Course structure
&
Outcome Based Syllabus

Under Choice Based Credit System (CBCS)

B.Sc. (Hons.) Geology
2019-20

&

M.Sc. (Applied Geology)
2019-20

DEPARTMENT OF GEOLOGY
ALIGARH MUSLIM UNIVERSITY
ALIGARH
Programme Objectives (POs): B.Sc. (Hons) Geology

Some major program outcomes of B.Sc. (Hons) Geology are:

- To impart knowledge of Earth/Geological Sciences.
- To apply the knowledge of science, mathematics and allied disciplines in understanding geological science.
- To develop insightful understanding of Environment with emphasis on sustainable development.

Programme Specific Objectives (PSOs): B.Sc. (Hons) Geology

Some major program specific outcomes of B.Sc. (Hons) Geology are:

- To develop an understanding of dynamics of Earth and its interior.
- To impart knowledge of genesis of various rocks and earth’s energy resources including metals, non-metals, hydrocarbons etc.
- To carry out field training sessions and projects to enhance various skills among students like working as team, communication and project management etc.
**Programme Objectives (POs): M.Sc. (Applied Geology)**

Some major program outcomes of M.Sc. (Applied Geology) are:

- To impart knowledge of Geology with special emphasis on various applied aspects of geology.
- To enhance knowledge of geological science with more sophisticated tools and techniques.
- To develop project management skills via post-graduation dissertation on different aspects of geology.

**Programme Specific Objectives (PSOs): M.Sc. (Applied Geology)**

Some major program specific outcomes of M.Sc. (Applied Geology) are:

- To impart knowledge and hands-on exercises related to various applied disciplines of geology having great societal impact.
- To enhance scientific skills and promote research and development activities.
- To train students to join in various premier public and private organizations related to geology (Geological Survey of India (GSI), Central Groundwater Board (CGWB), Bhabha Atomic Research Centre (BARC), Oil and Natural Gas Corporation (ONGC) Limited, Coal India Ltd., Oil Industry, Geotechnical and Infrastructure sector.
- To acquire knowledge about exploration and exploitation of earth’s energy and water resources.
- To carry out Geological field training in various practical field skills among students and also support team work and project management etc.
Programme: B.Sc. (Hons.) Geology  
Session 2019-20  
Choice Based Credit System (CBCS)

### Semester I

<table>
<thead>
<tr>
<th>Type of Course</th>
<th>Course No.</th>
<th>Course Title</th>
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L= Lecture period, T= Tutorial, P= Practical Period

# Semester VI

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L= Lecture period, T= Tutorial, P= Practical Period
Course Objective:
1. Preliminary acquaintance about Geology.
2. Introductory knowledge of Earth. Its inorganic and organic constituent and landscaping processes and the manifested elements.

Course Outcome:
The course helps the students to understand
1. About the origin of Solar system in particular Earth, its internal and external features
2. Geological time scale, origin of landscapes. Stress induced features and fossils.
3. Crystals, their symmetry elements and notation systems
4. Minerals and their identification properties

UNIT 1:
General characteristics and origin of the Universe. Solar System and its planets
Earth’s origin and internal structure. The geomagnetic field
Concept of sea-floor spreading and plate tectonics
Geotectonic units of the Earth – Shields, Cratons, Platforms, Orogenic belts, Mid Oceanic Ridges, Transform faults, Island arcs and Deep-sea trenches.
Seismicity and Volcanism

UNIT 2:
Concept of time in geological studies – Standard stratigraphic time scale.
Concept weathering, erosion and denudation
Erosional and depositional landforms related to the action of wind, running water and glacier.
Structural Geology and its attributes
Folds, faults and their geometrical orientation
Paleontology – scope, elements and ambit
Fossils, types and their significance

UNIT 3:
Crystal: definition and its morphological elements (crystallographic axes and axial angles).
Laws of crystallography. Concept of lattice: planar, space
Symmetry, symmetry elements and operations
Crystallographic notations for planes: Miller indices, crystal forms and their nomenclature
Point group symmetry and derivation of 27 classes
Herman-Maugin system of symmetry
Classification of crystals into systems and description of symmetry elements of normal classes.
UNIT 4:
Mineral and Mineral Science
Physical properties:
Properties based on interaction with light (color, luster, streak, play of colors, Chatoyancy and Asterism, Luminescence)
Mechanical Properties (cleavage, parting, fracture, hardness, tenacity)
Mass related properties (density and specific gravity)
Miscellaneous properties (magnetism, radioactivity, piezoelectricity, proectricity)
Rock forming silicate minerals and structures
Petrological microscope: parts and function
Optical properties of minerals (color, pleochroism, refractive index, relief, twinkling, birefringence, isotropism / anisotropism, interference colors, extinction angle, twinning)

Books Recommended:
Course code: GLB1P1
Course title: Lab work for Earth Systems and Mineral Science
Credits: 2
Course No: BL1

Earth Systems and Mineral Science:
1. Reading topographic maps and exercises related to contour maps
2. Laboratory exercise on structural geology problems: Completion of outcrops, drawing and interpretation of cross-sections through elementary representative geological structures.
3. Study of symmetry elements of at least one representative crystal from normal classes of seven crystal systems.
4. Study of physical properties of minerals in hand specimen
5. Identification of fossils and diagrammatic accounts of their external and internal views.
Semester: II

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Course Objective:
1. To impart knowledge of basic elements of Petrology
2. To train the students to understand the processes of formations of different rock groups

Course Outcome:
Upon successful completion of course the students would be able to
1. Understand the basic concept of petrology and understand formation and types of mineral deposits associated with rocks.
2. Understand magma generation and evolution, and classify igneous rocks.
3. Understand fundamentals of sedimentary processes and stratigraphic correlation.
4. Understand factors of metamorphism, and to classify metamorphic rocks.

UNIT 1:
Petrology: definition and scope. Introduction to common rock forming: silicates and non-silicates, ore forming and industrial minerals. Radioactive minerals, Fuel minerals
Formation and types of mineral deposits, rock association.
Mineral deposits associated with igneous rocks, sedimentary rocks and metamorphic rocks.

UNIT 2:
Magma: Definition, physical properties and chemical composition, origin. Crystallization of magma: Bowen’s reaction series, magmatic differentiation and assimilation.
Forms and structures of extrusive and intrusive igneous rocks.
Igneous textures: crystallinity, grain shape, size and mutual relationship of grains.
Bases of classification and types of igneous rocks.

UNIT 3:
Sediments: origin, transportation, deposition and lithofication.
Fabric and texture of sedimentary rocks.
Roundness of particles and its geological significance.
Classification of sedimentary rocks: terrigenous and chemical sedimentary rocks.
Important primary sedimentary structure-bedding, ripple marks, cross bedding and mud cracks.

UNIT 4:
Introduction to Metamorphic rock and their significance.
Factors of metamorphism. Classification of Metamorphic rocks.
Basic concepts of types of metamorphism.
Concepts of isograds and zones of metamorphism.
Relationship between matamorphism and deformation.
Texture of Metamorphic rocks.

Books Recommended:
1. Magma and Magmatic Rocks-Middlemost.
2. Igneous and Metamorphic petrology-Best.
4. Fundamentals of Historical Geology and Stratigraphy of India-Ravindra Kumar.
Elements of Petrology:
1. Handling optical microscope
2. Optical properties and identification of common rock forming minerals (Quartz, Plagioclase, Microcline, Biotite, Muscovite and Garnet).
3. Identification of some common Igneous, Sedimentary and Metamorphic rocks under hand specimen with particular emphasis on texture and structures.

**Igneous rocks:** Granite, Rhyolite, Basalt, Dolerite, Gabbro, Diorite etc.

**Sedimentary rocks:** Sandstone, Limestone, Shale, Conglomerate, Breccia etc.

**Metamorphic rocks:** Slate, Phyllite, Schist, Gneiss, Marble, Quartzite etc.
Semester-III

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<tr>
<th>Course code: GLB 351</th>
<th>Course title: Paleobiology and Stratigraphy</th>
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Course Objective:
1. To impart basic knowledge about Paleobiology and Stratigraphy.
2. To train the students to understand the processes of formations of different sedimentary basins and significance of fossils.

Course Outcome:
Upon successful completion of course the students would be able to
1. Understand the basic concept of paleontology and stratigraphy.
2. Understand fossil identification and description and application of fossils in organic evolution.
4. Understand stratigraphy and sedimentation history of different sedimentary basins of India.

UNIT 1:
Microfossils: Definition, significance and a brief account of important groups.
Brachiopioda: Morphology and geological distribution.
Echinoidea: Morphology and geological distribution.
Trilobite: Morphology and geological distribution.

UNIT 2:
Pelecypoda: Morphology and geological distribution.
Gastropoda: Morphology and geological distribution.
Cephalopoda: Morphology and geological distribution of Nautiloidea and Ammonoidea.
Origin of vertebrates and landmarks in vertebrate evolution.
Evolutionary history of Equidae.
Palaebotany: Broad classification of plant kingdom and application of palaeobotanical studies.
Morphology, classification and geological range of important Lower and Upper Gondwana flora.

UNIT 3:
Stratigraphy and its branches.
Stratigraphic correlation, stratigraphic classifications.
Stratigraphic succession, essential lithology and economic significance of the following Precambrian Cratons of India:
Dharwar, Singhbhum, Bundelkhand, Aravalli.

UNIT 4:
Stratigraphy and brief sedimentation history of the following Sedimentary Basins of India:
Proterozoic: Delhi, Vindhyan Supergroups
Phanerozoic Stratigraphy of India: Gondwana Supergroup.
Triassic of Spiti, Jurassic of Kutch, Cretaceous of south east coast of India,

**Books Recommended:**
1. Invertebrate Palaeontology - Woods.
2. The Elements of Palaeontology - Black.
3. Introduction to Paleobotany - Arnold.
4. Essential of Paleobotany - Shukla and Mishra.
5. Geology of India and Burma - Krishnan.
6. Fundamentals of Historicals geology and Stratigraphy of India - Ravindra Kumar
7. Precambrian Geology of India - Naqvi and Rogers.
Palaeobiology and Stratigraphy:
1. Study of morphological characters of important fossil phyla designated in theory paper.
2. Exercises related to major stratigraphic and lithotectonic units on the map of India.
Semester: IV

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Course Objective:
1. To impart knowledge of basic concepts of Earth Processes and Resources
2. To train the students to understand the processes of formations of different ore deposits, energy resources and non-metallic mineral deposits.

Course Outcome:
Upon successful completion of course the students would be able to
1. Understand the basic concept of Renewable and non-renewable energy resources.
2. Understand physical properties and composition of silicates, carbonates, oxides and sulfides. Geological setting, mineralogical characteristics and Indian distribution of metallic mineral deposits
3. Understand process of formation of different types of ore deposits.
4. Understand geological setting, mineralogical characteristics and Indian distribution of non-metallic mineral deposits and building materials

UNIT 1:
Renewable and non-renewable energy resources.
Hydroelectric power. Energy from the sun, wind, hot springs and sea waves.
Use of conventional and non-conventional sources of energy. Energy efficiency and conservation.
Distribution of mineral deposits in space and time.
Physiographic, mineralogical, stratigraphic, lithologic and structural guides to ore.

UNIT 2:
Systematic classification of minerals. Physical properties and chemical composition of the following classes of minerals:
Silicates: (a) Nesosilicates – Olivine and Garnet groups; (b) Inosilicates – Pyroxene and Amphibole groups,
(c) Tectosilicates – Quartz and Feldspar groups.
Carbonates: Calcite, Aragonite and Dolomite groups.
Oxides: Simple and multiple oxides.
Sulfides: Copper, Iron, Lead and Zinc sulfides.
Geological setting, mineralogical characteristics and Indian distribution of metallic mineral deposits of iron, manganese, chromium, copper, gold, aluminum, lead and zinc.

UNIT 3:
Ore forming minerals: metallic and non-metallic minerals. Processes of ore formation.
Ore deposits related to magmatic activity.
Hydrothermal and skarn deposits – Role of replacement and colloidal deposition.
Ore deposits formed by sedimentation. Weathering products and Residual deposits.
Ore deposits formed by oxidation & supergene enrichment.
Ore deposits formed by biochemical activity,
Ore deposits formed by evaporation.
Metamorphism and ore deposits.

UNIT 4:
Geological setting, mineralogical characteristics and Indian distribution of non-metallic mineral deposits related to and with examples from Indian stratigraphic records:
Materials for construction (building stones and cement), ceramics, refractories and fillers, organic chemicals and synthetics, precious and decorative stones, fertilizers.

Books Recommended:
Course code: GLB4P1  
Course title: Lab work for Earth’s Processes and Resources  
Credits: 2  
Course No: BL4

**Earth’s Processes and Resources:**

1. Study of physical and optical properties of metallic and non-metallic minerals/resources.
2. Hand specimen study of different types of coal.
3. Preparation of maps showing distribution of important ores and other economic minerals of India. Study of metallogenetic maps.
Course Objective:
1. To impart basic understanding of geology to students having no background in earth sciences
2. To impart awareness of the dynamics of the earth systems and its implications for natural resources

Course Outcome:
Upon successful completion of the course, the students should be able to:
1. Understand the earth systems and how they interact?
2. Understand the dynamics of the earth’s interiors, plate tectonic processes, seismicity, and volcanism
3. Understand the origin and occurrence of minerals and rocks
4. Understand the energy and mineral resources on earth

UNIT 1:
Introduction and scope of geology.
The solar system – Planets, asteroids and meteorites.
Origin of the Earth – its position in the solar system.
Geological time scale. Internal structure and constitution of the Earth – Physical and chemical layering.
The hydrosphere, atmosphere and biosphere.
Interacting Earth systems.

UNIT 2:
Earthquakes – their mechanism and distribution
Volcanoes – their types and distribution
Uses of minerals.
Formation of igneous rocks, Origin of magmas, Intrusive and extrusive igneous rocks, Classification of igneous rocks.

UNIT 3:
Formation of sedimentary rocks – Weathering, erosion and transportation
Classification of sedimentary rocks – Clastic, chemical and biochemical.
Primary and secondary sedimentary structures.
Landforms and their origin. Fossils and the process of fossilization.
Formation of metamorphic rocks, heat and pressure
Types of metamorphism – Contact and regional metamorphism
Foliated and non-foliated metamorphic rocks.
Metamorphic rock textures.
UNIT 4:
Introduction of folds, faults, joints, cleavage, foliation, lineation and unconformities. Isostasy; Introduction to plate tectonics, mountain building processes.
Mineral and energy resources from the Earth
Non-renewable energy resources – Coal, petroleum & natural gas, nuclear fuel materials
Renewable energy resources – Solar, Wind, wave, Tidal, Hydroelectric, Geothermal and Biomass
Surface and groundwater resources

Books Recommended:
Course Objective:
1. To impart knowledge about the magmatic systems
2. To train the students about the dynamism of the earth

Course Outcome:
Upon successful completion of course the students would be able to
1. Understand the mantle system and magmatic processes with special reference to Precambrian rock association.
2. Understand basic principles of equilibrium thermodynamics, binary and ternary systems and origin of different igneous rocks.
3. Understand internal structure and layers of the Earth and plate tectonics.
4. Understand different earth processes in relation to plate tectonics.

UNIT 1:
Mantle petrology: Mineralogy and Chemistry.
Primary and parental magma: Physical and Chemical properties, volatile contents.
Magmatic differentiation: Fractional crystallization, magma mixing, crystal settling, liquid immiscibility, assimilation.
Major and trace elements in magmas; application of trace elements in igneous petrogenesis.
Classification of igneous rocks, bases of classification, IUGS classification.
Igneous rock associations in space and time; Mineralogy and chemical characteristics of the following Precambrian igneous rock assemblages: (a) Komatiites (b) Anorthosites and (c) Tonalite-trondhjemite-granodiorite (TTG).

UNIT 2:
Basic principles of equilibrium thermodynamics;
Concept of system, phase and component; Chemical potential and phase rule.
Phase equilibria of the two and three component silicate systems:
Binary System- Albite-Anorthite, Diopside-Anorthite, Nepheline-silica, Forsterite-silica,
Diopside-Anorthite-Albite, Nepheline-Kalsilite-Silica ternary systems.
Basaltic magmatism in relation to plate tectonics. Concept of igneous rock series.
Mineralogical Characteristics and origin of the following rock types:
(i) Granite, Granodiorite, Diorite, Rhyolite (ii) Basalt, Dolerite, gabbro (iii) Syenites, nepheline-syenite, trachyte (iv) Preidotites
UNIT 3:
Internal structure of the earth.
Geophysical conditions of the earth: gravity, magnetism, heat flow.
Concept and theories of isostacy.
Plate tectonic theory: the mechanism of the plate tectonics.
Nature and types of plate margins.
Geometry and driving mechanism of plate motion.

UNIT 4:
Plate tectonics with time, Evolution of continents and oceans.
Magnetic anomaly patterns in the ocean basins and sea-floor spreading.
Origin, Significance and distribution of divergent margins, mid oceanic ridges.
Origin, Significance and distribution of subduction zones, Islands arcs and trenches.
Tectonics of continental rifts, continental margins, shelves, marginal basins and intracratonic basins.
Plate Tectonics and magmatism.
Neotectonics: Active fault system.
Indicators of recent tectonic activity.

Books Recommended:
1. Principles of igneous and metamorphic petrology-Philpots
2. Magma and magmatic rocks- Middlemost
3. Igneous and metamorphic petrology- Best
4. Plate tectonics and crustal evolution- Condie
5. Aspects of Tectonics- Valdiya
6. Global Tectonics- Kearey and Vine
7. Igneous petrology- M.K.Bose
8. Igneous petrogenesis- M.Wilson
10. Igneous Petrology – Alexander R. McBirney
Course Code: GLB552 | Course: Structural Geology
Credits: 4 | Course No: B6

Course objectives:
1. To educate the students about the concept rock deformation.
2. To understand qualitative aspects of brittle and ductile deformation processes, and descriptive analysis.

Course outcomes:
Upon successful completion of course the students would be able to
1. Understand significance of ductile deformation. Various types of folds and their mechanics.
2. Understand formation of various types of unconformities and be able to recognise on geological maps.
4. Understand rock fabrics and types of planar and linear fabrics produced during tectonic deformation.

UNIT 1:
Description and nomenclature of folds. Geometric and genetic classification of folds. Recognition and interpretation of folds in field and geological maps.

UNIT 2:

UNIT 3:
Description and classification of faults. Geometric and Genetic Classification of fault. Criteria for recognition of faults, in the field and on geological maps.

UNIT 4:
Planar and linear structures, their identification and description. Type of cleavage and schistosity and their origin. Relation of cleavage and schistosity to major structures. Types of lineations, their origin and their relation to major structures.

Books Recommended:
3. An outline of Structural Geology-Rubbs, Mears and William.
4. Structural Geology – M.P. Billings
Course Objective:
1. To impart knowledge of formation of sedimentary rocks.
2. To train the students to understand the mode of formations, transportation and deposition of the sediments and also about the processes modifying the sediments after their burial.

Course Outcome:
Upon successful completion of course the students would be able to:
1. Understand the concept of grain size and lithofacies analysis in evaluating the hydrodynamic conditions, depositional environments and palaeoclimatic conditions.
2. Understand generation of primary and biogenic sedimentary structures and their significance.
3. Understand the processes of deposition of sediments and their diagenetic modifications.
4. Understand origin and classification of siliciclastics and carbonates.

UNIT 1:
Particle size of detrital rocks–grade scales in Phi and mm. Significance of grain size in sedimentological investigations.
Shape and sphericity of clastic particles. Zingg’s and Folk’s shape classes.
Chemistry of weathering processes.
Concept of sedimentary facies. Basic principles of paleoenvironment and paleoclimate analysis.

UNIT 2:
Basic ideas about depositional environments and their classification. Reynold number and Froude number. Laminar and turbulent flows and flow regimes.
Morphology of important primary sedimentary structures and their significance.
Biogenic structures and ichnofossils and their significance.

UNIT 3:
Processes of sediment deposition: aqueous, Aeolian, glacial and gravitational (turbidity, mud and debris flows).
Diagenesis of terrigenous and chemical sediments.
Heavy minerals and their geological significance.
Conglomerates: origin and classification.
Petrography and geological significance of diamicrites and tillites.

UNIT 4:
Sandstone: classification and origin. Petrography and geological significance of quartz arenite, arkose and greywacke.
Concept of maturity – mineralogical and textural.
Shale: types, mineralogy and their bedding characteristics.
Origin and classification of carbonates with special reference to Folk’s classification.
Tectonics and sedimentation. Geosynclinal basins and facies. Krynine’s cycle.
Books Recommended:
Course Code: GLB554  
Course: Natural Environment and Remote Sensing  
Credits: 2  
Course No: B8

**Course Objective:** To impart knowledge of environmental geology, natural hazards and basic concepts of remote sensing and GIS.

**Course outcome:**  
Upon successful completion of course the students would be able to:  
1. To understand the Earth’s ecosystem and interrelations of various components of the Earth.  
2. To understand geological aspects of various natural hazards and geoengineering projects.  
3. To develop elementary idea about remote sensing technique.  
4. To develop concepts of maps and GIS.  

**UNIT 1:**  
Environmental Geology: Concept and interdisciplinary approach. Earth as closed system, understanding hazardous earth processes. Natural ecosystems on the earth and their interactions (atmosphere, hydrosphere, lithosphere and biosphere): Cycles in earth system: carbon energy cycle, biogeochemical cycle, rock cycle, geochemical cycle.

**UNIT 2:**  

**UNIT 3:**  

**UNIT 4:**  
Books Recommended:
1. Environmental Geology-Keller
6. Remote Sensing and image interpretation – Lillesand and Keifer
1. **Igneous Petrology & Geodynamics:**
Hand specimen study of different types of extrusive and intrusive igneous rocks, Microscopic study of igneous textures, mineralogy and petrogenetic features of igneous rocks.

2. **Sedimentary Petrology:**
Hand specimen study of different types of clastic and chemical sedimentary rocks, Study of Primary sedimentary structures in hand specimens. Microscopic study of textures, mineralogy and diagenetic features of sedimentary rocks.

3. **Disaster Management:**
Study and analysis of vulnerable regions of India. Exercises on various disasters in India. Disaster vulnerability Index and its relevance. Exercises related to drought assessment and flood prone regions.

4. **Geoinformatics:**
Accessing, searching and extracting metadata, Spatial data infrastructure of Census of India, DST, Ministry of Environment and Forest, Climate Change, CPCB, Ministry of Water resources. Exercises related to spatial data analysis, overlay and composite analysis.
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<thead>
<tr>
<th>Course Code: GLB5P2</th>
<th>Course: Lab work for B6 and B8</th>
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<tr>
<td>Credits: 2</td>
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1. **Structural Geology:**

2. **Natural Environment & Remote Sensing:**
Course Objective:
To impart knowledge of natural hazards and their management.

Course Outcome:
1. To understand the basic of natural disasters.
2. To understand geological aspects of various natural disasters.
3. To develop skills for managing natural disasters.

UNIT 1:

UNIT 2:

UNIT 3:

UNIT 4:

Books Recommended:
1. Disaster Management by Mukesh Kapoor
2. Disaster Management : Future challenges and opportunities by Jagbir Singh
3. Disaster Management: Edited by H K Gupta, Universities Press, Hyderabad
5. Disaster Education and Management – R.K. Bhandari (2014). Springer, New Delhi,
Course Objective: To impart knowledge of geoinformatics, geo-data and effective management and use of data.

Course outcome:
Upon successful completion of course the students would be able to:
1. To understand the basic concepts of geoinformatics and its implications.
2. To understand the concept and applications of GIS, spatial and non-spatial data.
3. To develop skills in handling and managing database.
4. To develop concepts of maps and GIS along with their applications in Geosciences.

UNIT 1:

UNIT 2:

UNIT 3:

UNIT 4:
Books Recommended:
1. Fundamentals of GIS by Micheal Demers
2. Remote Sensing and Geographic Information System by Anji Reddy
3. Remote Sensing and Geographic Information System by A.M. Chandra
5. www.GISdevelopment.net
Course Code: GLB571  
Course: Geological Field Techniques  
Credits: 2  
Course No: BAE1(a)

Course Objective:
1. To impart knowledge of geological field survey.
2. To train the students to understand functioning of necessary instruments required during geological field survey.

Course Outcome:
Upon successful completion of course the students would be able to:
1. Understand the basic concept of geological field work and various instruments used in field work
2. Understand various geological structures found at outcrops.
3. Understand fundamentals of geological processes and stratigraphic correlation.
4. Understanding observations and recording of important filed information and to classify various types of features procured from field study.

UNIT 1:
Introduction to field geology, Objectives of field work, deciding where to do the fieldwork. Importance of field safety.
The Field Notebook: Purpose of Field Notes, Field Notebook Layout, Field Sketches.
Written Notes: Recording Data. Field report writing.
Scale of observation: Regional context, Whole exposure, Hand specimens.
Instruments used in field: GPS, Brunton compass, Geological Hammer & altimeter.
Parts, functions and use of Brunton compass, GPS.
Preparedness for field survey: Base map, Geological maps, toposheets and Indian numbering system, Reading toposheets, interpretation of contour patterns.

UNIT 2:
Concept of dip and strike, Recording orientation of planar and linear features.
Reporting orientation data: Azimuth, Quadrant reading.
Stereographic projections of geological structures.
Cross-Sections and 3D Illustrations: Cross-Sections, Down-Plunge Projection Method, Columnar Sections, Block Diagrams.
Establishment of relative ages: cross-cut relations, xenoliths.
Recognition of folds, faults and unconformities in the field.
Measuring thickness of inclined strata.
Locating position on toposheet and concept of forward bearing and backward bearing.
UNIT 3:
Observations and Recording of important field information.
Recording features of sedimentary: Recording sedimentary lithology, Recording sedimentary structures, Graphic logs.
Recording Features of Igneous Rocks: Relationships with surrounding rocks, Internal architecture: Joints, veins, and other exposure-scale fabrics. Mineralogy and small-scale textures of igneous rocks.
Recording Features of Metamorphic Rocks: Field relations and context, Textures, Identifying common metamorphic minerals. Pre-kinematic features, Syn-kinematic features, Post-kinematic features.

UNIT 4:
Importance of field photographs.
Sampling: Selecting and labelling samples, Samples for thin-sections, oriented samples.
Samples for geochemical analysis.
Recording Palaeontological information: Sampling Strategies & Estimating abundance.
Mapping techniques: traverse mapping, contact mapping, exposure mapping. Map symbols.
Structural measurements and notations, Brittle structures: Faults, joints and veins, Ductile structures: Shear zones, foliations and folds.

Books Recommended:
Course Objective:
Description of statistical parameters employed to analyse / synthesize geological data for accurate and authentic interpretation / resolution of any geological event / riddle.

Course Outcome:
The course helps the students to understand
1. Primary idea about various laws of statistical distribution
2. Primary attributes (indices) to characterize a geological data
3. Primary dispersion ideologues of
4. Primary statistical discrepancy measures

UNIT 1:

UNIT 2:

UNIT 3:

UNIT 4:
functions and analysis of diagrams: models of random fields in space and time, mathematical
prognosis, dispersion, correlation function.

Books Recommended:
Verlag.
Inc., New Jersey.
7. Hindusthan Publishing Corporation (India), New Delhi Spiegel, M.r. (1982) Probability and
Geophysics, Elsevier.
Press.
Sons, New York.
Geological Field Survey:
Field work including geological and structural mapping.
Preparation of field report based on the recorded data, mapping data as well as laboratory work on the rock samples collected during the field work.
Semester: VI

Course Code: GLB651  
Course: Metamorphic Petrology  
Credits: 2  
Course No: B9

Course Objective:
1. To impart knowledge about Metamorphism and metasomatism of rocks.
2. To train the students to understand the different processes of formations of metamorphic rocks and their significance.

Course Outcome:
Upon successful completion of course the students would be able to
1. Understand the factors and agents of metamorphism.
2. Understand the textures and different zones of metamorphism.
3. Understand the processes of metasomatism and their types.
4. Understand the representation of mineral paragenesis of metamorphic rocks & graphical representation.

UNIT 1:
Metamorphic processes and a detailed account of agents and their role in metamorphism. Texture and structures of metamorphic rocks and their significance. Types of metamorphism: Contact, regional, cataclastic and metasomatism. Cataclastic metamorphic and its products.

UNIT 2:
Barrovian zone of regional metamorphism and principles of isograd mapping. Rosenbusch’s zones of thermal metamorphism, contact aureole. Contact metamorphism of carbonate rocks. Regional metamorphism of pelitic rocks. Metamorphism in relation to plate tectonic. Paired metamorphic belts.

UNIT 3:

UNIT 4:

Books Recommended:
1. Metamorphic Petrology-Turner.
Course Objective:
1. To impart knowledge of Energy Resources and Mineral Exploration.
2. To train the students to understand the energy resources, methods of exploration and mineral economics.

Course Outcome:
Upon successful completion of course the students would be able to:
1. Understand the basic concept of coal and petroleum formation and classification.
2. Understand the origin, exploration and distribution of gas hydrates and nuclear waste.
4. Understand the principles of mineral economics and bore hole logging.

UNIT 1:

UNIT 2:

UNIT 3:

UNIT 4:
Books Recommended:
2. Text Book of Coal – Chandra, Singh and Singh.
Course Code: GLB653  
Credits: 2

Course: Applied Geology  
Course No: B11

Course objective:
1. To impart knowledge of application of geology in various applied fields.
2. To train students on role of geology in urban planning, medical geology and gemology.

Course outcome:
Upon successful completion of course the students would be able to
1. Understand role of geology and hydrogeology in urban planning and impact of urban waste disposal on environment and its management.
2. Understand the role of geologic environment including impacts of trace elements on human health.
3. Understand the basic concept of hydrogeology, rock properties affecting the occurrence and movement of groundwater and its quality.
4. Understand the types of geochemical sampling, methods of analysis and knowledge of common instruments.

UNIT 1:

UNIT 2:

UNIT 3:

UNIT 4:
Geochemical sampling: types and techniques. Biogeochemical sampling. Geochemical analysis techniques. Introductory knowledge about common analytical instrument; flame photometer, spectrophotometer, AAS, XRF, XRD and ICP. Study of minerals as gem identification parameters
important qualities, association and occurrence. Synthetic gems and their manufacturing. Mineral processing and beneficiation: method and size reduction and screening.

**Books Recommended:**
2. Environmental Sciences-Miller.
4. Techniques in Mineral Exploration-Read man.
5. Geochemical Exploration-Bjorklund.
1. **Metamorphic Petrology:**
Identification of common foliated and non-foliated metamorphic rocks. Microscopic study of mineralogy and textures of metamorphic rocks. Laboratory exercises on graphic plots for petrochemistry and interpretation of paragenetic diagrams.

2. **Energy Resources & Mineral Exploration:**
Exercises in showing the distribution of important economic minerals – coal, hydrocarbons and atomic mineral resources in maps of India. Exercises aimed at promoting investigation, discussion, critical thinking, and balanced use of various sources of energy viz., biomass, coal, geothermal, hydropower, natural gas, petroleum, solar, wind and atomic.
1. **Applied Geology:**
Preparation of depth to water table maps, Preparation and interpretation of water table maps. Representation of chemical analyses data. Identification and classification of water on the basis of quality (drinking, irrigation and industrial purpose).

2. **Water resource management:**
Components of hydrogeological cycle. Presentation of rainfall data-arithmetic mean, isohyetal map, exercises on porosity, grain size, analysis for evaluation of permeability,

3. **Geochemistry:**
i) Calculation of petrologic indices  
ii) Calculation of norms  
iii) Exercises on igneous rock classification

4. **Marine Geology:**

5. **Geomorphology:**
Identification of some common landforms on topographic maps and satellite images. Quantitative analysis of landforms using topographic maps.
Course Code: GLB661
Course: Water Resource Management
Credits: 4
Course No: BE2(a)

Course objective:
1. To impart knowledge of global and national scenario of water resources and associated challenges.
2. To familiarize about occurrence and movement of sub-surface water. Also to train students about various groundwater management techniques

Course outcome:
Upon successful completion of course the students would be able to
1. Understand global and national scenario of water resources, understand hydrologic cycle and its various components.
2. Understand hydrogeological classification of geologic formation and occurrence of groundwater in various formations.
3. Understand the method of groundwater resource evaluation and management potential of aquifer
4. Understand management of coastal aquifers including causes of saline water intrusion and their control, water logging causes and its impact and protection of water quality in aquifers.

UNIT 1:
Global scenario of water resources – Key challenges and needs. Water resources scenario in India. Surface water and groundwater resources. Hydrological cycle, components of hydrologic cycle – Precipitation, evapotranspiration, infiltration, runoff and their measurements. Water resources in some states. Role of National Water Development Agency (NWDA).

UNIT 2:

UNIT 3:

UNIT 4:
Books Recommended:
Course objective
1. To impart basic knowledge of elemental and isotopic concentrations, classification and behaviour of elements in the crust, continental lithospheric mantle and mantle.
2. To train the students to understand the behaviour of geochemical elements in different igneous rock types.

Course outcome:
1. To understand the basic concepts of geochemistry to distinguish igneous, sedimentary and metamorphic rocks and their differentiations.
2. To understand magma generation, evolutionary trend and classification of igneous rocks.

UNIT 1:

UNIT 2:
Classification of trace elements: trace element groupings in periodic table, trace element behavior in magmatic system: compatible elements, incompatible elements, high field strength (HFS), large ion lithophile (LILE), elements, Raoult's law, Henry’s Law. Partition co-efficient.

UNIT 3:
Geological control on the distribution of trace elements. Element mobility, partial melting, crystal fractionation, Rare earth elements (REE), chemistry of REE, Presentation of REE data. Eu-anomaly. Interpreting REE patterns. Bivariate plots.

UNIT 4:

Books Recommended:
Course Code: GLB664  
Course: Marine Geology  
Credits: 4  
Course No: BE2(c)

Course objective:
1. To impart basic knowledge of morphological and structural features, and operating processes in sea and ocean basins.
2. To train the students to in understanding the marine economic resources.

Course outcome:
1. To understand the basic concepts of geochemistry to distinguish different types of rocks.
2. To understand magma generation evolution and classification of igneous rocks.

UNIT 1:
Exploring the ocean floor: Surveying the seabed, Geological observations of the sea-floor.
Ocean drilling, Magnetic surveys and satellite mapping of the sea-floor.
Coastal morphology and sea-level fluctuations.

UNIT 2:
Fracture patterns in the sea-floor and transform faults.

UNIT 3:
Origin and morphology of ocean margins.
Sources of marine sediments. The sediment cycle. Sediments and sea-water composition.
Major sediment types: Lithogenous, biogenous and hydrogenous sediments. Sedimentation rates.

UNIT 4:
Resources in the continental shelves - Phosphorites, Shell and placer deposits, sand and gravel.

Books Recommended:
Course Code: GLB665
Credits: 4
Course: Geomorphology
Course No: BE2(d)

Course Objective: To understand landforms and their evolution

Course Outcome: At the end of the course, the student should be able to appreciate and understand:
1. The diversity of landforms present on planet earth
2. The processes that carve the surface of earth
3. How the landscapes evolve with time?
4. How humans have modified the natural landscapes?

UNIT 1:

UNIT 2:

UNIT 3:

UNIT 4:
Glacial and Periglacial processes and landforms: Horn, Arête, Col, Cirque, Nunatak, Groove & Striation, Roche Moutonnée & Flyygbbergs, Crag & Tail forms, Glacial Trough, Fiord, Hanging Valley, Moraines, Drumlin, Esker, Kame, Outwash Plain, Kettle, Scabland topography, Permafrost, Talik, Ice Wedge, Pingo, Thermokarst, Patterned Ground, Solifluction Lobe & Terrace, Rock Glacier, Cryoplanation Terrace & Cryopediment. Coastal processes and landforms: Wave Dynamics,

Books Recommended:
<table>
<thead>
<tr>
<th>Course Code: GLB6S1</th>
<th>Course: Seminar/Project</th>
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<tr>
<td>Credits:</td>
<td>Course No: BAE4</td>
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**Seminar/Project:** Seminar/Project, Assessment based on in-depth knowledge of Geology.
Course structure
&
Outcome Based Syllabus
Under Choice Based Credit System (CBCS)

M.Sc. (Applied Geology)
2019-20
### Programme: M.Sc. (Applied Geology)
**Session 2019-20**
Choice Based Credit System (CBCS)

### Semester I

<table>
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<th>Course Title</th>
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<td>Core ML2</td>
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<td>Lab Work: Mineralogy, Instrumentation and Analytical Techniques, Geotectonics and Hydrogeology</td>
<td>Continuous evaluation - 40 60</td>
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<td>a) Coal Petrology</td>
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<td>b) Oceanography</td>
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<td>c) Watershed Management</td>
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<td>Field Geology/Industrial/ Laboratory Training</td>
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## Semester II

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<td>a) Geodynamic Processes and Crustal Evolution</td>
<td>GLM2011</td>
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<td>b) Global Climate Change</td>
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<td>c) Quaternary Geology</td>
<td>GLM2014</td>
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<td>d) Applied Geomorphology</td>
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### Semester III

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L = Lecture period, T = Tutorial, P = Practical Period
Course Objective:
1. To impart knowledge of Ore Geology and Mining Geology
2. To train the students to understand the processes of formations of ore deposits and their exploration.

Course Outcome:
Upon successful completion of course the students would be able to
1. Understand the basic concept of ore genesis, textures and control.
2. Understand fluid inclusions and ore association.
3. Understand the formation of different types of ore deposits and mineralogy, genesis and Indian distribution of important ore minerals in India.
4. Understand rock mechanics and exploration methods.

UNIT 1:
Modern concepts of ore genesis.
Spatial and temporal distribution of ore deposits – A global perspective.
Comparison between Earth’s evolutionary history and evolutionary trends in ore deposits.
Ore deposits and Plate Tectonics.
Mode of occurrence of ore bodies – morphology and relationship of host rocks.
Textures of ores and their genetic significance.
Ore bearing fluids, their origin and migration. Wall-rock alteration.
Structural, physico-chemical and stratigraphic controls of ore localization.
Petrological Ore associations with Indian examples wherever feasible:

UNIT 2:
Inversion points, exsolution textures and stable isotopes as indicators of depositional temperatures. Geochemistry of ores- major, trace elements, REE and isotopic studies
Ores of mafic-ultramafic association- diamonds in kimberlite; REE in carbonatites; Ti-V ores;
chromite and PGE; Ni ores; Cu, Pb-Zn.
Ores of silicic igneous rocks with special reference to disseminated and stock work deposits, porphyry associations.
UNIT 3:
Ores of sedimentary affiliation—chemical and clastic sedimentation, stratiform and stratabound ore deposits (Mn, Fe, non-ferrous ores), placers and palaeoplacers.
Ores of metamorphic affiliations—metamorphism of ores, Ores related to weathering and weathered surfaces laterite, bauxite. Contemporary ore-forming systems e.g., black smokers, mineralized crusts, Mn nodules. Mineralogy, genesis and important Indian distribution of ore minerals related to: Mn, Au, Sn, W and U.

UNIT 4:
Application of rock mechanics in mining.
Planning, exploration and exploratory mining of surface and underground mineral deposits involving diamond drilling, shaft sinking, drifting, cross cutting, winzing, stoping, room and pillarng, top-slicing, sub-level caving and block caving.
Types of drilling methods. Mining hazards: mine inundation, fire and rock burst.

Books Recommended:
10. Mining Geology II Ed. – H.E. McKinstry, 1962. Asia Publishing House,
Course Objective:
1. To impart comprehensive knowledge of mineral identification techniques, their classification, association and distribution.
2. To acquaint about the instruments used for structural and geochemical analysis of minerals and rocks based upon various analytical signals.

Course Outcome:
Upon successful completion of course the students would be able to
1. In-depth knowledge of optical properties and staining methods of mineral identification. Instrumentation for chemical and structural analysis of minerals.
2. Understand crystal chemistry and mineralogy of silicates.
3. Understand crystal structure and mode of occurrence of non-silicate minerals.
4. Instrumentation for bulk chemical analysis of rocks

UNIT 1:
Indicatrix- concept and application.
Orthoscopy- pleochroism and absorption schemes, Interference colours, dispersion
Conoscopy- interference figures (uni- and biaxial)
Determinative mineralogy-Refractive index, axiality, optic sign, and optic axial angle (2V) by microscope
Description and function of microscopic aids- compensation plates and wedges, Universal stage.
Sample- Definition, field samples, sampling methods. Sample preparation for geochemical analysis.
Thin Section Studies-Etching and Staining techniques particularly for feldspars, carbonates, dolomite, paragonite and quartz
Model analysis and techniques, Polished Sections and determination of micro hardness.
Scanning and Transmission Electron Microscope (SEM & TEM) :Principle, parts, function and application. Diffraction and imaging
Electron Probe Microanalyser (EPMA):Principle, parts, operation and application
Principles, instruments and geological applications of Cathodo luminescence and thermoluminescence.

UNIT 2:
Properties associated with bond types (ionic size, radius ratio, coordination principle, coordination number) Polymorphism, polytypism, pseudomorphism
Atomic structure, mineral chemistry, and mode of occurrence of following mineral groups
(a) Nesosilicates-Garnet, Olivine, (b) Sorosilicates- Epidote (c) Ionosilicates – Pyroxene, Amphibole
(d) Phyllosilicates - Mica, Clay minerals (e) Tectosilicates-Quartz, Feldspar, Feldspathoids, Zeolites, Spinel.
P.T. stability diagrams and their significance with suitable examples.
UNIT 3:
Chemical composition, crystal structure and mode of occurrence of following groups of non-silicate minerals. Native elements: Gold, Silver, Copper, Platinum, Iron, Sulfides- Cu, Fe, Pb, and Zn sulfides.
Sulfosalts-Ag, Cu and Pb sulfosalts, Oxides-simple and multiple oxides excluding SiO2
Hydroxides- Brucite, Gibbsite, Goethite, Limonite, Psilomelane, Carbonates-Calcite, Magnesite, Rhodochrosite, Dolomite, Siderite
Mineral assemblages- Assemblages and phase rule, Assemblages and rock types
Gem and Semi-precious minerals – identification, diagnostic properties, classification, important deposits of India

UNIT 4:
Powdering methods, tools, contaminations
X-rays: Nature, generation and spectra of X-ray, Diffraction, Bragg’s law, X – rays and Crystal structure
X-ray Diffractometry, X-ray diffractrometer (XRD) :Principle, parts, operation
X-rays and Petrochemistry
XRF (wave length dispersive and Energy Dispersive): Principle, parts and function
Rock digestion through acid treatment, Rock digestion through fusion with alkali salts, Soil samples digestion, Water samples.
Conventional analytical methods and Instruments:
Classical, Photometric, Flame photometric and Titration (EDTA)
Rapid methods and Instruments:
Determination of ferrous iron, Determination of water & CO2.
Optical spectrometry- Principles, Nature of light, Absorption and emission of light
Instrumentation for optical spectrometry, Monochromaters, optical filter, slits, photon detectors etc
Principles, parts, operation mechanism, advantages and limitations of the following:
Atomic Absorption Spectrometer- Single and double beam (AAS)
Inductively Coupled Plasma - Atomic Emission Spectrometer (ICP-AES)
HPLC (for water analysis)
Mass Spectrometry & Instruments: Principles and Types
Theoretical working knowledge of the following instruments:
(a) ICP-Mass, (b) Thermal Ionization-Mass, (c) Gas Source-Mass

Books Recommended:
Course Code: GLM1003  
Course: Structural Geology  
Credits: 2  
Course No: M3

Course objectives:
1. To teach students basic concepts of stress and strain and how they are manifest in rock microstructure.
2. To teach students to recognize deformation mechanisms in rocks deformed at different conditions within Earth's lithosphere.

Course outcomes:
Upon successful completion of course the students would be able to:
1. Understand the concept of stress, strain and Mohr’s diagram.
2. Understand aspects of kinematic analysis and parameters used in measuring strain.
4. Understand structural geometry developed in extensional, compressional, and strike slip settings.

UNIT 1:

UNIT 2:

UNIT 3:
Fold shape classifications and projection techniques of fold orientations. Mechanism of single layer and multilayer folds and associated structures. Flexure folds and flow folds.

UNIT 4:
Fault and its classifications .Normal fault systems, Thrust systems. Strike slip fault systems. Fault orientation in relations to stress and strain axes.

Books Recommended:
5. Structural Geology: Haakon Fossen
7. Structural geology: fundamentals and modern developments: S.K. Ghosh
Course Code: GLM1004  
Course: Geotectonics  
Credits: 2  
Course No: M4

**Course outcome:**
To impart knowledge of various tectonic features and their evolution.

**Course outcome:**
Upon successful completion of course the students would be able to
1. Understand the formation of continent and ocean and distribution of volcanoes and earthquakes.
2. Understand the sea-floor spreading processes and ocean ridges using marine magnetic anomalies.
3. Comprehend the evolutionary processes of ocean associated with continental rift.
4. Apply the concept of plate convergence and crustal building processes.

**UNIT 1:**

**UNIT 2:**
Sea-floor spreading, Marine magnetic anomalies, geomagnetic reversals, Magnetostratigraphy, Dating the sea-floor.  
Oceanic ridges: Ridge topography, structure of the upper mantle beneath ridges, Heat-flow and hydrothermal circulation, transform faults and oceanic fracture zones.

**UNIT 3:**

**UNIT 4:**
Subduction zones: Oceanic trenches, Morphology of island arc systems, rock assemblages, Structure deciphered from earthquakes, Volcanic and plutonic activity, High pressure Metamorphism, Gravity anomalies of subduction zones.  
Orogenic belts: Ocean-continent convergence, Compressional sedimentary basins, Continent-Continent collision, arc-continent collision, suture zones.

**Books Recommended:**
1. Plate tectonics and crustal evolution - K.C.Condie
2. Aspects of Tectonics - K.S.Valdiya
3. Global Tectonics - Kearey and Vine
Course Code: GLM1005  
Course: Hydrogeology  
Credits: 2  
Course No: M5

Course objective:
1. To impart knowledge of basic hydrogeology including groundwater origin, occurrence and distribution.
2. To train students on basics of well hydraulics, method of exploration, water budget and management.

Course outcome:
Upon successful completion of course the students would be able to
1. Understand hydrologic cycle and its components, hydrologic properties of rock and method of their measurements.
2. Understand basic concepts of well hydraulics including Darcy’s law and groundwater flow equations.
3. Understand methods of artificial recharge in varied hydrologic and geologic conditions, methods of water balance and groundwater management.
4. Understand various surface and sub-surface methods of groundwater exploration including geologic and geophysical.

UNIT 1:
Hydrologic cycle and its components. Ground water origin, types, importance, occurrence, renewable and non-renewable ground water resources. Sub surface movement and vertical distribution of groundwater.

UNIT 2:
Hydraulic properties of aquifer and aquitard and their controlling factors, transmissivity, storativity and Specific yield, Well Hydraulics, Darcy’s law and its validity, confined, unconfined steady, unsteady and radial flow. Determination of permeability in the lab and field. Ground water flow equations.

UNIT 3:

UNIT 4:
Surface and subsurface geophysical and geological methods of ground water exploration. Hydro geomorphic and lineament mapping using various remote sensing techniques.
Surface geophysical methods: resistivity, seismic, gravity and magnetic methods. Well logging for delineation of aquifers and estimation of water quality, electrical resistivity and SP, radiation logging, Gamma, Gamma Gamma, Neutron Caliper and temperature logging

Books Recommended:
5. Raghunath, N.M., 1982: Ground Water-Wiley Eastern
1. **Ore Geology and Mining Geology:**

   **Ore Geology:**
   Preparation of polished blocks of ore minerals.
   Handling reflected light type microscope.
   Physical and optical properties of common oxide and sulfide ore minerals using reflected light microscopy.
   Systematic identification of ore minerals.

   **Mining Geology:**
   Diagrammatic representation of open cast and underground mining.
   Exercises on mine sampling and determination of tenor, cut-off grades and ore reserves.

2. **Structural Geology:**

   Preparation and interpretation of geological maps and sections.
   Structural problems concerning economic deposits.
   Recording and plotting of field data.
   Plotting and interpretation petrofabric data and resultant diagrams.
   Study of large scale tectonic features of the Earth.

3. **Survey:**

   Survey by using Plane table, Theodolite and GPS.
   Surveying of point, line and area features using a handheld GPS.
   Georeferencing maps and satellite images.
   Use of GPS-based coordinates to find pre-determined locations.
1. **Mineralogy, Instrumentation and Analytical Techniques:**
Microscopic study of rock forming minerals using optical accessories. Exercises on thin section and polished section making, etching and staining. Exercises in sample dissolution, determination of elemental composition of minerals and rocks by flame photometer and AAS, sample preparation for powder diffraction by XRD and interpretation of X-ray diffractograms of common minerals and components of the bulk rocks.

2. **Geotectonics:**
Understanding and Diagrammatic presentation of the following:
APW paths and their tectonic implications, supercontinent assembly; P-T-t paths in relation to geodynamics; Calculation of rate and vector of plate motion: absolute and relative motion; Plate motion on transform and transcurrent faults, types of transform margins; Delineation of modern-day plate margins and vector of plate motion; Present-day hotspots: oceanic and continental; Different stages of Wilson cycle; Magnetic anomalies: ocean floor spreading; Mariana and Cordilleran type margins; Thermal structure and gravity anomaly patterns of shield, MOR, trench, arc, continental rift; Accretionary orogens, collision orogens: tectonic division of Himalayan collision orogeny

3. **Hydrogeology:**
Presentation of rainfall data-arithmetic mean, isohyetal and Thiessen Polygon methods. Analyses of hydrograph and estimation of infiltration capacity. Exercises related to porosity, Estimation of permeability by grain size and laboratory methods, Preparation and interpretation of water table contour maps, calculation of hydraulic gradient, Three point problem to determine groundwater movement. Chemical analyses of water.
Course Code: GLM1011  Course: Coal Petrology  Credits: 4  Course No: ME1(a)

Course objective:
1. To understand genesis and geological aspects of coal
2. To understand exploration methods for coal deposits.

Course outcome:
Upon successful completion of course the students would be able to
1. Understand the basic concept of formation of coal and its explorations.
2. Understand various petrographic composition of coal and various techniques of rank/quality assessment.
3. Understand industrial use of coal and associated hydrocarbons.
4. Understanding environmental impacts of coal and its waste disposal.

UNIT 1:
Coal Petrology- Definition, Formation of coal, varieties of coal.
Coal rank - physico-chemical coalification, processes associated with rank change
Maturation concept: physico-chemical coalification – rank change
Origin and Indian distribution of coal, stratigraphy of coal measures. Methods of coal exploration

UNIT 2:
Petrographic composition of organic matter and types, Proximate analysis, Ultimate analysis
Biochemical coalification : The maceral concept, Mceral groups and sub-groups, Vitrinite group and sub-groups, Inertinite macerals, Liptinite macerals, Telovitrinite
Detrovitrinite subgroup, Gelovitrinite subgroup, Liptinite group, Sporinite
Chemical affinities of the Liptinite macerals: cutinite , suberinite, resinite , liptodetrinite, alginite, bituminite, exsudatinite.
The inertinite group: fusinite, semifusinite, inertodetrinite, macrinite, micrinite, funginite, secretinite, microlithotypes
Organic petrological methods: vitrinite reflectance, optical properties of vitrinite and their influence on measurements, relationship of reflectance to other optical properties Techniques for measuring vitrinite reflectance: use of various immersion media, mean maximum reflectance, Random measurements but with polar, Random reflectance carbonization: mesophase development in natural bitumen, natural coke, little limestone coal, visean, meta-exsudatinite

UNIT 3:
Industrial application of coal- Coal carbonization, Hydrogenation, Liquification and gasification, underground coal gasification, Coal bed Methane, coal mining methods

UNIT 4:
Coal hazards and mitigation measures- Environmental impact of coal mining, acid mine drainage, mine subsidence, groundwater inundation, spontaneous combustion of coal, environmental impact of coal based power plants, disposal of coal ash, carbon sequestration.
**Books recommended**


Course Code: GLM1012  
Course: Oceanography  
Credits: 4  
Course No: ME1(b)

Course objective:
1. To impart basic knowledge about the oceans and oceanic currents, their behaviour in the northern and southern hemisphere.
2. To train the students to understand the atmospheric conditions and climate change.

Course outcome:
1. To understand the basic concepts of oceanography to distinguish different climates.
2. To understand ocean current generation, evolution and classification of climate.

UNIT 1:
Topography of the ocean floor. Sea-floor features: Shelf, slope, rise, basin, oceanic ridges, seamounts, trenches and island arcs.
Physical and chemical properties of sea-water and their spatial variations.
Residence time of elements in sea-water. Major water masses of the world’s oceans.
Ocean currents, waves and tides. Important current systems.

UNIT 2:
Thermohaline circulation and the oceanic conveyor belt.
Structure and chemical composition of the atmosphere, lapse rate and stability, scale height, geopotential height, greenhouse gases and global warming.
Waves in atmospheric and oceanic systems. Ocean-atmosphere coupling.

UNIT 3:
Atmospheric turbulence and boundary layer.
Clouds: types, formation and development of clouds
Precipitation: forms of precipitation & precipitation processes (Collision-Coalescence and Bergeron process).
Coriolis force and Pressure gradient force.
General circulation of the atmosphere: Single cell and three cell model.
General circulation of the ocean: Surface, sub-surface and deep ocean currents.

UNIT 4:
El Nino Southern Oscillation (ENSO) in Pacific Ocean and concept of Indian Ocean dipole.
General weather systems of India. Concept of Indian Monsoon system, factors controlling Indian Monsoon and distribution of precipitation over India.
Marine and atmospheric pollution and their controlling factors. Ozone depletion.
Biological productivity in the oceans.
Books Recommended:
Course Code: GLM1014  
Course: Watershed Management  
Credits: 4  
Course No: ME1(c)

Course objective:
To impart knowledge of characteristics of watershed and its implications in geosciences.

Course outcome:
On successful completion of the course, the students would be able:
1. To develop concepts of watershed, morphometry and their implications in geosciences.
2. To understand hydrologic components and art of prioritization.
3. To understand use of remote sensing in watershed management.

UNIT 1:

UNIT 2:

UNIT 3:

UNIT 4:
Water harvesting structures. Techniques of water harvesting- indigenous and engineering methods. Interlinking of rivers-prospects and challenges. Location and planning of water harvesting structures in watersheds using remote sensing and GIS. Case studies and examples from India.

Suggested Books:
1. Watershed management: Madan Mohan Das and Mimi Das Saikia, PHI publications.
3. Watershed management: JVS Murty, New Age international
<table>
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<tr>
<th>Course Code: GLM1073</th>
<th>Course: Field Geology / Industrial / Laboratory training</th>
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<td>Credits: 2</td>
<td>Course No: MAE1</td>
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Field visit to places of geological interest. Geological and structural mapping.
Semester: II

<table>
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<tr>
<th>Course Code: GLM2001</th>
<th>Course: Paleobiology and Indian Stratigraphy</th>
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<td>Credits: 4</td>
<td>Course No: M6</td>
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Course Objective:
1. To impart basic knowledge about advanced Paleobiology and Indian Stratigraphy
2. To train the students to understand the processes of formations of different sedimentary basins and significance of fossils

Course Outcome:
Upon successful completion of course the students would be able to
1. Understand the advanced concepts in paleontology and Indian stratigraphy.
2. Understand fossil record through time and major events in the history of life.
3. Understand Precambrian Stratigraphy of India and crustal evolution.
4. Understand different geological boundary problems in Indian subcontinent.

UNIT 1:
Origin of life, Pre-Cambrian fossil record and major events in the history of life.
Taphonomy: taphonomic processes, types of fossil assemblages and their application.

UNIT 2:
Application of fossils in palaeoclimatic interpretations, climatic bioindicators, use of stable isotopes in palaeoclimatic studies.
Major groups of microfossils with special reference to morphology and geological applications of foraminifera.
Origin and evolution of early vertebrates: fishes and amphibians, major groups, general characters and geological distribution.
Reptiles: general characters, major groups, their geological distribution, evolution and extinction of dinosaurs.
Aves and mammals: evolution, general features and geological distribution, adaptive radiation of Cenozoic mammals.
Evolutionary histories of Proboscideans and Homonidae.
UNIT 3:
Precambrian stratigraphy of India.
Crustal evolution and cratonizing history of Aravalli craton: lithostratigraphy and geochronology of TTG gneisses and granitoids. Contrasts between BGC-I and BGC-II.
Aravalli Supergroup: basement, age and lithostratigraphy.
North Delhi Fold Belt and South Delhi Fold Belt: Contrasts, age and lithostratigraphy.
Bundelkhand craton: lithology and radiometric ages of TTG gneisses, granitoids and mafic dyke swarms.
Singhbhum craton: Older Metamorphic Group, Iron Ore group, Singhbhum Granite, Newer Dolerite, Chhotonagpur terrain.
Bastar craton: Gneisses and granitoids, Spracrustal sequences, Mafic dyke swarms.
Dharwar Craton: lithological and age contrasts between Western Dharwar Craton and Eastern Dharwar Craton, Greenstone belts, Closepet granite.
Mobile belts: Eastern Ghat Mobile Belt, Central Indian Tectonic Zone.

UNIT 4:
Basin configuration, stratigraphy and sedimentary evolution of the following basins. Vindhyan, Chattisgarh and Cuddappah.
Paleogeographic and paleoclimatic conditions prevailing in Indian subcontinent during Paleozoic, Mesozoic and Cenozoic eras. Igneous activity in Indian subcontinent in relation to break up of Gondwanaland. Mountain building activities in Indian subcontinent during Cenozoic Era.
Archean-Proterozoic; Proterozoic-Cambrian, Permian-Triassic and Cretaceous-Tertiary boundary problems in Indian subcontinent.

Books Recommended:
Course Code: GLM2006  Course: Metamorphic Petrology
Credits: 2  Course No: M7

Course Objective:
1. To understand the processes involved in formation of metamorphic rocks
2. To understand implications of various physic-chemical parameters in formulating metamorphic history of rocks.

Course outcome: Upon successful completion of the syllabus the students would be able to
2. Types of metamorphic facies.
3. Condition of the metamorphism and graphical representation of the metamorphic reactions.
4. To understand the P-T-t path that associated with metamorphism and tectonic chemical zoning.

UNIT 1:
Mineralogical Phase rule of closed and open systems.
Factors and processes of matamorphism, diffusion, nucleation.
Fabric of metamorphic rocks, mylonite.
Metasonatism-types, principle of polarity.

UNIT 2:
Metamorphic facies, detailed description of each facies of low pressure, medium to high pressures and very high pressure with special reference to characteristic metamorphic zones and subfacies: albite-epidote hornfels, hornblende - hornfels, pyroxene hornfels, sanidinite, green schist, amphibolite, granulite, prehenite - pumpellite, glaucophane-lawsonite (blueschist), eclogite.

UNIT 3:
Nature of metamorphic reactions and pressure-temperature.
Conditions of metamorphism.
Isoreaction grade, Schreinmakers rule and construction of petrogenetic grids. Graphical representation: ACF, AKF, AFM.
Metamorphic differentiation.
Anatexis and origin of migmatites.
Regional metamorphism and paired metamorphic belts.

UNIT 4:
Metamorphism and Tectonics. Metamorphic facies series.
P-T-t paths and their implications.
Ultra high temperature, ultra-high pressure and ocean-floor metamorphism.
Partial melting during granulite metamorphism.
Chemical zoning and its relation to tectonism.
Books Recommended:
2. Yardley, B.W. 1989: An Introduction to Metamorphic Petrology-Longman,
Course Objective: To impart knowledge and applications of remote sensing and GIS in Geology.

Course outcome:
Upon successful completion of course the students would be able to:
1. To understand the concepts of sensors and satellites.
2. To understand the concepts of aerial photography and its applications in geosciences.
3. To develop elementary idea about remote sensing technique.
4. To develop concepts of maps and GIS.

UNIT 1:

UNIT 2:

UNIT 3:

UNIT 4:
Digital image processing techniques: radiometric and geometric corrections. Image registration and correction, basic concept of geocoding, digital image classification and image enhancement, spatial filtering, band ratioing, FCCs, principal component analysis, IHS and NDVI images. Supervised and unsupervised classification and its utility in land-cover mapping. Application of GIS and RS in geohazards monitoring (landslides, floods, droughts, cyclones, earthquakes). Examples and case studies from India.
Books Recommended:
6. Thornbury, W.D. Principles of Geomorphology
7. Fundamentals of GIS – M. Demers
Course Objective:
1. To impart knowledge of Geophysics and applications of physics in geology
2. To enhance knowledge and applications of geophysics in exploration of earth resources.

Course Outcome:
Upon successful completion of course the students would be able to
1. Understand the basic concept of gravity, gravity corrections and interpretation of gravity data for mineral exploration.
2. Understand concepts of magnetism related to genesis and exploration.
3. Understand fundamentals resistivity and its applications in geology.
4. Understand basic principles of seismic survey.

UNIT 1:
Concept of gravity and gravitational field.
Variations of gravity over the earth’s surface.
Measuring gravity, Gravimeters: types and working principles and concept of Instrumental drift.
Gravity survey practice. Reduction of gravity data: Drift correction, Latitude correction, Elevation correction (Free-air, Bouger and terrain corrections), Eötvös correction.
Interpretation of gravity maps. Gravity signatures of mineral deposits.
Density of common rocks and minerals.

UNIT 2:
The geomagnetic field and its variations. Short term variations, secular variations and Magnetic reversal. Concept of magnetic declination and magnetic inclination.
Magnetic surveying instruments: Fluxgate magnetometer, Proton magnetometer, Optically pumped magnetometer, Magnetic gradiometers.
Magnetic survey in practice: Ground and airborne surveys, Criteria for selecting reference station and survey pattern.
Reduction of Magnetic data: Temporal & regional variations, Elevation & terrain effects.
Rock magnetism and Interpretation of magnetic anomalies.
Applications of magnetic surveying in Geosciences.

UNIT 3:
Resistivity methods: Basic principles, various types of electrode configurations.
Field procedures: Profiling and Sounding.
Applications of electrical methods in groundwater prospecting and civil engineering problems.
Description of borehole environment, Brief outline of various well/logging techniques.
Principles of electrical logging and its applications in petroleum, groundwater and mineral exploration.
UNIT 4:
Seismic methods: Fundamental principles of wave propagation, Refraction and reflection surveys of single interface, Horizontal and dipping cases.
Concept of seismic channel and multi-channel recording of seismic data, End-on and split spread shooting techniques, CDP method of data acquisition, soring, gather stacking and record section.

Books Recommended:
Course Code: GLM2007

Course: Well Hydraulics and Water Chemistry

Credits: 2

Course No: M10

Course objective
1. To impart knowledge about pumping test and application of various well hydraulics equations for analyses of pumping test data.
2. To impart knowledge about water chemistry and analysis of hydrochemical and isotopic data and water quality classification for various uses.

Course outcome
Upon successful completion of course the students would be able to
1. Understand methods of pumping test and analysis of test data by using steady and non-steady equations.
4. Understand representation of hydrochemical data on various diagrams and indices used for drinking, irrigation and industrial uses. Understand evaluation of pollution potential and monitoring of groundwater quality.

UNIT 1:

UNIT 2:
Water well technology, well types drilling methods, (cable tool, direct rotary, and reverse rotary), yield tests, construction and design, development and maintenance of wells. Salt water intrusion in coastal aquifers and their remedial measures. Electrical and Mathematical modeling, data requirement and application of model; Finite difference and finite element method.

UNIT 3:
Chemistry of natural water. Mineral stability in Eh-pH diagram. Types of chemical reaction in water, chemical activities, carbonate equilibrium, oxidation potential, SAR, CEC, major ionic species, hydrochemical facies, major constituents, minor constituents, trace elements of natural waters.
Isotope hydrology: tritium, radio carbon dating of ground water.
REE in sea and river water.
Ground Water quality, estimation and methods of treatment for various uses.
UNIT 4:
Hydrochemical provinces of India.
Problem of arsenic and fluoride, radioisotopes in hydrogeological studies.

Books Recommended:
5. Raghunath, N.M., 1982: Ground Water-Wiley Eastern
Course Objective:
1. To impart knowledge about Geodynamic Processes
2. To train the students about the Crustal evolution

Course Outcome:
Upon successful completion of course the students would be able to
1. Understand the origin and evolution of early earth systems.
2. Understand differentiation processes.
3. Understand origin and evolution of continental crust.
4. Understand the origin and evolution of atmosphere.

UNIT 1:

UNIT 2:

UNIT 3:

UNIT 4:

Books Recommended:
1. Plate Tectonics and Crustal evaluation-Condie.
2. Aspects of Tectonics-Valdiya.
Course Objective:
To impart knowledge about global climate changes and their impacts.

Course Outcome:
Upon successful completion of course the students would be able to:
1. Understand various components of the Earth and their interrelations.
2. Understand ongoing dynamic processes within atmosphere resulting adverse impacts on global climate.
3. Understand global policies for managing global climate change.

UNIT 1:

UNIT 2:
Composition and structure of the atmosphere, Importance of atmosphere to human life, Change in atmospheric composition in the recent time. Burning of fossil fuel, deforestation, global land use/land cover changes. Green house gases and their effects.

UNIT 3:

UNIT 4:
Sea level rise- causes, impacts and adaptation measures. UNFCCC-role, summits, declarations, and protocols on climate change and its mitigation. Role of IPCC in policy making. CoP summits and accords. Policy changes at international level.

Suggested books:
Course Objective:
To provide comprehensive knowledge about the geological activities during Quaternary period.

Course Outcome:
The course helps the students to understand about the
1. Significance of Quaternary period in the evolutionary history of the Earth and an overview of Quaternary events.
2. Methods employed for dating Quaternary events.
3. Characteristics of Quaternary sediment deposits
4. Climatic oscillations during Quaternary period and their significance in modern perspective.

Unit 1
Definition, characteristics and duration of Quaternary Period.
Chronostratigraphic status of Quaternary Period, its divisions and their climatic significance, Standard global stratotype sections and points, Neogene-Quaternary boundary problem.
Quaternary Stratigraphy- Oxygen isotope stratigraphy, biostratigraphy and magnetostratigraphy.

Unit 2
Quaternary dating methods: Radiocarbon, Uranium series Luminescence, OSL, AMS, Amino Acid, Relative dating methods.
Application of pollen, spores and phytoliths in Quaternary stratigraphy.

Unit 3
Sedimentation pattern / records during Pliocene and Holocene (Fluvial, Glacial, Slope and cave sediments, Coastal sediments – storm, tsunami/paleotsunami ). Eustatic changes during Quaternary (long / short term), Marine records, continental - marine correlation of Quaternary record in India.

Unit 4
Climatic transect across Cenozoic to Pleistocene: Facts and controversies
Plate tectonics and climate change.
Milankovitch cycles.

Recommended Books
1. Ravindrakumar: - Historical Geology
2. Dunbar and Rogers: - Principles of Stratigraphy
4. Alastair G. Dawson: - Ice Age Earth: Late Quaternary Geology and Climate
6. Geological Society of India: Quaternary of India
8. Ruddiman: “Earth’s Climate, Past and Future”
Course Code: GLM2015  
Course: Applied Geomorphology  
Credits: 4  
Course No: ME2(d)

Course Objective:  
1. To build concepts of geomorphology and its applications in geological studies.  
2. To understand landforms and their evolution

Course Outcome:  
At the end of the course, the student should be able to appreciate and understand:  
1. Geomorphic features and their evolution.  
2. Geomorphic indices and their applications in geosciences.  
3. Landforms associated with fluvial, eolian, glacial and coastal environment.

UNIT 1:  

UNIT 2:  
Introduction, Hypsometric Curve and Hypsometric Integral, drainage basin asymmetry, stream length-gradient index (SL), mountain-front sinuosity (Smf), ratio of valley-floor width to valley height (Vf), alluvial fans and tectonic activity at mountain fronts. Introduction, bedrock rivers, alluvial rivers, and river grade, coseismic modification of river systems, fluvial responses to tectonic modification, aggradation and degradation, changes in drainage and stream pattern, responses of bedrock channels, changes in longitudinal profile, fluvial terraces, other responses to longitudinal deformation, responses to lateral tilting, models of tectonic adjustment

UNIT 3:  
Fluvial geomorphic cycle. Characteristics of various Stream types. Drainage patterns and their significance. Linear, areal and relief parameters of a drainage basin. Landforms formed by rivers-terraces, alluvial fans, flood plains, natural levees, point/channel bars, ox bow lakes, paleochannels, cut off meanders etc. Identification of landforms on satellite images Drainage development in deserts. Hydro-geomorphic mapping and its significance.

UNIT 4:  
Arid geomorphologic cycle. Characteristics of arid and semi arid regions. Landforms formed by wind- pedestal rock, dunes, loess, bajada, salina, blow holes, pediments, inselberg, ruware, yardang, ventifacts etc. Landforms formed in sedimentary and igneous rocks. Glacial landforms- arte, cirque, moraines, hanging valleys, drumlins, etc. Coastal processes and resulting landforms. Applied geomorphology: civil engineering, environmental studies, groundwater targeting etc.
Books Recommended:
2. Geomorphology by Arthur L Bloom, PHI Publishers
1. **Paleobiology & Indian Stratigraphy:**
Recognition of fossil groups in an assorted assemblage and identification of their classes. Study of important fossils from Indian stratigraphic horizons. Measurement of dimensional parameters and preparation of elementary growth-curves and scatter-plots. Exercises on stratigraphic classification and correlation. Exercises on interpretation of seismic records for stratigraphy study of palaeogeographic maps of all geological periods.

2. **Metamorphic Petrology:**
Megascopic and microscopic study of metamorphic rocks of different facies. Time relationship between deformation and recrystallisation. Graphic construction of ACF, AKF and AFM diagrams. Estimation of pressure and temperature from important models of geothermobarometry. Interpretation of reaction textures.
1. **Remote Sensing in Geosciences:**
Delineation of drainage pattern. Interpretation and identification of common rock types on aerial photographs. Morphometric analysis using aerial photographs based on watershed and water divide. Scene identification of IRS and Landsat data using NRSA website. Cultural details on images, land use and land cover mapping using IRS data. Mapping of geomorphological landforms on remote sensing data.

2. **Geophysical Exploration:**
Study of gravimeter, magnetometer and seismographs. Resistivity survey. Interpretation of underground structure on the basis of seismic data.

3. **Well Hydraulics and Water Chemistry:**
Course Objective:
1. To impart knowledge of formation and utilization of conventional, non-conventional and radioactive resources
2. To train the students to understand the processes of formations and exploration of hydrocarbon reserves.

Course Outcome:
Upon successful completion of course the students would be able to
1. Understand the basic concept of occurrences, distribution and exploration of coal deposits.
2. Understand formation and exploration of hydrocarbon reserves.
3. Understand the methods used in the formation evaluation for hydrocarbon reserves.
4. Understand the mode of occurrences of radioactive deposits.

UNIT 1:

UNIT 2:

UNIT 3:
Methods of subsurface geological mapping. Reservoir rocks: sandstone reservoirs, carbonate reservoirs and fractured reservoirs. Trapping mechanism for oil and gas, characteristic of structural, stratigraphic and combination traps. Oil fields- water, oil and gas occurrence. Formation evaluation: well-logging, types of well logs, interpretation of lithology, quality and quantity of formation fluids from well logs. Sedimentary basins: mechanism of sedimentary basin formation, oil bearing basins
of India and the world. Geology of productive oil fields of India, position of oil and gas in India, future prospects and the economic scenario.

UNIT 4:
Physico-chemical behaviour of U and Th, classification of radioactive minerals. Mode of occurrence and association of atomic minerals in nature, atomic minerals as source of energy. Methods of prospecting and productive geological horizons of India. Geology, geochemistry and origin of hydrothermal, syngenetic, pegmatitic and carbonatitic deposits of U and Th, Placer deposits of Th: origin and distribution. Nuclear power stations of the country and future prospects.

Books Recommended:
Course Code: GLM3002  
Course: Engineering Geology  
Credits: 2  
Course No: M12

Course Objective:
To develop concept and applied aspect of geology in various civil or geoengineering projects.

Course Outcome:
1. To develop understanding of site selection by applying concepts of geology and geophysics.
2. To develop basic concepts of rock and soil mechanics and to built scientific understanding of geotechnical problems.
3. To develop understanding of various geoengineering projects and to develop geotechnical skills of the students.

Detailed topics taught in each unit are as follows:

UNIT 1:

UNIT 2:

UNIT 3:

UNIT 4:
Mass movements with special emphasis on landslides and rockfalls. Slope stabilization and protection measures. Geological consideration for evaluation of dams and reservoir sites. Reservoir siltation. Geotechnical evaluation of tunnel alignments and transportation routes, methods of tunneling, classification of ground for tunneling purposes, various types of support. Geotechnical investigations for bridges and coastal barriers. Case history of the following engineering projects: (a) Sardar Sarovar hydroelectric project; (b) Tehri hydroelectric project.
Books /Articles Recommended:
Course Code: GLM3006  Course: Igneous Petrology
Credits: 2  Course No: M13

Course objective:
To understand characteristics and genesis of Igneous rocks

Course outcome:
Upon successful completion of the syllabus the students would be able to
1. Mantle geochemistry of the Earth and physical properties of magma.
2. Classification of the igneous rocks and their textures.
3. Application of the silicate phase equilibrium to understand magma genesis and crystallization.
4. Origin of volcanic and plutonic rock

UNIT 1
Mineralogy and chemistry of earth’s mantle; Mantle components. Physics of magma generation in the mantle, their nature. Physical properties of magma: temperature, density, viscosity, volatile components their nature, Factors affecting magma and evolution of magma. Norms - CIPW

UNIT 2

UNIT 3

UNIT 4
Petrogenesis of the following igneous rock types: Ultramafic (Peridotite and Picrite, Komatiite), Basalts, Andesites, Granites, Syenite, Carbonatite, Anorthosite.

Books Recommended:
Course Code: GLM3003

Course: Geochemistry and Radiogenic isotopes

Course No: M14

Course Objective:
1. To impart training about the abundance and distribution of elements.
2. To date different geological events by employing radioactive isotope techniques.

Course Outcome:
Upon successful completion of course the students would be able to
1. Understand the abundance and distribution of elements and classification of elements.
2. Understand how to unravel geological processes using element behaviour.
3. Understand how radiogenic ages are determined.

UNIT 1:
Cosmic abundances of elements, nucleosynthesis, meteorites.
Periodic Table: Atomic structure, physical and chemical properties of different element groups.
Geochemical classification of elements: major elements, trace elements, transition elements, Compatible and incompatible elements, HFSE, LILE, LFSE, PGE, REE.
Special properties of alkali elements (AE), alkaline earth (AEE), transition (TE) and rare earth elements (REE).

UNIT 2:
Behaviour of trace elements including REE in igneous, metamorphic and sedimentary rocks.
Distribution of elements during crystallization of magma.
Partition coefficient : general principle and determination in natural and experimental systems.
Trace elements modeling of partial melting, crystal fractionation.

UNIT 3:
Radioactive decay law, radiogenic isotopes.
Radioactive decay schemes of U-Th-Pb.
Geochemistry of U and Th, their decay series, growth of daughter isotopes U, Th, Pb methods of dating, U-Pb concordia, analytical methods of zircon dating, dating of individual zircons.
Decay scheme of Sm-Nd, growth of daughter isotopes, geochemistry of Sm and Nd, age determination, CHUR, epsilon and model dates.

UNIT 4:
Geochemistry of Rb, Sr, decay scheme and growth of daughter isotopes.
Dating of minerals and whole rock, isochron dates, errorchrons, initial ratio.
Principles and methodology of K-Ar dating.
Books Recommended:
**Course Code:** GLM3004  
**Course:** Sedimentology  
**Credits:** 2  
**Course No:** M15

**Course Objective:**
1. To impart knowledge of hydrodynamic conditions, mode of transport and depositional conditions for the clastic sediments.
2. To train the students to understand the processes of formation of clastic and carbonate rocks.

**Course Outcome:**
Upon successful completion of course the students would be able to
1. Understand the hydrodynamic conditions for deposition of clastic sediments.
2. Understand the processes of generation of sedimentary structures and lithofacies analysis in reconstruction of depositional environment.
3. Understand the classification of different types of depositional environments.
4. Understand the origin, classification and distribution non clastic sediments.

**UNIT 1:**
Earth surface systems: Liberation and flux of sediments. Fundamentals of fluids laminar and turbulent flow.
Reynolds number, Froude number, velocity profiles and bed roughness.
Flow regimes- Idealized sequence of structures in lower and upper flow regimes. Hyulstroms diagram.
Particle transport by sediment gravity flow. Boumas ideal sequence.

**UNIT 2:**
Processes of transport and generation of sedimentary structures,
Controls on the sedimentary rock records, Geometry and significance of sedimentary bodies.
Facies definition, Facies association, Walther’s law of Facies and Application.
Sedimentary cycles and cyclotherms

**UNIT 3:**
Classification of sedimentary environments.
Facies Models of alluvial-fluvial, lacustrine, desert-aeolian and glacial sedimentary systems.
Shallow coastal clastics, Marine and continental evaporates

**UNIT 4:**
Deep sea basins.
Modern carbonate sediments- shallow water carbonates, deep sea carbonates, fresh water carbonates, evaporitic carbonates, Eolian carbonates, Mineralogy and chemical composition of carbonate minerals.
Genetic concept of classification of limestone. Petrography and genesis of carbonate rocks.
Dolomite: mineralogy, occurrence and mechanism of formation.
Limestone Facies: stromatolitic (Tidal Flat), biohermal, cross-bedded winnowed shelf, nodular limestone, chalk (Pelagic) and evaporitic carbonatic facies.
Books Recommended:
Course Code: GLM3005  
Course: Environmental Geology  
Credits: 2  
Course No: M16

Course objective  
1. To impart the knowledge about basics of environmental geology.  
2. To train students about the basic fundamental aspects of atmosphere, its composition vis a vis the recent global climate change and their effects.

Course outcome  
Upon successful completion of course the students would be able to  
1. Understand basics of environmental geology and global changes in earth system and climate.  
2. Understand air quality pollutants and environmental impact, oceanic and atmospheric circulation and its impact on climate.  
3. Understand the structure and chemical evaluation of atmosphere; understand the causes, impacts and adaptation in context of climate change.  
4. Understand the systematic/nonsystematic changes in climate and its impact on human evolution.

UNIT 1:  
Spectrum of environmental geology, global changes in the Earth system and climate Anthropogenic impacts on the atmosphere, local impacts changing the landscape, role of geology in understanding atmospheric changes

UNIT 2:  
Thermal inversion, suspended particulate matter, heavy metals, carbon mono oxide, sulfur dioxide, nitrogen oxide, volatile organic compounds, ground level ozone, natural sources, smog and tropospheric ozone.  
Impact of circulation in atmosphere and oceans on climate, rainfall and agriculture, wind system, global circulation, Coriolis effect.  
Thermal interactions between oceans and atmosphere, advective and convective processes, Heat budget of ocean, ocean ecosystem, ocean currents, general pattern of oceanic circulation.

UNIT 3:  

UNIT 4:  
Nitrogen oxide and ozone layer, cycling of carbon, records of paleotemperature in ice cores of glaciers, palaeo-temperature changes during the glacial ages, glacial ages, last ice age, causes of glaciation, Limestone deposits and climate change.  
Cenozoic climate extremes, evolution of life especially the impact on human evolution.
Books Recommended:
2. Keller, E.A., 1978: Environmental Geology-Bell and Howell, USA
1. **Fuel Geology:**
Maps and exercises related to coal geology. Study of geological maps and sections of important oilfields of India. Exercises and maps related to petroleum geology. Study of geological sections of U-Th bearing rocks of the country. Megascopic study of some uranium and thorium bearing minerals and rocks.

2. **Engineering Geology:**
Exercises related with geomechanical and physical characteristics of rocks and soils. Exercises related with landslide and slope stability studies. RQD and Rock mass classification (Rock mass rating, Slope mass rating and geological strength index etc.). Study of maps and models of important engineering structures as dam sites and tunnels.

3. **Environmental Geology:**
Study of seismic and flood-prone areas in India. Analyses for alkalinity, acidity, pH and conductivity (electrical) in water samples. Classification of ground water for use in drinking, irrigation and industrial purposes. Presentation of chemical analyses data and plotting chemical classification diagram.
Course Code: GLM3072
Course: Lab work: Geochemistry and Radiogenic isotopes, Igneous Petrology, Sedimentology and Computer Applications
Credits: 2
Course No: ML4

1. **Geochemistry and Radiogenic Isotopes:**
Rocks/Soil/sediments/water analysis. Calculation of mineral formulae from concentration of various oxides in minerals.

2. **Igneous Petrology:**
Study of hand specimen of different types of extrusive and intrusive igneous rocks. Microscopic study of igneous textures, mineralogy and petrogenetic features of igneous rocks.

3. **Sedimentology:**
Study of primary, secondary and biogenic sedimentary structures in hand specimens, in photographic atlases, field photographs and wherever possible on the outcrops. Exercises related to palaeocurrent data from different environments. Tilt corrections of palaeocurrent data.

4. **Computer Applications:**
Computer applications in geological and environmental studies using satellite imageries, digital elevation data, virtual globes and different software packages:
   i. Land cover change detection using GIS and reflectance imageries.
   ii. Mapping urban sprawl around a moderately sized urban agglomeration and assessing its implications.
   iii. Preparing landslide inventory maps using Virtual Globes.
   iv. Geological mapping using reflectance imagery as a base map.
Course Objective:
To develop concepts and applications of remote sensing and GIS in Geology.

Course outcome:
Upon successful completion of course the students would be able to:
1. To understand the characteristics of various sensors and satellite missions.
2. To understand the role of remote sensing and GIS in agricultural and hydro-meteorological studies.
3. To develop concepts of digital elevation model and hyperspectral remote sensing.
4. To develop concepts of maps and GIS.

UNIT 1:
Microwave remote sensing: EMR and spectrum. SAR, LIDAR, RADARSAT, SEASAT, MEOSAT, SIR missions. Thermal and infrared remote sensing and their applications in forest and coal mine fires, volcanic eruptions and urban heat island.

UNIT 2:
Application of remote sensing in drought monitoring and assessment- hydrological drought, agricultural drought and meteorological drought. CAPE and CADA missions of Indian government. Sediment yield index- role of remote sensing and GIS. Case studies and examples. RS and GIS applications for site selection of dams, water harvesting structures and waste disposal. Examples and case studies.

UNIT 3:
Digital elevation models, Types of DEMs, Methods for obtaining elevation data used to create DEMs, Use of DEMs in topographic and geologic mapping, mineral exploration, morphometric analysis, Floodplain mapping and analysis, Watershed management, Erosion control, Commercial applications of DEMs, Availability of global elevation data. Hydrogeomorphic mapping for ground water potential zones.

UNIT 4:
Hyperspectral remote sensing-Imaging spectrometry, Characteristics of hyperspectral data, reflection and absorption processes, causes of absorption, spectral signatures and spectral libraries, atmospheric corrections applied to hyperspectral data, Data analysis software, Methodology, Availability of data, Application of hyperspectral remote sensing for geological mapping and exploration.

Books Recommended:
3. Fundamentals of GIS – M. Demers
4. Encyclopedia of Applied Geology – Finkiel
6. Remote sensing and Geographic Information System by A.M. Chandra
Course Objective:
1. To impart knowledge of Advanced Ore Geology.
2. To train the students to understand the processes of formations of different ore deposits, textures, global tectonics, metallogeny and Mineral deposits at terrestrial impact structures.

Course Outcome:
Upon successful completion of course the students would be able to
1. Understand the basic concept of ore deposits related to various geological processes.
2. Understand the description of various ore deposits.
3. Understand fundamentals of textures of ore minerals and their significance.
4. Understand global tectonics, metallogeny and Mineral deposits at terrestrial impact structures.

UNIT 1:
Ore deposits related to chemical sedimentation: Sedimentary base-metal deposits and other chemical precipitates, Sedimentary iron deposits, Sedimentary manganese deposits, Phosphate deposits, Evaporites, Manganese nodules.
Ore deposits related to clastic sedimentation: Placer deposits.
Ore deposits related to weathering: Nickel laterite deposits, Manganese deposits, Bauxite deposits, Supergene sulfide enrichment.

UNIT 2:
Ore deposit types and their primary expressions:
Dispersion around magmatic deposits, contact metasomatic (skarn) deposits, hydrothermal deposits, exhalative deposits, marine-sedimentary deposits, metamorphic deposits, residual & supergene deposits and placer deposits

UNIT 3:
Paragenesis and zoning of ores and their significance.
Textures of ore minerals and their significance.
Textures formed due to deposition in open spaces.
Textures formed due to crystallization from melts.
Textures formed due to replacement.
Textures formed due to exsolution.
Textures formed due to precipitation from colloids.
Textures formed due to deformation.

UNIT 4:
Ore deposits in a global tectonic context: Patterns in the distribution of mineral deposits, Continental growth rates, Crustal evolution and metallogenesis, Metallogeny through time, Plate tectonics and ore deposits. Mineralization through Geological time. Mineral deposits at terrestrial impact structures.
Books Recommended:
4. Ore Deposit Types and their Primary Expressions – K K.G. McQueen, CRC LEME, Australian National University, Canberra, ACT 0200 and School of REHS, University of Canberra, ACT 2601. 14p.
Course objective
1. To impart knowledge about groundwater resources evaluation by using empirical methods and groundwater flow modeling.
2. To train students on groundwater contamination monitoring and assessment, role of stable isotopes in quality and recharge evaluation.

Course outcome
Upon successful completion of course the students would be able to
2. Understand principle of groundwater flow and forces acting on it, pumping test methods including (SDT) and (APT) and analysis of test data.

UNIT 1:

UNIT 2:
Principle of groundwater flow: mechanical energy, hydraulic head, force potential and hydraulic head. Darcy Law in terms of force potential.
Step draw down test (SDT) and its application in evaluation of well performance. Aquifer performance test (APT), determination of aquifer parameters using Theis recovery, Boultons and distance draw down methods. Hydrogeological boundaries; recharge boundary condition and barrier boundary. Determination of aquifer boundaries.

UNIT 3:
UNIT 4:

Books Recommended:
Course Code: GLM3024  Course: Petroleum Geology  Credits: 4  Course No: ME3(d)

Course Objective:
1. To impart knowledge of occurrence and exploration of conventional, non-conventional and radioactive resources.
2. To train the students to understand the processes of formations, prospecting and evaluation and exploration of hydrocarbon reserves.

Course Outcome:
Upon successful completion of course the students would be able to
1. Know about the origin and migration hydrocarbon to form a commercial pool.
2. Understand the methods used for the exploration of hydrocarbon.
3. Understand the application of different logs and microfossils in the evaluation of hydrocarbon bearing formations.
4. Understand the different methods used for hydrocarbon exploration and non-conventional resources for future prospects.

UNIT 1:
Origin of Petroleum: Organic and Inorganic, Production and preservation of organic matter and formation of Kerogen, Petroleum migration, Petroleum System and Basin Modeling, Physical and chemical properties of petroleum

UNIT 2:
Geophysical methods of petroleum exploration: Magnetic, Gravity, and Seismic surveys, 4-D Seismic survey.
Application of remote sensing in petroleum exploration.
Reservoirs: Types and characters, Reservoir continuity, Traps and seals: Structural, Stratigraphic, diapric.

UNIT 3:
Application of microfossils in Petroleum Exploration, Sampling procedures and processing of microfossils in commercial laboratories, Biosteering: method and application, Types and hydrocarbon potential of organic reefs.
Application of logs in petrophysics and facies analysis.

UNIT 4:
Drilling rigs and their components, Types of drilling: Cabe tool, Rotary, Directional, Horizontal, Hydrocarbon reserve calculation and production methods, Enhanced Recovery methods.
Non-conventional Petroleum Resources; Tar Sand, Oil Shale, Shale Gas, CBM, Gas Hydrate, Prospects and probabilities of hydrocarbon, Prospect Appraisal: Geologic and Economic aspects, assessment of Basin and Global reserves
Books Recommended
Course Objective: The course is designed for the students who willing to take structural geology or rock mechanics in their research.

Course outcomes:
Upon successful completion of course the students would be able to
2. Understand mechanics of folding and buckling.
3. Understand rock failure criteria and be able to perform structural analysis and interpret various deformational structures.
4. Understand linear and planar fabrics (L-S Tectonites) and their relation to major geological structures.

UNIT 1:

UNIT 2:
Folding mechanism and fold geometry. Classification of folds based on layer shape. Buckling, oblique shear and flow folding. Kinking and formation of chevron folds.

UNIT 3:
Study of various types of fractures. Application of fracture analysis. Brittle and ductile shear zones, geometry and products of shear zones; Mylonites and cataclasites,. Palaeostress analysis using fault-slip data. Determination fabrics in deformed rocks and interpretation.

UNIT 4:

Books Recommended:
1. Structural analysis of metamorphic Tectonics-Turner and Weiss
2. Structural Geology of Rocks and Regions- George H. Davis- 3rd edition
3. Folding and Fracturing of Rocks-Ramsay
4. An Outline of Structural Geology-Rubbs, Mears and William
5. Structural Geology: Haakon Fossen
7. Structural geology: fundamentals and modern developments: S.K. Ghosh
<table>
<thead>
<tr>
<th>Course Code: GLM3073</th>
<th>Course: Field Geology / Industrial / Laboratory Training</th>
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<tbody>
<tr>
<td>Credits: 4</td>
<td>Course No: MAE4</td>
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Visit to areas of geological interest, Visit to important underground and open cast mines.
Semester IV

<table>
<thead>
<tr>
<th>Course Code: GLM4001</th>
<th>Course: Geochemistry and Stable Isotopes</th>
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<tbody>
<tr>
<td>Credits: 2</td>
<td>Course No: M17</td>
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**Course Objective:**
1. To impart knowledge about geochemical characteristics of different earth systems
2. To train the students about the stable isotopes and its applications

**Course Outcome:**
Upon successful completion of course the students would be able to
1. Understand the isotopic characteristics of different mantle components.
2. Understand how stable isotopes are employed to unravel different earth processes.
3. Understand how thermodynamic principles are applied to understand low temperature geochemical behaviors.

**UNIT 1:**
Geochemical characteristics of different mantle geochemical components: HIMU, EM – 1, EM- 2, PREMA and DUPAL. Isotopes as petrogenetic indicators.
Stable isotopes: nature, abundance and fractionation.
Oxygen and hydrogen isotopes in water and water vapour, SMOW.

**UNIT 2:**
Carbon isotopes in modern biosphere and in sediments, fossil fuels, marine and non-marine carbonates.
Nitrogen-isotopic fractionation, nitrogen isotopes of igneous, meteorite and lunar rocks, nitrogen on the surface of the earth, fossil fuels.
Sulfur-biogenic fractionation, sulfur isotopes in recent sediments, petroleum and coal.

**UNIT 3:**
Laws of thermodynamics, concept of free energy, activity, fugacity and equilibrium constant, thermodynamics of ideal, non-ideal and dilute solutions. Principles of ionic, substitution in minerals, element partitioning in mineral/rock formation.
Concept of simple distribution co-efficient and exchange reaction distribution coefficients.
Elements partitioning in mineral assemblages and its use in P-T estimation.

**UNIT 4:**
Rock weathering and soil formation. Elementary mobility in surface environment.
Soil geochemistry, sediment geochemistry.
Concept of geochemical-biogeochemical cycling and global climate.
Identification and evaluation of geochemical anomalies.
Atmosphere composition, evolution of atmosphere and differentiation of elements through geological times.
Books Recommended:
Course Objective:
1. To impart knowledge of origin and classification of clastic rocks
2. To train the students to understand the processes of formations primary sedimentary structures in determination of palaeoenvironment.

Course Outcome:
Upon successful completion of course the students would be able to
1. Understand the basic concept of textural and mineralogical maturity of clastic rocks.
2. Understand formation of sedimentary basins in relation to plate tectonics.
3. Understand the proxies of paleoclimate and paleoenvironment.
4. Understand the criterion used in basin analysis.

UNIT 1:
Textural and mineralogical maturity of clastic rocks.

UNIT 2:
Evaluation of sedimentary basins: tectonics and sedimentation; craton facies, geosyncline and related facies.Sedimentary basins and plate tectonics: intraplate basins, divergent margin basins, Rifts, failed rifts aulacogens, convergent margin basins, trench, subduction complex, fore arc, back arc, and inter arc basins

UNIT 3:
Clastic petrofacies: paleoclimate and paleoenvironment analysis.
Application of trace element, rare earth element and stable isotope geochemistry to sedimentological problem.Field and laboratory techniques in sedimentology: recording of sedimentary structures, preparation of lithologs, rocks and thin section staining, cathodoluminescence

UNIT 4:
Paleocurrent and basin analysis: use of various sedimentary structures like ripple marks, cross bedding, sole marks in reconstruction of paleocurrents, Impact of paleocurrents on size shape, roundness, fabric and bed thickness, Distribution of paleocurrents in space and time and usefulness in paleogeographic reconstruction and basin analysis.

Books Recommended:
Course Code: GLM4004  
Course: Environmental Pollution and Natural Hazards  
Credits: 2  
Course No: M19

Course objective
1. To impart knowledge of nature of groundwater and soil pollutants
2. To train the students to understand impact of the natural/anthropogenic hazards on environment and their monitoring and mitigations.

Course outcome
Upon successful completion of course the students would be able to
1. Understand behavior of contaminants in environment and their impact on surface and groundwater
2. Understand causes of water logging and its impact, causes of floods, flood hazards and its management
3. Understand about soil formation, classification and deterioration of soil due to engineering and agricultural practices.
4. Understand the seismic distribution of India, understand the causes, impacts and assessment of sea level rise and desertification.

UNIT 1:
Pollutants and contaminants. Behaviour of contaminants in environment. Point and non-point sources. Assessment and impact of contamination for surface and ground water quality due to industrialization and urbanization. Induced pollution, water quality criteria for different uses.

UNIT 2:
Water logging, problems of water logging due to indiscrete construction of canals, reservoirs, dams, water logging problem in India, Floods, causes of floods, flood hazard, management of floods

UNIT 3:
Soil formation and their classification, soil nature, soil profile, soil types of India, soil erosion by running water, wind, soil deterioration by agricultural and engineering practices. Soil pollution and soil amendments, effects of fertilizers, pesticides and insecticides

UNIT 4:

Books Recommended:
2. Keller, E.A., 1978: Environmental Geology-Bell and Howell, USA

Vulnerability, threats and analysis-Case Studies from India, TERI, The Energy & Resources Institute, New Delhi.
<table>
<thead>
<tr>
<th>Course Code: GLM4071</th>
<th>Course: Lab work: Geochemistry and Stable Isotopes and Computer Applications</th>
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<tr>
<td>Credits: 2</td>
<td>Course No: ML5</td>
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</table>

1. **Geochemistry and Stable Isotopes:**
   Calculation of weathering indices in soil and sediments. Presentation of analytical data.

2. **Computer Applications:**
   Exercises in basin morphometry using digital elevation data and GIS software. Calculation of Relief Ratio ($R_r$), Channel sinuosity ($C_s$), Bifurcation Ratio ($R_b$), Asymmetry factor ($A_f$), Drainage density ($D_d$), Basin elongation ratio ($R_e$), Basin Shape ($B_s$), Hypsometric integral (HI), Valley floor width-to-height ratio ($V_f$), Stream-length gradient index (SL)
<table>
<thead>
<tr>
<th>Course Code: GLM4072</th>
<th>Course: Lab work: Applied Sedimentation and Environmental Pollution and Natural Hazards</th>
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<td>Credits: 2</td>
<td>Course No: ML6</td>
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1. **Applied Sedimentation:**

2. **Environmental Pollution and Natural Hazards:**
Evaluation of environmental impact of air pollution groundwater, landslides, deforestation, cultivation and building construction in specified areas.
<table>
<thead>
<tr>
<th>Course Code: GLM</th>
<th>Course: Project oriented Dissertation</th>
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<tr>
<td>Credits: 2</td>
<td>Course No: ML7</td>
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Project dissertation on the assigned topic and preparation of report.

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<thead>
<tr>
<th>Course Code: GLM40V1</th>
<th>Course: Viva-voce on project Dissertation</th>
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<td>Credits: 4</td>
<td>Course No: ML8</td>
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Presentation cum Viva-voce on the project dissertation.
Course objective:
To develop understanding of geochemical data and its use in geological studies.

Course outcome:
Upon successful completion of course the students would be able to
1. Explain element fractionation and geochemical data analysis to understand geochemical processes.
2. Explain geochemical exploration method to understand distribution of metallic and hydrocarbon deposits.
3. Understand dating technique like OSL, fission tract plateau and Radon to determine age of rocks.
4. Explain cosmogenic radionuclides to understand evolution of the early Earth from protoplanetary material and its differentiation to present day state

UNIT 1:
Geochemical data analysis- evaluation of quality of data,
Precision and accuracy, presentation and statistical treatment of data.
Interpretation of data
Distribution of elements, primary dispersion, secondary dispersion.
Abundance, distribution, and migration of ore forming elements
Use of isotopes in geochemical exploration

UNIT 2:
Evolution and geochemical characteristics of the regolith,
Factors controlling the mobility and form of elements in various environments
Selection of appropriate sampling and analytical method.
Geological exploration methods-lithogeochemical, hydrogeochemical, atmogeochemistry.
Soil survey, pedochemical methods, overburden geochemistry.
Drainage survey, stream sediment survey-bed sediments, flood plain geochemistry, lake sediments.
Geobotanical survey, biogeochemical survey.

UNIT 3:
Geochemical prospecting
Radon as a geochemical exploration tool-generation, migration, radon measuring methods, applications in exploration
Quaternary dating methods
Fission tract plateau dating
Thermoluminiscence/OSL dating
Marine and Lacustrine sediments dating with $^{210}\text{Pb}$
UNIT 4:
Geochemical background survey
Causes of geochemical anomalies
Radionuclides and their use in geochemical exploration
Cosmogenic radionuclides in ground water
Production of $^{10}$Be, $^{26}$Al, Residence times in ocean, Dating sediments with cosmogenic radionuclides: marine sediments, Mn nodules, biogenic silica, continental sediments and soils.

Books Recommended:
Course Code: GLM4013
Course: Sedimentary Environments and Sedimentary Basins
Credits: 4
Course No: ME4(b)

Course Objective:
1. To impart knowledge of different depositional facies and its economic significance
2. To train the students to understand about the sedimentation pattern and deposition environment.

Course Outcome:
Upon successful completion of course the students would be able to
1. Understand the basic concept of different depositional facies.
2. Understand sedimentation pattern and depositional environment of various sedimentary basins.
3. Understand the sequence stratigraphy and its applications.
4. Understand about trace fossils and its significances.

UNIT 1:
Sedimentary cycles, rhythms and cyclothems. Analysis of sedimentary facies and preparation of facies maps. Lithofacies, biofacies, dynamics and primary structures associated with the environments-alluvial fan, river plains, glaciers, deltas and estuaries.

UNIT 2:
Sedimentation pattern and depositional environment of selected undeformed sedimentary basins of India representing Precambrian, Phenerozoic and contemporary basins. Volacniclastics- formation and general characteristics, types of pyroclastics.

UNIT 3:
Sequence stratigraphy-historical perspective, concepts and principles, sequence stratigraphic tools, application to depositional system. Clay deposits-physical properties, mineralogy, chemistry and genesis. Evaporites-mineralogy, physico-chemical controls on precipitation and dissolution. Phosphorites- mineralogy, occurrence. origin of various types of cement.

UNIT 4:
Trace fossils- occurrence, association and petrographic characteristics, use of trace fossils, stromatolites,thrombolites and related structures in paleoenvironment analysis.

Books Recommended:
Miall , A.D., 2000: Principles of Sedimentary Basin Analysis-Springer Verlag
Course Code: GLM4017  Course: Impact of Geology on Environment  Credits: 4  Course No: ME4(c)

Course objective:
1. To impart knowledge on ecological perspective of environment, biodiversity, sustainable development and environmental priorities and environmental law in India.
2. To impart knowledge about environmental impact assessment caused by natural and anthropogenic activities.

Course outcome:
Upon successful completion of course the students would be able to
1. Understand ecological prospective of environment, biodiversity, and environmental priorities in India, sustainable development.
2. Understand the environmental implications of road, canal, dams and reservoir construction, Natural hazards and their mitigation.
3. Understand the environmental impact of mineral development, mining activities, and hazardous waste disposal impact and their management.

UNIT 1:
Concept of Ecosystem; Ecology, Ecological perspective of Environment, Biotic communities, Biological Diversity. Values of Indian Biodiversity, Indian Biodiversity under serious threat. Concept of sustainable development- sustainable living and non-living resources. Environmental priorities in India and sustainable development. The nature of earth resources.

UNIT 2:
Geotechnical consideration and Environmental implication of Roads and Canal construction, Dams and Reservoirs. Landslides and related phenomeno. Coastal hazards, Hazards on Indian coasts, Cyclones and their mitigation methods. Renewable and non renewable resources, alternative sources of energy. Energy from solar radiation, geothermal energy, tapping geothermal energy, Energy from Biomass, Alternative fuel, Nuclear energy options.

UNIT 3:

UNIT 4:
Books Recommended:
2. Keller, E.A., 1978: Environmental Geology-Bell and Howell, USA
Course Code: GLM4020
Credit: 4
Course Objective:
To develop research skills in the field of geotechnical engineering. The course content has great societal impacts particularly in development of hilly regions.

Course Outcome: On successful completion of the course, students would be able to:
1. Understand a detailed insight of geoengineering properties and behaviour of rocks.
2. Develop understanding of rock quality parameters and characterization of rock mass
3. Understand the concepts of soil mechanics and foundations
4. Manage geological issues related with landslides and various geoengineering projects like dams, tunnels, bridges, coastline

UNIT 1:
Concept of Intact rock, discontinuities and rock mass. Scale effects and rock strength.
Index properties of intact rock and their correlations: Porosity, Density, Point load Index, Schmidt Hammer Rebound test, Compressive, shear & tensile strength, Slake Durability test, Poisson’s ratio.
Discontinuities: Types, Orientation, Spacing, RQD by direct and indirect methods, Block size, Persistence, Roughness, Aperture, Filling, Matching.

UNIT 2:
Rock mass classification and their correlations: Rock mass rating, Q-system, Rock mass index, Geological strength index, Slope mass rating, Continuous Slope mass rating, Chinese slope mass rating, Slope stability rating, Q-slope, Concept of Rockfall hazard rating system.
Slope failures: Plane, wedge, toppling and circular failures. Rock mass reinforcement and protection measures.

UNIT 3:
Engineering soil: Specific gravity, Geotechnical characteristics of clay minerals in soil, Soil gradation, Consistency limits and their measurements, Plasticity index, Liquidity index, Activity.
Classification of soil: Textural, AASHTO and Unified soil classification.
Shear strength of soil: Basic principles of Direct shear and triaxial test.
Foundations: Types, Stress distribution and bearing capacity.

UNIT 4:
Landslides: Classification, Causes, Monitoring, Reporting landslides, Remedial measures
Dams: Parts, Geological and Geotechnical requirements, Forces on dam site.
Reservoirs: Geotechnical investigations and rim stability, leakage, Capacity and siltation. Remedial measures to control siltation, Reservoir induced seismicity.
Tunnels: Parts, Classification, Payline, Lining and overbreak, Stand-up time, Geological and geotechnical consideration, Problems and treatment of soft and hard ground during tunnelling.
Geological and geotechnical investigations for Coastlines and Bridges.
**Book Recommended:**

Course Code: GLM4022  
Course: Glaciology  
Credits: 4  
Course No: ME4(e)

Course Objective:
1. To impart knowledge of Glaciological studies
2. To train the students to use various techniques in investigating the characteristics of glaciers in a region.

Course Outcome:
Upon successful completion of course the students would be able to
1. Understand the linkage between climate change and glaciers variations.
2. Understand the different techniques use in glaciological studies.
3. Use the GIS and GPS techniques in glaciological investigations.
4. Understand the hydrological and hydrochemical characteristics of the streams draining from glaciers.

UNIT 1: Glacier variations and Climate: Response to Climate Changes; Mass Balance study of glaciers, Glacier Advance and Retreat, Linear- Systems Model for a Glacier, Surging glacier. Impact of Climate change on Himalayan glaciers: The records of glacier retreat and advancement in centuries with spatial distribution

UNIT 2: Glaciological Techniques: Reconstructing Pleistocene climate based on landforms, glacier mass balance determination, Glacier runoff measurements, Glacier ice core studies, palynology, Lichenometry, Tree rings studies, optically stimulated luminescence (OSL) use in glacier dating, GPR (Ground Penetrating Radar) for thickness determination.

UNIT 3: Application of Remote sensing and GIS and GPS in Himalayan Glaciology: Snow cover evolution, Inventory and mapping of glaciers, glacier evolution, velocity, Snow/ice differentiation, Determination of TSL and ELA on glacier surface, Mass balance and snowmelt runoff, Temporal change in glacier DEMs and climate change, LIDAR, and SAR technology and glacier study.

UNIT 4: Glacial Hydrology and Hydrochemistry: Glacial hydrological system, meltwater process, mechanism of water discharge, characteristics of glacier runoff, diurnal and annual cycle, longterm variation, process of solute acquisition two component mixing model, chemical weathering process, meltwater character of Himalayan glacier, Application of isotopes in cryosphere studies.

Books Recommended:
1. Field Techniques in Glaciology and Glacial Geomorphology by Bryn Hubbard and Neil F. Glasser, Wiley International.
5. Snow and Glacier Hydrology, 2000, P. Singh, Vijay P. Singh
Course Objective:
To impart basic knowledge of Solar system with geologic perspective to the students pursing Post Graduate courses in other disciplines of science.

Course Outcome:
The course helps the students to understand about the:
1. Origin of Solar system and its celestial constituents
2. Means and tools to used in the study of Celestial bodies.
3. Evolutionary processes of Celestial bodies
4. Non terrestrial material and planets

UNIT 1:

UNIT 2:
Tools and techniques of planetary geology – Telescopes, spectroscopy, computer modeling. Observation and exploration of the Jovian planets – Jupiter, Saturn, Uranus and Neptune. Basic planetary data of Jovian planets – Atmospheres, surfaces and interiors; magnetic fields and magnetospheres;

UNIT 3:

UNIT 4:
The Kuiper Belt and dwarf planets – Basic astronomical data; Atmospheres, surfaces and interiors of Pluto, Eris and Ceres. Comets and the Oort Cloud, Structure, Composition, Orbits and exploration of Comets.

Books Recommended:

The four major categories of geological processes that shape the solid-surface planets. Dawes, R. https://commons.wvc.edu/rdawes/ASTR217/Plan_Geol_Lecture.htm Accessed 15.08.2018.
Course Objective:
To impart basic knowledge of processes about the evolution of Earth and their societal impact and its resources to the students pursuing Post Graduate courses in other disciplines of science.

Course Outcome:
The course helps the students to understand about the
1. Origin and evolution of Earth in respect in tandem with Solar system
2. Physical and chemical properties of Earth and their controlling / modification factors and processes
3. Economic resources
4. Social impact of orogenic processes of Earth

UNIT 1:
Origin of earth, Formation of solar system, Cosmic abundance and neucleosynthesis, Meteorites, Interior of earth (major divisions and discontinuities), Movements of earth (Plate tectonic theory, Isostasy, Sea floor spreading). Supercontinents and Continental drift theory, Fossils: Important landmarks of evolution of life, Major extinction events and their causes

UNIT 2:
Physical processes inside the earth, magmatism: mechanism and causes, Earthquakes at plate margins, Stable Continental Region (SCR) Earthquakes, Mountain building activities, gravity and magnetic properties of earth. Magnetic polarity reversals. Radioisotopes and age determination, Formation of various rock types (Igneous, sedimentary and Metamorphic)

UNIT 3:
Economic resources of earth, mineral deposits and exploration, ore forming processes, Geophysical techniques and prospecting (Well Logging instrument and techniques), Geology of fuels (Coal and Petroleum), Hydrocarbons, Radioactive minerals

UNIT 4:

Books Recommended:
5. Fundamentals of Historical Geology and Stratigraphy of India-Ravindra Kumar.
7. Igneous and Metamorphic petrology-Best.
12. Radioactivity in Geology-Principles and Application-Durrance.