic description of past life forms as fossils. It aids in the reconstruction of paleoclimate, paleo bathymetry and paleogeography. It is very much used as a tool of hydrocarbon exploration.

Unit 1: Introduction to Paleontology **(L: 4) 4classes (Marks: 10)**

- Palaeontology: definition, branches, scopes and applications of palaeontology. Concept of palaeoclimate, palaeoecology, and palaeobiogeography. Definition of palaeobotany, palaeozoology, palynology.
- Fossil: definition, types, process of fossilization, modes of preservation.

Unit 2: Fossil Nomenclature and Taxonomy **(L: 5) 5classes (Marks: 12)**

- Fossil: Nomenclature, type specimens.
- Taxonomy and Species concept: Species concept with special reference to paleontology, Taxonomic hierarchy. Theory of organic evolution interpreted from fossil records.

Unit 3: Vertebrate Fossils **(L: 6) 6classes (Marks: 10)**

- General idea of vertebrate fossils: Origin of vertebrates and major steps in vertebrate evolution, Mesozoic reptiles with special reference to origin diversity and extinction of dinosaurs. Evolution of horse and intercontinental migrations. Human evolution.

Unit 4: Invertebrate Fossils **(L: 10 T: 2) 12classes (Marks: 15)**

- Brief introduction to important invertebrate groups: Foraminifera, Brachiopoda, Pelecypoda, Gastropoda, Chephalopoda, Trilobita, Echinoidea and Anthozoa, and their biostratigraphic significance.

Unit 5: Palaeobotany **(L: 5) 5classes (Marks: 7)**

- General Idea about Palaobotany and Plant fossils: Gondwana Flora of India.

Unit 6: Application of Fossils **(L: 4) 4classes (Marks: 6)**

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

GEOH401P2: Paleontology (End sem 32+ Insem 8) Marks: 40 24 Hours

Course, C8 (PRACTICAL)

Practical 1: Study of fossils showing various modes of preservation.
Practical 2: Study of diagnostic morphological characters, systematic position, stratigraphic position and age of various invertebrate, vertebrate and plant fossils.

SUGGESTED READINGS

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

GEOH402T4: Stratigraphic Principles and Indian Stratigraphy
Course, C9 (THEORY) (End sem 48+ Insem 12) Marks: 60 48 Hours

Objectives: The principles of stratigraphy help us to understand the order of superposition of rocks in space and time. Indian stratigraphy helps us to know distribution of different stratigraphic horizons in India and their significances.

Unit 1: Principles of Stratigraphy (L:6 T:2) 8 classes (Marks: 15)

- Principles of stratigraphy: Fundamentals of litho-, bio- and chrono-stratigraphy; Introduction to concepts of dynamic stratigraphy (chemostratigraphy, seismic stratigraphy, sequence stratigraphy).

Unit 2: Stratigraphic Nomenclature& Laws of Facies (L:8 T:2) 10 classes (Marks: 15)

- Codes of stratigraphic nomenclature: International Stratigraphic Code – development of a standardized stratigraphic nomenclature. Concepts of Stratotypes. Global Stratotype Section and Point (GSSP). Codes of lithostratigraphy, biostratigraphy, chronostratigraphy, magnetostratigraphy, sequence stratigraphy.
- Principles of stratigraphic analysis. Facies concept in stratigraphy: Walther's Law of Facies. Concept of paleogeographic reconstruction.

Unit 3: Stratigraphy of India (L: 15 T: 2) 17classes (Marks: 30)

- Physiographic and tectonic subdivisions of India. Introduction to Indian Shield. Introduction to Proterozoic basins of India. Geology of Vindhyan and Cudappah basins of India.

- Paleozoic Succession of Kashmir and its correlatives from Spiti and Zanskar Stratigraphy. Structures and hydrocarbon potential of Gondwana basins.
- Mesozoic stratigraphy of India: Triassic successions of Spiti, Jurassic of Kutch, Cretaceous, successions of Cauvery basins, Mesozoic rocks of NE India.
- Cenozoic stratigraphy of India: Kutch basin, Siwalik successions, Assam-Arakan basins.
- Stratigraphy and structure of Krishna-Godavari basin, Cauvery basin, Bombay offshore basin, Kutch and Saurashtra basins and their potential for hydrocarbon exploration.
- Volcanic provinces of India: Deccan, Rajmahal, Sylhet Traps.
- Stratigraphic boundaries: Important Stratigraphic boundaries in India - a. Precambrian-Cambrian boundary, b. Permian-Triassic boundary, and c. Cretaceous-Tertiary boundary.

GEOH402P2 : Stratigraphic Principles and Indian Stratigraphy
Course, C9 (PRACTICAL) (End sem 32+ Insem 8) Marks: 40 24 Hours

Practical 1: Study of geological map of India and identification of major stratigraphic units.
Practical 2: Study of rocks in hand specimens from known Indian stratigraphic horizons.
Practical 3: Drawing various paleogeographic maps of Precambrian time.
Practical 4: Study of different Proterozoic supercontinent reconstructions.

SUGGESTED READINGS:

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

GEOH403T4 : Hydrogeology and Oceanography
Course, C10 (THEORY) (End sem 48+ Insem 12) (Marks: 60) 48 Hours

Objectives: Hydrogeology deals with hydrogeologic cycle, occurrences, movement and distribution of groundwater in different regions and its utility.
Oceanography deals with origin, distribution and chemistry of sea water as well as marine flora and fauna, effect of ocean currents and controls on climatic cycles.

Unit 1: Introduction to Hydrogeology (L: 3) 3classes (Marks: 6)

- Hydrogeology - definition and applications, its societal relevance.
- Hydrologic cycle, rock properties and groundwater, vertical distribution of subsurface water.

Unit 2: Groundwater and Aquifers (L: 8) 8classes (Marks: 10)

- Types of aquifer, aquifer parameters, anisotropy and heterogeneity of aquifers. Physical and chemical properties of water and water quality. Sea water intrusion in coastal aquifers.
- Groundwater flow: Darcy's law and its validity, intrinsic permeability and hydraulic conductivity. Groundwater flow rates and flow directions. Laminar and turbulent groundwater flows.

Unit 3: Groundwater Exploration (L: 7) 7 classes (Marks: 15)

- Well hydraulics and Groundwater exploration, Basic concepts of drawdown, cone of depression, specific drawdown, specific yield, specific capacity. Elementary concepts related to equilibrium and non-equilibrium conditions for water flow into a well in confined and unconfined aquifers. Surface-based groundwater exploration methods. Introduction to subsurface borehole logging methods.

Unit 4: Groundwater management **(L: 4)** 4 **classes (Marks: 6)**

- Surface and subsurface water interaction. Groundwater level fluctuations. Basic concepts of water balance, issues related to groundwater resources development and management. Rainwater harvesting and artificial recharge of groundwater.

Unit 5: Fundamentals of Oceanography **(L: 3)** 3 **classes (Marks: 8)**

- General idea on oceanography. Theories of origin of ocean basins.
- Branches of oceanography: Biological oceanography, Chemical oceanography, Geological oceanography and Physical oceanography.

Unit 7: Marine Physics **(L: 5)** 5 **classes (Marks: 8)**

- Physical properties of ocean temperature-salinity structure, mixing, surface waves, internal waves, surface tides, internal tides, and currents.

Unit 8: Marine geology **(L: 5)** 5 **classes (Marks: 7)**

- Geology of the ocean floor,Ocean floor features and their study, Ring of Fire, Tsunami, Littoral and Deep Sea Sediments, mid-oceanic rift zones volcanism, hydrothermal vents, extremophile, oceanic trenches. Palaeooceanography.
- Paleomorphic Aspect- Nutrient supply.

GEOH403P2 : Hydrogeology and Oceanography
Course, C10 (PRACTICAL) **(End sem 32+ Insem 8) Marks: 40** **24 Hours**

Practical 1: Preparation and interpretation of water level contour maps and depth to water level maps.
Practical 2: Study, preparation and analysis of hydrographs for differing groundwater conditions.
Practical 3: Water potential zones of India (map study).
Practical 4: Simple numerical problems related to determination of permeability in field and laboratory, groundwater flow, well hydraulics.

Suggested Readings:

1. Todd, D. K. 2006. Groundwater hydrology, 2nd Ed., John Wiley & Sons, N.Y.
2. Davis, S. N. and De Weist, R.J.M. 1966. Hydrogeology, John Wiley & Sons Inc., N.Y.

3. Karanth K.R., 1987, Groundwater: Assessment, Development and management, Tata McGraw-Hill Pub. Co. Ltd.
3. Gross,M.G., 1977. *Oceanography: A view of the Earth*, Prentice Hall.

4th Sem
Generic Electives (GE)

GEOH GE401AT4: SOILS: PRESENT AND PAST
Course GE4 (End sem 48+ Insem 12) Marks: 60 48 Hours

Objectives: Imparts the knowledge about the soil of the past and the present, its forming processes and classification.

Unit 1: Soil forming processes: Chemical weathering, major buffer maintaining ocean/atm/biosphere O2 and CO2, new compounds/minerals of greater volume and lower density; Oxidation; Carbonation; Hydrolysis; Hydration; Base Exchange; Chelation; Microbial weathering
(L: 4 T: 1) 5classes (Marks:10)

Unit 2: General soil forming regimes: Gleization; podzolization; lessivage; ferrallitizatin; calcification; Salinization
(L: 3) 3classes (Marks:6)

Unit 3: Soil forming processes: Physical weathering, loosening and particle size reduction; pressure release; thermal expansion; growth of foreign crystal.
(L: 4) 4classes (Marks:8)

Unit 4: Modern soils and key pedofeatures: Soil structures; horizons; roots; Fe-Mn mottles and concretions; pedogenic carbonate
(L: 2) 2classes (Marks:3)

Unit 5: Introduction to paleopedology and paleosols; role of factors controlling paleosol formation- parent material, climate, vegetation, topography, time.
(L: 2) 2classes (Marks:3)

Units 6: Introduction to soil taxonomy and paleosol taxonomy
(L: 2) 2classes (Marks:3)

Unit 7: Micromorphology: Thin section analysis of paleosols
(L: 2) 2classes (Marks:3)

Unit 8: Geochemistry: molecular rations; chemical weathering indices
(L: 2) 2classes (Marks:3)

Units 9: Stable isotope geochemistry: carbon13 and oxygen18 system for vegetation, temperature, pCO2
(L: 2) 2classes (Marks:3)

Unit 10: Diagenetic overprinting in fossil soils: compaction; oxidation of organic matter; cementation; illitization
(L: 2) 2classes (Marks:3)

Unit 11: Geological record of fossil soils- Precambrian paleosols- evolution of paleoatmospheric conditions
(L: 2) 2classes (Marks:3)

Unit 12: Geological record of fossil soils- Paleozoic paleosols- evolution of land animals and plants, coal, Permian-Triassic transition paleosols and extinction events
(L: 2) 2classes (Marks:3)

Unit 13: Geological record of fossil soils- Mesozoic-Cenozoic paleosols- fossil soils at K-T extinction event, Paleogene fossil soils at green house to ice house transition, evolution of Asian monsoon system.
(L: 2) 2classes (Marks:3)

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

(L: 2) 2classes (Marks:3)

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

(L: 2) 2classes (Marks:3)

GEOH GE401AP2: SOILS: PRESENT AND PAST

Course GE4 PRACTICAL (End sem 32+ Insem 8) Marks: 40 24 Hours

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
5- Field trip to examine modern and fossil soils- field characterization and sampling procedures

SUGGESTED READINGS:

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

GEOH GE401BT4: STUDIES ON CRYOSPHERE

Course GE4 (End sem 48+ Insem 12) Marks: 60 48 Hours

Objectives: Cryosphere is all about the study of frozen water part of the Earth system. Subject deals with basic concept of Cryosphere, terrestrial and Marine Cryosphere, their formation and characteristics.

Unit 1: Introduction to Cryosphere (L: 10) 10 **classes**

Cryosphere, Distribution and its components, Terrestrial and Marine cryosphere, Role of cryosphere in the climate system, Remote sensing of cryosphere and its applications.

Unit 2: Terrestrial Cryosphere (L: 18 T: 2) 20 **classes**

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

present, past and future.

Unit 3: Marine Cryosphere **(L: 6)** 6 **classes**
Ice shelves, Ice bergs, Sea ice characteristics, Ice islands, Ice streams, Mass balance of Sea ice, Ice drift and ocean circulation. Marine Cryosphere in the present, past and future

GEOH GE401AP2: STUDIES ON CRYOSPHERE :PRACTICALS
Course GE4 **(End sem 32+ Insem 8) Marks: 40** **24 Hours**

1. Linear and non-linear regression algorithms to estimate SWE (snow water equivalent) from remote sensed data (mainly microwave data)
2. Estimation of precipitation from remote sensed data
Snowmelt run-off modeling
1. Empirical (Snow cover to spring snowmelt relation)
2. One of the non-empirical model (Degree-day, modified degree-day or energy balance methods)
SUGGESTED READINGS:
1. The Global Cryosphere by Roger Berry and Thian Yew Gan
Cambridge University Press
2. Web inputs from sites sources such as TRMM and SMMR (Scanning Multichannel Microwave Radiometer) sites

SUGGESTED READINGS:

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

4th Sem
Skill Enhancement Courses (SEC)

GEOHSEC401AT2 : Precambrian Geology Fieldwork
Course, SEC2 **(End sem 24+ Insem 6) Marks: 30** **24 Hours**

Objectives: Field work at the Precambrian terrain for better understanding of the Precambrian basins and enhance the skill of field techniques.

Unit 1: Field transect in any Precambrian terrain **(L: 2) (Marks: 6)**

Unit 2: Study of craton ensemble including basic intrusive suites **(L: 4) (Marks: 8)**

Unit 3: Precambrian sedimentary basin **(L: 6) (Marks: 10)**

Unit 4: Basement-Cover relation in: a. fold belts, b. sedimentary successions **(L: 3) (Marks: 6)**

SUGGESTED READINGS:

1. Precambrian Geology by S.M. Naqvi and J.J.W. Rogers

GEOHSEC401BT2 : Visit to Engineering Project sites

Course, SEC2 **(End sem 24+ Insem 6) Marks: 30** **24 Hours**

Objectives: Field visit to engineering project site and enhance the knowledge of geological mapping, various geotechnical and environmental aspects (problems and solutions), enhancing the skill to understand the engineering structures and its potential and probable disaster.

Unit 1: Geological mapping of a project site (Dam sites, Tunnel alignments etc) **(L: 4) (Marks: 7)**

Unit 2: On site visit & to study various geotechnical aspects related to the project site. **(L: 3) (Marks: 7)**

Unit 3: Identification of geotechnical problems of a project site and remedial measures to be taken. **(L: 2) (Marks: 3)**

Unit 4: Identification of environmental problems of a project site and remedial measures to be taken. **(L: 3) (Marks: 3)**

Unit 5: Computation of rock mass Properties (RQD, RMR & Q) in the field. **(L: 4) (Marks: 5)**

Unit 6: Identification of potential suspected/probable sites of Natural Disaster and suggestions about corrective/preventive measures. **(L: 2) (Marks: 5)**

SUGGESTED READINGS:

1. Krynin, D.P. and Judd W.R. 1957. Principles of Engineering Geology and Geotechnique,
2. Waltham, T., 2009. Foundations of Engineering Geology (3rd Edn.) Taylor & Francis.

GEOHSEC401CT2: Stratigraphy and palaeontology Fieldwork

Course, SEC2 **(End sem 24+ Insem 6) Marks: 30** **24 Hours**

Objectives: Field work with documentation to understand the detail stratigraphy of the area, enhancing the skill of collecting data, sample collecting techniques and their description and representation.

Unit 1: Field training in Phanerozoic basin of India **(L: 4)** 4 **classes (Marks: 7)**

Unit 2: Documentation of stratigraphic details in the field **(L: 3)** 3 **classes (Marks: 5)**

Unit 3: Collection of sedimentological, stratigraphic and paleontological details and their representation **(L: 3)** 3 **classes (Marks: 5)**

Unit 4: Facies concept and its spatio-temporal relation (Walther's Law) and concept of facies distribution at basinal-scale **(L: 4)** 4 **classes (Marks: 8)**

Unit 5: Fossils sampling techniques and their descriptions **(L: 3)** 3 **classes (Marks: 5)**

SUGGESTED READINGS:

1. Geology of Assam by A.K. Biswas and A.B. Dasgupta.
2. Fundamentals of historical geology and stratigraphy of India by Ravindra Kumar.

GEOHSEC401DT2: Project work
Course, SEC2 (End sem 24+ Insem 6) Marks: 30 24 Hours

Field based / data based geological investigations

5th Sem
Core Courses

GEOH501T4 : Surveying and Engineering Geology
Course, C11 (THEORY) (End sem 48+ Insem 12) Marks: 60 48 Hours

Objectives: Surveying and Engineering geology provides geological and geotechnical recommendations, analysis, and design associated with human development and various types of civil structural construction.

Unit 1: Introduction to Surveying (L: 4) 4classes (Marks: 4)

- The Great Trigonometrical Survey of India. Geodetic and Plane Surveying. Concept of Datum, Control Points, Horizontal and Vertical Controls. Geoid: topographic surface, geodetic surface, ellipsoidal surface. Azimuth and bearing. Triangulation and Traversing.

Unit 2: Plane Surveying (L: 6) 6classes (Marks: 15)

- Compass, Chain and Plane Table Surveying. Electronic Distance Measurement System. Global Positioning System. GPS and its use in surveying.

Unit 3: Leveling (L: 6) 6classes (Marks: 15)

- Level, Types of levels and Methods of Levelling.

Unit 4: Introduction to Engineering Geology (L: 4) 4classes (Marks: 4)

- Role of engineering geologists in planning, design and construction of major man-made engineering structures. Geological field investigation for engineering projects. Reconnaissance and detail site investigation. Construction and building materials.

Unit 5: Geotechnical idea about engineering structures (L: 5) 5classes (Marks: 7)

Foundation treatment; Grouting, Rock Bolting and other support mechanisms. Intact Rock and Rock Mass properties. Rock aggregates; Significance as construction material. Rock quality designation (RQD). Rock mass rating (RMR). Q-index.

GEOH501P2 : Surveying and Engineering Geology
Course, C11 (PRACTICAL) (End sem 32+ Insem 8) Marks: 40 24 Hours

Practical 1: Use of compass for determining forward, backward bearing and azimuths.
Practical 2: Use of GPS for determining Latitude, Longitude and Elevation values.
Practical 3: Use of chain, compass and plane table for computation of area and length.
Practical 4: Computation of reservoir area, catchment area, reservoir capacity and reservoir life.
Practical 5: Computation of RQD, RMR and 'Q'.

SUGGESTED READINGS:

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

GEOH502T4 : Geomorphology

Course, C12 (THEORY) (End sem 48+ In sem 12) Marks: 60 48 Hours

Objectives: Geomorphology is the scientific study of the origin and evolution of landscapes and bathymetric features created by physical, chemical or biological processes operating at or near the Earth's surface.

Unit 1: Introduction to Geomorphology (L: 4) 4classes (Marks: 6)

- Concept of Geomorphology, Endogenic and Exogenic processes; uniformitarianism, geomorphic cycle.

Unit 2: Understanding Earth's Physiography (L: 6) 6classes (Marks: 8)

- Geoid, Topography, Hypsometry, Global Hypsometry, Major Morphological features, Large Scale Topography - Ocean basins, mountain ranges (with emphasis on Himalayas).

Unit 3: Geomorphic Processes (L: 15) 15classes (Marks: 20)

Surficial Processes and geomorphology, Weathering and Erosion. Soil, Soil Profile and its classification. Mass movement and debris flow processes. Discussion on geomorphic processes and landforms of: Fluvial, Glacial, Aeolian, Coastal and Volcanic Environments.

Unit 4: Tectonics and Geomorphology (L: 7) 7classes (Marks: 10)

- Role of plate tectonics in changing morphology of earth's surface. Features associated with different tectonic setup. Endogenic- Exogenic interactions, Rates of uplift and denudation, Tectonics and drainage development, Sea-level change, Long-term landscape development

Unit 5: Indian Geomorphology **(L: 4) 4classes (Marks: 8)**

- Overview of Indian Geomorphology and the features of: Extra-Peninsular, Peninsular India, Great Indo-Gangetic-Brahmaputra Plain, Rann of Kutch, Coastal Areas and islands of India.

GEOH502P2 : Geomorphology
Course, C12 (PRACTICAL) **(End sem 32+ Insem 8) Marks: 40** **24 Hours**

Practical 1: Study and identification of geomorphic features from image/photo/satellite imagery.
Practical 2: Study and identification of geomorphic features from geomorphic models.
Practical 3: Study and identification of geomorphic features from contour maps.
Practical 4: Drawing of profile and discussion of geomorphic features from topographical maps.

SUGGESTED READINGS:

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

5th Sem
Department Specific Elective (DSE)

GEOHDSE501AT4 : Exploration Geology
Course, DSE1 (THEORY) **(End sem 48+ Insem 12) Marks: 60** **48 Hours**

Objectives: Aims to study the mineral resources of the earth, its prospect, reserve estimation and different exploration technique.

Unit 1: Mineral Resources **(L: 8)** 8 **classes (Marks: 15)**

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

Unit 2: Prospecting and Exploration **(L: 8)** 8 **classes (Marks: 15)**

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

Unit 3: Evaluation of data **(L: 4)** 4 **classes (Marks: 5)**

Evaluation of sampling data
Mean, mode, median, standard deviation and variance

Unit 4: Drilling and Logging **(L: 8)** 8 **classes (Marks: 15)**

Core and non-core drilling
Planning of bore holes and location of boreholes on ground
Core-logging

Unit 5: Reserve estimations and Errors **(L: 7)** 7 **classes (Marks: 10)**

Principles of reserve estimation, density and bulk density
Factors affecting reliability of reserve estimation
Reserve estimation based on geometrical models (square, rectangular, triangular and polygon blocks)
Regular and irregular grid patterns, statistics and error estimation

GEOHDSE501AP2 : Exploration Geology
Course, DSE1 (PRACTICAL) **(End sem 32+ Insem 8) Marks: 40** **24 Hours**

1. Identification of anomaly
2. Concept of weighted average in anomaly detection
3. Geological cross-section
4. Models of reserve estimation

SUGGESTED READINGS:

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

GEOHDSE501BT4 Fuel Geology
Course, DSE1 (THEORY) **(End sem 48+ Insem 12) Marks: 60** **48 Hours**

Objectives: Study of origin, classification, composition, occurrence, accumulation and habitat of fossil fuels especially Coal and Petroleum with few other fuels.

Unit 1: Coal **(L: 7)** 7 **classes (Marks: 12)**
Definition and origin of Coal
Basic classification of coal
Fundamentals of Coal Petrology - Introduction to lithotypes, microlithotypes and macerals in coal
Proximate and Ultimate analysis

Unit 2: Coal as a fuel **(L: 7)** 7 **classes (Marks: 12)**
Coal Bed Methane (CBM): global and Indian scenario
Underground coal gasification
Coal liquefaction

Unit 3: Petroleum **(L: 7)** 7 **classes (Marks: 12)**
Chemical composition and physical properties of crudes in nature
Origin of petroleum
Maturation of kerogen; Biogenic and Thermal effect

Unit 4: Petroleum Reservoirs and Traps **(L: 8)** 8 **classes (Marks: 16)**
Reservoir rocks: general attributes and petrophysical properties.
Classification of reservoir rocks - clastic and chemical.
Hydrocarbon traps: definition, anticlinal theory and trap theory
Classification of hydrocarbon traps - structural, stratigraphic and combination
Time of trap formation and time of hydrocarbon accumulation.
Cap rocks - definition and general properties.
Plate tectonics and global distribution of hydrocarbon reserves

Unit 5: Other fuels **(L: 6)** 6 **classes (Marks: 8)**

Gas Hydrate

Nuclear Fuel

Course, DSE1 (PRACTICAL) **(End sem 32+ Insem 8) Marks: 40** **24 Hours**

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

SUGGESTED READINGS:

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

GEOHDSE502AT4 : River Science
Course, DSE2 (THEORY) (End sem 48+ Insem 12) Marks: 60 48 Hours

Objectives: Deals in the study of the river system, its basin, drainage network, hydrology, its diversity in space and time, different channel processes and evolution of the landscape and its associated hazards and management.

Unit 1: Stream hydrology **(L: 7)** 7 **classes (Marks: 10)**
Basic stream hydrology
Physical properties of water, sediment and channel flow
River discharge, River hydrographs (UH, IUH, SUH, GIUH) and its application in hydrological analysis
Flood frequency analysis

Unit 2: River basin **(L: 7)** 7 **classes (Marks: 10)**
Sediment source and catchment erosion processes
Sediment load and sediment yield
Sediment transport processes in rivers
Erosion and sedimentation processes in channel.

Unit 3: Drainage **(L: 7)** 7 **classes (Marks: 10)**
Drainage network
Quantitative analysis of network organization - morphometry
Random Topology (RT) model and fractal analysis
Role of drainage network in flux transfer
Evolution of drainage network in geological time scale.

Unit 4: Rivers in time and space **(L: 7)** 7 **classes (Marks: 10)**
River diversity in space, Patterns of alluvial rivers - braided, meandering and anabranching channels,
Dynamics of alluvial rivers
Channel patterns in stratigraphic sequences
Different classification approaches in fluvial geomorphology and its applications.

Unit 5: Channels and Landscapes **(L: 4)** 4 **classes (Marks: 10)**
Bedrock channels, Bedrock incision process
River response to climate, tectonics and human disturbance
Bedrock channel processes and evolution of fluvial landscapes.

Unit 6: Fluvial hazards **(L: 3)** 3 **classes (Marks: 10)**
Integrated approach to stream management
Introduction to river ecology.

GEOHDSE502AP2 : River Science
Course, DSE2 (PRACTICAL) (End sem 32+ Insem 8) Marks: 40 24 Hours

Stream power calculation
Longitudinal profile analysis
Hydrograph analysis and other related problems

SUGGESTED READINGS:

1. Davies, T. (2008) Fundamentals of hydrology. Routledge Publications.
2. Knighton, D. (1998) Fluvial forms and processes: A new perspective. Amold Pubs.

3. Richards. K. (2004) Rivers: Forms and processes in alluvial channels. Balckburn Press.
4. Bryirely and Fryirs (2005) Geomorphology and river management. Blackwell Pub.,
5. Julien, P.Y. (2002) River Mechanics. Cambridge University Press.
6. Robert, A. (2003) River Processes: An introduction to fluvial dynamics. Arnold Publications.
7. Vanoni, V.A. (2006) Sedimentation Engineering. ASCE Manual, Published y American Society of
Civil Engineering,
8. Tinkler, K.J., Wohl, E.E. (eds.) 1998. Rivers over rock. American Geophyscial UnionMonogrpah,
Washington, DC.

GEOHDSE502BT4: Surveying and Mapping
Course, DSE2 (THEORY) (End sem 48+ Insem 12) Marks: 60 48 Hours

Objectives: Main objective is to impart knowledge on various field based techniques- surveying, mapping and profile sections. Aims on the study of their principles, their history and development, instrument and techniques and their applications.

Unit 1: Principles of Survey (L: 8) 8 **classes (Marks: 15)**

History of development of surveying, applications of surveying in the field of planning and development, revenue collection, territorial demarcation, cartography, geography, exploration, geology and engineering. Great Trigonometric Survey of India, Indian surveying agencies.
Concept of Geodetic and Plan Survey: Datum, Control Points, Horizontal and Vertical Controls, Geoid: topo surface, geodetic surface, ellipsoidal surface and its significance in maps, Azimuth and bearing. Triangulation and Traversing.

Unit 2: Surveying and Levelling (L: 10) 15 **classes (Marks: 20)**

Compass, Chain and Plane Table Surveying.Electronic Distance Measurement System.Theodolite and Total Stations.Global Positioning System and its use in surveying.

Level, Types of levels and Methods of Levelling: direct method, trigonometrical method, differential leveling, reciprocal method, barometric method

Contouring from leveling: triangular intersection method, DEM, Digital TIN

Application of surveying in construction of dam, tunnel, road, bridge, building and artificial islands
Application of surveying in Geological Mapping and Sampling

Unit 3: Mapping (L: 10) 10 **classes (Marks: 15)**
Cartography and history of development of cartography, application of cartography
Concept of scale and projection
Types of maps on the basis of scale, projection and application

Methods of Geological Mapping: direct method, indirect method, map modification, reconnaissance, detail and regional scale maps, Descipline and information specific geological maps

Map elements, symbols, plotting and reproduction
Use of modern tools and techniques for preparation of maps

Unit 4: Profile Section **(L: 4)** 4 **classes (Marks: 10)**

Drawing of geological profile sections, exaggeration, Arc and Kink Methods of profile drawing, drawing of profile from geological map, construction of 3D model from geological map

GEOHDSE502BP2 : Surveying and Mapping
Course, DSE2 (PRACTICAL) (End sem 32+ Insem 8) Marks: 40 24 Hours

Use of compass, chain, tape and plane table for plane surveying
Use of GPS and GIS for surveying and mapping
Construction of Geological Maps
Geological Map Problems
Construction of Geological Profile Sections form map and traverse sections

SUGGESTED READINGS:

1. Surveying and Leveling by N.N. Basak.
2. Surveying and Leveling by Rangawala.
3. Barnes, J.W. 4th Edition, Basic Geological Mapping.

6th Sem
Core Courses

GEOH601T4 : ECONOMIC GEOLOGY, COAL AND PETROLEUM
Course, C13 (THEORY) (End sem 48+ In sem 12) Marks: 60 48 Hours

Objectives: Economic geology is the study of the formation and extraction of earth materials that have economic potential in the society. It helps us to understand the genesis, occurrences and distribution of mineral resources and its uses a raw material in mineral based industries.

Unit 1: Introduction to Economic Geology **(L: 3) 3classes (Marks: 3)**

- Economic minerals, ores and gangues, tenor and grades. Resources and reserves. Structure and texture of ore deposits: Concordant and discordant ore bodies.

Unit 2: Ore genesis **(L: 10) 10classes (Marks: 20)**

- Mineral occurrences. Processes of formation of ore deposits: Endogenous processes: Magmatic concentration, skarns, greisens, and hydrothermal deposits. Exogenous processes: weathering products and residual deposits, oxidation and supergene enrichment, placer deposits.

Unit 3: Mineral exploration **(L: 6) 6classes (Marks: 10)**

- Exploration and exploitation techniques. Remote Sensing, Geophysical and Geochemical Explorations. Geological mapping at different scales, drilling, borehole logs and transverse sections. Reserve estimation.

Unit 4: Metallic and Nonmetallic ores **(L: 6) 6classes (Marks: 10)**

- Metallogenic provinces and epochs. Important deposits of India including atomic minerals. Non-metallic and industrial rocks and minerals, in India. General idea about Gemstones.

Unit 5: Coal **(L: 5) 5classes (Marks: 7)**

- Origin and occurrence of coal. Chemical and Physical properties of coal. Proximate and ultimate composition, calorific value. Rank & Grade of coal.
- Distribution of coal in India with special reference to NE India.
- Coal Bed Methane (CBM)

Unit 6: Petroleum **(L: 6) 6classes (Marks: 10)**

- General idea about Petroleum: crude oil, natural gas. Physical properties and chemical composition. Introduction to gas hydrates, shale gas, bituminous shale or shale oil.
- Introduction to source rocks, reservoir rocks and cap rocks, origin, migration and entrapment of petroleum.
- Oil-Gas bearing territories of India with special reference of NE India.

GEOH601P2 : ECONOMIC GEOLOGY, COAL AND PETROLEUM
Course, C13 (PRACTICAL) (End sem 32+ Insem 8) Marks: 40 24Hours
Hours

Practical 1: Megascopic identification of Economic Minerals
Practical 2: Study of microscopic properties of ore minerals/ reservoir rock slides/ source rock slides
Practical 3: Ore reserve estimation by using extended, included and channel method of estimation
Practical 4: Preparation of maps: Distribution of important ores and other economic minerals in India.

SUGGESTED READINGS:

1. Guilbert, J.M. and Park Jr., C.F. (1986) The Geology of Ore deposits. Freeman & Co.
2. Bateman, A.M. and Jensen, M.L. (1990) Economic Mineral Deposits. John Wiley.
3. Evans, A.M. (1993) Ore Geology and Industrial minerals. Wiley
4. Laurence Robb. (2005) Introduction to ore forming processes. Wiley.
5. Gokhale, K.V.G.K. and Rao, T.C. (1978) Ore deposits of India their distribution and processing,
Tata-McGraw Hill, New Delhi.
6. Deb, S. (1980) Industrial minerals and rocks of India. Allied Publishers.
7. Sarkar, S.C. and Gupta, A. (2014) Crustal Evolution and Metallogeny in India. Cambridge Publications.
8. Leverson, A.L. (2006) Geology of Petroleum.

GEOH602T4: REMOTE SENSING, GIS AND GPS
Course, C14 (THEORY) (End sem 48+ In sem 12) Marks: 60 48 Hours

Objectives: Remote sensing is the acquisition of information about an object or phenomenon without making physical contact with them. Remote sensing and GIS are used as tools for geological investigation and various other purposes.

Unit 1: Photo geology (L: 8) 8classes (Marks: 8)

- Introduction to Photo geology: definition, types and acquisition of aerial photographs; scale and resolution; principles of stereoscopy, relief displacement, vertical exaggeration and distortion.
- Elements of air photo interpretation: identification of sedimentary, igneous and metamorphic rocks and various aeolian, glacial, fluvial and marine landforms

Unit 2: Remote Sensing (L: 12) 12classes (Marks: 25)

- Concepts in Remote Sensing: definition, applications, sensors and scanners, satellites and their characteristics, data formats- raster and vector.
- Digital Image Processing, Image Errors, Rectification and Restoration, FCC, Image Enhancement, Filtering, Image Rationing, Image classification and accuracy assessment.
- Digital Elevation Models: General idea and their applications.

Unit 3: Geographic Information System (L: 13) 13classes (Marks: 20)

- Geographic Information System. Components of GIS, working mechanism of GIS,
- GIS Data types: Raster and Vector Data, Point Data, Line Data, Polygonal Data. Datum, Coordinate systems and Projection systems. Georeferencing. Spatial data models and data editing.
- Introduction to DEM analysis: contouring, shade analyses, slope analyses and profiling.

Unit 4: GPS (L: 5) 5classes (Marks: 7)

- General idea about of Global Positioning System (GPS) and GLONASS. Indian Regional Navigation Satellite System (IRNSS) and Indian Navigation System NAVIC.
- General idea about use of digital navigational systems.

GEOH602P2: REMOTE SENSING, GIS AND GPS
Course, C14 (PRACTICAL) (End sem 32+ Insem 8) Marks: 40 24Hours

Practical 1: Aerial Photo/Satellite Imagery interpretation, identification of sedimentary, igneous and metamorphic rocks and various aeolian, glacial, fluvial and marine landforms

Practical 2: DEM analysis: generating slope map, aspect map and drainage network map andits applications

Practical 3: GPS mapping

SUGGESTED READINGS:

1. Demers, M.N., 1997. *Fundamentals of Geographic Information System*, John Wiley & sons. Inc.
2. Hoffmann-Wellenhof, B., Lichtenegger, H. and Collins, J., 2001. *GPS: Theory & Practice*, Springer Wien New York.
3. Jensen, J.R., 1996. *Introductory Digital Image Processing: A Remote Sensing Perspective*, Springer- Verlag.
4. Lillesand, T. M. & Kiefer, R.W., 2007. *Remote Sensing and Image Interpretation*, Wiley.
5. Richards, J.A. and Jia, X., 1999. *Remote Sensing Digital Image Analysis*, Springer-Verlag.

6th Sem
Department Specific Electives (DSE)

GEOHDSE601AT4 : Introduction to Geophysics
Course, DSE3 (THEORY) (End sem 48+ Insem 12) Marks: 60 48 Hours

Objectives: Use of the physics in understanding the geodynamic features of the earth. Aims to study different types of the geophysical methods, integrated geophysical methods its anomalies and application.

Unit 1: Geology and Geophysics (L: 4) 4classes (Marks: 6)
Interrelationship between geology and geophysics, Role of geological and geophysical data in explaining geodynamical features of the earth.

Unit 2: General and Exploration geophysics (L: 8) 8classes (Marks: 15)
Different types of geophysical methods - gravity, magnetic, electrical and seismic; their principles and applications
Concepts and Usage of corrections in geophysical data

Unit 3: Geophysical field operations (L: 6) 6classes (Marks: 15)
Different types of surveys, grid and route surveys, profiling and sounding techniques,
Scales of survey, Presentation of geophysical data

Unit 4: Application of Geophysical methods (L:3) 3classes (Marks: 15)
Regional geophysics, oil and gas geophysics, ore geophysics, groundwater geophysics, engineering geophysics

Unit 5: Geophysical anomalies (L: 3) 3classes (Marks: 5)
Correction to measured quantities, geophysical, anomaly, regional and residual (local) anomalies, factors controlling anomaly, and depth of exploration

Unit 6: Integrated geophysical methods (L: 3) 3classes (Marks: 4)
Ambiguities in geophysical interpretation, planning and execution of geophysical surveys

GEOHDSE601AP2 : Introduction to Geophysics
Course, DSE3 (PRACTICAL) (End sem 32+ Insem 8) Marks: 40 24Hours

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

SUGGESTED READINGS:

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

GEOHDSE601BT4: Geology of North East India
Course, DSE3 (THEORY) (End sem 48+ Insem 12) Marks: 60 48 Hours

Objectives: Aims to impart the knowledge about the Geology of the North east India, its physiographical and stratigraphical overview, understanding of the different geological features, occurrences of different economic minerals, seismic and flood associated hazards and disasters.

Unit 1: Physiographical Overview (L: 6) 6classes (Marks: 10)

Physiography of North-East India: Brahmaputra Plain, Sikkim-Arunachal Himalaya, Mishmi Hills, Naga-Patkai Range, Manipur Plain, Tripura-Cachar Belt, Meghalaya Plateau and Mikir Hills.
Major drainage systems of North-East India.Tectonic framework of North-East India and its control in physiographical development.

Unit 2: Stratigraphical Overview (L: 8) 8classes (Marks: 15)

Stratigraphical units of North-East India: Archean, Proterozoic, Precambrian-Paleozoic rocks of Arunachal Pradesh, Sikkim and Arunachal Himalayas, Lower Gondwana Group, Cretaceous Alkaline-Carbonatite Complexes of Northeast India, Permian-Mesozoic volcanics, Late Mesozoic Ophiolites, Ophiolite Suite of Nagaland – Manipur, Cretaceous sediments of Meghalaya, Tertiary of Northeast India, Recent-Quaternary Sediments.

Unit 3: Geological Features (L: 15) 15classes (Marks: 15)

Indo-Eurassian Collision and Accretion: ITSZ, Higher and Lesser Himalayan Crystalline Nappe and Windows, activation of MCT and MBT, Gondwana, Permian Volcanics, formation of Sub-Himalayas and activation of MFT.Eastern Himalayan Syntaxis (EHS), Po Chu Fault,Jialifaul, BameTutinFault,Lohit Thrust, Mishmi Thrust, Tidding suture.

Indo-Myanmar Collision and Accretion: Indo-Myanmar range and its relation to Andaman Nicobar Arc System, Naga and Disang Thrust System, Ophiolite zone of Nagaland and Manipur, Palaeogene fold belt, Surma basin, Termination of Oceanic Pelagic Sedimentation and development of Disang-Barail-Surma.

Brahmaputra and Meghalaya Plateau: Brahmaputra valley, basement faulting and high, Oldham fault, Dauki fault, Kopili Lineament, Dhansiri Valley. Arakan-Yoma Folded Belt.

Unit 4: Economic Significance **(L: 3) 3classes (Marks: 10)**

Mineral Resources of: Assam, Meghalaya, Arunachal Pradesh, Nagaland, Mizoram, Tripura, Manipur and Sikkim. Petroliferous basins of Assam and Nagaland.

Unit 5: Natural hazards and disasters **(L: 3) 3classes (Marks: 10)**

Past major earthquakes of North East India and assessment of disaster. Calamity caused by floods in last decayed and their sources.

GEOHDSE601BP2 : Geology of North East India
Course, DSE3 (PRACTICAL) (End sem 32+ Insem 8) Marks: 40 24Hours

Study of geological maps of North-East India
Preparation of Mineral resource map of North-East India
Study of geological structures of important oil fields of Assam
Study of tectonic map of different areas of North-East India

SUGGESTED READINGS:

1. Geology of Arunachal Pradesh by Gopendra Kumar.
2. Geology of Assam by A.K. Biswas and A.B. Dasgupta.
3. Geodynamics of North East India and adjoining regions By D.R. Nandy

GEOHDSE602AT4: Earth and Climate
Course, DSE4 (THEORY) (End sem 48+ Insem 12) Marks: 60 48 Hours

Objectives: Aims in study of the earth, its heat budget, its climate, atmosphere and hydrosphere and their changes through time and it effects and responses produce by the biosphere.

Unit 1: Climate system: Forcing and Responses **(L: 8) 8classes (Marks: 15)**

Components of the climate system
Climate forcing, Climate controlling factors
Climate system response, response rates and interactions within the climate system
Feedbacks in climate system

Unit 2: Heat budget of Earth **(L: 6) 6classes (Marks: 10)**

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

Unit 3: Atmosphere – Hydrosphere **(L: 6) 8classes (Marks: 10)**
Layering of atmosphere and atmospheric Circulation
Atmosphere and ocean interaction and its effect on climate
Heat transfer in ocean
Global oceanic conveyor belt and its control on earth's climate
Surface and deep circulation
Sea ice and glacial ice

Unit 4: Response of biosphere to Earth's climate **(L: 6) 8classes (Marks: 10)**
Climate Change: natural vs. anthropogenic effects
Humans and climate change
Future perspectives
Brief introduction to archives of climate change
Archive based climate change data from the Indian continent

Unit 5: Orbital cyclicity and climate **(L: 6) 8classes (Marks: 10)**
Milankovitch cycles and variability in the climate
Glacial-interglacial stages
The Last Glacial maximum (LGM)
Pleistocene Glacial-Interglacial cycles
Younger Dryas
Marine isotope stages

Unit 6: Monsoon **(L: 4) 4classes (Marks: 5)**
Mechanism of monsoon
Monsoonal variation through time
Factors associated with monsoonal intensity
Effects of monsoon

GEOHDSE602AP2 : Earth and Climate
Course, DSE4 (PRACTICAL) (End sem 32+ Insem 8) Marks: 40 24Hours

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

SUGGESTED READINGS:

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

GEOHDSE602BT4 : Evolution of life through time
Course, DSE4 (THEORY) (End sem 48+ Insem 12) Marks: 60 48 Hours

Objectives: Deals in the study of the life through geological time- their origin, evolution in the past up to the age of the humans.

Unit 1: Life through ages **(L: 6) 6classes (Marks: 7)**
Fossils and chemical remains of ancient life.
Geological Time Scale with emphasis on major bio-events.
Fossilization processes and modes of fossil preservation.
Exceptional preservation sites- age and fauna

Unit 2: Geobiology **(L: 6) 6classes (Marks: 8)**

Biosphere as a system, processes and products
Biogeochemical cycles
Abundance and diversity of microbes, extremophiles
Microbes-mineral interactions, microbial mats

Unit 3: Origin of life **(L: 6) 8classes (Marks: 15)**

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

Unit 4: Paleozoic Life **(L: 4) 4classes (Marks: 7)**

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

Unit 5: Mesozoic Life **(L: 5) 6classes (Marks: 8)**

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

Unit 6: Cenozoic Life **(L: 5) 6classes (Marks: 10)**

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

Unit 7: The age of humans **(L: 4) 4classes (Marks: 5)**

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

GEOHDSE602BP2 : Evolution of life through time
Course, DSE4 (PRACTICAL) (End sem 32+ Insem 8) Marks: 40 24Hours

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

SUGGESTED READINGS:

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