

**PRESCRIBED SYLLABUS
FOR CBCS
GEOLOGY HONOURS
SEMESTER-WISE COURSES**

Submitted to



**Submitted by
Department of Applied Geology, Dibrugarh University**

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

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

CORE COURSE (14c) General Structure:

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

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

| Semester | Paper Structure | Papers available for selection |
|----------|-----------------|---|
| III | SEC 1 (2c) | <ul style="list-style-type: none"> • Basic field training) • Geological Mapping) • Economic Geology fieldwork • Himalayan Geology fieldwork |
| IV | SEC 2 (2c) | <ul style="list-style-type: none"> • Precambrian Geology fieldwork • Visit to Engineering Project sites) • Stratigraphy and Paleontology fieldwork <p>PROJECT WORK –VIII</p> |

Elective Discipline Specific DSE (4c)General Structure:

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

Elective Generic GE (4c)General Structure:

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

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

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

1st Sem

| | Course | Paper code | Title of the Course | Credit | | | Marks Distribution | | | | |
|---------------------|----------|----------------|--------------------------------|--------|------|-------|--------------------|---------|-----------|---------|-------|
| | | | | Th | Prac | Total | Theory | | Practical | | Total |
| | | | | | | | End Sem | In- Sem | End Sem | In- Sem | |
| 1 st Sem | C1 | GEOH101T4 | Earth System Science | 4 | | 6 | 48 | 12 | | | 100 |
| | | GEOH101P2 | | | 2 | | | | 32 | 8 | |
| | C2 | GEOH102T4 | Crystallography and Mineralogy | 4 | | 6 | 48 | 12 | | | 100 |
| | | GEOH102P2 | | | 2 | | | | 32 | 8 | |
| | GE 1(6C) | GEOH GE101A T4 | Rocks and Minerals | 4 | | 6 | 48 | 12 | | | 100 |
| | | GEOH GE101A P2 | | | 2 | | | | 32 | 8 | |
| | | GEOH GE101B T4 | PHYSICS AND CHEMISTRY OF EARTH | 4 | | 6 | 48 | 12 | | | 100 |
| | | GEOH GE101BP 2 | | | 2 | | | | 32 | 8 | |
| | | Total | | | | 18 | | | | | 300 |

2nd Sem

| | Course | Paper code | Title of the Course | Credit | | | Marks Distribution | | | | |
|---------------------|----------|----------------|--|--------|------|-------|--------------------|---------|-----------|---------|-------|
| | | | | Th | Prac | Total | Theory | | Practical | | Total |
| | | | | | | | End Sem | In- Sem | End Sem | In- Sem | |
| 2 nd Sem | C3 | GEOH201T4 | Geochemistry & Optical Mineralogy | 4 | | 6 | 48 | 12 | | | 100 |
| | | GEOH201P2 | | | 2 | | | | 32 | 8 | |
| | C4 | GEOH202T4 | Structural Geology and Tectonics | 4 | | 6 | 48 | 12 | | | 100 |
| | | GEOH202P2 | | | 2 | | | | 32 | 8 | |
| | GE2 (6C) | GEOH GE201A T4 | EARTH RESOURCES | 4 | | 6 | 48 | 12 | | | 100 |
| | | GEOH GE201A P2 | | | 2 | | | | 32 | 8 | |
| | | GEOH GE201B T4 | EARTH SURFACE PROCESSES | 4 | | 6 | 48 | 12 | | | 100 |
| | | GEOH GE201BP2 | | | 2 | | | | 32 | 8 | |
| | Total | | | | | 18 | | | | | 300 |
| | | | | | | | | | | | |

3rd Sem

| | Course | Paper code | Title of the Course | Credit | | | Marks Distribution | | | | |
|---------------------|--------|------------|-----------------------|--------|------|-------|--------------------|---------|-----------|---------|-------|
| | | | | Th | Prac | Total | Theory | | Practical | | Total |
| | | | | | | | End Sem | In- Sem | End Sem | In- Sem | |
| 3 rd Sem | C5 | GEOH301T4 | Igneous Petrology | 4 | | 6 | 48 | 12 | | | 100 |
| | | GEOH301P2 | | | 2 | | | | 32 | 8 | |
| | C6 | GEOH302T4 | Sedimentary petrology | 4 | | 6 | 48 | 12 | | | 100 |
| | | GEOH302P2 | | | 2 | | | | 32 | 8 | |
| | C7 | GEOH302T4 | Metamorphic petrology | 4 | | 6 | 48 | 12 | | | 100 |

| | | | | | | | | | | | |
|--|---------------------|----------------------|-----------------------------------|---|---|----|----|----|----|---|-----|
| | | GEOH30 2P2 | | | 2 | | | | 32 | 8 | |
| | GE 3 (6 C) | GEOH GE301A T4 | Fossils and their applications | 4 | | 6 | 48 | 12 | | | 100 |
| | | GEOH GE301A P2 | | | 2 | | | | 32 | 8 | |
| | | GEOH GE301B T4 | Martian Geology | 4 | | 6 | 48 | 12 | | | 100 |
| | | GEOH GE301BP 2 | | | 2 | | | | 32 | 8 | |
| | SE C 1- 2C | GEOHSE C301AT2 | Basic Field Training | 2 | | 2 | 24 | 6 | | | 30 |
| | | GEOHSE C301BT2 | Geological Mapping | 2 | | 2 | 24 | 6 | | | 30 |
| | | GEOHSE C301CT2 | Economic Geology Fieldwork | 2 | | 2 | 24 | 6 | | | 30 |
| | | GEOHSE C301DT2 | Himalayan Geology Fieldwork | 2 | | 2 | 24 | 6 | | | 30 |
| | Total | | | | | 26 | | | | | 430 |
| | | | | | | | | | | | |

4th Sem

| | Co urs e | Paper code | Title of the Course | Credit | | | Marks Distribution | | | | |
|------------|----------------|---------------|--|--------|------|-------|--------------------|---------|------------|------------|-------|
| | | | | Th | Prac | Total | Theory | | Practical | | Total |
| | | | | | | | End Sem | In- Sem | End Sem | In- Sem | |
| 4th Sem | C8 | GEOH40 1T4 | Palaeontology | 4 | | 6 | 48 | 12 | | | 100 |
| | | GEOH40 1P2 | | | 2 | | | | 32 | 8 | |
| | C9 | GEOH40 2T4 | Stratigraphic principles and Indian stratigraphy | 4 | | 6 | 48 | 12 | | | 100 |
| | | GEOH40 2P2 | | | 2 | | | | 32 | 8 | |
| | C1 0 | GEOH40 3T4 | Hydrogeology and Oceanography | 4 | | 6 | 48 | 12 | | | 100 |

| | | | | | | | | | | | |
|--|----------|---------------|---|---|---|----|----|----|----|---|-----|
| | | GEOH403P2 | | | 2 | | | | 32 | 8 | |
| | GE4 (6C) | GEOHGE401AT4 | Soils: Present and past | 4 | | 6 | 48 | 12 | | | 100 |
| | | GEOHGE401AP2 | | | 2 | | | | 32 | 8 | |
| | | GEOHGE401BT4 | Studies on Cryosphere | 4 | | 6 | 48 | 12 | | | 100 |
| | | GEOHGE401BP2 | | | 2 | | | | 32 | 8 | |
| | SEC 2-2C | GEOHSEC401AT2 | Precambrian geology field work | 2 | | 2 | 24 | 6 | | | 30 |
| | | GEOHSEC401BT2 | Visit to engineering project sites | 2 | | 2 | 24 | 6 | | | 30 |
| | | GEOHSEC401CT2 | Stratigraphy and Palaeontology field work | 2 | | 2 | 24 | 6 | | | 30 |
| | | GEOHSEC401DT2 | Project work | 2 | | 2 | 24 | 6 | | | 30 |
| | Total | | | | | 26 | | | | | 430 |
| | | | | | | | | | | | |

5th Semester

| | Cou rse | Paper code | Title of the Course | Credit | | | Marks Distribution | | | | |
|--------------------|------------|---------------|--------------------------------------|--------|------|-------|--------------------|---------|------------|------------|-------|
| | | | | Th | Prac | Total | Theory | | Practical | | Total |
| | | | | | | | End Sem | In- Sem | End Sem | In- Sem | |
| 5t h Se m | C11 | GEOH50 1T4 | Surveying and engineering geology | 4 | | 6 | 48 | 12 | | | 100 |
| | | GEOH50 1P2 | | | 2 | | | | 32 | 8 | |
| | C12 | GEOH50 2T4 | Geomorphology | 4 | | 6 | 48 | 12 | | | 100 |
| | | GEOH50 2P2 | | | | | 2 | | | 32 | |

| | | | | | | | | | | | |
|--|----------------------|-----------------------|--------------------------|---|---|----|----|----|----|---|-----|
| | DS E1 (6C) | GEOH DSE501 AT4 | Exploration Geology | 4 | | 6 | 48 | 12 | | | 100 |
| | | GEOH DSE501 AP2 | | | 2 | | | | 32 | 8 | |
| | | GEOH GE501B T4 | Fuel Geology | 4 | | 6 | 48 | 12 | | | 100 |
| | | GEOH GE501BP 2 | | | 2 | | | | 32 | 8 | |
| | DS E 2(6 C) | GEOH GE502A T4 | River Science | 4 | | 6 | 48 | 12 | | | 100 |
| | | GEOH GE502A P2 | | | 2 | | | | 32 | 8 | |
| | | GEOH GE502B T4 | Surveying and mapping | 4 | | 6 | 48 | 12 | | | 100 |
| | | GEOH GE502BP 2 | | | 2 | | | | 32 | 8 | |
| | Total | | | | | 24 | | | | | 400 |
| | | | | | | | | | | | |

6th Semester

| | Cou rse | Paper code | Title of the Course | Credit | | | Marks Distribution | | | | |
|----------------------------|------------|-----------------------|---|--------|------|-------|--------------------|---------|------------|------------|-------|
| | | | | Th | Prac | Total | Theory | | Practical | | Total |
| | | | | | | | End Sem | In- Sem | End Sem | In- Sem | |
| 6 th Se m | C13 | GEOH60 1T4 | Economic geology: coal and petroleum | 4 | | 6 | 48 | 12 | | | 100 |
| | | GEOH60 1P2 | | | 2 | | | | 32 | 8 | |
| | C14 | GEOH60 2T4 | Remote sensing , GIS and GPS | 4 | | 6 | 48 | 12 | | | 100 |
| | | GEOH60 2P2 | | | 2 | | | | 32 | 8 | |
| | DS E3 | GEOH DSE601 AT4 | Introduction to geophysics | 4 | | | 48 | 12 | | | |

| | | | | | | | | | | |
|--|-----------|-----------------|--------------------------------|---|----|----|----|----|---|-----|
| | (6C) | GEOH DSE601 AP2 | | 2 | 6 | | | 32 | 8 | 100 |
| | | GEOH GE601B T4 | Geology of north east India | 4 | 6 | 48 | 12 | | | 100 |
| | | GEOH GE601BP 2 | | 2 | | | | 32 | 8 | |
| | DSE 4(6C) | GEOH GE602A T4 | Earth and climate | 4 | 6 | 48 | 12 | | | 100 |
| | | GEOH GE602A P2 | | 2 | | | | 32 | 8 | |
| | | GEOH GE602B T4 | Evolution of life through time | 4 | 6 | 48 | 12 | | | 100 |
| | | GEOH GE602BP 2 | | 2 | | | | 32 | 8 | |
| | Total | | | | 24 | | | | | 400 |
| | | | | | | | | | | |

1st Semester Core courses

GEOH101T4: Earth System Science Course, C1 (THEORY)48 hours

Unit 1: Universe and Solar System

5 classes

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

Unit 2: Earth System

10classes

- 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

20classes

- Various branches of geology and relation to other branches of science, concept of seismology.

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

**GEOH101P2 Earth System Science
Course, C1 (PRACTICAL)**

24 Hours

Practical 1: Study of major geomorphic features from physiographical models.

Practical 2: Study of topographic sheets/contour maps and description of physiography.

Practical 3: Study of soil profile of any specific area.

Practical 4: Study of earthquake and volcanic belts of the world.

Practical 5: Study of major ocean currents of the World.

**GEOH102T4 : Crystallography and Mineralogy
Course, C2 (THEORY)**

48 Hours

Unit 1: Crystallography

15classes

- 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

20classes

- Introduction to mineralogy: composition of common rock-forming minerals, silicate and non-silicate structures; CCP and HCP structures.
- Significance of atomic structure in physical properties of minerals, Physical properties of minerals: colour, luster, streak, density, specific gravity and hardness - their definition and varieties with examples. Moh's hardness scale and determination of hardness of minerals.

Cleavage, parting and fracture - their definition and mineral examples. Form and habit of minerals; types, examples and use in identification.

- Physical and chemical properties of some important silicates: Tectosilicates, Phyllosilicates, Inosilicates, Cyclosilicates, Sorosilicates and Orthosilicates; Non-Silicates: Native elements, Sulfides, Oxides, Halides, Sulfate and Phosphate families.

GEOH102P2 : Crystallography and Mineralogy

Course, C2 (PRACTICAL)

24 Hours

Practical 1: Identification of crystal models.

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

Practical 3: Stereographic projections of crystal models of different systems.

Practical 4: Study and identification of minerals in hand specimen.

1st Semester Generic Electives (GE)

**GEOH GE101AT4 Rocks and Minerals
Course GE1**

48Hrs

Unit 1: Minerals-Definitions, Physical properties of minerals
Mineralogical structure of earth, planetary minerals and native elements

5classes

Unit 2: Mineral structures
Mineralogy of the Earth's crust, mantle and core

5classes

Unit 3: Nature of light and principles of optical mineralogy
Optical classification of minerals.
An overview of environmental and radiation mineralogy, biomineralisation and gemology.

5classes

Unit 4: 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

20classes

**GEOH GE101AP2: Rocks and Minerals
Course GE1**

24Hours

1. Study of physical properties of minerals

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

GEOH GE101BT4:): PHYSICS AND CHEMISTRY OF EARTH
Course GE1

48 Hours
35classes

Unit 1: Earth: surface features
 Continents, continental margins, oceans

4classes

Unit 2: Earth's interior - variation of physical quantities and seismic wave velocity inside the earth, major sub divisions and discontinuities.

Concepts of Isostasy; Airy and Pratt Model

Core: Seismological and other geophysical constraints

The geodynamo - Convection in the mantle

8classes

Unit 3: Elements of earth's magnetism.

Secular variation and westward drift

Solar activity and magnetic disturbance

6classes

Unit 4: Elements: Origin of elements/nucleosynthesis.

Abundance of the elements in the solar system / planet earth

Geochemical classification of elements.

Earth accretion and early differentiation

Isotopes and their applications in understanding Earth processes.

Stable isotopes: Stable isotope fractionation. Oxygen isotopes

Sublithospheric Mantle (Mineralogy/phase transitions)

10classes

Unit 5: Environmental geochemistry

Geological disposal of nuclear waste

Lead in environment and effect of lead on human health

7classes

GEOH GE101BP2: PHYSICS AND CHEMISTRY OF EARTH: PRACTICALS
Course GE1

24 Hours

PRACTICALS

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

2nd Semester Core courses

GEOH201T4 : Geochemistry & Optical Mineralogy **48 Hours**
Course, C3(THEORY)

35classes

Unit 1: Concepts of Geochemistry **4 classes**

- 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 **5 classes**

- 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 **4 classes**

- 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 **12classes**

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 **10classes**

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

GEOH201P2 : Geochemistry & Optical Mineralogy **24 Hours**
Course, C3(PRACTICAL)

Practical 1: Identification and understanding of different parts of petrological microscope.

Practical 2: Identification of rock-forming minerals under petrological microscope.

Practical 3: Study of interference figure and determination of optic signs from minerals.

GEOH 202T4 : Structural Geology and Tectonics **48 Hours**
Course, C4 (THEORY)

Unit 1: Geological Structures and Topography**2classes**

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

Unit 2: Stress& Strain**5classes**

- 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**20classes**

- 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**8classes**

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

**GEOH202P2 : Structural Geology and Tectonics
Course, C4 (PRACTICAL)****24 Hours**

Practical 1: Use of clinometer and Brunton compass for structural measurements.

Practical 2: Study of contour maps, structural maps and sub-surface graphical problems.

Practical 3: Three point structural problems and structural projections.

Practical 4: Reconstruction of structure from given profiles.

**2nd Semester
Generic Electives (GE)****GEOH GE201AT4: EARTH RESOURCES
Course GE2****48 Hours**

Unit 1: Earth Resources

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

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

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: Nuclear, Hydroelectric, Solar, Wind and Wave- General Principles.

Ground water resources and its role in economic development of a country

Current Scenario and Future Prospects of Solar Power, Hydrogen Power and Fuel Cells.

GEOH GE201AP2: EARTH RESOURCES: PRACTICALS

Course GE2

24 Hours

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

GEOH GE201BT4: EARTH SURFACE PROCESSES

Course GE2

48 Hours

Unit 1: Introduction to earth surface processes

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

Unit 2: Energy flow and relative energy of surface processes.

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

Unit 3: Rates and changes in surface processes

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

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

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

Unit 5: Geomorphic concepts in cause-effect relationship

Spatial & temporal scales, geomorphic system, connectivity, buffering, magnitude-frequency concept, time lag, sensitivity, equilibrium, threshold, non-linearity & complexities

Mega geomorphology and process interrelationship

Surface processes and natural hazards; Applied aspects of geomorphology; Introduction to planetary geomorphology.

GEOH GE201BP2: EARTH SURFACE PROCESSES: PRACTICALS

Course GE2

24 Hours

Mapping of different landforms and interpretation of surface processes

Exercises on hill slope development, fluvial channel, sediment erosion and transport, sediment budgeting, aggradation and degradation events, drainage basin, drainage morphometry

Basic exercises on computation of rate for different surface processes

3rd Semester Core courses

GEOH301T4 : Igneous Petrology

Course, C5 (THEORY)

48 Hours

36classes

3classes

Unit 1: Introduction to Igneous petrology

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

Unit 2: Magma & Lava

4classes

- 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

6classes

- 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

8classes

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

5classes

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

Unit 6: Igneous rocks and Petrogenesis

10classes

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

GEOH301P2 : Igneous Petrology Course, C5 (PRACTICAL)

24 Hours

Practical 1: Study of igneous rocks in hand specimens.

Practical 2: Study of igneous rocks in thin section.

Practical 3: Study of texture in thin sections and hand specimens.

Practical 4: Study of phase diagrams to understand melts composition and crystallization.

GEOH302T4 : Sedimentary Petrology Course, C6 (THEORY)

48 Hours

Unit 1: Origin of Sediments

5classes

- 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

6classes

- 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**3classes**

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

Unit 4: Processes of formation of sedimentary rocks**10classes**

- Process of formation of sedimentary rocks- weathering, transportation and deposition.
- Diagenesis-compaction, cementation, lithification, 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**(Credits: 10)****10classes**

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

GEOH302P2: Sedimentary Petrology**Course, C6 (PRACTICAL)****24 Hours**

Practical 1: Study of sedimentary rocks in hand specimens.

Practical 2: Study of sedimentary rocks in thin sections.

Practical 3: Study of texture in thin sections and hand specimens.

Practical 4: General overview on depositional conditions and provenance from the study of framework, cement and matrix of given sedimentary rock in thin sections.

GEOH303T4 : Metamorphic Petrology**Course, C7 (THEORY)****Unit 1: Introduction of Metamorphism****6classes**

- 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 isograds. Concept of metamorphic facies and grade.

Unit 2: Thermodynamic Considerations in Metamorphism**5classes**

- 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**8classes**

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

Unit 4: Metasomatism and Migmatites**8classes**

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

Unit 5: Descriptive Metamorphic Petrology**10classes**

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

GEOH303P2: Metamorphic Petrology**24 Hours****Course, C7 (PRACTICAL)**

Practical 1: Study of metamorphic rocks in hand specimens.

Practical 2: Study of metamorphic rocks in thin sections.

Practical 3: Study of texture in thin section and hand specimens.

Practical 4: Study of metamorphic phase diagrams.

3rd Semester Generic Electives (GE)

GEOH GE301AT4: FOSSILS AND THEIR APPLICATIONS**Course GE3****48 Hours**

Unit 1: Introduction to fossils

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

Unit 2: Species concept

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

Unit 3: Introduction to various fossils groups

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

Unit 4: Application of fossils

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

Unit 5: Societal importance of fossils

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

GEOH GE301AP2: FOSSILS AND THEIR APPLICATIONS

Course GE3

24 Hours

1. Study of fossils showing various modes of fossilization
2. Distribution of age diagnostic fossils in India
3. Biostratigraphic correlation

GEOH GE301BT4: Martian Geology

Course GE3

48 Hours

Unit 1: MARS – OUR POTENTIAL HOME?

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

Unit 2: The characteristics of Mars and its interior

The Martian atmosphere and hydrosphere.

Unit 3: Surface provinces of Mars

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

Unit 4: Geochemical analogs and Martian meteorites

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

Unit 5: Life in Mars

Is there evidence for life on Mars?

Physical and chemical conditions supportive of permanent Mars occupation; Terraforming of Mars and its challenges

New Trends for Human Missions to Mars and Human colonization of Mars

GEOH GE301BP2: Martian Geology

Course GE3 PRACTICAL

24 Hours

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

3rd Sem

Skill Enhancement Courses (SEC)

GEOHSEC301AT2 : Basic Field Training Course, SEC1

24 Hours

Unit 1: Orientation of Topographic sheet in field, marking location in toposheet, Bearing (Front and back). Concepts of map reading, Distance, height and pace approximation

Unit 2: Identification of rock types in field; structures and texture of rocks, Use of hand lense

Unit 3: Basic field measurement techniques: Bedding dip and strike, Litholog measurement

Unit 4: Reading contours and topography

GEOHSEC301BT2 : Geological Mapping Course, SEC1

24 Hours

Unit 1: Geological mapping, stratigraphic correlation

Unit 2: Primary (scalars and vectors) and secondary structures (linear and planar)

Unit 3: Trend, plunge, Rake/Pitch

Unit 4: Stereoplots of linear and planar structures, Orientation analyses

GEOHSEC301CT2 : Economic Geology Fieldwork Course, SEC1

24 Hours

Module I

Unit 1: Visit to any mineral deposit

Unit 2: Mode occurrence of ore, Ore mineralogy

Unit 3: Ore-Host rock interrelation

Unit 4: Ore formation process

Unit 5: Basic techniques of surveying, concept of outcrop mapping

Module 2

Unit 1: Visit to underground or open cast mine

Unit 2: Practical experience of mining methods

Unit 3: Underground mapping/ Bench mapping

Unit 4: Isopach and Isochore maps

**GEOHSEC301DT2 : Himalayan Geology Fieldwork
Course, SEC1**

24 Hours

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

or

Field along any suitable transect of Himalayan foreland

or

Field transect in Siwalik

or

Identification of Himalayan and pre-Himalayan elements

**4th Sem
Core Courses**

**GEOH401T4 : Paleontology
Course, C8 (THEORY)**

48 Hours

Unit 1: Introduction to Paleontology

4 classes

- 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

5 classes

- 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

6 classes

- 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

12 classes

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

Unit 5: Palaeobotany

5 classes

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

Unit 6: Application of Fossils**4classes**

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

**GEOH401P2: Paleontology
Course, C8 (PRACTICAL)****24 Hours**

Practical 1: Study of fossils showing various modes of preservation.

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

**GEOH402T4 : Stratigraphic Principles and Indian Stratigraphy
Course, C9 (THEORY)****48 Hours****Unit 1: Principles of Stratigraphy****8 classes**

- 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**10 classes**

- 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**17 classes**

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

GEOH402P2 : Stratigraphic Principles and Indian Stratigraphy
Course, C9 (PRACTICAL)
Hours

24

Practical 1: Study of geological map of India and identification of major stratigraphic units.

Practical 2: Study of rocks in hand specimens from known Indian stratigraphic horizons.

Practical 3: Drawing various paleogeographic maps of Precambrian time.

Practical 4: Study of different Proterozoic supercontinent reconstructions.

GEOH403T4 : Hydrogeology and Oceanography
Course, C10 (THEORY)

48 Hours

Unit 1: Introduction to Hydrogeology

3classes

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

Unit 2: Groundwater and Aquifers

8classes

- 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

7classes

- 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

4classes

- 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

3classes

- 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**5classes**

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

Unit 8: Marine geology**5classes**

- 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. Palaeoceanography.
- Paleomorphic Aspect- Nutrient supply.

**GEOH403P2 : Hydrogeology and Oceanography
Course, C10 (PRACTICAL)****24 Hours**

Practical 1: Preparation and interpretation of water level contour maps and depth to water level maps.

Practical 2: Study, preparation and analysis of hydrographs for differing groundwater conditions.

Practical 3: Water potential zones of India (map study).

Practical 4: Simple numerical problems related to determination of permeability in field and laboratory, groundwater flow, well hydraulics.

**4th Sem
Generic Electives (GE)****GEOH GE401AT4: SOILS: PRESENT AND PAST
Course GE4****48 Hours**

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

Unit 2: General soil forming regimes: Gleization; podzolization; lessivage; ferrallitization; calcification; salinization

Unit 3: Soil forming processes: Physical weathering, loosening and particle size reduction; pressure release; thermal expansion; growth of foreign crystal.

Unit 4: Modern soils and key pedofeatures: Soil structures; horizons; roots; Fe-Mn mottles and concretions; pedogenic carbonate

Unit 5: Introduction to paleopedology and paleosols; role of factors controlling paleosol formation- parent material, climate, vegetation, topography, time.

Units 6: Introduction to soil taxonomy and paleosol taxonomy

Unit 7: Micromorphology: Thin section analysis of paleosols

Unit 8: Geochemistry: molecular ratios; chemical weathering indices

Units 9: Stable isotope geochemistry: carbon13 and oxygen18 system for vegetation, temperature, pCO₂

Unit 10: Diagenetic overprinting in fossil soils: compaction; oxidation of organic matter; cementation; illitization

Unit 11: Geological record of fossil soils- Precambrian paleosols- evolution of paleoatmospheric conditions

Unit 12: Geological record of fossil soils- Paleozoic paleosols- evolution of land animals and plants, coal, Permian-Triassic transition paleosols and extinction events

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

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

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

GEOH GE401AP2: SOILS: PRESENT AND PAST

Course GE4 PRACTICAL

24 Hours

1- Micromorphic detailing of the paleosols- structure, horizonation, color, rhizcretions, pedogenic carbonate etc.

2- Particle size analysis and clay mineral analysis of the paleosols

3- Micromorphological analysis- thin section preparation, description, and interpretation

4- Geochemical analysis- bulk geochemistry, molecular ratios and weathering indices

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

GEOH GE401BT4: STUDIES ON CRYOSPHERE

Course GE4

48 Hours

Unit 1: Introduction to Cryosphere

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

Unit 2: Terrestrial Cryosphere

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

Unit 3: Marine Cryosphere

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

GEOH GE401AP2: STUDIES ON CRYOSPHERE :PRACTICALS**Course GE4****24 Hours**

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

4th Sem**Skill Enhancement Courses (SEC)****GEOHSEC401AT2 : Precambrian Geology Fieldwork****Course, SEC2****24 Hours**

Field transect in any Precambrian terrain

Study of craton ensemble including basic intrusive suites

Precambrian sedimentary basin

Basement-Cover relation in: a. fold belts, b. sedimentary successions

GEOHSEC401BT2 : Visit to Engineering Project sites**Course, SEC2****24 Hours**

Unit 1: Geological mapping of a project site (Dam sites, Tunnel alignments etc)

Unit 2: On site visit & to study various geotechnical aspects related to the project site.

Unit 3: Identification of geotechnical problems of a project site and remedial measures to be taken.

Unit 4: Identification of environmental problems of a project site and remedial measures to be taken.

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

Unit 6: Identification of potential suspected/probable sites of Natural Disaster and suggestions about corrective/preventive measures.

**GEOHSEC401CT2 : Stratigraphy and palaeontology Fieldwork
Course, SEC2**

24 Hours

Field training along Phanerozoic basin of India

Documentation of stratigraphic details in the field

Collection of sedimentological, stratigraphic and paleontological details and their representation

Facies concept and its spatio-temporal relation (Walther's Law) and concept of facies distribution at basinal-scale

Fossils sampling techniques and their descriptions

**GEOHSEC401DT2: Project work
Course, SEC2**

24 Hours

Field based / data based geological investigations

**5th Sem
Core Courses**

**GEOH501T4 : Surveying and Engineering Geology
Course, C11 (THEORY)**

48 Hours

Unit 1: Introduction to Surveying

4classes

- 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

6classes

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

Unit 3: Leveling

6classes

- Level, Types of levels and Methods of Levelling.

Unit 4: Introduction to Engineering Geology

4classes

- 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**5classes**

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

**GEOH501P2 : Surveying and Engineering Geology
Course, C11 (PRACTICAL)****24 Hours**

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

**GEOH502T4 : Geomorphology
Course, C12 (THEORY)****48 Hours****Unit 1: Introduction to Geomorphology****4classes**

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

Unit 2: Understanding Earth's Physiography**6 classes**

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

Unit 3: Geomorphic Processes**15 classes**

- 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**7 classes**

- 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

4classes**Unit 5: Indian Geomorphology 4classes**

- 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.

4 classes**GEOH502P2 : Geomorphology
Course, C12 (PRACTICAL)****24 Hour**

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

5th Sem
Department Specific Elective (DSE)

GEOHDSE501AT4 : Exploration Geology
Course, DSE1 (THEORY)

48 Hours

Unit 1: Mineral Resources

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

Unit 2: Prospecting and Exploration

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

Unit 3: Evaluation of data

Evaluation of sampling data

Mean, mode, median, standard deviation and variance

Unit 4: Drilling and Logging

Core and non-core drilling

Planning of bore holes and location of boreholes on ground

Core-logging

Unit 5: Reserve estimations and Errors

Principles of reserve estimation, density and bulk density

Factors affecting reliability of reserve estimation

Reserve estimation based on geometrical models (square, rectangular, triangular and polygon blocks)

Regular and irregular grid patterns, statistics and error estimation

GEOHDSE501AP2 : Exploration Geology
Course, DSE1 (PRACTICAL)

24 Hours

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

GEOHDSE501BT4 Fuel Geology

48Hours

Course, DSE1 (THEORY)

Unit 1: Coal

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

Coal Bed Methane (CBM): global and Indian scenario

Underground coal gasification
Coal liquefaction

Unit 3: Petroleum

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

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

Gas Hydrate
Nuclear Fuel

Course, DSE1 (PRACTICAL)

24 Hours

1. Study of hand specimens of coal
 2. Reserve estimation of coal
 3. Section correlation and identification of hydrocarbon prospect
 4. Panel and Fence diagrams
-

GEOHDSE502AT4 : River Science

Course, DSE2 (THEORY)

48 Hours

Unit 1: Stream hydrology

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

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

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

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

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

Integrated approach to stream management
Introduction to river ecology.

**GEOHDSE502AP2 : River Science
Course, DSE2 (PRACTICAL)****24 Hours**

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

**GEOHDSE502BT4 : Surveying and Mapping
Course, DSE2 (THEORY)****48 Hours****Unit 1: Principles of Survey**

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

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

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, Discipline 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

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

GEOHDSE502BP2 : Surveying and Mapping Course, DSE2 (PRACTICAL)

24 Hours

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

6th Sem Core Courses

GEOH601T4 : ECONOMIC GEOLOGY, COAL AND PETROLEUM Course, C13 (THEORY)

48 Hours

Unit 1: Introduction to Economic Geology

3classes

- 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

10classes

- 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

6classes

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

Unit 5: Metallic and Nonmetallic ores**6classes**

- 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 6: Coal**5classes**

- 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 7: Petroleum**6classes**

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

**GEOH601P2 : ECONOMIC GEOLOGY, COAL AND PETROLEUM
Course, C13 (PRACTICAL)****24 Hours**

Practical 1: Megascopic identification of Economic Minerals

Practical 2: Study of microscopic properties of ore minerals/ reservoir rock slides/ source rock slides

Practical 3: Ore reserve estimation by using extended, included and channel method of estimation

Practical 4: Preparation of maps: Distribution of important ores and other economic minerals in India.

**GEOH602T4 : REMOTE SENSING, GIS AND GPS
Course, C14 (THEORY)****48 Hours****Unit 1: Photogeology****8classes**

- Introduction to Photogeology: 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**12classes**

- 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**13 classes**

- 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**5 classes**

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

**GEOH602P2 : REMOTE SENSING, GIS AND GPS
Course, C14 (PRACTICAL)****24 Hours**

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

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

Practical 3: GPS mapping

6th Sem**Department Specific Electives (DSE)****GEOHDSE601AT4 : Introduction to Geophysics
Course, DSE3 (THEORY)****48 Hours****Unit 1: Geology and Geophysics****(Class: 4)**

Interrelationship between geology and geophysics, Role of geological and geophysical data in explaining geodynamical features of the earth.

Unit 2: General and Exploration geophysics**(Class: 8)**

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

Different types of surveys, grid and route surveys, profiling and sounding techniques
Scales of survey, Presentation of geophysical data **(Class: 6)**

Unit 4: Application of Geophysical methods**(Class: 3)**

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

Unit 5: Geophysical anomalies**(Class: 3)**

Correction to measured quantities, geophysical, anomaly, regional and residual (local) anomalies, factors controlling anomaly, and depth of exploration

Unit 6: Integrated geophysical methods**(Class: 3)**

Ambiguities in geophysical interpretation, planning and execution of geophysical surveys

GEOHDSE601AP2 : Introduction to Geophysics**Course, DSE3 (PRACTICAL)****24 Hours**

Anomaly and background- Graphical method

Study and interpretation of seismic reflector geometry

Problems on gravity anomaly

GEOHDSE601BT4: Geology of North East India**Course, DSE3 (THEORY)****48 Hours****40 classes****Unit 1: Physiographical Overview**

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.

6classes**Unit 2: Stratigraphical Overview**

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.

8 classes**Unit 3: Geological Features**

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, Jialifault, BameTutinFault, Lohit Thrust, Mishmi Thrust, Tidding suture.

8classes

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.

8classes

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

4classes**Unit 4: Economic Significance**

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

3classes**Unit 5: Natural hazards and disasters**

Past major earthquakes of North East India and assessment of disaster. Calamity caused by floods in last decayed and their sources. *3classes*

GEOHDSE601BP2 : Geology of North East India
Course, DSE3 (PRACTICAL)

24 Hours

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

GEOHDSE602AT4 : Earth and Climate
Course, DSE4 (THEORY)

48 Hours
40classes

Unit 1: Climate system: Forcing and Responses

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

8classes

Unit 2: Heat budget of Earth

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

6classes

Unit 3: Atmosphere – Hydrosphere

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

8classes

Unit 4: Response of biosphere to Earth's climate

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

8classes

Unit 5: Orbital cyclicity and climate

Milankovitch cycles and variability in the climate
 Glacial-interglacial stages
 The Last Glacial maximum (LGM)
 Pleistocene Glacial-Interglacial cycles
 Younger Dryas
 Marine isotope stages

6classes

Unit 6: Monsoon

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

Effects of monsoon

4classes

**GEOHDSE602AP2 : Earth and Climate
Course, DSE4 (PRACTICAL)**

24 Hours

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

**GEOHDSE602BT4 : Evolution of life through time
Course, DSE4 (THEORY)**

48 Hours

Unit 1: Life through ages

(Class: 6)

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

(Class: 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

(Class: 8)

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

(Class: 4)

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

(Class: 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

(Class: 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

(Class: 4)

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

GEOHDSE602BP2 : Evolution of life through time
Course, DSE4 (PRACTICAL)

24 Hours

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