PRESCRIBED SYLLABUS

FOR CBCS

GEOLOGY HONOURS

SEMESTER-WISE COURSES

Submitted to

ডিব্রুগড় বিশ্ববিদ্যালয়
Dibrugarh University

Submitted by
Department of Applied Geology, Dibrugarh University

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

Semester	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	

GENERAL STRUCTURE: CORE COURSES (14Courses)

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

General Structure:Skill EnhancementCourse - SEC (2 Courses) (As per recommendations)

Semester	Paper Structure	Papers available for selection
III	**SEC 1 (2c)**	• Basic Field Training (Option 1) • Geological Mapping (Option 2) • Economic Geology Fieldwork (Option 3) • Himalayan Geology Fieldwork (Option 4)
IV	**SEC 2 (2c)**	• Precambrian Geology Fieldwork (Option 1) • Visit to Engineering Project Sites (Option 2) • Stratigraphy and Paleontology Fieldwork (Option 3) • Project Work (Option 4)

General Structure:Discipline Specific Elective - DSE (4 Courses)

Semester	Paper	Papers available for selection
V	**DSE – 1**	1. Exploration Geology (Option 1) 2. Fuel Geology (Option 2)
	DSE – 2	3. River Science (Option 1) 4. Surveying &Mapping (Option 2)
VI	**DSE – 3**	5. Introduction to Geophysics (Option 1) 6. Geology of North-East India (Option 2)
	DSE – 4	7. Earth and Climate (Option 1) 8. Evolution of life through time (Option 2)

General Structure: Generic Elective - GE (4 Courses)

Semester	Paper	Papers available for selection
I	**GE – 1**	1. Introduction to Geology (Option 1) 2. Rocks and Minerals (Option 2) 3. Physics and Chemistry of Earth (Option 3)
II	**GE – 2**	4. Palaeontology (Option 1) 5. Earth Resources (Option 2) 6. Earth Surface Processes (Option 3)
III	**GE – 3**	7. Structural Geology and Tectonics (Option 1) 8. Fossils and their Applications (Option 2) 9. Martian Geology (Option 3)
IV	**GE – 4**	10. Geomorphology, Remote Sensing & GIS (Option 1) 11. Soils: Present and Past (Option 2) 12. Studies on Cryosphere (Option 3)

SEMESTER WISE 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	GEOH101T4 GEOH101P2	AECC1						GE-1	GEOHGE101AT4 GEOHGE101AP2 GEOHGE101BT4 GEOHGE101BP2 GEOHGE101CT4 GEOHGE101CP2
	C2	GEOH102T4 GEOH102P2	AECC2							
2	C3	GEOH201T4 GEOH201P2	AECC3						GE-2	GEOHGE201AT4 GEOHGE201AP2 GEOHGE201BT4 GEOHGE201BP2 GEOHGE201CT4 GEOHGE201CP2
	C4	GEOH202T4 GEOH202P2								
3	C5	GEOH301T4 GEOH301P2			SEC1	GEOHSEC301AT2 GEOHSEC301BT2 GEOHSEC301CT2 GEOHSEC301DT2			GE-3	GEOHGE301AT4 GEOHGE301AP2 GEOHGE301BT4 GEOHGE301BP2 GEOHGE301CT4 GEOHGE301CP2
	C6	GEOH302T4 GEOH302P2								
	C7	GEOH303T4 GEOH303P2								
4	C8	GEOH401T4 GEOH401P2			SEC2	GEOHSEC401AT2 GEOHSEC401BT2 GEOHSEC401CT2 GEOHSEC401DT2			GE4	GEOHGE401AT4 GEOHGE401AP2 GEOHGE401BT4 GEOHGE401BP2 GEOHGE401CT4 GEOHGE401CP2
	C9	GEOH402T4 GEOH402P2								
	C10	GEOH403T4 GEOH403P2								
5	C11	GEOH501T4 GEOH501P2					DSE 1	GEOHDSE501AT4 GEOHDSE501AP2 GEOHDSE501BT4 GEOHDSE501BP2		
	C12	GEOH502T4 GEOH502P2					DSE 2	GEOHDSE502AT4 GEOHDSE502AP2 GEOHDSE502BT4 GEOHDSE502BP2		
6	C13	GEOH601T4 GEOH601P2					DSE 3	GEOHDSE601AT4 GEOHDSE601AP2 GEOHDSE601BT4 GEOHDSE601BP2		
	C14	GEOH602T4 GEOH602P2					DSE 4	GEOHDSE602AT4 GEOHDSE602AP2 GEOHDSE602BT4 GEOHDSE602BP2		

1st SEMESTER (B.Sc. Honours Geology)

SEM	Course	Paper code	Title of the Course	Credit			Marks Distribution				
							Theory		Practical		
				Th	Prac	Total	End Sem	In-Sem	End Sem	In-Sem	Total
1st	C1	GEOH101T4 (Theory)	Earth System Science	4		6	48	12			100
		GEOH101P2 (Practical)			2				32	8	
	C2	GEOH102T4 (Theory)	Crystallography and Mineralogy	4		6	48	12			100
		GEOH102P2 (Practical)			2				32	8	
	GE-1	GEOHGE101AT4 (Theory)	Introduction to Geology	4		6	48	12			100
		GEOHGE101AP2 (Practical)			2				32	8	
		GEOHGE101BT4 (Theory)	Rocks and Minerals	4			48	12			
		GEOHGE101BP2 (Practical)			2				32	8	
		GEOHGE101CT4 (Theory)	Physics and Chemistry Of Earth	4			48	12			
		GEOHGE101CP2 (Practical)			2				32	8	
		Total				18					300

2nd SEMESTER (B.Sc. Honours Geology)

SEM	Course	Paper code	Title of the Course	Credit			Marks Distribution				
							Theory		Practical		
				Th	Prac	Total	End Sem	In- Sem	End Sem	In- Sem	Total
2ND	C3	GEOH201T4 (Theory)	Geochemistry & Optical Mineralogy	4		6	48	12			100
		GEOH201P2 (Practical)			2				32	8	
	C4	GEOH202T4 (Theory)	Structural Geology & Tectonics	4		6	48	12			100
		GEOH202P2 (Practical)			2				32	8	
	GE-2	GEOHGE201AT4 (Theory)	Palaeontology	4		6	48	12			100
		GEOHGE201AP2 (Practical)			2				32	8	
		GEOHGE201BT4 (Theory)	Earth Resources	4			48	12			
		GEOHGE201BP2 (Practical)			2				32	8	
		GEOHGE201CT4 (Theory)	Earth Surface Processes	4			48	12			
		GEOHGE201CP2 (Practical)			2				32	8	
		Total				18					300

3rd SEMESTER (B.Sc. Honours Geology)

SEM	Course	Paper code	Title of the Course	Credit			Marks Distribution				
							Theory		Practical		
				Th	Prac	Total	End Sem	In-Sem	End Sem	In-Sem	Total
3RD	C5	GEOH301T4 (Theory)	Igneous Petrology	4		6	48	12			100
		GEOH301P2 (Practical)			2				32	8	
	C6	GEOH302T4 (Theory)	Sedimentary Petrology	4		6	48	12			100
		GEOH302P2 (Practical)			2				32	8	
	C7	GEOH303T4 (Theory)	Metamorphic Petrology	4		6	48	12			100
		GEOH303P2 (Practical)			2				32	8	
	GE-3	GEOHGE301AT4 (Theory)	Structural Geology & Tectonics	4		6	48	12			100
		GEOHGE301AP2 (Practical)			2				32	8	
		GEOHGE301BT4 (Theory)	Fossils and Their Applications	4			48	12			
		GEOHGE301BP2 (Practical)			2				32	8	
		GEOHGE301CT4 (Theory)	Martian Geology	4			48	12			
		GEOHGE301CP2 (Practical)			2				32	8	
	SEC-1	GEOHSEC301AT2	Basic Field Training	2		2	24	6			30
		GEOHSEC301BT2	Geological Mapping	2			24	6			
		GEOHSEC301CT2	Economic Geology Fieldwork	2			24	6			
		GEOHSEC301DT2	Himalayan Geology Fieldwork	2			24	6			
		Total				26					430

4th SEMESTER (B.Sc. Honours Geology)

SEM	Course	Paper code	Title of the Course	Credit			Marks Distribution				
							Theory		Practical		
				Th	Prac	Total	End Sem	In-Sem	End Sem	In-Sem	Total
4TH	C8	GEOH401T4 (Theory)	Palaeontology	4		6	48	12			100
		GEOH401P2 (Practical)			2				32	8	
	C9	GEOH402T4 (Theory)	Stratigraphic Principles And Indian Stratigraphy	4		6	48	12			100
		GEOH402P2 (Practical)			2				32	8	
	C10	GEOH403T4 (Theory)	Hydrogeology & Oceanography	4		6	48	12			100
		GEOH403P2 (Practical)			2				32	8	
	GE-4	GEOHGE401AT4 (Theory)	Geomorphology, Remote Sensing & GIS	4		6	48	12			100
		GEOHGE401AP2 (Practical)			2				32	8	
		GEOHGE401BT4 (Theory)	Soil: Present & Past	4			48	12			
		GEOHGE401BP2 (Practical)			2				32	8	
		GEOHGE401CT4 (Theory)	Studies on Cryosphere	4			48	12			
		GEOHGE401CP2 (Practical)			2				32	8	
	SEC-2	GEOHSEC401AT2	Precambrian Geology Field Work	2		2	24	6			30
		GEOHSEC401BT2	Visit to engineering Project Sites	2			24	6			
		GEOHSEC401CT2	Stratigraphy & Palaeontology Field Work	2			24	6			
		GEOHSEC401DT2	Project Work	2			24	6			
		Total				26					430

5th SEMESTER (B.Sc. Honours Geology)

sem	Course	Paper code	Title of the Course	Credit			Marks Distribution				
							Theory		Practical		Total
				Th	Prac	Total	End Sem	In- Sem	End Sem	In- Sem	
5TH	C11	GEOH501T4 (Theory)	Survying and Engineering Geology	4		6	48	12			100
		GEOH501P2 (Practical)			2				32	8	
	C12	GEOH502T4 (Theory)	Geomorphology	4		6	48	12			100
		GEOH502P2 (Practical)			2				32	8	
	DSE-1	GEOHDSE501AT4 (Theory)	Exploration Geology	4		6	48	12			100
		GEOHDSE501AP2 (Practical)									
		GEOHDSE501BT4 (Theory)	Fuel Geology		2				32	8	
		GEOHDSE501BP2 (Practical)									
	DSE-2	GEOHDSE502AT4 (Theory)	River Science	4		6	48	12			100
		GEOHDSE502AP2 (Practical)									
		GEOHDSE502BT4 (Theory)	Surveying & Mapping		2				32	8	
		GEOHDSE502BP2 (Practical)									
		Total				24					400

6th SEMESTER (B.Sc. Honours Geology)

sem	Course	Paper code	Title of the Course	Credit			Marks Distribution				
							Theory		Practical		Total
				Th	Prac	Total	End Sem	In- Sem	End Sem	In- Sem	
6TH	C13	GEOH601T4 (Theory)	Economic Geology: Coal & Petroleum	4		6	48	12			100
		GEOH601P2 (Practical)			2				32	8	
	C14	GEOH602T4 (Theory)	Remote Sensing, GIS & GPS	4		6	48	12			100
		GEOH602P2 (Practical)			2				32	8	
	DSE-1	GEOHDSE601AT4 (Theory)	Introduction to Geophysics	4		6	48	12			100
		GEOHDSE601AP2 (Practical)									
		GEOHDSE601BT4 (Theory)	Geology of NE India		2				32	8	
		GEOHDSE601BP2 (Practical)									
	DSE-2	GEOHDSE602AT4 (Theory)	Earth & Climate	4		6	48	12			100
		GEOHDSE602AP2 (Practical)									
		GEOHDSE602BT4 (Theory)	Evolution of life Through time		2				32	8	
		GEOHDSE602BP2 (Practical)									
		Total				24					400

1st Semester: Geology
Core Course: C-1: Earth System Science
Total Mark: 100 (60Th+40Pr), Total Credit: 6 (4 Th + 2 Pr)

C1: GEOH101T4: Earth System Science (Theory)
Credit 4: Marks 60 (End-sem 48+ In-sem 12) 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: 8)

- 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: 10)

- 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.

C1: GEOH101P2: Earth System Science (Practical)
Credit 2: Marks 40 (End-sem 32+ In-sem 8) 24 Hours

Practical 1: Study of major geomorphic features from physiographical models. **(6 Marks)**
Practical 2: Study of topographic sheets/contour maps and description of physiography. **(6 Marks)**
Practical 3: Study of soil profile of any specific area. **(4 Marks)**
Practical 4: Study of earthquake and volcanic belts of the world. **(6 Marks)**
Practical 5: Study of major ocean currents of the World. **(6 Marks)**
Note Book **(2 Marks)**
Viva Voce **(2 Marks)**

SUGGESTED READINGS

1. Brian J. Skinner, B. J. & Porter, S. C.: (2012).*The Blue Planet: An Introduction to Earth System Science*. John Wiley & Sons. Inc.
2. Thompson G.R.R., Turk J. (1997) *Introduction to Physical Geology*. Brooks Cole.
3. Tarbuck, E. J. &Lutgens, F. K. (1998). *Earth: An Introduction to Physical Geology*. Pearson
4. Charles, C. P., Carlson, D., &Mcgeary, D. (2009) *Physical Geology*. McGraw-Hill Higher Education
5. Duff, P. M. D., & Duff, D. (Eds.). (1993). *Holmes' principles of physical geology*. Taylor &Francis.
6. Emiliani, C. (1992). *Planet earth: cosmology, geology, and the evolution of life and environment*.Cambridge University Press.

1st Semester: Geology
Core Course: C-2: Crystallography and Mineralogy
Total Mark: 100 (60 Th +40 Pr), Total Credit: 6 (4 Th + 2 Pr)

C2: GEOH102T4: Crystallography and Mineralogy (Theory)
Credit 4: Marks 60 (End-sem 48+ In-sem 12) 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: 20)

- 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: 28)

- 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.

C2: GEOH102P2: Crystallography and Mineralogy (Practical)

Credit 2: Marks 40 (End-sem 32+ In-sem 8) 24 Hours

Practical 1: Identification of crystal models.**(7 Marks)**
Practical 2: Study of crystals and symmetry elements of crystal-models. **(7 Marks)**
Practical 3: Stereographic projections of crystal models of different systems. **(7 Marks)**
Practical 4: Study and identification of minerals in hand specimen. **(7 Marks)**
Note Book **(2 Marks)**
Viva Voce **(2 Marks)**

SUGGESTED READINGS:

1. Perkins, D. (2015). *Mineralogy*. Pearson Education India.
1. Klein, C., Dutrow, B., Dwight, J., & Klein, C. (2007). *The 23rd Edition of the Manual of MineralScience* (after James D. Dana). J. Wiley & Sons.
2. Deer, W. A., Howie, R. A., &Zussman, J. (1992). *An introduction to the rock-formingminerals* (Vol. 696). London: Longman.
3. Gribble, C. D. (2005). *Rutley's Elements of Mineralogy*. CBS.
4. Mason & Berry (2004). *Mineralogy*. CBS.
5. Rabindra, H. N. (2012). *Practical Approach to Crystallography and Mineralogy*. CBS.
6. Sands, D. E. (1994). *Introduction to Crystallography*. Dover Publications Inc.
7. Schwarzenbach, D. (1997). *Crystallography*. Willey.

1st Semester: Geology
Generic Elective: GE-1: Introduction to Geology
Total Mark: 100 (60+40), Total Credit: 6 (4 Th + 2 Pr)

GE1: GEOHGE101AT4: Introduction to Geology (Theory)
Credit 4: Marks 60 (End-sem 48+ In-sem 12) 48 Hours

Objectives: *The Science of geology is dedicated for the study of earth and deals with all the features of earth's surface along with their origin, composition, structure and inhabitants of the earth.*

Unit 1: Solar System and Earth

(L: 3 T: 1) 4 classes (Marks: 8)

- Solar system, planets, earth and moon, planetary orbital and rotational characteristics of earth, gravity, magnetic field, theories of origin, age of earth, evolution of life on earth. Interior of the Earth: core, mantle and crust.

Unit 2: Principles of Geology

(L: 3 T: 1) 4 classes (Marks: 6)

- Various branches of geology, minerals and rocks, rock forming minerals, igneous, metamorphic and sedimentary rocks and minerals.
- Uniformitarianism, actualism, catastrophism
- Rock cycle

Unit 3: Earth's Exogenic Processes

(L: 5 T: 1) 6 classes (Marks: 10)

- Activities of running water, wind, gravity, ice and sea waves, rock weathering and erosion, soil profile and classification, geomorphic environments associated with fluvial, glacial, coastal, volcanic and desertic environments, physiographical divisions of Indian subcontinent.

Unit 4: Earth's Dynamics &Edogenic Processes

(L: 5 T: 1) 6 classes (Marks: 8)

- Concept of plate tectonics, sea-floor spreading and continental drift, mid oceanic ridges and transform faults volcanic and island arcs,trenches,origin of oceans, continents, mountains and rift valleys and earthquake belts.

Unit 5: Genesis of Rock

(L: 5 T: 1) 6 classes (Marks: 8)

- Volcanoes: types, types of lava and lava flow
- Magma: composition, physical and chemical properties of magma, intrusive igneous bodies
- Sedimentary environment, clastic and non-clastic.
- Metamorphism, metamorphic rocks, metasomatism.

Unit 5: Introduction to Paleontology

(L: 5 T: 1) 6 classes (Marks: 8)

- Brief idea about palaeontology, palynology, palaeobotany and palaeozoology
- Fossils, fossil taxonomy and nomenclature, modes of preservation of fossils, types of fossil. Application of fossil in geological science.

GE1: GEOHGE101AP2: Introduction to Geology (Practical)
Credit 2: Marks 40 (End-sem 32+ In-sem 8) 24 Hours

- Study of minerals in hand specimen: quartz, feldspar, mica, olivine, amphibole, gypsum, calcite**(10 Marks)**
- Study of rocks in hands specimen: sandstone, shale, limestone, rhyolite, basalt, granite, gabbro, gneiss, schist, marble **(10 Marks)**
- Study of geomorphic models**(4 Marks)**
- Study of Geological maps**(4 Marks)**
- Note Book **(2 Marks)**
- Viva Voce **(2 Marks)**

SUGGESTED READINGS:

1. Thompson G.R.R., Turk J. (1997) *Introduction to Physical Geology*. Brooks Cole.
2. Tarbuck, E. J. &Lutgens, F. K. (1998). *Earth: An Introduction to Physical Geology*. Pearson
3. Duff, P. M. D., & Duff, D. (Eds.). (1993). *Holmes' principles of physical geology*. Taylor &Francis.
4. Emiliani, C. (1992). *Planet earth: cosmology, geology, and the evolution of life and environment*. Cambridge University Press.

1st Semester: Geology
Generic Elective: GE-1: Rocks and Minerals
Total Mark: 100 (60+40), Total Credit: 6 (4 Th + 2 Pr)

GE1: GEOHGE101BT4: Rocks and Minerals (Theory)
Credit 4: Marks 60 (End-sem 48+ In-sem 12) 48 Hours

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: **(L: 4 T:1) 5classes (Marks: 7)**

- Minerals-Definitions, Physical properties of minerals
- Mineralogical structure of earth, planetary minerals and native elements

Unit 2: **(L: 4 T:1) 5classes (Marks: 8)**

- Mineral structures
- Mineralogy of the Earth's crust, mantle and core

Unit 3: **(L:13 T:2) 5classes (Marks: 8)**

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

Unit 4: **(L:18 T:2) 20classes (Marks: 25)**

- Rocks- Definitions and types, Basics of rock formation.
- Igneous rock- magma generation and differentiation
- Sedimentary rocks- surface processes and sedimentary environments
- Metamorphic rocks- chemical system and types of metamorphism
- Rock cycle-interactions between plate tectonics and climate systems

GE1: GEOHGE101BP2: Rocks and Minerals (Practical)
Credit 2: Marks 40 (End-sem 32+ In-sem 8) 24 Hours

1. Study of physical properties of minerals**(4 Marks)**
2. Introduction to optical microscopy**(2 Marks)**
3. Study of optical properties of minerals**(4 Marks)**
4. Study of physical properties of rocks**(4 Marks)**
5. Study of optical properties of rock under thin sections**(4 Marks)**
6. Understanding crystal symmetry via wooden models**(2 Marks)**
7. Stereographic projection of mineral faces**(2 Marks)**
8. Mineral formula calculation**(2 Marks)**
9. Crystal chemical calculation**(2 Marks)**
10. Introduction to analytical techniques for rock and mineral study. **(2 Marks)**
11. Note Book **(2 Marks)**
12. Viva Voce **(2 Marks)**

SUGGESTED READINGS:

1. Ehlers & Blatt. (1999). *Petrology, Igneous, Sedimentary, Metamorphic*. CBS.
2. Winter. (2015). *Principles of Igneous and Metamorphic Petrology*. Pearson Education India
3. Perkins, D. (2015). *Mineralogy*. Pearson Education India.
4. Earth Materials- Introduction to Mineralogy and Petrology, Cornelis Klein and Anthony Philpotts,
5. Cambridge University Press, 2013.
6. Understanding Earth (Sixth Edition), John Grotzinger and Thomas H. Jordan, 2010, W.H. Freeman andcompany, New York.

1st Semester: Geology
Generic Elective: GE-1: Physics and Chemistry of Earth
Total Mark: 100 (60+40), Total Credit: 6 (4 Th + 2 Pr)

GE1: GEOHGE101CT4: Physics and Chemistry of Earth (Theory)
Credit 4: Marks 60 (End-sem 48+ In-sem 12) 48 Hours

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

Unit 2: **(L: 7 T: 1) 8classes (Marks: 10)**
Earth's interior - variation of physical quantities and seismic wave velocity inside the earth, majorsub divisions and discontinuities.
Concepts of Isostasy; Airy and Pratt Model
Core: Seismological and other geophysical constraints
The geodynamo - Convection in the mantle

Unit 3: **(L: 5 T: 1) 6classes (Marks: 8)**
Elements of earth's magnetism.
Secular variation and westward drift
Solar activity and magnetic disturbance

Unit 4: **(L: 9 T: 1)10classes (Marks: 15)**
Elements: Origin of elements/nucleosynthesis.
Abundance of the elements in the solar system / planet earth
Geochemical classification of elements.
Earth accretion and early differentiation
Isotopes and their applications in understanding Earth processes.
Stable isotopes: Stable isotope fractionation. Oxygen isotopes
Sublithospheric Mantle (Mineralogy/phase transitions)

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

GE1: GEOHGE101CP2: Physics and Chemistry of Earth (Practical)
Credit 2: Marks 40 (End-sem 32+ In-sem 8) 24 Hours

1. Projection of major elements on binary and triangular diagrams for rock classification. **(6 Marks)**
2. Projection of major element data on Harker's diagram to characterize magmatic differentiation. **(6 Marks)**
3. Study of trace elements through a) Projection of chondrite/primitive normalized trace elements tocharacterize sources b) Projection of trace elements on tectonic discrimination diagrams. **(6 Marks)**
4. Understanding Earth structure through behavior of seismic wave propagation. **(6 Marks)**
5. Problems on isostasy.**(4 Marks)**
6. Note Book **(2 Marks)**
7. Viva Voce **(2 Marks)**

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.
8. Brady, P.V. (1996). The Physics and Chemistry of Mineral Surfaces. Taylor & Francis Us.
9. K. H. Wedepohl (1969). Handbook of Geochemistry. Springer.
10. Montgomery, C. W. (2017). Environmental Geology. McGraw Hill Education.

2nd Semester: Geology
Core Course: C-3: Geochemistry & Optical Mineralogy
Total Mark: 100 (60+40), Total Credit: 6 (4 Th + 2 Pr)

C3: GEOH201T4: Geochemistry & Optical Mineralogy (Theory)
Credit 4: Marks 60 (End-sem 48+ In-sem 12) 48 Hours

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: 8)

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: 8)

- 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: 8)

- 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: 12)

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: 12)

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.

C3: GEOH201P2: Geochemistry & Optical Mineralogy (Practical)
Credit 2: Marks 40 (End-sem 32+ In-sem 8) 24 Hours

Practical 1: Identification and understanding of different parts of petrological microscope.
(10 Marks)

Practical 2: Identification of rock-forming minerals under petrological microscope.
(10 Marks)

Practical 3: Study of interference figure and determination of optic signs from minerals.
(8 Marks)

Note Book **(2 Marks)**
Viva Voce **(2 Marks)**

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.
6. Verma, P. K. (2010). *Optical Mineralogy (Four Colour)*. Ane Books Pvt Ltd.
7. Rabindra, H. N. (2012). Practical Approach to Crystallography and Mineralogy. CBS.

2nd Semester: Geology
Core Course: C-4: Structural Geology and Tectonics
Total Mark: 100 (60+40), Total Credit: 6 (4 Th + 2 Pr)

C4: GEOH202T4: Structural Geology and Tectonics (Theory)
Credit 4: Marks 60 (End-sem 48+ In-sem 12) 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 Structuresand 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: 8)
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: 15)

- 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.

C4: GEOH202P2: Structural Geology and Tectonics (Practical)
Credit 2: Marks 40 (End-sem 32+ In-sem 8) 24 Hours

Practical 1: Use of clinometer and Brunton compass for structural measurements. **(4 Marks)**
Practical 2: Study of contour maps, structural maps and sub-surface graphical problems. **(10 Marks)**
Practical 3: Three point structural problems and structural projections. **(7 Marks)**
Practical 4: Reconstruction of structure from given profiles. **(7 Marks)**
Note Book **(2 Marks)**
Viva Voce **(2 Marks)**

SUGGESTED READINGS:

1. Fossen, H. (2016). Structural Geology. Cambridge University Press
2. Davis, G. R. (1984). Structural Geology of Rocks and Region. John Wiley
3. Billings, M. P. (1987). Structural Geology, 4th edition, Prentice-Hall.
4. Park, R. G. (2004). Foundations of Structural Geology.Chapman& Hall.
5. Pollard, D. D. (2005). Fundamental of Structural Geology. Cambridge University Press.
6. Ragan, D. M. (2009). Structural Geology: an introduction to geometrical techniques (4th Ed).Cambridge University Press (For Practical).
7. Kearey, P., Klepeis, K. A. & Vine, F. J (2011). Global Tectonics. Wiley
8. Molnar, P. (2015). Plate Tectonics: A Very Short Introduction (Very Short Introductions). Oxford.

2nd Semester: Geology
Generic Elective: GE-2: Palaeontology
Total Mark: 100 (60+40), Total Credit: 6 (4 Th + 2 Pr)

GE 2: GEOHGE201AT4: Palaeontology (Theory)
Credit 4: Marks 60 (End-sem 48+ In-sem 12) 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:

(L: 28 T: 2) 30 *classes* (Mark 5)

Palaeontology: definition, branches, allied subjects, scopes and applications of palaeontology. Fossil: definition, types, process of fossilization, mode of preservation

Unit 2:

(L: 28 T: 2) 30 *classes* (Mark 10)

Nomenclature of fossil: two fold system of nomenclature, types of specimens (Prototype, Neotype, Lectotype etc.)Taxonomy and Species concept: Species concept with special reference to paleontology, Taxonomic hierarchy Theory of organic evolution interpreted from fossil record

Unit 3:

(L: 28 T: 2) 30 *classes* (Mark 8)

Vertebrate fossils: Palaeozoic and Mesozoic vertebrate organisms, origin diversity and extinction of dinosaurs. Evolution of horse, Human evolution.

Unit 4:

(L: 28 T: 2) 30 *classes* (Mark 10)

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

Unit 5:

(L: 28 T: 2) 30 *classes* (Mark 5)

Gondwana Flora of India.

Unit 6:

(L: 28 T: 2) 30 *classes* (Mark 10)

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

GE 2: GEOHGE201AP2: Paleontology (Practical)
Credit 2: Marks 40 (End-sem 32+ In-sem 8) 24 Hours

Practical 1: Study of fossils showing various modes of preservation**(10 Marks)**

Practical 2: Study of diagnostic morphological characters, systematic position, stratigraphic position and age of various invertebrate, vertebrate and plant fossils. **(18 Marks)**

Note Book **(2 Marks)**
Viva Voce **(2 Marks)**

SUGGESTED READINGS

1. Jain &Anantharaman (2016). PalaeontologyPalaeobiology.Vishal Publishing Co.
2. Benton , M. (2014). Vertebrate Palaeontology 4th Edition. Wiley-Blackwell
3. Raup, D. M., Stanley, S. M., Freeman, W. H. (1971) Principles of Paleontology
4. Clarkson, E. N. K. (2012) Invertebrate paleontology and evolution 4th Edition by BlackwellPublishing.
5. Benton, M. (2009). Vertebrate paleontology. John Wiley & Sons.
6. Shukla, A. C., &Misra, S. P. (1975). Essentials of paleobotany. Vikas Publisher
7. Armstrong, H. A., &Brasier, M.D. (2005) Microfossils. Blackwell Publishing.

2nd Semester: Geology
Generic Elective: GE-2: Earth Resources
Total Mark: 100 (60+40), Total Credit: 6 (4 Th + 2 Pr)

GE2: GEOHGE201BT4: Earth Resources (Theory)
Credit 4: Marks 60 (End-sem 48+ In-sem 12) 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: 8)**

- 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: 10)

- 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: 15)

- 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: 15)

- 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.

GE2: GEOHGE201BP2: Earth Resources (Practical)
Credit 2: Marks 40 (End-sem 32+ In-sem 8) 24 Hours

1. Plotting of major Indian oil fields on map of India**(6 Marks)**

2. Problems related to hydroelectric power generation**(6 Marks)**

3. Problems related to assessment of possible oil exploration site from geological maps **(6 Marks)**
4. Problems related to energy demand projection of India and possible mitigation pathways **(6 Marks)**
5. Problems related to biofuel**(4 Marks)**

6. Note Book **(2 Marks)**
7. Viva Voce **(2 Marks)**

SUGGESTED READINGS:

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

2nd Semester: Geology
Generic Elective: GE-2: Earth Surface Processes
Total Mark: 100 (60+40), Total Credit: 6 (4 Th + 2 Pr)

GE2: GEOHGE201CT4: Earth Surface Processes (Theory)
Credit 4: Marks 60 (End-sem 48+ In-sem 12) 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: 5)

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: 10)

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 inriver 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: 8)

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

Unit 4: Controlling factors (tectonics, climate, sea level changes and anthropogenic) and surfaceProcesses

(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 affectsIntroduction 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 planetarygeomorphology.

GE2: GEOHGE201CP2: Earth Surface Processes (Practical)
Credit 2: Marks 40 (End-sem 32+ In-sem 8) 24 Hours

- Mapping of different landforms and interpretation of surface processes**(10 Marks)**
- Exercises on hill slope development, fluvial channel, sediment erosion and transport, sediment budgeting,aggradation and degradation events, drainage basin, drainage morphometry**(10 Marks)**
- Basic exercises on computation of rate for different surface processes**(8 Marks)**
- Note Book **(2 Marks)**
- Viva Voce **(2 Marks)**

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,* PearsonEducation.
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: Geology
Core Course: C-5: Igneous Petrology
Total Mark: 100 (60+40), Total Credit: 6 (4 Th + 2 Pr)

C5: GEOH301T4: Igneous Petrology (Theory)
Credit 4: Marks 60 (End-sem 48+ In-sem 12) 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.*

Unit 1: Introduction to Igneous petrology

(L: 3) 3classes (Marks: 5)

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

Unit 2: Magma & Lava

(L: 4) 4classes (Marks: 7)

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: 8)

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: 8)

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: 5)

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: 15)

- 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), Plg-Px-Ol (plutonic rocks), 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.

C5: GEOH301P2: Igneous Petrology (Practical)
Credit 2: Marks 40 (End-sem 32+ In-sem 8) 24 Hours

Practical 1: Study of igneous rocks in hand specimens.**(7 Marks)**

Practical 2: Study of igneous rocks in thin section. **(7 Marks)**

Practical 3: Study of texture in thin sections and hand specimens. **(7 Marks)**

Practical 4: Study of phase diagrams to understand melts composition and crystallization. **(7 Marks)**

Note Book **(2 Marks)**
Viva Voce **(2 Marks)**

SUGGESTED READINGS:

1. Philpotts, A., & Ague, J. (2009). Principles of igneous and metamorphic petrology. CambridgeUniversity 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.
6. McBirney, A. R. (1984). Igneous Petrology. San Francisco (Freeman, Cooper & Company) andOxford (Oxford Univ. Press),
7. Myron G. Best (2001). Igneous and Metamorphic Petrology,
8. K. G. Cox, J. D. Bell. (1979). The Interpretation of Igneous Rocks. Springer/Chapman & Hall.
9. Bose M.K. (1997). Igneous Petrology.
10. G W Tyrrell. (1926). Principles of Petrology. Springer

3rd Semester: Geology
Core Course: C-6: Sedimentary Petrology
Total Mark: 100 (60+40), Total Credit: 6 (4 Th + 2 Pr)

C6: GEOH302T4: Sedimentary Petrology (Theory)
Credit 4: Marks 60 (End-sem 48+ In-sem 12) 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: 8)

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: 5)

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

Unit 4: Processes of formation of sedimentary rocks

(L:9 T:1)10classes (Marks: 15)

- 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.

C6: GEOH302P2: Sedimentary Petrology (Practical)
Credit 2: Marks 40 (End-sem 32+ In-sem 8) 24 Hours

Practical 1: Study of sedimentary rocks in hand specimens.**(7 Marks)**
Practical 2: Study of sedimentary rocks in thin sections.**(7 Marks)**
Practical 3: Study of texture in thin sections and hand specimens.**(7 Marks)**
Practical 4: General overview on depositional conditions and provenance from the study of framework, cement and matrix of given sedimentary rock in thin sections.
(7 Marks)

Note Book **(2 Marks)**
Viva Voce **(2 Marks)**

SUGGESTED READINGS

1. Boggs, S. (2004). Petrology of Sedimentary Rocks 2nd Edition. Cambridge University Press.
2. Sengupta, S.M. (2007). Introduction to Sedimentology. CBS.
3. Prothero, D. R., & Schwab, F. (2004). Sedimentary geology. Macmillan.
4. Tucker, M. E. (2006) Sedimenary Petrology, Blackwell Publishing.
5. Collinson, J. D. & Thompson, D. B. (1988) Sedimentary structures, Unwin- Hyman, London.
6. Nichols, G. (2009) Sedimentology and Stratigraphy Second Edition. Wiley Blackwell

3rd Semester: Geology
Core Course: C-7: Metamorphic Petrology
Total Mark: 100 (60+40), Total Credit: 6 (4 Th + 2 Pr)

C7: GEOH303T4: Metamorphic Petrology (Theory)
Credit 4: Marks 60 (End-sem 48+ In-sem 12) 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: 10)

- 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: 5)

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

Unit 5: Descriptive Metamorphic Petrology

(L:9 T:1) 10 classes (Marks: 8)

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

C7: GEOH303P2: Metamorphic Petrology (Practical)
Credit 2: Marks 40 (End-sem 32+ In-sem 8) 24 Hours

Practical 1: Study of metamorphic rocks in hand specimens.**(7 Marks)**
Practical 2: Study of metamorphic rocks in thin sections.**(7 Marks)**
Practical 3: Study of texture in thin section and hand specimens.**(7 Marks)**
Practical 4: Study of metamorphic phase diagrams.**(7 Marks)**
Note Book **(2 Marks)**
Viva Voce **(2 Marks)**

SUGGESTED READINGS:

1. Philpotts, A., & Ague, J. (2009). *Principles of igneous and metamorphic petrology*. CambridgeUniversity Press.
2. Winter, J. D. (2014). *Principles of igneous and metamorphic petrology*. Pearson.
3. Rollinson, H. R. (2014). *Using geochemical data: evaluation, presentation, interpretation*.
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: Geology
Generic Elective: GE-3: Structural Geology and Tectonics
Total Mark: 100 (60+40), Total Credit: 6 (4 Th + 2 Pr)

GE3: GEOHGE301AT4: Structural Geology and Tectonics (Theory)
Credit 4: Marks 60 (End-sem 48+ In-sem 12) 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 learned through this subject. Structural geology also helps to understand the geodynamics of regional to global dimension.*

Unit 1: Structural Geology

(L: 18 T: 2) 20 *classes* (Marks: 30)

- Deformation in rocks: stress and strain in rocks, type of stress and strain, strain ellipses,
- Effects of topography on structural features, topographic and structural maps; importance representative factors of the map, concept of planar and linear structures; dip and strike;
- Study of components, morphology, classification and occurrences of deformational features: fold, joint-fracture, faults, lineation and foliation
- Role of structural features for the development of typical topographical landscapes, economic mineral reserves and in accumulation of oil and natural gas

Unit 2: Tectonics

(L: 14 T: 1) 15 *classes* (Marks: 18)

- Concept of tectonic plates, continental and oceanic crust, boundaries between lithosphere and mantle, divergent, convergent and transform plate boundaries, important features associated with different plate boundaries
- Theories of development of concept of plate tectonics, continental drifting, formation of ocean
- Role of tectonic activities in rock deformation, development of structural features and typical landforms,

GE3: GEOHGE301AP2: Structural Geology and Tectonics (Practical)
Credit 2: Marks 40 (End-sem 32+ In-sem 8) 24 Hours

Practical 1: study of structural maps**(7 Marks)**
Practical 2: use of compass**(7 Marks)**
Practical 3: 3 point problems of structural geology**(7 Marks)**
Practical 4: stereo projections of beds, fold, fault, lineation etc. **(7 Marks)**
Note Book **(2 Marks)**
Viva Voce **(2 Marks)**

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

3rd Semester: Geology
Generic Elective: GE-3: Fossils and Their Applications
Total Mark: 100 (60+40), Total Credit: 6 (4 Th + 2 Pr)

GE3: GEOHGE301BT4: Fossils and Their Applications (Theory)
Credit 4: Marks 60 (End-sem 48+ In-sem 12) 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)6 classes (Marks: 8)

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 samplingtechniques.

Unit 2: Species concept

(L:5 T:1) 6 classes (Marks: 10)

Definition of species, species problem in paleontology, speciation, methods of description and naming offossils, code of systematic nomenclature

Unit 3: Introduction to various fossils groups

(L:10 T:2) 12 classes (Marks: 10)

Brief introduction of important fossils groups: invertebrate, vertebrate, microfossils, spore, pollensandplant fossils. Important age-diagnostic fossiliferous horizons of India.

Unit 4: Application of fossils

(L: 6) 6 Classes (Marks: 10)

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

Unit 5: Societal importance of fossils

(L: 5) 5 classes (Marks: 10)

Implication of larger benthic and micropaleontology in hydrocarbon exploration: identificationofreservoirs and their correlation. Application of spore and pollens in correlation of coal seams, spore andpollens as indicator of thermal maturity of hydrocarbons reservoirs, fossils associated with mineraldeposits, fossils as an indicator of pollution.

GE3: GEOHGE301BP2: Fossils and Their Applications (Practical)
Credit 2: Marks 40 (End-sem 32+ In-sem 8) 24 Hours

1. Study of fossils showing various modes of fossilization**(10 Marks)**

2. Distribution of age diagnostic fossils in India**(10 Marks)**

3.Biostratigraphic correlation**(8 Marks)**

4. Note Book **(2 Marks)**
5.Viva Voce **(2 Marks)**

SUGGESTED READINGS:

1. Schoch, R.M. 1989. Stratigraphy, Principles and Methods.VanNostrand Reinhold.
2. Clarkson, E.N.K.1998. Invertebrate Paleontology and Evolution George AlIen&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.

3rd Semester: Geology
Generic Elective: GE-3: Martian Geology
Total Mark: 100 (60+40), Total Credit: 6 (4 Th + 2 Pr)

GE3: GEOHGE301CT4: Martian Geology (Theory)
Credit 4: Marks 60 (End-sem 48+ In-sem 12) 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) 4 Classes (Marks: 8)

History of the exploration of Mars; The Journey of Mangalyaan
Evolution of Mars

Unit 2:

(L: 6) 6 Classes (Marks: 10)

The characteristics of Mars and its interior.
The Martian atmosphere and hydrosphere.

Unit 3:

(L: 10 T: 2) 12 Classes (Marks: 10)

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

Unit 4:

(L: 6) 6 Classes (Marks: 10)

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

Unit 5: Life in Mars

(L:6 T:1) 7 Classes (Marks: 10)

Is there evidence for life on Mars?
Physical and chemical conditions supportive of permanent Mars occupation; Terraforming of Mars and itschallenges
New Trends for Human Missions to Mars and Human colonization of Mars

GE3: GEOHGE301CP2: Martian Geology (Practical)
Credit 2: Marks 40 (End-sem 32+ In-sem 8) 24 Hours

The course will also include discussions on topics determined by students in Tutorial. There would be 4 student presentations apart from the lectures. The topics would be assigned to students based ontheir interest.

4 Presentation **(5 x 4 = 28 Marks)**
4 Reports **(2 x 4 = 8 Marks)**
Viva Voce **(2 Marks)**

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 Marswarm 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 Semester: Geology
Skill Enhancement Course: SEC-1: Basic Field Training
Total Mark: 30, Total Credit: 2

SEC1: GEOHSEC301AT2: Basic Field Training
Credit 4: Marks 30 (End-sem 24+ In-sem 6) 24 Hours

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

Unit 1:

(L: 4) 4 Classes (Marks: 4)

Orientation of Topographic sheet in field, marking location in toposheet, Bearing (Front andback). Concepts of map reading, Distance, height and pace approximation

Unit 2:

(L: 6) 6 Classes (Marks: 8)

Identification of rock types in field; structures and texture of rocks, Use of hand lens.

Unit 3:

(L: 6) 6 Classes (Marks: 8)

Basic field measurement techniques: Bedding dip and strike, Litholog measurement.

Unit 4:

(L: 2) 2 Classes (Marks: 4)

Reading contours and topography.

SUGGESTED READINGS

1. Mathur, S.M (2001). Guide to Field Geology. Prentice Hall India Learning Private Limited.
2. Gokhale, N.W. (2009). A Guide to Field Geology. CBS.
3. Lahee, F.H. 1916. Field Geology.
4. Compton, R.R, 1985. Geology in the Field.

3rd Semester: Geology
Skill Enhancement Course: SEC-1: Geological Mapping
Total Mark: 30, Total Credit: 2

SEC1: GEOHSEC301BT2: Geological Mapping
Credit 4: Marks 30 (End-sem 24+ In-sem 6) 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:

(L: 6) 6 Classes (Marks: 6)

Geological mapping, stratigraphic correlation

Unit 2:

(L: 4) 4 Classes (Marks: 6)

Primary (scalars and vectors) and secondary structures (linear and planar)

Unit 3:

(L: 4) 4 Classes (Marks: 6)

Trend, plunge, Rake/Pitch

Unit 4:

(L: 5) 5 Classes (Marks: 6)

Stereoplots of linear and planar structures, Orientation analyses

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.
4. Mathur, S.M (2001). Guide to Field Geology. Prentice Hall India Learning Private Limited.
5. Gokhale, N.W. (2009). A Guide to Field Geology. CBS.

3rd Semester: Geology
Skill Enhancement Course: SEC-1: Economic Geology Fieldwork
Total Mark: 30, Total Credit: 2

SEC1: GEOHSEC301CT2: Economic Geology Fieldwork
Credit 4: Marks 30 (End-sem 24+ In-sem 6) 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:

(L: 2) 2 field classes (Marks: 2)

Visit to any mineral deposit

Unit 2:

(L: 2) 2 field classes (Marks: 2)

Mode occurrence of ore, Ore mineralogy

Unit 3:

(L: 2) 2 field classes (Marks: 2)

Ore-Host rock interrelation

Unit 4:

(L: 2) 2 field classes (Marks: 4)

Ore formation process

Unit 5:

(L: 2) 2 Classes (Marks: 2)

Basic techniques of surveying, concept of outcrop mapping

Module 2

Unit 1:

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

Visit to underground or open cast mine

Unit 2:

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

Practical experience of mining methods

Unit 3:

(L: 2) 2 Classes (Marks: 3)

Underground mapping/ Bench mapping

Unit 4:

(L: 2) 2 Classes (Marks: 3)

Isopach and Isochore maps

SUGGESTED READINGS

1. Tiwari S.K. 1993. Ore Geology, Economic Minerals and Mineral Economics.Atlantic.
2. Umathay, R M, 2002.Textbook of Mining Geology. Dattsons

3rd Semester: Geology
Skill Enhancement Course: SEC-1: Himalayan Geology Fieldwork
Total Mark: 30, Total Credit: 2

SEC1: GEOHSEC301DT2: Himalayan Geology Fieldwork
Credit 4: Marks 30 (End-sem 24+ In-sem 6) 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.*

Unit 1:

(L: 18) 18 field classes (Marks: 24)

Identification and characterization of major structural boundaries in Himalaya viz. MBT, MFT etc.

Or

(L: 18) 18 field classes (Marks: 24)

Field along any suitable transect of Himalayan foreland

Or

(L: 18) 18 field classes (Marks: 24)

Field transect in Siwalik

Or

(L: 18) 18 field classes (Marks: 24)

Identification of Himalayan and pre-Himalayan elements

SUGGESTED READING

1. Kumar, G. 1997, Geology of Arunachal Pradesh.
2. Lahee, F.H. 1916, Field Geology.
3. Geological Map of Western Himalaya, 1992 by V.C. Thakur & B.S. Rawat. WIHG.
4. The Siwalik Foreland Basin,(Dehra Dun – Nahan Sector), (WIHG Spl. Publ. 1,1991) by Rohtash Kumar and Others. WIHG.

4th Semester: Geology
Core Course: C-8: Paleontology
Total Mark: 100 (60+40), Total Credit: 6 (4 Th + 2 Pr)

C8: GEOH401T4: Paleontology (Theory)
Credit 4: Marks 60 (End-sem 48+ In-sem 12) 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: 8)

- 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: 8)

- 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: 10)

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: 5)

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

Unit 6: Application of Fossils (L: 4)4classes (Marks: 7)

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.

C8: GEOH401P2: Paleontology (Practical)
Credit 2: Marks 40 (End-sem 32+ In-sem 8) 24 Hours

Practical 1: Study of fossils showing various modes of preservation.**(10 Marks)**
Practical 2: Study of diagnostic morphological characters, systematic position, stratigraphic position and age of various invertebrate, vertebrate and plant fossils.**(18 Marks)**
Note Book **(2 Marks)**
Viva Voce **(2 Marks)**

SUGGESTED READINGS

1. Jain &Anantharaman (2016). PalaeontologyPalaeobiology.Vishal Publishing Co.
2. Benton , M. (2014). Vertebrate Palaeontology 4th Edition. Wiley-Blackwell
3. Raup, D. M., Stanley, S. M., Freeman, W. H. (1971) Principles of Paleontology
4. Clarkson, E. N. K. (2012) Invertebrate paleontology and evolution 4th Edition by BlackwellPublishing.
5. Benton, M. (2009). Vertebrate paleontology. John Wiley & Sons.
6. Shukla, A. C., &Misra, S. P. (1975). Essentials of paleobotany. Vikas Publisher
7. Armstrong, H. A., &Brasier, M.D. (2005) Microfossils. Blackwell Publishing.

4th Semester: Geology
Core Course: C-9: Stratigraphic Principles and Indian Stratigraphy
Total Mark: 100 (60+40), Total Credit: 6 (4 Th + 2 Pr)

C9: GEOH402T4: Stratigraphic Principles and Indian Stratigraphy (Theory)
Credit 4: Marks 60 (End-sem 48+ In-sem 12) 48 Hours

Objectives: ***T****he 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: 14)

- 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: 14)

- 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: 20)

- 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.

C9: GEOH402P2: Stratigraphic Principles and Indian Stratigraphy (Practical)
Credit 2: Marks 40 (End-sem 32+ In-sem 8) 24 Hours

Practical 1: Study of geological map of India and identification of major stratigraphic units. **(7 Marks)**
Practical 2: Study of rocks in hand specimens from known Indian stratigraphic horizons. **(7 Marks)**
Practical 3: Drawing various paleogeographic maps of Precambrian time.**(7 Marks)**
Practical 4: Study of different Proterozoic supercontinent reconstructions.**(7 Marks)**
Note Book **(2 Marks)**
Viva Voce **(2 Marks)**

SUGGESTED READINGS:

1. Kumar, R. (2010). Fundamentals of Historical Geology and Stratigraphy of India. New Age International Publishers Ltd.-New Delhi
2. Boggs, S. (Jr). (2016). Principles of Sedimentology and Stratigraphy. Pearson.
3. Doyle, P. & Bennett, M. R. (1996) Unlocking the Stratigraphic Record. John Wiley
4. Ramakrishnan, M. &Vaidyanadhan, R. (2008) Geology of India Volumes 1 & 2, Geologicalsociety of India, Bangalore.
5. Valdiya, K. S. (2010). The making of India, Macmillan India Pvt. Ltd.

4th Semester: Geology
Core Course: C-10: Hydrogeology and Oceanography
Total Mark: 100 (60+40), Total Credit: 6 (4 Th + 2 Pr)

C10: GEOH403T4: Hydrogeology and Oceanography (Theory)
Credit 4: Marks 60 (End-sem 48+ In-sem 12) 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: 5)
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: 8)
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: 10)
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: 5)**
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: 7)**
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: 5)**
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.

C10: GEOH403P2: Hydrogeology and Oceanography (Practical)
Credit 2: Marks 40 (End-sem 32+ In-sem 8) 24 Hours

Practical 1: Preparation and interpretation of water level contour maps and depth to water level maps.**(7 Marks)**
Practical 2: Study, preparation and analysis of hydrographs for differing groundwater conditions.**(7 Marks)**
Practical 3: Water potential zones of India (map study).**(7 Marks)**
Practical 4: Simple numerical problems related to determination of permeability in field and laboratory, groundwater flow, well hydraulics.**(7 Marks)**
Note Book **(2 Marks)**
Viva Voce **(2 Marks)**

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.
4. Gross,M.G., 1977. *Oceanography: A view of the Earth*, Prentice Hall.

4th Semester: Geology
Generic Elective: GE-4: Geomorphology, Remote Sensing and GIS
Total Mark: 100 (60+40), Total Credit: 6 (4 Th + 2 Pr)

GE4: GEOHGE401AT4: Geomorphology, Remote Sensing and GIS (Theory)
Credit 4: Marks 60 (End-sem 48+ In-sem 12) 48 Hours

Objectives: *Geomorphology is the scientific study of the origin and evolution of landforms and bathymetric features created by physical, chemical or biological processes operating at or near the Earth's surface.*
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: Geomorphology (L: 19 T: 1) 20 *classes* (Marks: 15)

Endogenic and Exogenic processes, geomorphic cycle,
Surficial Processes and geomorphology, Weathering and Erosion, activities of running water, wind, ice, gravity and sea waves, Soil, Soil Profile and its classification. Mass movement and debris flow processes.
Landforms of: Fluvial, Glacial, Aeolian, Coastal and Volcanic Environments.
Overview of Indian Geomorphology

Unit 2: Remote Sensing (L: 9 T: 1) 10 *classes* (Marks: 18)

Photogeology, aerial photographs; scale and resolution, air photo interpretation: identification of sedimentary, igneous and metamorphic rocks and various aeolian, glacial, fluvial and marine landforms
Remote Sensing: definition, applications, sensors and scanners, satellites and their characteristics, data formats- raster and vector, Indian remote sensing satellites, satellite data products
Application of Remote Sensing in Geological Science

Unit 3: Geographical Information System (L: 8 T: 2) 10 *classes* (Marks: 15)

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
General idea about of Global Positioning System (GPS) of America, Indian Regional Navigation Satellite System (IRNSS) and Indian Navigation System NAVIC

GE4: GEOHGE401AP2: Geomorphology, Remote Sensing and GIS (Practical)
Credit 2: Marks 40 (End-sem 32+ In-sem 8) 24 Hours

Practical 1: Study of landforms from given geomorphic model/image/map**(10 Marks)**

Practical 2: Interpretation of aerial photo/satellite image**(14 Marks)**

Practical 3: Use of GPS**(4 Marks)**

Note Book **(2 Marks)**
Viva Voce **(2 Marks)**

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

4th Semester: Geology
Generic Elective: GE-4: Geomorphology, Remote Sensing and GIS
Total Mark: 100 (60+40), Total Credit: 6 (4 Th + 2 Pr)

GE4: GEOHGE401BT4: Soils: Present and Past (Theory)
Credit 4: Marks 60 (End-sem 48+ In-sem 12) 48 Hours

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

Unit 1: **(L: 4 T: 1) 5classes (Marks: 5)**

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

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

General soil forming regimes: Gleization; podzolization; lessivage; ferrallitizatin; calcification;Salinization

Unit 3: **(L: 4) 4classes (Marks: 3)**

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

Unit 4: **(L: 2) 2classes (Marks: 3)**

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

Unit 5: **(L: 2) 2classes (Marks: 3)**

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

Units 6: **(L: 2) 2classes (Marks: 3)**

Introduction to soil taxonomy and paleosol taxonomy

Unit 7: **(L: 2) 2classes (Marks: 3)**

Micromorphology: Thin section analysis of paleosols

Unit 8: **(L: 2) 2classes (Marks: 3)**

Geochemistry: molecular rations; chemical weathering indices

Units 9: **(L: 2) 2classes (Marks: 3)**

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

Unit 10: **(L: 2) 2classes (Marks: 3)**

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

Unit 11: **(L: 2) 2classes (Marks: 3)**

Geological record of fossil soils- Precambrian paleosols- evolution of paleoatmosphericconditions

Unit 12: **(L: 2) 2classes (Marks: 3)**

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

Unit 13: **(L: 2 T:2) 4classes (Marks: 4)**

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

Unit 14: **(L: 2) 2classes (Marks: 3)**

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

Unit 15: **(L: 2) 2classes (Marks: 3)**

Paleosolsand non-marine sequence stratigraphy based on paleopedology and sedimentology offluvial successions.

GE4: GEOHGE401BP2: Soils: Present and Past (Practical)
Credit 2: Marks 40 (End-sem 32+ In-sem 8) 24 Hours

1- Micromorphic detailing of the paleosols- structure, horizonation, color, rhizocretions, pedogeniccarbonate etc.**(6 Marks)**
2- Particle size analysis and clay mineral analysis of the paleosols**(4 Marks)**
3- Micromorphological analysis- thin section preparation, description, and interpretation **(6 Marks)**
4- Geochemical analysis- bulk geochemistry, molecular rations and weathering indices **(6 Marks)**
5- Field trip to examine modern and fossil soils- field characterization and sampling procedures**(6 Marks)**
6- Note Book **(2 Marks)**
7- Viva Voce **(2 Marks)**

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 ThinSection Description. Waine Research Publication, Wolverhampton (152 pp.).
4. Sheldon, N.D., Tabor, N.J. (2009) Quantitative paleoenvironmental and paleoclimaticreconstruction using paleosols. Earth-Science Reviews 95, 1–52.
5. Stoops, G. (2003) Guidelines for analysis and distribution of soil and regolith thin sections. SoilSci. Soc. Am., Madison, Wisconsin, 184 pp.
6. Soil Survey Staff, (2006) Key to Soil Taxonomy, 10th ed. USDA Natural ResourcesConservation Service, Washington D.C.(341 pp.)
7. Bhattacharyya T., Sarkar, D., Pal, D. K. (Eds.) **Soil Survey Manual.** NBSSLUP Publication No146.

4th Semester: Geology
Generic Elective: GE-4: Studies on Cryosphere
Total Mark: 100 (60+40), Total Credit: 6 (4 Th + 2 Pr)

GE4: GEOHGE401CT4: Studies on Cryosphere(Theory)
Credit 4: Marks 60 (End-sem 48+ In-sem 12) 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 (Marks 10)**

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

Unit 2: Terrestrial Cryosphere **(L: 18 T: 2)** 20 **classes (Marks 30)**

Snow formation, Snowfall and Snow cover, Metamorphism of snow, Snow and Remote sensing,Snowmelt modeling, Glacier Characteristics, Types of Glaciers, Erosional and Depositional features ofGlaciers, 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 levelchanges and Ice sheet, Permafrost and its features, Lake and River ice.

Terrestrial Cryosphere in thepresent, past and future.

Unit 3: Marine Cryosphere **(L: 6)** 6 **classes (Marks 8)**

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

GE4: GEOHGE401CP2: Studies on Cryosphere (Practical)
Credit 2: Marks 40 (End-sem 32+ In-sem 8) 24 Hours

1. Linear and non-linear regression algorithms to estimate SWE (snow water equivalent) fromremote sensed data (mainly microwave data)**(7 Marks)**
2. Estimation of precipitation from remote sensed data Snowmelt run-off modeling **(7 Marks)**
3. Empirical (Snow cover to spring snowmelt relation)**(7 Marks)**
4. One of the non-empirical model (Degree-day, modified degree-day or energy balance methods)**(7 Marks)**
5. Note Book **(2 Marks)**
6. Viva Voce **(2 Marks)**

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 MicrowaveRadiometer) sites.

4th Semester: Geology
Skill Enhancement Course: SEC-2: Precambrian Geology Fieldwork
Total Mark: 30, Total Credit: 2

SEC2: GEOHSEC401AT2: Precambrian Geology Fieldwork
Credit 4: Marks 30 (End-sem 24+ In-sem 6) 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: **(L: 2) 2classes (Marks: 6)**
Field transect in any Precambrian terrain

Unit 2: **(L: 4) 4classes (Marks: 6)**
Study of craton ensemble including basic intrusive suites

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

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

SUGGESTED READINGS:

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

4th Semester: Geology
Skill Enhancement Course: SEC-2: Visit to Engineering Project sites
Total Mark: 30, Total Credit: 2

SEC2: GEOHSEC401BT2: Visit to Engineering Project sites
Credit 4: Marks 30 (End-sem 24+ In-sem 6) 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: **(L: 4) (Marks: 4)**
Geological mapping of a project site (Dam sites, Tunnel alignments etc)

Unit 2: **(L: 3) (Marks: 4)**
On site visit & to study various geotechnical aspects related to the project site.

Unit 3: **(L: 2) (Marks: 4)**
Identification of geotechnical problems of a project site and remedial measures to be taken.

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

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

Unit 6: **(L: 2) (Marks: 4)**
Identification of potential suspected/probable sites of Natural Disaster and suggestions about corrective/preventive measures.

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.

4th Semester: Geology
Skill Enhancement Course: SEC-2: Stratigraphy and palaeontology Fieldwork
Total Mark: 30, Total Credit: 2

SEC2: GEOHSEC401CT2: Stratigraphy and palaeontology Fieldwork
Credit 4: Marks 30 (End-sem 24+ In-sem 6) 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: **(L: 4) 4 classes (Marks: 6)**
Field training in Phanerozoic basin of India

Unit 2: **(L: 3) 3 classes (Marks: 4)**
Documentation of stratigraphic details in the field

Unit 3: **(L: 3) 3 classes (Marks: 4)**
Collection of sedimentological, stratigraphic and paleontological details and their representation

Unit 4: **(L: 4) 4 classes (Marks: 6)**
Facies concept and its spatio-temporal relation (Walther's Law) and concept of facies distribution atbasinal-scale

Unit 5: **(L: 3) 3 classes (Marks: 4)**
Fossils sampling techniques and their descriptions

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.

4th Semester: Geology
Skill Enhancement Course: SEC-2: Project Work
Total Mark: 30, Total Credit: 2

SEC2: GEOHSEC401DT2: Project Work
Credit 4: Marks 30 (End-sem 24+ In-sem 6) 24 Hours

Field based / data based geological investigations **(L: 20) (Marks: 24)**

5th Semester: Geology
Core Course: C-11: Surveying and Engineering Geology
Total Mark: 100 (60+40), Total Credit: 6 (4 Th + 2 Pr)

C11: GEOH501T4: Surveying and Engineering Geology (Theory)
Credit 4: Marks 60 (End-sem 48+ In-sem 12) 48 Hours

Objectives: *Surveying andEngineering 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: 8)

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: 10)

Level, Types of levels and Methods of Levelling.

Unit 4: Introduction to Engineering Geology

(L: 4)4 classes (Marks: 8)

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)5 classes (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.

C11: GEOH501P2: Surveying and Engineering Geology (Practical)
Credit 2: Marks 40 (End-sem 32+ In-sem 8) 24 Hours

Practical 1: Use of compass for determining forward, backward bearing and azimuths. **(6 Marks)**

Practical 2: Use of GPS for determining Latitude, Longitude and Elevation values. **(6 Marks)**

Practical 3: Use of chain, compass and plane table for computation of area and length. **(6 Marks)**

Practical 4: Computation of reservoir area, catchment area, reservoir capacity and reservoir life. **(6 Marks)**

Practical 5: Computation of RQD, RMR and 'Q'. **(4 Marks)**

Note Book **(2 Marks)**

Viva Voce **(2 Marks)**

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

5th Semester: Geology
Core Course: C-12: Geomorphology
Total Mark: 100 (60+40), Total Credit: 6 (4 Th + 2 Pr)

C12: GEOH502T4: Geomorphology (Theory)
Credit 4: Marks 60 (End-sem 48+ In-sem 12) 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: 5)

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

Unit 2: Understanding Earth's Physiography

(L: 6)6classes (Marks: 6)

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: 7)

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.

C12: GEOH502P2: Geomorphology (Practical)
Credit 2: Marks 40 (End-sem 32+ In-sem 8) 24 Hours

Practical 1: Study and identification of geomorphic features from image/photo/satellite imagery. **(7 Marks)**
Practical 2: Study and identification of geomorphic features from geomorphic models. **(7 Marks)**
Practical 3: Study and identification of geomorphic features from contour maps.**(7 Marks)**
Practical 4: Drawing of profile and discussion of geomorphic features from topographical maps.**(7 Marks)**
Note Book **(2 Marks)**
Viva Voce **(2 Marks)**

SUGGESTED READINGS:

1. Principles of Geomorphology: by William D. Thornbury
2. Fundamentals of Geomorphology: by Richard Huggett
3. Tectonic Geomorphology: by Douglas W. Burbank and Robert Anderson
4. Robert S. Anderson and Suzzane P. Anderson (2010): Geomorphology - The Mechanics andChemistry of Landscapes. Cambridge University Press.
5. M.A. Summerfield (1991) Global Geomorphology. Wiley & Sons.

5th Semester: Geology
Discipline Specific Elective (DSE) Courses: DSE-1: Oceanography
Total Mark: 100 (60+40), Total Credit: 6 (4 Th + 2 Pr)

DSE-1: GEOHDSE501AT4: Exploration Geology (Theory)
Credit 4: Marks 60 (End-sem 48+ In-sem 12) 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: 10)**

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

Unit 2: Prospecting and Exploration

(L: 8) 8 **classes (Marks: 15)**

Principles of mineral exploration, Prospecting and exploration- conceptualization, methodology andstages, 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: 8)**

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

DSE-1: GEOHDSE501AP2: Exploration Geology (Practical)
Credit 2: Marks 40 (End-sem 32+ In-sem 8) 24 Hours

1. Identification of anomaly**(7 Marks)**
2. Concept of weighted average in anomaly detection**(7 Marks)**
3. Geological cross-section**(7 Marks)**
4. Models of reserve estimation**(7 Marks)**
5. Note Book **(2 Marks)**
6. Viva Voce **(2 Marks)**

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.

5th Semester: Geology
Discipline Specific Elective (DSE) Courses: DSE-1: Fuel Geology
Total Mark: 100 (60+40), Total Credit: 6 (4 Th + 2 Pr)

DSE-1: GEOHDSE501BT4: Fuel Geology (Theory)
Credit 4: Marks 60 (End-sem 48+ In-sem 12) 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: 10)**

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: 8)**

Coal Bed Methane (CBM): global and Indian scenario
Underground coal gasification
Coal liquefaction

Unit 3: Petroleum

(L: 7) 7 **classes (Marks: 10)**

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: 4)**

Gas Hydrate
Nuclear Fuel

DSE-1: GEOHDSE501BP2: Fuel Geology (Practical)
Credit 2: Marks 40 (End-sem 32+ In-sem 8) 24 Hours

1. Study of hand specimens of coal**(7 Marks)**
2. Reserve estimation of coal**(7 Marks)**
3. Section correlation and identification of hydrocarbon prospect**(7 Marks)**
4. Panel and Fence diagrams**(7 Marks)**
5. Note Book **(2 Marks)**
6. Viva Voce **(2 Marks)**

SUGGESTIVE 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.

5th Semester: Geology
Discipline Specific Elective (DSE) Courses: DSE-2: River Science
Total Mark: 100 (60+40), Total Credit: 6 (4 Th + 2 Pr)

DSE-2: GEOHDSE502AT4: River Science (Theory)
Credit 4: Marks 60 (End-sem 48+ In-sem 12) 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: 8)**

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: 8)**

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: 8)**

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: 8)**

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: 6)**

Integrated approach to stream management
Introduction to river ecology.

DSE-2: GEOHDSE502AP2: River Science (Practical)
Credit 4: Marks 40 (End-sem 32+ In-sem 8) 24 Hours

1. Stream power calculation**(10 Marks)**
2. Longitudinal profile analysis**(10 Marks)**
3. Hydrograph analysis and other related problems**(8 Marks)**
4. Note Book **(2 Marks)**
5. Viva Voce **(2 Marks)**

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 GeophyscialUnionMonogrpah, Washington, DC.

5th Semester: Geology
Discipline Specific Elective (DSE) Courses: DSE-2: Surveying and Mapping
Total Mark: 100 (60+40), Total Credit: 6 (4 Th + 2 Pr)

DSE-2: GEOHDSE502BT4: Surveying and Mapping (Theory)
Credit 4: Marks 60 (End-sem 48+ In-sem 12) 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: 10)**

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: 10)**

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: 8)**

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

DSE-2: GEOHDSE502BP2: Surveying and Mapping (Practical)
Credit 2: Marks 40 (End-sem 32+ In-sem 8) 24 Hours

- Use of compass, chain, tape and plane table for plane surveying**(6 Marks)**
- Use of GPS and GIS for surveying and mapping**(4 Marks)**
- Construction of Geological Maps**(6 Marks)**
- Geological Map Problems**(6 Marks)**
- Construction of Geological Profile Sections form map and traverse sections **(6 Marks)**
- Note Book **(2 Marks)**
- Viva Voce **(2 Marks)**

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 Semester: Geology
Core Course: C-13: Economic Geology, Coal and Petroleum
Total Mark: 100 (60+40), Total Credit: 6 (4 Th + 2 Pr)

C13: GEOH601T4: Economic Geology, Coal and Petroleum (Theory)
Credit 4: Marks 60 (End-sem 48+ In-sem 12) 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: 4)

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: 12)

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: 8)

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: 8)

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: 8)

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: 8)

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.

C13: GEOH601P2: Economic Geology, Coal and Petroleum (Practical)
Credit 2: Marks 40 (End-sem 32+ In-sem 8) 24 Hours

Practical 1: Megascopic identification of Economic Minerals **(7 Marks)**

Practical 2: Study of microscopic properties of ore minerals/ reservoir rock slides/ source rock slides**(7 Marks)**

Practical 3: Ore reserve estimation by using extended, included and channel method of estimation**(7 Marks)**

Practical 4: Preparation of maps: Distribution of important ores and other economic minerals in India.**(7 Marks)**

Note Book **(2 Marks)**
Viva Voce **(2 Marks)**

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.
1. Gokhale, K.V.G.K. and Rao, T.C. (1978) Ore deposits of India their distribution and processing. Tata-McGraw Hill, New Delhi.
5. Deb, S. (1980) Industrial minerals and rocks of India. Allied Publishers.
2. Sarkar, S.C. and Gupta, A. (2014) Crustal Evolution and Metallogeny in India. Cambridge Publications.
6. Leverson, A.L. (2006) Geology of Petroleum.

6th Semester: Geology
Core Course: C-14: Remote Sensing, GIS and GPS
Total Mark: 100 (60+40), Total Credit: 6 (4 Th + 2 Pr)

C14: GEOH602T4: Remote Sensing, GIS and GPS (Theory)
Credit 4: Marks 60 (End-sem 48+ In-sem 12) 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: 10)

- 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: 15)

- 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: 15)

- 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: 8)

- 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.

C14: GEOH602P2: Remote Sensing, GIS and GPS (Practical)
Credit 2: Marks 40 (End-sem 32+ In-sem 8) 24 Hours

Practical 1: Aerial Photo/Satellite Imagery interpretation, identification of sedimentary, igneous and metamorphic rocks and various aeolian, glacial, fluvial and marine landforms **(10 Marks)**

Practical 2: DEM analysis: generating slope map, aspect map and drainage network map andits applications**(10 Marks)**

Practical 3: GPS mapping**(8 Marks)**

Note Book **(2 Marks)**

Viva Voce **(2 Marks)**

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 Semester: Geology
Discipline Specific Elective (DSE) Courses: DSE-3: Introduction to Geophysics
Total Mark: 100 (60+40), Total Credit: 6 (4 Th + 2 Pr)

DSE-3: GEOHDSE601AT4: Introduction to Geophysics (Theory)
Credit 4: Marks 60 (End-sem 48+ In-sem 12) 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: 10)

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: 10)

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: 10)

Regional geophysics, oil and gas geophysics, ore geophysics, groundwater geophysics, engineering geophysics

Unit 5: Geophysical anomalies

(L: 3) 3classes (Marks: 6)

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: 6)

Ambiguities in geophysical interpretation, planning and execution of geophysical surveys

DSE-3: GEOHDSE601AP2: Introduction to Geophysics (Practical)
Credit 2: Marks 40 (End-sem 32+ In-sem 8) 24 Hours

Anomaly and background- Graphical method**(10 Marks)**
Study and interpretation of seismic reflector geometry**(10 Marks)**
Problems on gravity anomaly**(8 Marks)**
Note Book **(2 Marks)**
Viva Voce **(2 Marks)**

SUGGESTED READINGS:

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

6th Semester: Geology
Discipline Specific Elective (DSE) Courses: DSE-3: Geology of North East India
Total Mark: 100 (60+40), Total Credit: 6 (4 Th + 2 Pr)

DSE-3: GEOHDSE601BT4: Geology of North East India (Theory)
Credit 4: Marks 60 (End-sem 48+ In-sem 12) 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: 9)

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: 10)

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: 8)

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: 6)

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

DSE-3: GEOHDSE601BP2: Geology of North East India (Practical)
Credit 2: Marks 40 (End-sem 32+ In-sem 8) 24 Hours

Study of geological maps of North-East India**(7 Marks)**

Preparation of Mineral resource map of North-East India**(7 Marks)**

Study of geological structures of important oil fields of Assam**(7 Marks)**

Study of tectonic map of different areas of North-East India**(7 Marks)**

Note Book **(2 Marks)**
Viva Voce **(2 Marks)**

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. Nand

6th Semester: Geology
Discipline Specific Elective (DSE) Courses: DSE-4: Earth and Climate
Total Mark: 100 (60+40), Total Credit: 6 (4 Th + 2 Pr)

DSE-4: GEOHDSE602AT4: Earth and Climate (Theory)
Credit 4: Marks 60 (End-sem 48+ In-sem 12) 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: 8)

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: 8)

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: 8)

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: 8)

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: 6)

Mechanism of monsoon
Monsoonal variation through time
Factors associated with monsoonal intensity
Effects of monsoon

DSE-4: GEOHDSE602AP2: Earth and Climate (Practical)
Credit 2: Marks 40 (End-sem 32+ In-sem 8) 24 Hours

1. Study of distribution of major climatic regimes of India on map**(7 Marks)**
2. Distribution of major wind patterns on World map**(7 Marks)**
3. Preparation of paleogeographic maps (distribution of land and sea) of India during specific geologicaltime intervals**(7 Marks)**
4. Numerical exercises on interpretation of proxy records for paleoclimate**(7 Marks)**
5. Note Book **(2 Marks)**
6. Viva Voce **(2 Marks)**

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

6th Semester: Geology
Discipline Specific Elective (DSE) Courses: DSE-4: Evolution of life through time
Total Mark: 100 (60+40), Total Credit: 6 (4 Th + 2 Pr)

DSE-4: GEOHDSE602BT4: Evolution of life through time (Theory)
Credit 4: Marks 60 (End-sem 48+ In-sem 12) 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: 8)

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: 6)

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: 10)

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: 6)

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: 6)

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: 6)

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: 6)

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

DSE-4: GEOHDSE602BP2: Evolution of Life Through Time (Practical)
Credit 2: Marks 40 (End-sem 32+ In-sem 8) 24 Hours

1. Study of modes of fossil preservation**(8 Marks)**
2. Study of fossils from different stratigraphic levels**(10 Marks)**
3. Exercises related to major evolutionary trends in important groups of animals and plants **(10 Marks)**
4. Note Book **(2 Marks)**
5. Viva Voce **(2 Marks)**

SUGGESTED READINGS:

1. Stanley, S.M., 2008 Earth System History
2. Jonathan I. LumineW.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