SYLLABUS FOR B. SC. GEOLOGY (HONOURS)

Six Semester Course under
Choice Based Credit System (CBCS)

(This is approved in the Academic Council held on 08-11-2019)

Department of Geological Sciences
Gauhati University

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

Semester	Core Course (14)#	AECC (2)#	SEC (2)#	DSE (4)#	HG (4)#	Credit per semester
I	GLG-HC-1016 GLG-HC-1026	ENG-AE-1014			GLG-HG-1016	22
II	GLG-HC-2016 GLG-HC-2026	ENV-AE-2014			GLG- HG -2016	22
III	GLG-HC-3016 GLG-HC-3026 GLG-HC-3036		*(GLG-SE-3014/ GLG-SE-3024/ GLG-SE-3034/ GLG-SE-3044)		GLG- HG -3016	28
IV	GLG-HC-4016 GLG-HC-4026 GLG-HC-4036		**(GLG-SE-4014/ GLG-SE-4024/ GLG-SE-4034/ GLG-SE-4044)		GLG- HG -4016	28
V	GLG-HC-5016 GLG-HC-5026			GLG-HE-5016 GLG-HE-5026		24
VI	GLG-HC-6016 GLG-HC-6026			GLG-HE-6016 GLG-HE-6026		24
Total Credit	84	8	8	24	24	148

 # Number of courses
** Any one SE from this group should be selected*
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CORE COURSE (CCM-14) General Structure

Semester	PAPERS	Prescribed Core Course	**Credit** (Theory + Practical)
I	GLG-HC-1016	Earth System Science	4+2=6
	GLG-HC-1026	Mineral Science	4+2=6
II	GLG-HC-2016	Elements of Geochemistry	4+2=6
	GLG-HC-2026	Structural Geology	4+2=6
III	GLG-HC-3016	Igneous Petrology	4+2=6
	GLG-HC-3026	Sedimentary Petrology	4+2=6
	GLG-HC-3036	Paleontology	4+2=6
IV	GLG-HC-4016	Metamorphic Petrology	4+2=6
	GLG-HC-4026	Stratigraphic Principles and Indian Stratigraphy	4+2=6
	GLG-HC-4036	Hydrogeology	4+2=6
V	GLG-HC-5016	Economic Geology	4+2=6
	GLG-HC-5026	Geomorphology	4+2=6
VI	GLG-HC-6016	Engineering Geology	4+2=6
	GLG-HC-6026	Remote Sensing and GIS	4+2=6
		Total	**84**

Abbreviations:
GLG: Geology, **HC**: Honours Course, **ENG**: English, **AE**: Ability Enhancement, **SE**: Skill Enhancement, **HE**: Honours Elective, **HG**: Generic Elective, **AECC**: Ability Enhancement Compulsory Course, **SEC**: Skill Enhancement Course, **DSE**: Discipline Specific Elective, **ENV**: Environmental Science

Skill Enhancement Course SEC (2) General Structure**

Semester	Paper	Papers available for selection
III	**GLG-SE-3014**	• Basic field training
	GLG-SE-3024	• Geological mapping
	GLG-SE-3034	• Economic Geology fieldwork
	GLG-SE-3044	• Himalayan Geology fieldwork
IV	**GLG-SE-4014**	• Precambrian Geology fieldwork
	GLG-SE-4024	• Visit to Engineering Project sites
	GLG-SE-4034	• Stratigraphy and palaeontology fieldwork
	GLG-SE-4044	• Project work

** If a student completes a summer/winter internship in a recognized institute (INSA, HBCSE etc.) of duration not less than one month and submit a completion report, this will be considered equivalent to SEC of 3rd Semester and SEC of 4th semester

Discipline Specific Elective DSE (4) General Structure

Semester	Paper	Papers available for selection
V	**GLG-HE-5016**	• Exploration Geology
	GLG-HE-5026	• Earth and Climate
VI	**GLG-HE-6016**	• Fuel Geology
	GLG-HE-6026	• Introduction to Geophysics

Regular Core Course (4) General Structure

GENERIC ELECTIVE

Semester	Paper	Papers available
I	GLG-HG-1016	• General Geology and Structural Geology
II	GLG- HG -2016	• Crystallography and Mineralogy
III	GLG- HG -3016	• Petrology
IV	GLG- HG -4016	• Stratigraphy and Palaeontology

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

1st SEMESTER

Subject	Sem.	Paper Type	Paper Code	Paper Name	Total Mark	Distribution of mark					Paper Credit (Theory=4, Practical=2)
						End Semester Mark		Internal Mark			
						Theory	Practical	Sessional	Practical	Attendance	
Geology	1st	Core Course	GLG-HC-1016	Earth System Science	100	60	20	10	6	4	6
			GLG-HC-1026	Mineral Science	100	60	20	10	6	4	6
		AEC-1	ENG-AE-1014	English Communication	60	---	---	---	---	---	4
		Generic Elective (GE)	GLG-HG-1016	General Geology and Structural Geology	100	60	20	10	6	4	6
Total					360						22

2nd SEMESTER

Subject	Sem.	Paper Type	Paper Code	Paper Name	Total Mark	Distribution of mark					Paper Credit (Theory=4, Practical=2)
						End Semester Mark		Internal Mark			
						Theory	Practical	Sessional	Practical	Attendance	
Geology	**2nd**	**Core Course**	**GLG-HC-2016**	Elements of Geochemistry	**100**	**60**	**20**	**10**	**6**	**4**	**6**
			GLG-HC-2026	Structural Geology	**100**	**60**	**20**	**10**	**6**	**4**	**6**
		AEC-2	**ENV-AE-2014**	Environmental Science	**60**	**---**	**---**	**---**	**---**	**---**	**4**
		Generic Elective (GE)	**GLG-HG-2016**	Crystallography and Mineralogy	**100**	**60**	**20**	**10**	**6**	**4**	**6**
Total					**360**						**22**

3rd SEMESTER

Subject	Sem.	Paper Type	Paper Code	Paper Name	Total Mark	Distribution of mark					Paper Credit (Theory=4, Practical=2)
						End Semester Mark		Internal Mark			
						Theory	Practical	Sessional	Practical	Attendance	
Geology	3rd	Core Course	GLG-HC-3016	Igneous Petrology	100	60	20	10	6	4	6
			GLG-HC-3026	Sedimentary Petrology	100	60	20	10	6	4	6
			GLG-HC-3036	Palaeontology	100	60	20	10	6	4	6
		Field Work - I (Any one of Skill Enhancement Course)	GLG-SE-3014	Basic field training	60	--	--	--	--	--	4
			GLG-SE-3024	Geological mapping	60	--	--	--	--	--	4
			GLG-SE-3034	Economic Geology fieldwork	60	--	--	--	--	--	4
			GLG-SE-3044	Himalayan Geology fieldwork	60	--	--	--	--	--	4
		Generic Elective (GE)	GLG-HG-3016	Petrology	100	60	20	10	6	4	6
Total					460						28

4th SEMESTER

Subject	Sem.	Paper Type	Paper Code	Paper Name	Total Mark	Distribution of mark					Paper Credit (Theory=4, Practical=2)
						End Semester Mark		Internal Mark			
						Theory	Practical	Sessional	Practical	Attendance	
Geology	4th	Core Course	GLG-HC-4016	Metamorphic Petrology	100	60	20	10	6	4	6
			GLG-HC-4026	Stratigraphic Principle and Indian Stratigraphy	100	60	20	10	6	4	6
			GLG-HC-4036	Hydrogeology	100	60	20	10	6	4	6
		Field Work - II (Any one of Skill Enhancement Course)	GLG-SE-4014	Precambrian Geology Field work	60	---	---	---	---	---	4
			GLG-SE-4024	Visit to Engineering Project Site	60	---	---	---	---	---	4
			GLG-SE-4034	Stratigraphy and Palaeontology Field work	60	---	---	---	---	---	4
			GLG-SE-4044	Project work	60	---	---	---	---	---	4
		Generic Elective (GE)	GLG-HG-4016	Stratigraphy and Palaeontology	100	60	20	10	6	4	6
Total					460						28

5th SEMESTER

Subject	Sem.	Paper Type	Paper Code	Paper Name	Total Mark	Distribution of mark					Paper Credit (Theory=4, Practical=2)
						End Semester Mark		Internal Mark			
						Theory	Practical	Sessional	Practical	Attendance	
Geology	5th	Core Course	GLG-HC-5016	Economic Geology	100	60	20	10	6	4	6
			GLG-HC-5026	Geomorphology	100	60	20	10	6	4	6
		DSE (Discipline Specific Elective)	GLG-HE-5016	Exploration Geology	100	60	20	10	6	4	6
			GLG-HE-5026	Earth and Climate	100	60	20	10	6	4	6
Total					400						24

6th SEMESTER

Subject	Sem.	Paper Type	Paper Code	Paper Name	Total Mark	Distribution of mark					Paper Credit (Theory=4, Practical=2)
						End Semester Mark		Internal Mark			
						Theory	Practical	Sessional	Practical	Attendance	
Geology	6th	Core Course	GLG-HC-6016	Engineering Geology	100	60	20	10	6	4	6
			GLG-HC-6026	Remote Sensing and GIS	100	60	20	10	6	4	6
		DSE (Discipline Specific Elective)	GLG-HE-6016	Fuel Geology	100	60	20	10	6	4	6
			GLG-HE-6026	Introduction to Geophysics	100	60	20	10	6	4	6
Total					400						24

Abbreviations:
HC : Core Course Major
AEC : Ability Enhancement Compulsory Course
SEC : Skill Enhancement Course
DSE : Discipline Specific Elective
HG : Generic Elective
ENV : Environmental Science

Credit:
1 Credit=1contact hour per week in case of Theory

1 Credit=2 contact hours per week in case of Practical
1 week=6 working days
6 classes of 45 minutes duration
Per week 4.5 hours; (4.5 hours per week should be allotted to a 4 Credit Theory paper)
4 weeks per month = 18 hours x 3 months = 54 hours for three months

Time allotment:
Theory: 1 Theory Class of 45 minutes duration to be allotted in the routine daily
54 hours / 72 classes per semester / 18 classes per Unit
Practical: 2 Practical Classes of minimum 1 hour 20 minutes duration to be allotted in the routine thrice weekly; 54 hours / 72 classes per semester

1st SEMESTER

Core Courses
Paper Code: GLG-HC-1016
Paper Name: EARTH SYSTEM SCIENCE
Credits: 6 (THEORY - 4, PRACTICALS - 2)

Distribution of mark					
End Semester Mark		Internal Mark			
Theory	Practical	Sessional	Practical	Attendance	Total
60	20	10	6	4	100

THEORY (Marks 60)

Unit 1: Earth as a planet **10**

- Holistic understanding of dynamic planet 'Earth' through Astronomy, Geology, Meteorology and Oceanography.
- General characteristics and origin of the Universe, Solar System and its planets. The terrestrial and jovian planets.
- Earth and its origin
- Introduction to various branches of Earth Sciences.

Unit 2: Earth's magnetic field **8**

- Earth's magnetic field
- Formation of core, mantle, crust, hydrosphere, atmosphere and biosphere
- Convection in Earth's core and production of its magnetic field

Unit 3: Plate Tectonics **10**

- Concept of plate tectonics, sea-floor spreading and continental drift
- Geodynamic elements of Earth- Mid Oceanic Ridges, trenches, transform faults and island arcs
- Origin of oceans, continents, mountains and rift valleys
- Earthquake and earthquake belts
- Volcanoes- types, products and their distribution.

Unit 4: Hydrosphere and Atmosphere **6**

- Oceanic current system and effect of Coriolis force
- Concepts of eustasy
- Land-air-sea interaction
- Atmospheric circulation
- Earth's heat budget.

Unit 5: Soil **6**

- Soils- processes of formation, soil profile and soil types.

Unit 6: Understanding the past from stratigraphic records **10**

- Nature of stratigraphic records
- Standard stratigraphic time scale and introduction to the concept of time in geological studies
- Introduction to geochronological methods and their application in geological studies
- History of development in concepts of uniformitarianism, catastrophism and neptunism
- Laws of superposition and faunal succession
- Introduction to geology and geomorphology of Indian subcontinent.

Unit 7: Cosmic abundance of elements **10**

- Distribution of elements in solar system and in Earth
- Chemical differentiation and composition of the Earth
- General concepts about geochemical cycles and mass balance
- Properties of elements

PRACTICALS: **Marks 20**

- Study of major geomorphic features and their relationships with outcrops through physiographic models.
- Detailed study of topographic sheets and preparation of physiographic description of an area
- Study of soil profile of any specific area
- Study of distribution of major lithostratigraphic units on the map of India
- Study of distribution of major dams on map of India and their impact on river systems
- Study of major ocean currents of the World
- Study of seismic profile of a specific area and its interpretation

SUGGESTED READINGS:

1. Duff, P. M. D., & Duff, D. (Eds.). (1993). *Holmes' principles of physical geology*. Taylor & Francis.
2. Emiliani, C. (1992). *Planet earth: cosmology, geology, and the evolution of life and environment*. Cambridge University Press.
3. Alan P. Trujillo and Harold B. Thurman, *Essentials of Ocenography*, Prentice Hall
4. J. T. Jenkins, *A Text book of Oceanography*, Constable and Co. Ltd., London
5. J.M. Weller, *Stratigraphic Principles and Practices*, Universal Book Stall, Delhi

Core Courses
Paper Code: GLG-HC-1026
Paper Name: MINERAL SCIENCE
Credits: 6 (THEORY - 4, PRACTICALS - 2)

Distribution of mark					
End Semester Mark		**Internal Mark**			
Theory	**Practical**	**Sessional**	**Practical**	**Attendance**	**Total**
60	**20**	**10**	**6**	**4**	**100**

THEORY (Marks 60)

Unit 1: Crystallography **12**

- Elementary ideas about crystal morphology in relation to internal structures
- Crystal parameters and indices
- Crystal symmetry and classification of crystals into six systems and 32 point groups

Unit 2: Crystal symmetry and projections **10**

- Elements of crystal chemistry and aspects of crystal structures
- Stereographic projections of symmetry elements and forms

Unit 3: Rock forming minerals **18**

- Minerals - definition and classification, physical and chemical properties
- Composition of common rock-forming minerals
- Silicate and non-silicate structures, CCP and HCP structures
- Scope of Mineralogy; Relationship of physical properties with atomic structure
- Study of physical & optical properties, atomic structure and chemistry of the following groups of mineral – Olivine, Garnet, Epidote, Pyroxene, Amphibole, Mica, Clay minerals, Silica, Feldspar and Feldspathoid

Unit 4: Properties of light and optical microscopy **20**

- Nature of light and principles of optical mineralogy
- Introduction to the petrological microscope and identification of common rock-forming minerals
- Scope & utility of optical mineralogy; Reflection and refraction of rays; Refractive index; Dispersion of light; Polarization of light
- Optical properties of minerals in thin section
- Isotropic and Anisotropic minerals (Uniaxial and Biaxial); Optic axis; Optical Indicatrix: Isotropic, Uniaxial & Biaxial indicatrices,
- Interference figure; Determination of optic sign; Measurement of optic axial angle.

PRACTICALS: **Marks 20**

- Observation and documentation on symmetry of crystals
- Study of physical properties of minerals in hand specimen: Olivine, Garnet, Andalusite, Sillimanite, Kyanite, Staurolite, Beryl, Tourmaline, Augite, Actinolite, Tremolite, Hornblende, Serpentine, Talc, Muscovite, Biotite, Phlogopite, Quartz, Orthoclase, Plagioclase, Microcline, Nepheline, Sodalite, Zeolite
- Quartz varieties: Chert, Flint, Chalcedony, Agate, Jasper, Amethyst, Rose quartz, Smoky quartz, Rock
- crystal.
- Native Metals/non-metals, Sulfides, Oxides- Copper, Sulfur, Graphite, Pyrite, Corundum, Magnetite
- Hydroxides, Halides, Carbonates, Sulfates, Phosphates: Psilomelane, Fluorite, Calcite, Malachite, Gypsum, Apatite.
- Study of some key silicate minerals under optical microscope and their characteristic properties
- Optic sign determination

SUGGESTED READINGS:

1. Klein, C., Dutrow, B., Dwight, J., & Klein, C. (2007). The 23rd Edition of the Manual of Mineral Science (after James D. Dana). J. Wiley & Sons.
2. Kerr, P. F. (1959). Optical Mineralogy. McGraw-Hill.
3. Verma, P. K. (2010). Optical Mineralogy (Four Colour). Ane Books Pvt Ltd.
4. Deer, W. A., Howie, R. A., & Zussman, J. (1992). An introduction to the rock-forming minerals (Vol. 696). London: Longman.
5. Mineralogy: Perkins and Henke
6. Textbook of Mineralogy, J.D. Dana

Generic Elective
Paper Code: GLG-HG-1016
Paper Name: GENERAL GEOLOGY AND STRUCTURAL GEOLOGY
Credits: 6 (THEORY - 4, PRACTICALS - 2)

Distribution of mark					
End Semester Mark		**Internal Mark**			
Theory	**Practical**	**Sessional**	**Practical**	**Attendance**	**Total**
60	**20**	**10**	**6**	**4**	**100**

THEORY (Marks 60)

Unit-1: General Geology 30

- Introduction to geology, its scope and its subdivisions and relation to other branches of science.
- Earth and Solar System: Origin, size, shape, mass, density and age of the earth. Major surface features of the earth: continents and ocean basins and their evolution.
- Introduction to igneous, sedimentary and metamorphic rocks and their distinguishing characters.
- Weathering and Erosion: factors, types and their effects.
- Volcanoes and volcanism; Types and distribution of volcanoes; Earthquake: Causes of earthquake; Earthquake belts; Prediction of earthquake; Earthquake zones of India; Use of seismic waves in the study of earth's internal constitution.

Unit-2: Structural Geology 30

- Definition and scope of Structural Geology; Primary, secondary and penecontemporaneous structures.
- Concept of non-diastrophic and diastrophic structures. Non-diastrophic structures: stratification, current or cross bedding, graded bedding, ripple marks, unconformities, mud cracks and rain prints, flow layers, primary joints, vesicular and amygdaloidal structures and pillow structure.
- Elementary idea of types of deformation, Concept of Stress and Strain, Mohr's stress circle; Elasticity, plasticity and brittleness; Diastrophic structures: Planar and linear structures; Strike direction, dip angle, dip direction, Basic concepts of Lineation, Foliation, Fold, Fault and Joints: their origin.

PRACTICAL Marks = 20

Unit-1: General Geology 10

- Study of contours: Pattern of contours to indicate various topographical features;
- Reading of topographical maps of the Survey of India; Interpretation of topographic maps; Drawing of profile
- Study of geomorphological features from topographic maps.
- Model study of different geomorphic features.

Unit-2: Structural Geology 10

- Study of Clinometer and Brunton Compass, Identification of different types of folds/faults from models. Preparation of cross-section profile from geological map.
- Use of Stereographic net (Wulf's net or Schmidt's net) in:
  (i) Plotting of planes.

(ii) Plotting of poles to the planes.
(iii) Plotting of lines.
(iv) Determination of plunge and bearing of the line of intersection between two planes.
(v) Determination of angle between two planes.
(vi) Determination of apparent dip/dips in different directions in a plane.
(vii) Determination of strike and true dip of a plane from apparent dip/dips.

SUGGESTED READINGS:

1. Holmes' *Principles of Physical Geology*. 1992. Chapman & Hall.
2. Patwardhan, A. M., The *Dynamic Earth System*, PHI Learning.
3. Park, R. G. (2004). *Foundations of Structural Geology*. Chapman & Hall.
4. Pollard, D. D. (2005). *Fundamental of Structural Geology*. Cambridge University Press.
5. Ragan, D. M. (2009). *Structural Geology: an introduction to geometrical techniques* (4th Ed). Cambridge University Press (For Practical)
6. Fossan, H. (2010). *Structural Geology*, Cambridge University Press.

2nd SEMESTER

Core Courses
Paper Code: GLG-HC-2016
Paper Name: ELEMENTS OF GEOCHEMISTRY
Credits: 6 (THEORY - 4, PRACTICALS - 2)

Distribution of mark					
End Semester Mark		**Internal Mark**			
Theory	**Practical**	**Sessional**	**Practical**	**Attendance**	**Total**
60	**20**	**10**	**6**	**4**	**100**

THEORY (Marks 60)

Unit- 1: Concepts of geochemistry **12**

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

Unit 2: Layered structure of Earth and geochemistry **15**

- Composition of different Earth reservoirs and the nuclides and radioactivity
- Conservation of mass, isotopic and elemental fractionation
- Concept of radiogenic isotopes in geochronology and isotopic tracers

Unit 3: Element transport **10**

- Advection and diffusion
- Chromatography
- Aqueous geochemistry- basic concepts and speciation in solutions, Eh, pH relations Elements of marine chemistry
- Mineral reactions- diagenesis and hydrothermal reactions.

Unit 4: Geochemistry of solid Earth **15**

- The solid Earth – geochemical variability of magma and its products.
- The Earth in the solar system, the formation of solar system
- Composition of the bulk silicate Earth
- Meteorites

Unit 5: Geochemical behavior of selected elements **8**

- Si, Al, K, Na etc.

PRACTICALS: **Marks 20**

- Types of geochemical data analysis and interpretation of common geochemical plots.
- Geochemical analysis of geological materials.
- Geochemical variation diagrams and its interpretations.

SUGGESTED READINGS:

1. Mason, B. and Moore (1986). Principles of Geochemistry. 3rd Edition, Wiley New York.
2. Rollinson, H. (2007). Using geochemical data – evaluation, presentation and interpretation. 2nd Edition. Publisher Longman Scientific & Technical.
3. Walther, J. V. (2009). Essentials of geochemistry. Jones & Bartlett Publishers.
4. Albarède, F. (2003). Geochemistry: an introduction. Cambridge University Press.
5. Faure, Gunter and Teresa M. Mensing (2004). Isotopes: Principles and Applications,Wiley India Pvt. Ltd

Core Courses
Paper Code: GLG-HC-2026
Paper Name: STRUCTURAL GEOLOGY
Credits: 6 (THEORY - 4, PRACTICALS - 2)

Distribution of mark					
End Semester Mark		**Internal Mark**			
Theory	**Practical**	**Sessional**	**Practical**	**Attendance**	**Total**
60	**20**	**10**	**6**	**4**	**100**

THEORY (Marks 60)

Unit- 1: Structure and Topography **12**

- Effects of topography on structural features, Topographic and structural maps, Importance representative factors of the map

Unit 2: Stress and strain in rocks **12**

- Concept of rock deformation: Stress and Strain in rocks, Strain ellipses of different types and their geological significance.
- Planar and linear structures; Concept of dip and strike; Outcrop patterns of different structures.

Unit 3: Folds **12**

- Fold morphology; Geometric and genetic classification of folds; Introduction to the mechanics of folding:
- Buckling, Bending, Flexural slip and flow folding

Unit 4: Foliation and lineation **12**

- Description and origin of foliations: axial plane cleavage and its tectonic significance
- Description and origin of lineation and relationship with the major structures

Unit 5: Fractures and faults **12**

- Geometric and genetic classification of fractures and faults
- Effects of faulting on the outcrops
- Geologic/geomorphic criteria for recognition of faults and fault plane solutions

PRACTICALS: **Marks 20**

- Basic idea of topographic contours, Topographic sheets of various scales.
- Introduction to Geological maps: Lithological and Structural maps
- Structural contouring and 3-point problems of dip and strike
- Drawing profile sections and interpretation of geological maps of different complexities Exercises of stereographic projections of mesoscopic structural data (planar, linear, folded etc.)
- Megascopic study of planar, linear, deformed structures

SUGGESTED READINGS:

7. Davis, G. R. and Reynolds G.J. (1996). *Structural Geology of Rocks and Region*. John Wiley
8. Park, R. G. (2004). *Foundations of Structural Geology*. Chapman & Hall.
9. Pollard, D. D. (2005). *Fundamental of Structural Geology*. Cambridge University Press.
10. Ragan, D. M. (2009). *Structural Geology: an introduction to geometrical techniques* (4th Ed). Cambridge University Press (For Practical)
11. Fossan, H. (2010). *Structural Geology*, Cambridge University Press.

Generic Elective
Paper Code: GLG-HG-2016
Paper Name: CRYSTALLOGRAPHY AND MINERALOGY
Credits: 6 (THEORY - 4, PRACTICALS - 2)

Distribution of mark					
End Semester Mark		Internal Mark			
Theory	Practical	Sessional	Practical	Attendance	Total
60	20	10	6	4	100

THEORY (Marks 60)

Unit-1: Crystallography 20

- Definition of crystal and amorphous substance; Crystallization and crystal growth; Unit cell; Symmetry operations and elements; Crystallographic axes and angles, Axial ratio; Crystal forms and habit;Face, Interfacial angle, solid angle, Parameters and indices.
- Study of the Normal class of Isometric, Tetragonal, Hexagonal, Orthorhombic, Monoclinic and Triclinic systems.

Unit-2: Mineralogy **20**

- Scope of Mineralogy; Definition of mineral; Physical properties of mineral, Mineral classification.
- Study of chemical composition and diagnostic physical properties of the following minerals: Quartz, Orthoclase, Microcline, Hypersthene, Hornblende, Garnet, Muscovite, Biotite, Enstatite, Olivine, Kyanite, Sillimanite, Calcite, Plagioclase.

Unit-3: Optical Mineralogy **20**

- Nature of light; Reflection and refraction of rays; Refractive index, Polarization of light; Polarising Microscope, Double refraction by Nicol prism, Pleochroism.
- Cleavage, Extinction, Interference colour, Accessory plates (Mica Plate, Gypsum Plate and Quartz Wedge) and their uses.
- Isotropic and Anisotropic minerals: Uniaxial and Biaxial; Optic axis; Interference figure, Optic sign.
- Study of optical properties of the following minerals: Quartz, Orthoclase, Microcline, Hypersthene, Hornblende, Garnet, Muscovite, Biotite, Enstatite, Olivine, Kyanite, Sillimanite, Calcite, Plagioclase.

PRACTICAL **Marks = 20**

Unit-1: Crystallography **7**

- Study of the forms and symmetry elements of crystals belonging to the holohedral classes of Isometric, Tetragonal, Hexagonal, Orthorhombic, Monoclinic and Triclinic systems with the help of either natural crystals or wooden and glass models;
- Drawing of crystals in clinographic projections.

Unit-2: Mineralogy **6**

- Identification of following minerals in hand specimen: Quartz, Orthoclase, Microcline, Hypersthene, Hornblende, Garnet, Muscovite, Biotite, Enstatite, Olivine, Kyanite, Sillimanite, Calcite, Plagioclase.

Unit-3: Optical Mineralogy **7**

- Study of optical properties of the following minerals in thin section: Quartz, Orthoclase, Microcline, Hypersthene, Hornblende, Garnet, Muscovite, Biotite, Enstatite, Olivine, Kyanite, Sillimanite, Calcite, Plagioclase.

SUGGESTED READINGS:

1. Cornelis Klein and Anthony Philpotts (2013), *Earth Materials- Introduction to Mineralogy and Petrology*, Cambridge University Press
2. Klein, C., Dutrow, B., Dwight, J., & Klein, C. (2007). The 23rd Edition of the Manual of Mineral Science (after James D. Dana). J. Wiley & Sons.
3. Kerr, P. F. (1959). Optical Mineralogy. Mc Graw-Hill.

4. Verma, P. K. (2010). Optical Mineralogy (Four Colour). Ane Books Pvt Ltd.
5. Deer, W. A., Howie, R. A., & Zussman, J. (1992). An introduction to the rock-forming minerals (Vol. 696). London: Longman.
6. Mineralogy: Perkins and Henke
7. J.D. Dana. Textbook of Mineralogy
8. C. Klein and C.S. Hurlbut, Jr (1985). Manual of Mineralogy. Jhon Wiley & Sons, New York

3rd SEMESTER

Core Courses
Paper Code: GLG-HC-3016
Paper Name: IGNEOUS PETROLOGY
Credits: 6 (THEORY - 4, PRACTICALS - 2)

Distribution of mark					
End Semester Mark		Internal Mark			
Theory	Practical	Sessional	Practical	Attendance	Total
60	20	10	6	4	100

THEORY (Marks 60)

Unit- 1: Concepts of Igneous petrology **12**

- Introduction to petrology: Heat flow, geothermal gradients through time, origin and nature of magma

Unit- 2: Forms **12**

- Classification of igneous rocks
- Textures and structures of igneous rocks
- Mode of occurrence of Igneous rocks

Unit- 3: Phase diagrams and petrogenesis **12**

- Binary and Ternary Phase diagrams in understanding crystal-melt equilibrium in basaltic and granitic magmas
- Magma generation in crust and mantle, their emplacement and evolution

Unit- 4: Magmatism in different tectonic settings **12**

- Magmatism in the oceanic domains (MORB, OIB)
- Magmatism along the plate margins (Island arcs/continental arcs)

Unit- 5: Petrogenesis of Igneous rocks **12**

- Petrogenesis of Felsic and Mafic igneous rocks
- Komatiites, Granitoides, Basalt, Gabbros
- Alkaline rocks, kimberlites and lamproites.

PRACTICALS: **Marks 20**

- Mineralogical and petrogenetic study of important igneous rocks in hand specimens and thin sections - granite, granodiorite, diorite, gabbro, anorthosites, ultramafic rocks, basalts, andesites, trachyte, rhyolite, dolerite, syenite,
- Study of Igneous textures in hand specimens and thin section

SUGGESTED READINGS:

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

2. Winter, J. D. (2014). *Principles of igneous and metamorphic petrology*. Pearson.
3. Raymond, L. A. (2002). *Petrology: the study of igneous, sedimentary, and metamorphic rocks*. McGraw-Hill Science Engineering.
4. Myron G. Best (2001). *Igneous and Metamorphic Petrology*,
5. K. G. Cox, J. D. Bell. (1979). *The Interpretation of Igneous Rocks*. Springer/Chapman & Hall.
6. Bose M.K. (1997). *Igneous Petrology*.

Core Courses
Paper Code: GLG-HC-3026
Paper Name: SEDIMENTARY PETROLOGY
Credits: 6 (THEORY - 4, PRACTICALS - 2)

Distribution of mark					
End Semester Mark		**Internal Mark**			
Theory	**Practical**	**Sessional**	**Practical**	**Attendance**	**Total**
60	**20**	**10**	**6**	**4**	**100**

THEORY (Marks 60)

Unit- 1: Origin of sediments **10**

- Weathering and sedimentary flux: Physical and chemical weathering, soils and paleosols

Unit 2: Sediment granulometry **10**

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

Unit 3: Sedimentary textures, structures and environment **15**

- Fluid flow, sediment transport and sedimentary structures: Types of fluids, Laminar vs. turbulent flow, Particle entrainment, transport and deposition.
- Paleocurrent analysis- Paleocurrents for different sedimentary environments Sedimentary structure- Primary and syn-sedimentary structures

Unit 4: Varieties of sedimentary rocks **15**

- Siliciclastic rocks: Conglomerates, sandstones, mudrocks.
- Carbonate rocks, controls of carbonate deposition, components and classification of limestone, dolomite and dolomitisation

Unit 5: Diagenesis **10**

- Concepts of diagenesis
- Stages of diagenesis
- Compaction and cementation.

PRACTICALS: **Marks 20**

- Exercises on sedimentary structures
- Particle size distribution and statistical treatment
- Paleocurrent analysis

- Petrography of clastic and non-clastic rocks through hand specimens and thin sections

SUGGESTED READINGS:

1. Tucker, M. E. (2006). Sedimenary Petrology, Blackwell Publishing.
2. Collinson, J. D. & Thompson, D. B. (1988). *Sedimentary structures*, Unwin- Hyman, London
3. Nichols, G. (2009). *Sedimentology and Stratigraphy* Second Edition. Wiley Blackwell
4. Sengupta S., *Introduction to Sedimentology*, Oxford & IBH Publishing Co.
5. Sam Boggs, Jr. (2009). *Petrology of Sedimentary Rocks*, Cambridge Univ. Press

Core Courses
Paper Code: GLG-HC-3036
Paper Name: PALEONTOLOGY
Credits: 6 (THEORY - 4, PRACTICALS - 2)

Distribution of mark					
End Semester Mark		**Internal Mark**			
Theory	**Practical**	**Sessional**	**Practical**	**Attendance**	**Total**
60	**20**	**10**	**6**	**4**	**100**

THEORY (Marks 60)

Unit-1: Fossilization and fossil record **10**

- Nature and importance of fossil record; Fossilization processes and modes of preservation
- Introduction to Paleobotany and Ichnology

Unit- 2: Taxonomy and Species concept **8**

- Species concept with special reference to paleontology, Taxonomic hierarchy, Theory of organic evolution interpreted from fossil record

Unit- 3: Invertebrates **15**

- Brief introduction to important invertebrate groups (Bivalvia, Gastropoda, Brachiopoda) and their biostratigraphic significance
- Significance of ammonites in Mesozoic biostratigraphy and their paleobiogeographic implications
- Functional adaptation in trilobites and ammonoids.

Unit- 4: Vertebrates **12**

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

Unit- 5: Application of fossils in Stratigraphy **15**

- Biozones, index fossils, correlation

- Fossils and paleoenvironmental analysis
- Fossils and paleobiogeography, biogeographic provinces, dispersals and barriers Paleoecology – fossils as a window to the evolution of ecosystems

PRACTICALS: **Marks 20**

- Study of fossils showing various modes of preservation
- Study of diagnostic morphological characters, systematic position, stratigraphic position and age of various invertebrate, vertebrate and plant fossils

SUGGESTED READINGS

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

Skill Enhancement Course (SEC-1)
Paper Code: GLG-SE-3014
Paper Name: BASIC FILED TRAINING
Credits: 4
Marks: 60

	Distribution of mark		
Field performance	Preparation of Field report	Field viva	Total
20	20	20	60

Unit 1:

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

Unit 2:

- Identification of rock types in field, structures and texture of rocks, Use of hand lense

Unit 3:

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

Unit 4:

- Reading contours and topography

Skill Enhancement Course (SEC-1)
Paper Code: GLG-SE-3024
Paper Name: GEOLOGICAL MAPPING
Credits: 4
Marks: 60

	Distribution of mark		
Field performance	Preparation of Field report	Field viva	Total
20	20	20	60

Unit 1:
- Geological mapping, stratigraphic correlation

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

Unit 3:
- Trend, plunge, Rake/Pitch

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

Skill Enhancement Course (SEC-1)
Paper Code: GLG-SE-3034
Paper Name: ECONOMIC GEOLOGY FIELD WORK
Credits: 4
(Either Module – I ***or*** Module - II)

Marks: 60

	Distribution of mark		
Field performance	Preparation of Field report	Field viva	Total
20	20	20	60

Module – I

Unit 1:
- Visit to any place of mineral deposits

Unit 2:
- Mode occurrence of ore, Ore mineralogy

Unit 3:
- Ore-Host rock interrelation

Unit 4:
- Ore formation process

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

Module – II

Unit 1:

- Visit to underground or open cast mine

Unit 2:

- Practical experience of mining methods

Unit 3:

- Underground mapping/ Bench mapping

Unit 4:

- Isopach and Isochore maps

Skill Enhancement Course (SEC-1)
Paper Code: GLG-SE-3044
Paper Name: HIMALAYAN GEOLOGY FIELD WORK
Credits: 4

Marks: 60

	Distribution of mark		
Field performance	Preparation of Field report	Field viva	Total
20	20	20	60

- Field along any suitable transect of Himalayan foreland: Identification and characterization of major structural boundaries in Himalaya viz. MBT, MFT etc.

or

- Field transect in Siwalik: Identification of Himalayan and pre-Himalayan elements

Generic Elective
Paper Code: GLG-HG-3016
Paper Name: PETROLOGY
Credits: 6 (THEORY - 4, PRACTICALS - 2)

Distribution of mark					
End Semester Mark		**Internal Mark**			
Theory	**Practical**	**Sessional**	**Practical**	**Attendance**	**Total**
60	**20**	**10**	**6**	**4**	**100**

THEORY (Marks 60)

Unit-1: Igneous Petrology 20

- Magma: Composition, origin and types; Crystallisation of Magma, Bowen's

reaction; Magmatic differentiation; Assimilation.

- Igneous rocks: Definition; Mode of occurrence; Textures and structures; Classification of igneous rocks on textural, mineralogical and chemical criteria.
- Petrography of Granite, Dolerite, Gabbro, Rhyolite, Syenite, Basalt and Diorite.

Unit-2: Sedimentary Petrology **20**

- Introduction; Processes of formation of sedimentary rocks–weathering, transportation, deposition, diagenesis.
- Textures and structures of sedimentary rocks; Sedimentary structures: lamination, ripple marks, current bedding, graded bedding, mud cracks, rain prints.
- Classification of sedimentary rocks; Petrographic description of: sandstone, siltstone, shale, limestone, breccia and conglomerate.

Unit-3: Metamorphic Petrology **20**

- Metamorphic rocks: Definition; Factors or Agents of Metamorphism; Types of Metamorphism; Grade of Metamorphism, Zones of Metamorphism; Textures and Structures of Metamorphic rocks.
- Descriptive petrography of Slate, Phyllite, Schist, Gneiss, Quartzite and Marble.

PRACTICAL **Marks = 20**

Unit-1: Igneous Petrology 5

- Hand specimen study of the following rocks: Granite, granodiorite, gabbro, diorite, pegmatite, rhyolite, dolerite, basalt.
- Study and identification of following rocks in thin sections under petrological microscope: Granite, Dolerite, Gabbro, Rhyolite, Syenite and Diorite.

Unit-2: Sedimentary Petrology 5

- Hand specimen study of the following rocks: Conglomerate, Sandstone, Shale, Fossiliferous limestone.
- Study and identification of following rocks in thin sections under petrological microscope: Sandstone, Shale, Limestone, Conglomerate.

Unit-3: Metamorphic Petrology 5

- Hand specimen study of the following rocks: Slate, phyllite, schists, gneiss, marble, quartzite, mylonite, migmatite and Amphibolite.
- Study and identification of following rocks in thin sections under petrological microscope: Chlorite schist, Biotite schist, Sillimanite schist, Amphibolite/ Hornblende schist, Quartzite, Granulite, Granite Gneiss.

Unit-4: Field Training and Viva Voce 5

- Students will be required to carry out 03 days field work in a suitable geological area to study the elementary aspects of field geology and submit a report there on.

SUGGESTED READINGS:

1. Winter, J. D. (2014). *Principles of igneous and metamorphic petrology*. Pearson.
2. Raymond, L. A. (2002). *Petrology: the study of igneous, sedimentary, and metamorphic rocks*. McGraw-Hill Science Engineering.
3. Myron G. Best (2001). *Igneous and Metamorphic Petrology*,
4. Bose M.K. (1997). *Igneous Petrology*.
5. Tucker, M. E. (2006). Sedimenary Petrology, Blackwell Publishing.
6. Collinson, J. D. & Thompson, D. B. (1988). *Sedimentary structures*, Unwin- Hyman, London
7. Sengupta S., *Introduction to Sedimentology*, Oxford & IBH Publishing Co.
8. Sam Boggs, Jr. (2009). *Petrology of Sedimentary Rocks*, Cambridge Univ. Press
9. Yardley, B.W., & Yardley, B.W.D. (1989). An *introduction to metamorphic petrology*. Longman Earth Science Series.

4th SEMESTER

Core Courses
Paper Code: GLG-HC-4016
Paper Name: METAMORPHIC PETROLOGY
Credits: 6 (THEORY - 4, PRACTICALS - 2)

Distribution of mark					
End Semester Mark		Internal Mark			
Theory	Practical	Sessional	Practical	Attendance	Total
60	20	10	6	4	100

THEORY (Marks 60)

Unit- 1: Metamorphism: controls and types. 15

- Definition of metamorphism. Factors controlling metamorphism Types of metamorphism - contact, regional, fault zone metamorphism, impact metamorphism.

Unit- 2: Metamorphic facies and grades 15

- Index minerals, chemographic projections
- Metamorphic zones and isograde s.
- Concept of metamorphic facies and grade
- Mineralogical phase rule of closed and open system
- Structure and textures of metamorphic rocks

Unit- 3: Metamorphism and Tectonism 15

- Relationship between metamorphism and deformation
- Metamorphic mineral reactions (prograde and retrograde)

Unit- 4: Migmatites and their origin 7

- Metasomatism and role of fluids in metamorphism

Unit- 5: Metamorphic rock associations 8

- Schists, gneisses, khondalites, charnockites, blue schists and eclogites

PRACTICALS: Marks 20

- Megascopic and microscopic study (textural and mineralogical) of the following metamorphic rocks: Low grade metamorphic rocks: serpentinites, albite-epidote-chloritequartz schist, slate, tac-tremolite-ca1cite-quartz schist.
- Medium to high grade metamorphic rocks: Gneisses, amphibolite, hornfels, garnetiferous schists, sillimanite-kyanite-bearing rocks, Granulites, eclogite, diopside-forsterite marble.
- Laboratory exercises in graphic plots for petrochemistry and interpretation of assemblages.

SUGGESTED READINGS:

1. Philpotts, A., & Ague, J. (2009). *Principles of igneous and metamorphic petrology*. Cambridge University Press.
2. Winter, J. D. (2014). *Principles of igneous and metamorphic petrology*. Pearson.

3. Raymond, L. A. (2002). *Petrology: the study of igneous, sedimentary, and metamorphic rocks*. McGraw-Hill Science Engineering.
4. Yardley, B.W., & Yardley, B.W.D. (1989). An *introduction to metamorphic petrology*. Longman Earth Science Series.

Core Courses
Paper Code: GLG-HC-4026
Paper Name: STRATIGRAPHIC PRINCIPLES AND INDIAN STRATIGRAPHY
Credits: 6 (THEORY - 4, PRACTICALS - 2)

Distribution of mark					
End Semester Mark		**Internal Mark**			
Theory	**Practical**	**Sessional**	**Practical**	**Attendance**	**Total**
60	**20**	**10**	**6**	**4**	**100**

THEORY (Marks 60)

Unit- 1: Principles of stratigraphy **10**

- Brief introduction of litho-, bio- and chrono-stratigraphy
- Introduction to concepts of dynamic stratigraphy (chemostratigraphy, seismic stratigraphy, sequence stratigraphy, Magnetostratigraphy)

Unit- 2: Code of stratigraphic nomenclature **10**

- International Stratigraphic Code – development of a standardized stratigraphic nomenclature.
- Concepts of Stratotypes. Global Stratotype Section and Point (GSSP).
- Facies concept in stratigraphy

Unit 3: Physiographic and tectonic subdivisions of India **15**

- Brief introduction to the physiographic and tectonic subdivisions of India.
- Introduction to Indian Shield and Proterozoic basins of India: Shillong plateau,Vindhyan and Cudappah basins of India

Unit 4: Phanerozoic Stratigraphy of India **15**

- Paleozoic Succession of Kashmir and its correlatives from Spiti and Zanskar
- Mesozoic stratigraphy of India: Triassic successions of Spiti, Jurassic of Kutch, Cretaceous successions of Cauvery basins
- Cenozoic stratigraphy of India: Kutch basin, Siwalik successions, Assam-Arakan and Andaman basins.

Unit 5: Volcanic provinces of India **5**

- Deccan, Rajmahal, Sylhet Trap

Unit 6: Stratigraphic boundaries **5**

- Stratigraphic boundaries in India - Precambrian-Cambrian boundary, Permian-Triassic boundary, and Cretaceous-Tertiary boundary

PRACTICALS: **Marks 20**

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

SUGGESTED READINGS:

1. Krishnan, M. S. (1982). *Geology of India and Burma*, CBS Publishers, Delhi
2. Doyle, P. & Bennett, M. R. (1996). *Unlocking the Stratigraphic Record*. John Wiley
3. Ramakrishnan, M. &Vaidyanadhan, R. (2008). *Geology of India Volumes 1 & 2*, Geological society of India, Bangalore.
4. Valdiya, K. S. (2010). *The making of India*, Macmillan India Pvt. Ltd.
5. Naqvi, S.M. and Rogers, J.J.W. *Precambrian Geology of India*, Oxford University Press.
6. Kumar, R., *Fundamentals of Historical Geology and Stratigraphy of India*, New Age International Publishers.

Core Courses
Paper Code: GLG-HC-4036
Paper Name: HYDROGEOLOGY
Credits: 6 (THEORY - 4, PRACTICALS - 2)

Distribution of mark					
End Semester Mark		**Internal Mark**			
Theory	**Practical**	**Sessional**	**Practical**	**Attendance**	**Total**
60	**20**	**10**	**6**	**4**	**100**

THEORY (Marks 60)

Unit 1: Introduction and basic concepts **15**

- Scope of hydrogeology and its societal relevance
- Hydrologic cycle: precipitation, evapo-transpiration, run-off, infiltration and subsurface movement of water
- Rock properties affecting groundwater, Vertical distribution of subsurface water
- Types of aquifer, aquifer parameters, anisotropy and heterogeneity of aquifers

Unit 2: Groundwater flow **15**

- Darcy's law and its validity
- Intrinsic permeability and hydraulic conductivity
- Groundwater flow rates and flow direction
- Laminar and turbulent groundwater flow

Unit 3: Well hydraulics and Groundwater exploration **15**

- Basic Concepts (drawdown; specific capacity etc)

- Elementary concepts related to equilibrium and non-equilibrium conditions for water flow to a well in confined and unconfined aquifers.
- Surface-based groundwater exploration methods
- Introduction to subsurface borehole logging methods

Unit 4: Groundwater management **15**

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

PRACTICALS: **Marks 20**

- Preparation and interpretation of water level contour maps and depth to water level maps
- Study, preparation and analysis of hydrographs for differing groundwater conditions
- Water potential zones of India (map study)
- Graphical representation of chemical quality data and water classification (C-S and Trilinear diagrams) Simple numerical problems related to: determination of permeability in field and laboratory, Groundwater flow, Well hydraulics etc.

SUGGESTED READINGS:

1. Todd, D. K. 2006. *Groundwater hydrology*, 2nd Ed., John Wiley & Sons, N.Y.
2. Davis, S. N. and De Weist, R.J.M. 1966. *Hydrogeology*, John Wiley & Sons Inc., N.Y.
3. Karanth K.R., 1987, *Groundwater: Assessment, Development and management*, Tata Mc Graw-Hill Pub. Co. Ltd.
4. Mahajan G. (2008), *Evaluation and Development of Groundwater,* APH Publishing Corporation, New Delhi

Skill Enhancement Course (SEC-2)
Paper Code: GLG-SE-4014
Paper Name: PRECAMBRIAN GEOLOGY FIELD WORK
Credits: 4

Marks: 60

	Distribution of mark		
Field performance	Preparation of Field report	Field viva	Total
20	20	20	60

- Field transect in any Precambrian terrain: study of craton ensemble including basic intrusive

suites

or

- Precambrian sedimentary basin: Basement-Cover relation in fold belts, sedimentary successions

Skill Enhancement Course (SEC-2)
Paper Code: GLG-SE-4024
Paper Name: VISIT TO ENGINEERING PROJECT SITES
Credits: 4

Marks: 60

	Distribution of mark		
Field performance	Preparation of Field report	Field viva	Total
20	20	20	60

- Geological mapping of a project site (Dam sites, Tunnel alignments etc)

or

- On site visit & to study various geotechnical aspects related to a project site.
- Identification of geotechnical problems of a project site and remedial measures to be taken.

or

- Identification of environmental problems of a project site and remedial measures to be taken.

or

- Computation of rock mass Properties (RQD, RSR, RMR & Q) in field.

or

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

Skill Enhancement Course (SEC-2)
Paper Code: GLG-SE-4034
Paper Name: STRATIGRAPHY AND PALEONTOLOGY FIELD WORK
Credits: 4
Marks: 60

	Distribution of mark		
Field performance	Preparation	Field viva	Total

	of Field report		
20	20	20	60

- Field training along Phanerozoic basin of India: documentation of stratigraphic details in the field, collection of sedimentological, stratigraphic and paleontological details and their representation, facies concept and its spatio-temporal relation (Walther's Law) and concept of facies distribution at basinal-scale, fossils sampling techniques and their descriptions

Skill Enhancement Course (SEC-2)
Paper Code: GLG-SE-4044
Paper Name: PROJECT WORK
Credits: 4
Marks: 60

	Distribution of mark		
Preparation of project report	Project work presentation	Viva on Project Work	Total
30	20	10	60

(Concern teacher will assign geological project work to the students**)**

Generic Elective
Paper Code: GLG-HG-4016
Paper Name: Stratigraphy and Palaeontology
Credits: 6 (THEORY - 4, PRACTICALS - 2)

Distribution of mark					
End Semester Mark		**Internal Mark**			
Theory	**Practical**	**Sessional**	**Practical**	**Attendance**	**Total**
60	**20**	**10**	**6**	**4**	**100**

THEORY (Marks 60)

Unit-1: Stratigraphy 20

- Definition and Scope, Principles of Stratigraphy: Superposition of strata; Neptunism, Uniformitarianism; Catastrophism, Smith and Applied Stratigraphy; Lyell's Principles of Geology.
- Standard Geological time scale; Stratigraphic classification – concepts of Time (Chronological), Time-Rock (Chronostratigraphic), Rock (Lithostratigraphic) and Bio-stratigraphic units.Concept of sedimentary facies; Principles of Stratigraphic

Correlation.

Unit-2: Indian Stratigraphy **20**

- A brief study of the Precambrian stratigraphy of India of the following areas with respect to lithology, tectonics and igneous activity:
  a) Dharwar Province (Karnataka)
  b) Assam-Meghalaya plateau (Shillong plateau)
  c) Delhi Super Group
  d) Cuddapah Super Group of Cuddapah basin
  e) Vindhyan Super Group of Sone Valley.
- Phanerozoic Succession of India:
  a) Triassic of Spiti
  b) Jurassic of Kutch
  c) Cretaceous of Trichinopoly
  d) Gondwana Super Group
  e) Cenozoic stratigraphy of NE India
  f) Deccan Traps
  g) Paleogene-Neogene sequence of NW Himalaya and Assam

Unit-3: Palaeontology 20

- Palaeontology: definition and kinds of fossils; Mode of preservation of fossils. Broad divisions of invertebrates into different phyla (binomial nomenclature and taxonomy) and their major characteristics. Significance of fossils.
- A study of the morphological characters and brief geological distribution of the following phyla/classes - Brachiopoda, Lamellibranchia, Cephalopoda, Trilobita and Echinoidea.
- Evolutionary history of Horse.
- A general idea on the plant fossils of Gondwana Flora, its distribution and palaeo-geographic significance.

PRACTICAL **Marks = 20**

Unit-1: Indian Stratigraphy 8

- Preparation of lithostratigraphic maps of India showing distribution of important geological formations:
- Dharwar Province, Shillong Group of rocks,Cuddapah Super Group, Vindhyan Super Group, Jurassic of Kutch, Cretaceous of Trichinopoly, Gondwana Super Group, Deccan Traps.

Unit-2: Palaeontology 12

- Identification of the following genera of fossils by their external morphology. Their stratigraphic ranges will also have to be studied:
  a) Cidaris, Hemiaster, Micraster, Echinolampus, Clypeaster, Stygmatopygus

b) Orthis, Productus, Spirifer, Terebratula, Pentamerus, Rhynchonella, Syringothyris
c) Arca, Cardita, Exogyra, Glycemeris, Pecten, Plicatula, Ostrea, Trigonia
d) Baculites, Belemnites, Ceratites, Hamites, Goniatite, Nautilus, Perisphinctes
e) Calymene, Phacops
f) Glossopteris, Gangamopteris, Ptillophyllum, Vertebraria

[In case of non-availability of fossils, representative casts of fossils may be used in the Exercises.]

SUGGESTED READINGS:

1. Schoch, R.M. 1989. Stratigraphy, Principles and Methods.VanNostrand Reinhold.
2. Clarkson, E.N.K.1998. Invertebrate Paleontology and Evolution George AlIen&Unwin
3. Benton, M.J. 2005. Vertebrate paleontology (3rd edition). Blackwell Scientific, Oxford.
4. Colbert's Evolution of the Vertebrates: A History of the Backboned Animals Through Time, EdwinH. Colbert, Michael Morales, Eli C. Minkoff, John Wiley & Sons, 1991.
5. Dasgupta A. *An introduction to palaeontology*.World Press, Kolkata
6. Krishnan, M. S. (1982). *Geology of India and Burma*, CBS Publishers, Delhi
7. Ramakrishnan, M. &Vaidyanadhan, R. (2008). *Geology of India Volumes 1 & 2*, Geological society of India, Bangalore.
8. Naqvi, S.M. and Rogers, J.J.W. *Precambrian Geology of India*, Oxford University Press.
9. Kumar, R., *Fundamentals of Historical Geology and Stratigraphy of India*, New Age International Publishers.

5th SEMESTER

Core Courses
Paper Code: GLG-HC-5016
Paper Name: ECONOMIC GEOLOGY
Credits: 6 (THEORY - 4, PRACTICALS - 2)

Distribution of mark					
End Semester Mark		Internal Mark			
Theory	Practical	Sessional	Practical	Attendance	Total
60	20	10	6	4	100

THEORY (Marks 60)

Unit 1 Ores and gangues **5**

- Ores, gangue minerals, tenor, grade and lodes
- Resources and reserves- Economic and Academic definitions

Unit 2: Mineral deposits and Classical concepts of Ore formation **5**

- Mineral occurrence, Mineral deposit and Ore deposit
- Historical concepts of ore genesis: Man's earliest vocation- Mining
- Plutonist and Neptunist concepts of ore genesis

Unit 3: Mineral exploration **10**

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

Unit 4: Structure and texture of ore deposits **20**

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

Unit 5: Metallic and Nonmetallic ores **20**

- Metallogenic provinces and epochs
- Important deposits of India including atomic minerals
- Non-metallic and industrial rocks and minerals, in India.
- Introduction to gemstones.

PRACTICALS: **Marks 20**

- Megascopic identification of ore minerals: Iron, copper, Manganese, Lead and Zinc, Aluminum, Chromium

- Study of microscopic properties of ore forming minerals (Oxides and sulphides).
- Preparation of maps**:** Distribution of important ores and other economic minerals in India.
- Assessment of grade of ore and reserve estimation

SUGGESTED READINGS:

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

Core Courses
Paper Code: GLG-HC-5026
Paper Name: GEOMORPHOLOGY
Credits: 6 (THEORY - 4, PRACTICALS - 2)

Distribution of mark					
End Semester Mark		**Internal Mark**			
Theory	**Practical**	**Sessional**	**Practical**	**Attendance**	**Total**
60	**20**	**10**	**6**	**4**	**100**

THEORY (Marks 60)

Unit 1: Introduction to Geomorphology, Endogenic and Exogenic processes **8**

Unit 2: Geoid, Topography, Hypsometry, Global Hypsometry, Major Morphological features Large Scale Topography - Ocean basins, Plate tectonics overview, Large scale mountain ranges (with emphasis on Himalaya). **15**

Unit 3: Surficial Processes and geomorphology, Weathering and associated landforms, Hill slopes Glacial, Periglacial processes and landforms, Fluvial processes and landforms, Aeolian Processes and landforms, Coastal Processes and landforms, Landforms associated with igneous activities **15**

Unit 4: Endogenic- Exogenic interactions, Rates of uplift and denudation, Tectonics and drainage development, Sea-level change, Long-term landscape development **15**

Unit 5: Overview of Indian Geomorphology, Extraterrestrial landforms **7**

PRACTICALS: **Marks 20**

- Reading topographic maps
- Concept of scale Preparation of a topographic profile
- Preparation of longitudinal profile of a river
- Preparing Hack Profile
- Calculating Stream length gradient index
- Morphometry of a drainage basin
- Calculating different morphometric parameters
- Preparation of geomorphic map
- Interpretation of geomorphic processes from the geomorphology of the area

SUGGESTED READINGS:

1. Robert S. Anderson and Suzzane P. Anderson (2010): *Geomorphology - The Mechanics and Chemistry of Landscapes*. Cambridge University Press.
2. Bloom A.L., (1998). *Geomorphology: A Systematic Analysis of Late Cenozoic Landforms,* Pearson Education.
3. Esterbrook D.J., (1992). *Surface Processes and Landforms,* MacMillan Publ.
4. Kale, V.S. and Gupta A. (2001). *Intoduction to Geomorphology,* Orient Longman Ltd.
5. Summerfield M.A. (1991). *Global Geomorphology* Prentice Hall.

Discipline Specific Elective (DSE-1)
Paper Code: GLG-HE-5016
Paper Name: EXPLORATION GEOLOGY
Credits: 6 (THEORY - 4, PRACTICALS - 2)

Distribution of mark					
End Semester Mark		**Internal Mark**			
Theory	**Practical**	**Sessional**	**Practical**	**Attendance**	**Total**
60	**20**	**10**	**6**	**4**	**100**

THEORY (Marks 60)

Unit 1: Mineral Resources **12**
- Resource reserve definitions, Mineral resources in industries – historical perspective and present, A brief overview of classification of mineral deposits with respect to processes of formation in relation to exploration strategies.

Unit 2: Prospecting and Exploration,
- Principles of mineral exploration, Prospecting and exploration- conceptualization, methodology and stages, Sampling, subsurface sampling including pitting, trenching and drilling, Geochemical exploration.

Unit 3: Evaluation of data **12**
- Evaluation of sampling data
- Mean, mode, median, standard deviation and variance

Unit 4: Drilling and Logging **12**
- Core and non-core drilling
- Planning of bore holes and location of boreholes on ground
- Core-logging

Unit 5: Reserve estimations and Errors **12**

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

PRACTICALS: **Marks 20**

- Identification of anomaly
- Concept of weighted average in anomaly detection
- Geological cross-section
- Models of reserve estimation

SUGGESTED READINGS:

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

Discipline Specific Elective (DSE-1)
Paper Code: GLG-HE-5026
Paper Name: EARTH AND CLIMATE
Credits: 6 (THEORY - 4, PRACTICALS - 2)

Distribution of mark					
End Semester Mark		Internal Mark			
Theory	Practical	Sessional	Practical	Attendance	Total
60	20	10	6	4	100

THEORY (Marks 60)

Unit 1: Climate system: Forcing and Responses **10**

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

Unit 2: Heat budget of Earth **10**

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

Unit 3: Atmosphere – Hydrosphere **10**

- Layering of atmosphere and atmospheric Circulation
- Atmosphere and ocean interaction and its effect on climate
- Heat transfer in ocean
- Global oceanic conveyor belt and its control on earth's climate
- Surface and deep circulation
- Sea ice and glacial ice

Unit 4: Response of biosphere to Earth's climate **10**

- Climate Change: natural vs. anthropogenic effects

- Humans and climate change
- Future perspectives
- Brief introduction to archives of climate change
- Archive based climate change data from the Indian continent

Unit 5: Orbital cyclicity and climate **10**

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

Unit 6: Monsoon **10**

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

PRACTICALS: **Marks 20**

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

SUGGESTED READINGS:

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

6th SEMESTER

Core Courses
Paper Code: GLG-HC-6016
Paper Name: ENGINEERING GEOLOGY
Credits: 6 (THEORY - 4, PRACTICALS - 2)

Distribution of mark					
End Semester Mark		Internal Mark			
Theory	Practical	Sessional	Practical	Attendance	Total
60	20	10	6	4	100

THEORY (Marks 60)

Unit 1: Geology vs. Engineering, Role of Engineering geologists in planning, design and construction of major man-made structural features 10

Unit 2: Site investigation and Geological, Geotechnical and Environmental characterization for Dams and Reservoirs, Tunnels. Types of Dam and tunnels 16

Unit 3: Foundation treatment: Grouting, Rock Bolting and other support mechanisms 8

Unit 4: Intact Rock and Rock Mass properties, Rock aggregates; Significance as Construction Material 8

Unit 5: Concept, Mechanism and Significance of: 10

- Rock Quality Designation (RQD)
- Rock Structure Rating (RSR)
- Rock Mass Rating (RMR)
- Tunneling Quality Index (Q)

Unit 6: Causes, Factors and corrective/Preventive measures of Landslides and Earthquakes 8

PRACTICALS: Marks 20

- Computation of reservoir area, catchment area, reservoir capacity and reservoir life.
- Merits, demerits & remedial measures based upon geological cross sections of project sites.
- Computation of Index properties of rocks.
- Computation of RQD, RSR, RMR and 'Q'

SUGGESTED READINGS:

1. Krynin, D.P. and Judd W.R. 1957. Principles of Engineering Geology and Geotechnique, McGraw Hill (CBS Publ).
2. Johnson, R.B. and De Graf, J.V. 1988. Principles of Engineering Geology, John Wiley.
3. Goodman, R.E., 1993. Engineering Geology: Rock in Engineering constructions. John Wiley & Sons, N.Y.

4. Waltham, T., 2009. Foundations of Engineering Geology (3rd Edn.) Taylor & Francis.
5. Bell: F.G-, 2006. Basic Environmental and Engineering Geology Whittles Publishing.
6. Bell, .F.G, 2007. *Engineering Geology,* Butterworth-Heineman

Core Courses
Paper Code: GLG-HC-6026
Paper Name: REMOTE SENSING AND GIS
Credits: 6 (THEORY - 4, PRACTICALS - 2)

Distribution of mark					
End Semester Mark		**Internal Mark**			
Theory	**Practical**	**Sessional**	**Practical**	**Attendance**	**Total**
60	**20**	**10**	**6**	**4**	**100**

THEORY (Marks 60)

Unit 1: Photogeology 14

- Types and acquisition of aerial photographs; Scale and resolution; Principles of stereoscopy, relief displacement, vertical exaggeration and distortion
- Elements of air photo interpretation
- Identification of sedimentary, igneous and metamorphic rocks and various aeolian, glacial, fluvial and marine landforms

Unit 2: Remote Sensing 14

- Concepts in Remote Sensing
- Sensors and scanners
- Satellites and their characteristics
- Data formats- Raster and Vector

Unit 3: Digital Image Processing 12

- Image Errors, Rectification and Restoration, FCC, Image Enhancement,
- Filtering, Image Rationing, Image classification and accuracy assessment.
- GIS integration and Case studies-Indian Examples

Unit 4: GIS 10

- Datum, Coordinate systems and Projection systems
- Spatial data models and data editing
- Introduction to DEM analysis

Unit 5: GPS 10

- Concepts of GPS
- Integrating GPS data with GIS
- Applications in earth system sciences

PRACTICALS: Marks 20

- Aerial Photo interpretation, identification of sedimentary, igneous and metamorphic rocks and various aeolian, glacial, fluvial and marine landforms
- Introduction to DIP and GIS softwares. Digital Image Processing exercises including analysis of satellite data in different bands and interpretation of various objects on the basis of their spectral signaturesCreating a FCC from raw data,Registration of satellite data with a toposheet of the area

- Enhancing the satellite images; Generating NDVI images and other image ratio and its interpretation
- Classification of images.DEM analysis: generating slope map, aspect map and drainage network map and its applications

SUGGESTED READINGS:

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

Discipline Specific Elective (DSE-1)
Paper Code: GLG-HE-6016
Paper Name: FUEL GEOLOGY
Credits: 6 (THEORY - 4, PRACTICALS - 2)

Distribution of mark					
End Semester Mark		**Internal Mark**			
Theory	**Practical**	**Sessional**	**Practical**	**Attendance**	**Total**
60	**20**	**10**	**6**	**4**	**100**

THEORY (Marks 60)

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

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

Unit 3: Petroleum **12**
- Chemical composition and physical properties of crudes in nature
- Origin of petroleum
- Maturation of kerogen; Biogenic and Thermal effect

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

Unit 5: Other fuels **8**

- Gas Hydrate
- Nuclear Fuel

PRACTICALS: **Marks 20**

- Study of hand specimens of coal
- Reserve estimation of coal
- Section correlation and identification of hydrocarbon prospect
- Panel and Fence diagrams

SUGGESTED READINGS:

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

Discipline Specific Elective (DSE-1)
Paper Code: GLG-HE-6026
Paper Name: INTRODUCTION TO GEOPHYSICS
Credits: 6 (THEORY - 4, PRACTICALS - 2)

Distribution of mark					
End Semester Mark		Internal Mark			
Theory	Practical	Sessional	Practical	Attendance	Total
60	20	10	6	4	100

THEORY (Marks 60)

Unit 1: Geology and Geophysics **10**

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

Unit 2: General and Exploration geophysics **10**

- Different types of geophysical methods - gravity, magnetic, electrical and seismic; their principles and
- applications
- Concepts and Usage of corrections in geophysical data

Unit 3: Geophysical field operations **10**

- Different types of surveys, grid and route surveys, profiling and sounding techniques
- Scales of survey, Presentation of geophysical data

Unit 4: Application of Geophysical methods **10**

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

Unit 5: Geophysical anomalies **10**

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

Unit 6: Integrated geophysical methods **10**

- Ambiguities in geophysical interpretation, planning and execution of geophysical surveys

PRACTICALS: **Marks 20**

- Anomaly and background- Graphical method

- Study and interpretation of seismic reflector geometry
- Problems on gravity anomaly

SUGGESTED READINGS:

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