Course Structure and Syllabus
for
Master of Science in Geology
(M.Sc. in Geology as per NEP 2020)

(Effective from Academic Session 2024-2025)

DEPARTMENT OF GEOLOGY
School of Earth, Biological and Environmental Sciences

Central University of South Bihar, Gaya

NH-120, Gaya- Panchanpur Road, P.O.: Fatehpur, P.S. Tekari
District: Gaya - 824236, Bihar, India

Course Structure for M. Sc. Geology as per NEP 2020
Course Duration: 2 years [4 Semesters] (80 Credits)

The Department of Geology, Central University of South Bihar Gaya is located in the geologically important terrain of Pre-Cambrian formations to Recent Quaternary deposits and it is established in 2020 under the School of Earth, Environment and Biological Sciences. Presently Department of Geology offering M.Sc. and Ph.D. Program in Geology. The department is committed to excellence in the creation of new knowledge about Earth, enabling life-long learning by all students about Earth processes to solve the challenges associated with earth dynamics. The fundamental objective of this programme to build young Minds in the field of Geology by providing a broad education in all aspects of the geoscience and equip the students with appropriate knowledge and skills to make them employable and capable to serve the Nation.

M. Sc. Degree in Geology

The two year (four semesters) Post-Graduate Programme in Geology has interdisciplinary approach based on NEP2020 pattern with an option of exit after one year leading to Post Graduate diploma in Geology. Field based study and professional training on field instruments are keys to our teaching pedagogy**.** The M.Sc. Geology Programme mainly focuses on to build the students a responsible educator/researcher and follow ethics in research and policy. We are equally giving emphasis on integrated approaches to geo resources evaluation and management through the use of recent technologies in the field of Geological Sciences, capacity building to solve the issues related to earth and its environment. The Program also comprised of project dissertation, Geological field visits, presentation and comprehensive viva-voce as part of evaluation system. There is option of entry in the second year M.Sc. program (3rd semester) provided the student fulfill the eligibility criteria completing the 4-year Bachelor degree in Research subject to availability of the seat in the department. Students are also visiting major research labs in the form of educational/excursion tour and industries to provide them opportunity to learn various aspects of advance research in the field of Geological Sciences. Currently, department offers major research activity in the areas of Groundwater Recharge & Management, Groundwater pollution Modeling, Natural Hazards (Landslide & Flood), River Basin Management, Remote Sensing & GIS, Paleontology, Sedimentology, Geochemistry, Geomorphology, Quaternary Geology and Geochronology.

Program Specific Objectives (PSOs)

Some program specific Objectives

- To enhance scientific skills and promote research and development activities.
- To impart knowledge and hands-on exercises related to various applied disciplines of geology having great societal impact.
- To train the students to join various premier public and private organizations related to geology and natural resources management.
- To acquire knowledge about exploration and exploitation of earth resources in a sustainable manner and support the SDGs.
- To carry out Geological field work/training in various applied field to develop the practical skills for evaluation and mapping of important earth resources.
- To train the students for project management and independent work for supporting the start-up and capacity building skills.

Program Outcome (POs)

Some major program outcomes of the M.Sc. Geology are:

- To impart knowledge of Geology with special emphasis on various applied aspects of geology.
- To produce skilled manpower with applied aspects of Geology employable for positions in the field of education, industry and government and non-government organizations.
- To enhance knowledge of geological science with more recent tools and techniques.
- To develop project management skills via post-graduation dissertation on different applied aspects of geology.
- To impart the basic understanding of the various societal issues and the role of Geologist to provide the solution.
- To promote comprehensive and interdisciplinary knowledge in both teaching and research by emphasizing inter-linking of geology with other branches of Science and Engineering.

SEMESTER I (Total Credits = 20)			
Nature of Course	**Course Code**	**Name of Course**	**Credit (L+T+P)**
Discipline Based Core Course	GEL81DC00104	Applied Geomorphology	3+0+1
Discipline Based Core Course	GEL81DC03604	Mineralogy and Mineral Optics	3+0+1
Discipline Based Core Course	GEL81DC03704	Structural Geology and Geotectonics	3+0+1
Discipline Based Core Course	GEL81DC03804	Igneous and Metamorphic Petrology	3+0+1
Credits = 16			
Open Elective Interdisciplinary Course		Elective Basket I	4 (For other departments)
Mandatory Elective Non-Credit Course		Elective Basket II	0
Total Credits = 20			

Elective Basket I (Open Elective Interdisciplinary Course)			
Nature of Course	**Course Code**	**Name of Course**	**Credit (L+T+P)**
Open Elective Interdisciplinary Course	GEL81OE03904	Geo-informatics	3+1+0
Open Elective Interdisciplinary Course	GEL81OE00604	Oceanography	3+1+0
Open Elective Interdisciplinary Course	GEL81SW00704	Introduction to climate change SWAYAM approved Course	3+1+0

Elective Basket II (Mandatory Elective Non-Credit Course)			
Nature of Course	**Course Code**	**Name of Course**	**Credit (L+T+P)**
Mandatory Elective Non-Credit Course	GEL81ME00700	Gemology	0

Course Details			
Course Title: Applied Geomorphology			
Course Code	GEL81DC00104	**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	First/Odd	**Contact Hours**	45 (L) + 30 (P) Hours
Course Type	Discipline Based Core Course		
Nature of the Course	Theory cum Practical		
Special Nature/ Category of the Course (*if applicable***)**	Core Course		
Methods of Content Interaction	(*Lecture, Tutorials, Practical and field work etc.)*		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives:

The main objective of this course is to introduce the student's basic and applied aspects of Geomorphology.

- ❖ The course is aimed to enable the students to understand different geomorphic processes and the landforms produced as a result of their interaction with the existing Earth surface features.
- ❖ Understanding the role of geomorphology in Earth Sciences and Earth Resource Evaluation and Management.

Course Learning Outcomes:

After completion of the course the students will be able to:

- ❖ Systematically study different landforms and associated features for resource evaluation and mapping.
- ❖ They will also be able to interpret the landforms and their relation with other applied fields of Earth Sciences.

Course Contents	Weightage (%)
Unit - I Basics of Geomorphology	**20** **12 Lectures**
The fundamental concept of Applied Geomorphology and their significance. Basic concepts of landform evolution; Exogenic/Endogenic processes–Weathering and geologic controls in weathering, mechanical weathering and products; Chemical weathering processes and products; Weathering and landform alteration. Soil formation and types; Soil profile and soil types of India.	
Unit- II Geomorphological Processes and Landforms	

Fluvial system and processes – Drainage basin, basin and stream characteristics, drainage types and patterns, erosion, transportation and deposition by running water, erosional landforms, depositional landforms; Fluvial landforms in arid areas - eolian processes – erosion by wind and erosional landforms, depositional landforms such as sand dunes and loess, types of dunes and mechanics of dune formation; Glacial processes, types of glaciers and glacial landforms.	**20** **12 Lectures**
Unit- III Aerial Photograph and Photogrammetry	**20** **12 Lectures**
Introduction of Aerial Photography and photogeology, Basic Principles of Aerial Photos (Photo flight planning, Types of Aerial Photos, Scale, Ground Coverage, Season of photography, Photographic Resolution), Spectral Sensitivity and Filters, Acquisition of Aerial Photographs, Production of aerial photographs, Procurement, and security of Aerial photos. stereoscopic parallax, relief displacement, Principles of photogrammetry.	
Unit - IV Applications of Geomorphology	**15** **09 Lectures**
Application of Geomorphology in surface and subsurface Hydrology, Urban Hydrology, Environmental studies, Application of Geomorphology in Mineral Prospecting, Civil Engineering projects, Military purposes, land use planning, hazard and risk studies, environmental monitoring environmental studies. Applied geomorphology in coastal zone studies.	
Unit –V Lab Experiments	**25** **30 Hours lab Sessions**
• Study of Survey of India toposheets and base map preparation. • Identification of landform on toposheets, aerial photographs and satellite Images • Identification and mapping of drainage patterns from toposheets. • Interpretation of aerial photos with special references to topography, drainage, structure and geology. • Surveying with total station • Exercise on aerial photographs	

Text / Reference Books:

1. Thornbury, W.D. (2004). Principles of Geomorphology. Wiley Easton Ltd., New York or 2nd edition CBS Publication.
2. Sharma, H.S. (1990). Indian Geomorphology. Concept Publishing Co. New Delhi.
3. Halis, J.R. (1983). Applied Geomorphology.
4. Shroder J. F. Treatise on Geomorphology. Academic Press Hall, London.
5. Edward A. Keller and Nicholas (1996) Active Tectonics: Earthquakes, Uplift and Landscape - Pinter, Prentice Hall.
6. Richard John Huggett and Routledge (2011) Fundamentals of Geomorphology. Routledge CRC Press.

Content Interaction Plan

Contact Hours	Topic
1-3	The fundamental concept of Applied Geomorphology and their significance. Basic concepts of landform evolution.
4 – 8	Exogenic/Endogenic processes–Weathering and geologic controls in weathering, mechanical weathering and products; Chemical weathering processes and products; Weathering and landform alteration.
8 – 12	Soil formation and types; Soil profile and soil types of India. Assignment, Quiz etc.
12-15	Fluvial system and processes – Drainage basin, basin and stream characteristics, drainage types and patterns, erosion, transportation and deposition by running water,
16 –18	Erosional landforms, depositional landforms; Fluvial landforms in arid areas - eolian processes and resultant landforms.
19 –21	Wind and erosional landforms, depositional landforms such as sand dunes and loess, types of dunes and mechanics of dune formation
22-23	Glacial processes, types of glaciers and glacial landforms, Assignment, Quiz etc.
24-31	Introduction of Aerial Photography and photogeology, Basic Principles of Aerial Photos (Photo flight planning, Types of Aerial Photos, Scale, Ground Coverage, Season of photography, Photographic Resolution)
32 –36	Spectral Sensitivity and Filters, Acquisition of Aerial Photographs, Production of aerial photographs, Procurement, and security of Aerial photos. stereoscopic parallax, relief displacement, Principles of photogrammetry.
37 –39	Application of Geomorphology in surface and subsurface Hydrology, Urban Hydrology, Environmental studies,
40 –45	Application of Geomorphology in Mineral Prospecting, Civil Engineering projects, Military purposes, land use planning, hazard and risk studies, environmental monitoring environmental studies. Applied geomorphology in coastal zone studies.
	List of Practical
P=30 Hours	• Study of Survey of India toposheets and base map preparation. • Identification of landform on toposheets, aerial photographs and satellite images. • Identification and mapping of drainage patterns from toposheets. • Interpretation of aerial photos with special references to topography, drainage, structure and geology. • Surveying with total station • Exercise on aerial photographs

Course Details			
Course Title: Mineralogy and Mineral Optics			
Course Code	GEL81DC03604	**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	First/Odd	**Contact Hours**	45 (L) + 30 (P) Hours
Course Type	Discipline Based Core Course		
Nature of the Course	Theory cum Practical		
Special Nature/ Category of the Course	Not Applicable		
Methods of Content Interaction	(*Lecture, tutorials, group discussion, assignments, presentations by students, fieldwork etc.)*		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives:

The Course aims to make the students well-versed in the strength:

- ❖ To understand the major rock-forming mineral groups and their classification based on silicate structures; rock-forming minerals composition and their physico-chemical properties.
- ❖ Light-mineral interaction and optical properties of minerals under the microscope, describe and identify minerals in hand specimen and in thin section study.
- ❖ Introduction of atomic structure, crystal systems and symmetry elements, P-T conditions of minerals, associations of rock-forming minerals and different analytical techniques for minerals characterization.

Course Learning Outcomes:

Upon successful completion of the course, students will be able to:

- ❖ Identify and classify different rock-forming silicate minerals; study the optical properties of minerals.
- ❖ Understand crystal systems and symmetry elements in crystallography; characterize isomorphs and polymorphs minerals; learn the common analytical techniques used in mineralogical studies.

Course Contents	Weightage (%)
Unit -I Rock-forming minerals classification	**20** **12 Lectures**
A comprehensive study of the different silicate mineral groups (listed below) with reference to general and structural formulae, atomic structure, elemental substitution, composition and classification, pressure-temperature stability, modes of occurrence and alterations: 1) Nesosilicates/Orthosilicates: Olivine Group, Garnet Group, Aluminosilicate Group 2) Sorosilicates: Epidote Group 3) Cyclosilicates: Beryl, Tourmaline 4) Inosilicates; Pyroxene Group; Amphibole Group. 5) Phyllosilicates: Clay minerals, Mica Group, Chlorite, Serpentine 6) Tectosilicate: Quartz, Feldspar,Feldspathoidminerals Brief introduction of Oxides, Carbonates, Phosphates and Sulphide minerals.	
Unit- II Crystallography	**20** **12 Lectures**
Introduction to crystals, crystal elements, crystal forms; Open and closed crystal forms;Interfacial angle of crystals, Classification of different crystalsystems;the concept of symmetryelements,external and internal symmetry, types of symmetry possible in minerals, 32 crystals classes and description of the different classes;Crystal lattices, Space groups; Miller indices;Differenttypes of crystal projections-spherical and stereographic projections and their uses, Twinning in crystals, the laws of twinning, common types of twins and their examples in minerals.	
Unit- III Minerals stability, colours and characterization	**15** **09 Lectures**
Radius ratio and coordination number, phase diagrams, mineral stability with emphasis on solid solution, exsolution and order, polymorphs and isomorphs of minerals, crystal defects and chemistry: colour, cause and enhancement techniques, thin section preparation for mineral studies; Application of different analytical instruments in mineral characterization; powder X-ray Diffraction (XRD) analysis, Electron Probe Micro Analysis (EPMA) and Scanning Electron Microscopy (SEM) in mineral sciences.	
Unit - IV Optical mineralogy	**20** **12 Lectures**
Optical microscope and its components, Determination of refractive Indices of minerals, Plane polarised and cross polarized light; Isotropic and Anisotropic minerals; Optical properties of minerals under microscope, Extinction angle measurement, Double refraction and Optic axis, Uniaxial and biaxial minerals, Birefringence, Interference of light, Order of Interference colour, Michael Levy's chart, Optical Indicatrix: uniaxial and biaxial,Scheme of pleochroism, Optical accessory plates (mica, gypsum and quartz), Sign of elongation, Determination of Optic sign	
Unit –V Lab Experiments	

• Megascopic hand specimen identification of common rock forming minerals • Microscopic study of important rock forming minerals. Determination of Birefringence using Michael Levy's chart. Measure Extinction angle. • Sign of elongation and Optic sign determination of uniaxial and biaxial minerals using the polarizing microscope • Study Pleochroic scheme in minerals under polarizing microscope. • Study of different forms of normal class in different systems; Study of a few important twin crystals. • Stereographic projection of crystals	**25** **30 Hours Lab Sessions**

Text & Reference Books

1. Berry, L.G., Mason, B. and Dietrich, R.V. (1982). Mineralogy, CBS Publ.
2. Dana, E.S. and Ford, W.E. (2002). A textbook of Mineralogy (Reprint).
3. Deer, W. A., Howie, R. A. and Zussman, J. (1966). An Introduction to the Rock-Forming Minerals. The Mineralogical Society, London.
4. Flint, F. (1964). Essentials of Crystallography. Peace Pub., Russia.
5. Kerr, P.F. (1977). Optical Mineralogy. McGraw Hill.
6. Moorhouse, W.W. (1951). Optical Mineralogy, Harper and row Publ.
7. Nesse, D.W. (1991). Introduction to Optical Mineralogy, Oxford University
8. Nesse, D.W. (1999). Introduction to Mineralogy, Oxford University Press
9. Perkins, D. (1998). Mineralogy. Pearson Education
10. Phillips, F.C. (1971). Introduction to Crystallography. Longman Group Publ.
11. Sharma, R.S. and Sharma, A. (2013). Crystallography and Mineralogy. Geological Society of India.

Content Interaction Plan

Contact Hours	Topic
1-2	Define Minerals, Silica Tetrahedron, Introduction of Silicate group minerals and their classification, discuss silicates minerals in terms of formula, Si:O ratio, crystal system and elemental substitution.
3 – 6	Nesosilicate minerals: Olivine Group, Garnet Group, Aluminosilicate Group; Sorosilicates: Epidote Group; Cyclosilicates: Beryl, Tourmaline.
7 – 10	Inosilicates; Pyroxene Group; Amphibole Group. Phyllosilicates: Clay minerals, Mica Group, Chlorite, Serpentine.
11-12	Tectosilicate: Quartz, Feldspar, Feldspathoid minerals Brief introduction of Oxides, Carbonates, Phosphates and Sulphide minerals.
13 –15	Introduction to crystals, crystal elements, crystal forms; Open and closed crystal forms; Interfacial angle of crystals, Classification of different crystal systems;
16 –22	Concept of symmetry elements, types of symmetry possible in minerals, 32 crystals classes and description of the different classes; Crystal lattices, Space groups; Miller indices.

23-24	Different types of crystal projections-spherical and stereographic projections and their uses, Twinning in crystals, the laws of twinning, common types of twins and their examples in minerals.
25-28	Radius ratio and coordination number, phase diagrams, mineral stability with emphasis on solid solution, exsolution and order, polymorphs and isomorphs of minerals, crystal defects and chemistry: colour, cause and enhancement techniques.
29-33	thin section preparation for mineral studies; Application of different analytical instruments in mineral characterization; powder X-ray Diffraction (XRD) analysis, Electron Probe Micro Analysis (EPMA) and Scanning ElectronMicroscopy (SEM) in mineral sciences.
34 –40	Optical microscope and its components, Determination of refractive Indices of minerals, Plane polarised and cross polarized light; Isotropic and Anisotropic minerals; Optical properties of minerals under microscope.
41 –45	Extinction angle measurement, Double refraction and Optic axis, Uniaxial and biaxial minerals, Birefringence, Interference of light, Order of Interference colour, Michael Levy's chart, Optical Indicatrix: uniaxial and biaxial, Scheme of pleochroism, Sign of elongation, Determination of Optic sign.
	List of Practical
P= 30 Hours	• Megascopic hand specimen identification of common rock-forming minerals • Microscopic study of important rock-forming minerals. Determination of Birefringence using Michael Levy's chart. Measure Extinction angle. • Sign of elongation and Optic sign determination of uniaxial and biaxial minerals using the polarizing microscope • Study Pleochroic scheme in minerals under polarizing microscope. • Study different forms of normal class in different systems; Study a few important twin crystals. • Stereographic projection of crystals

Course Details			
Course Title: Structural Geology & Geotectonics			
Course Code	GEL81DC03704	**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	First/Odd	**Contact Hours**	45 (L) +30 (P) Hours
Course Type	Discipline Based Core Course		
Nature of the Course	Theory cum Practical		
Special Nature/ Category of the Course (*if applicable***)**	Not Applicable		
Methods of Content Interaction	(*Lecture, Tutorials, Practical and field work etc.)*		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives:

- ❖ The main objective of this course is to introduce the students to rock deformation mechanisms and their interpretation. This will also enable the students to understand different brittle and ductile deformation structures, their genesis, identification and interpretation.
- ❖ Also, this course will introduce the students to the plate tectonics and the tectonic setup of different types of plate boundaries

Course Learning Outcomes:

- ❖ After completing this course, the students will have the basic understanding of stress and strain, behaviors of rocks under stress, different types of structures, their geological significance and deformation history.
- ❖ Determine the geological structures of deformed continental regimes and will be able to solve certain structural problems.
- ❖ The students will also be able to understand plate tectonic process and their effects associated with different types of plate boundaries and their significance to understand the earth dynamics.

Course Contents	Weightage (%)
Unit - I Introduction to geological structures and structural analysis	**20** **12 Lectures**
Classification of geologic structures; primary structures; microstructures; force and stress: two-dimensional stress and three-dimensional stress; principal planes and principal stresses; Mohr diagram for stress; mean and deviation stress; stress tensor; deformation and strain: homogeneous and inhomogeneous deformation, strain path, strain quantities; rheology: strain rate, the creep curve, steady-state flow, transient flow, isotropic and anisotropic materials, constitutive law, constitutive equations, rheological models, flow laws, rheology of the lithosphere.	
Unit- II Brittle deformation structures: Joint, Lineament, Fault.	**20** **12 Lectures**
Brittle deformation; joints: surface morphology and arrays, origin and interpretation of joints; veins and vein arrays; lineaments; faults and faulting: fault geometry and displacement, mechanism of faulting, recognizing and interpreting faults, relation of faulting to stress, fault systems: geometrical classification.	
Unit- III Deformation Structures	**20** **12 Lectures**
Folds and folding: anatomy of a folded surface, fold classification and geometry, superposed folding, mechanics of folding; foliations: geometry and relationship with folds and fault zones; lineation: categories and tectonic interpretation; Ductile deformation processes; shear zones: nature and types, shear zone rocks, shear-sense indicators, strain in shear zones, shear zone development.	
Unit - IV Introduction to plate tectonics	**15** **09 Lectures**
Concept of deformation, kinematics of deformation, dynamics of deformation, modes of deformation, brittle-ductile transition, factors controlling deformation of rocks, time-dependent deformation (creep), deformation mechanism maps, deformation and continuum mechanics. Plate tectonics: theory and mechanism; convergence tectonics: subduction and collision, fold-thrust belts; extensional tectonics: rifting and seafloor spreading, transform faults and mid-oceanic ridges; strike-slip tectonics.	
Unit- 5: Lab Experiments.	**25** **30 Hours Lab Sessions**
• Preparation and interpretation of Geological maps and sections. • Structural problems based on orthographic and stereographic projections, concerning economic deposit. • Recording and plotting of the field data • Study of the hand specimen of deformed structures. • Strain estimation from the data already collected from the field. • Study of dip-isogons from the fold profiles	

Text/Reference Books:

1. Condie, K. C. (1997). Plate Tectonics and Crustal Evolution, Butterworth Heinemann.
2. Donal M. Ragan (2009). Structural Geology: An Introduction to Geometrical Techniques. Cambridge University Press.
3. Douglas W. B., and Robert S. A. (2011). Tectonic Geomorphology, Wiley Blackwell.
4. Frisch, W. Meschede M. and Blakey R. (2010). Plate Tectonics: Continental Drift and Mountain Building. Springer.
5. Ghosh, S. K. (1993). Structural Geology: Fundamental and Modern Developments. Pergamon Press.
6. Haakon Fossen (2010). Structural Geology. Cambridge University Press.
7. Kearey, P. Klepeis K. A. and Vine F. J. (2009). Global Tectonics. Wiley-Blackwell
8. Marland P. Billings (2000). Structural Geology. Phi Learning.
9. Ragan D. M. (2009) Structural Geology: An Introduction to Geometrical Techniques. Cambridge University Press.
10. Ramsay, J. G. and Huber, M. I. (1983). Techniques of Modern Structural Geology. Vol. I. Strain Analysis, Academic Press.
11. Ramsay, J.G. and Huber, M.I., (1987). Techniques of Modern Structural Geology. Vol. II. Folds and Fractures, Academic Press.
12. Ramsay, J.G., (1967). Folding and fracturing of rocks. McGraw Hill.
13. Robert J. Twiss and Eldridge M. Moores (2006). Structural Geology. W. H. Freeman publisher.
14. Stephen Marshak and GautamMitra(1988). Basic Methods of Structural Geology. Prentice Hall.
15. SudiptaSengupta (1997). Evolution of Geological Structures in Micro- to Macro-scales. Springer

Content Interaction Plan

Contact Hours	Topic
1-3	Classification of geologic structures; primary structures; microstructures; force and stress: two-dimensional stress and three-dimensional stress;
4 – 8	Principal planes and principal stresses; Mohr diagram for stress; mean and deviation stress; stress tensor;
8 – 12	Deformation and strain: homogeneous and inhomogeneous deformation, strain path, strain quantities; rheology: strain rate, the creep curve, steady-state flow, transient flow, isotropic and anisotropic materials, constitutive law, constitutive equations, rheological models, flow laws, rheology of the lithosphere.
13-15	Brittle deformation; joints: surface morphology and arrays, origin and interpretation of joints; veins and vein arrays.
16 –18	Lineaments; faults and faulting: fault geometry and displacement,
19 –23	Mechanism of faulting, recognizing and interpreting faults, relation of faulting to stress, fault systems: geometrical classification.
24-28	Folds and folding: anatomy of a folded surface, fold classification and geometry, superposed folding, mechanics of folding;
29-30	Foliations: geometry and relationship with folds and fault zones;

31-33	Lineation: categories and tectonic interpretation;
34 –35	Shear zones: nature and types, shear zone rocks, shear-sense indicators, strain in shear zones, shear zone development.
36 –40	Concept of deformation, kinematics of deformation, dynamics of deformation, modes of deformation, brittle-ductile transition, factors controllingdeformationof rocks, time-dependent deformation (creep), deformation mechanism maps, deformation and continuum mechanics.
40 –45	Plate tectonics: theory and mechanism; convergence tectonics. Subduction and collision. Fold-thrust belts; extensional tectonics: rifting and seafloor spreading, transform faults and mid-oceanic ridges; strike-slip tectonics.
	List of Practical
P=30 Hours	• Preparation and interpretation of Geological maps and sections. • Structural problems based on orthographic and stereographic projections, concerning economic deposit. • Recording and plotting of the field data • Study of the hand specimen of deformed structures. • Strain estimation from the data already collected from the field. • Study of dip-isogons from the fold profiles.

Course Details			
Course Title: Igneous and Metamorphic Petrology			
Course Code	GEL81DC03804	**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	First/Odd	**Contact Hours**	45 (L) + 30 (P) Hours
Course Type	Discipline Based Core Course		
Nature of the Course	Theory cum Practical		
Special Nature/ Category of the Course	Not Applicable		
Methods of Content Interaction	(*Lecture, Tutorials, presentations by students, field work etc.)*		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives:

- The Course aims to make to the students well-versed with the subject.
- Explanation and interpretation of mineral identification, geochemical, textural, microtextural, and geochronologic features to interpret magma petrogenesis; controls on its emplacement at depth or eruption at the surface.
- To identify critical mineral assemblages, textural and mineral chemical data as well as provide theoretical basis for interpreting this data for past geodynamic processes.

Course Learning Outcomes:

Upon successful completion of the course, students will be able to:

- From this course the students can explain the composition and structure of igneous rock; acidic and mafic compositions of igneous rocks and metamorphic recrystallization processes.
- To transform the processes and principles involved during the origin and evolution of the Igneous and Metamorphic rocks. Data interpretation through binary and ternary diagrams using chemical composition data of rocks.

Course Contents	Weightage (%)
Unit - I Introduction of Igneous and Metamorphic process	**20** **10 Lectures**
Mantle depletion and enrichment. Composition of the upper and lower continental crust. Discussion of nature of the evidence. The oceanic crust, ophiolites and basalt-seawater interactions. Earth's internal structure based on compositional and physical properties. Variation in mineralogy as a function of pressure/depth. Mineralogy of the upper mantle. Peridotites and pyroxenites, heat flow, minerals as pure and impure phases. Textures of contact and regional metamorphism, Tectonic context of metamorphic transformations.	
Unit- II Classification of Igneous and Metamorphic rocks	**30** **15 Lectures**
Classification of quartz-bearing plutonic rocks in the IUGS scheme. Brief introduction to feldspathoid-bearing plutonic rocks. The IUGS mineralogical based classification and nomenclature scheme for phaneritic and aphanitic igneous rocks. Classification of gabbros, plagioclase-rich rocks and ultramafic rocks. Classification of volcanics and pyroclastic rock nomenclature. Graphical representation of metamorphic mineral assemblages, ACF, AKF, AFM, CaO-Mg-SiO_2, MgO-$Al2O_3$-SiO_2.	
Unit- III Magmatic differentiation	**30** **10 Lectures**
Closed-system fractional crystallization processes, and the open-systems that involve simultaneous crystallization and assimilation. Melt composition, mantle material, differentiation and field relations of intrusions. Partial melting (batch and fractional melting); Crystal fractionation (equilibrium and fractional (Rayleigh) crystallization); Contamination (AFC process) and dynamic melting of magma. Metamorphic facies and facies series, combinatorial formula and Schreinemakers rules, Mineral formula calculation, geothermobarometry.	
Unit – IV Phase diagram and crystallization processes	

Binary and ternary phase diagrams to identify the crystallization of magma systems. Phase relations in binary systems, feldspar-melt equilibria, anhydrous olivine and pyroxene crystal melt equilibria, (a) Albite-Anorthite (b) Diopside-Anorthite (c) Forsterite-Fayalite (d) ForsteriteSilica (e) Diopside-Albite-Anorthite (f) Diopside-Forsterite-silica. Crystallization of granitic magma in relation to Quartz Orthoclase-Aalbite-Anorthite-H2O system.	**20** **10 Lectures**
Unit – V Lab Experiment	
• Studies of megascopic hand specimen identification of Igneous and Metamorphic rock samples. • To study microscopic thin section analysis of rocks. • Plotting and interpretation of binary, ternary diagrams. Ternary chemical composition diagrams including ACF, AKF and AFM and data interpretations.	**15** **30 Hours Lab Sessions**

Text / Reference Books

1. A.A. Balkema, Rotterdam. Wilson, M., 1993. Igneous Petrogenesis. Chapman & Hall, London.
2. Best, Myron G., 2002. Igneous and Metamorphic Petrology, Blackwell Science.
3. Blatt, H. and Tracy, R.J. 1996. Petrology (Igneous, Sedimentary, Metamorphic), W.H. Freeman & Co., New York.
4. Bose, M.K., 1997. Igneous Petrology, World Press, Kolkata.
5. Cox, K.G., Bell, J.D. and Pankhurst, R.J., 1993.The Interpretation of Igneous Rocks. Champman& Hall, London.
6. Le Maitre, R.W., 2002.Igneous Rocks: A Classification and Glossary of Terms, Cambridge University Press
7. Mc Birney, 1994. Igneous Petrology, CBS Publishers, Delhi
8. Phillpotts, A.R., 1994. Principles of Igneous and Metamorphic Petrology, Prentice Hall of India.
9. Philpotts, A.R. 1994. Principles of Igneous and Metamorphic Petrology, Prentice Hall.
10. Powell, R. 1978. Equilibrium thermodynamics in Petrology: An Introduction, Harper & Row Publishers, London.
11. Rastogy, R.P. and Mishra, R.R. 1993. An Introduction to Chemical Thermodynamics, Vikash Publishing House.

Content Interaction Plan

Contact Hours	Topic
1- 2	Mantle depletion and enrichment. Composition of the upper and lower continental crust. Mineralogy of the upper mantle.
3 –5	Discussion of nature of the evidence. The oceanic crust, ophiolites and basalt-seawater interactions.
6 – 7	Earth's internal structure based on compositional and physical properties. Variation in mineralogy as a function of pressure/depth.

8 – 10	Peridotites and pyroxenites, heat flow, minerals as pure and impure phases. Textures of contact and regional metamorphism. Tectonic context of metamorphic transformations.
11 – 20	Classification of quartz-bearing plutonic rocks in the IUGS scheme. Classification of gabbros, plagioclase-rich rocks and ultramafic rocks.
21 - 23	Brief introduction to feldspathoid-bearing plutonic rocks. The IUGS mineralogical based classification and nomenclature scheme for phaneritic and aphanitic igneous rocks.
24 – 26	Classification of volcanics and pyroclastic rock nomenclature.Graphical representation of metamorphic mineral assemblages, ACF, AKF, AFM, CaO-Mg-SiO_2, MgO-$Al2O_3$-SiO_2.
27 – 28	Closed-system fractional crystallization processes, and the open-systems that involve simultaneous crystallization and assimilation.
29 – 32	Melt composition, mantle material, differentiation and field relations of intrusions. Partial melting (batch and fractional melting);
33–36	Crystal fractionation (equilibrium and fractional (Rayleigh) crystallization); Contamination (AFC process) and dynamic melting of magma.
37 –38	Metamorphic facies and facies series, combinatorial formula and Schreinemakers rules, Mineral formula calculation, geothermobarometry.
39–40	Binary and ternary phase diagrams to identify the crystallization of magma systems.
41–45	Phase relations in binary systems, feldspar-melt equilibria, anhydrous olivine and pyroxene crystal melt equilibria, (a) Albite-Anorthite (b) Diopside-Anorthite (c) Forsterite-Fayalite (d) ForsteriteSilica (e) Diopside-Albite-Anorthite (f) Diopside-Forsterite-silica. Crystallization of granitic magma in relation to Quartz Orthoclase-Aalbite-Anorthite-H2O system.
	List of Practical
P=30 Hours	• Studies of megascopic hand specimen identification of Igneous and Metamorphic rock samples. • To study microscopic thin section analysis of rocks. • Plotting and interpretation of binary, ternary diagrams. Ternary chemical composition diagrams including ACF, AKF and AFM and data interpretations.

Course Details			
Course Title: Geo-informatics			
Course Code	GEL81OE03904	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	First/Odd	**Contact Hours**	45 (L) + 15 (T) Hours
Course Type	Open Elective Interdisciplinary Course		
Nature of the Course	Theory		
Special Nature/ Category of the Course (*if applicable***)**	Skill Based Course		
Methods of Content Interaction	(*Lecture and Tutorials, Presentation by students)*		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives:

- ❖ Remote Sensing Technology has emerged as an important space borne tool for scientifically monitoring and mapping of earth resources at varying scale on spatial and temporal aspect.
- ❖ The main objective of this course is to acquaint the students to the principles of remote sensing and GIS techniques and their application in earth and environmental sciences.
- ❖ To learn the basics of satellite data interpretation and their application.

Course Learning Outcomes:

After successfully completion of course, the students would be able to

- ❖ To understand the basic physics, involve in Remote Sensing technology.
- ❖ To understand the interaction of EMR with earth surface material.
- ❖ To understand the information extraction form satellite data to map the important earth resources
- ❖ Development of decision making and utility of remote sensing and GIS techniques in sustainable earth resource evaluation and management

Course Contents	Weightage (%)
Unit - I Introduction and Physics of Remote Sensing	**30** **15 Lectures**
History and Development of Remote Sensing, Fundamental Principles of Remote Sensing, Electromagnetic radiation – characteristics, remote sensing regions and bands; General orbital and sensor characteristics of remote sensing satellites; Spectra of common natural objects – soil, rock, water and vegetation. Elements of satellite image interpretation.	
Unit- II Platforms and Sensors	**25** **11 Lectures**
Platforms- Satellite Orbits: Geostationary, Sun synchronous Satellites- Resolution: Spatial Resolution, Spectral Resolution, Radiometric Resolution, Temporal Resolution, Multispectral Resolution. Satellites & Sensors Landsat Series, SPOT Series, Indian Remote Sensing Satellites, Quick bird Satellite, World View, Geo Eye, ASTER.	
Unit- III Digital Image Processing	**25** **11 Lectures**
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 earth Sciences. Case studies.	
Unit – IV Geographical Information System & GPS	**20** **08 Lectures**
Introduction and application of GIS, components of geographical information system (GIS), database structures in raster and vector and its comparison. Spatial data analysis: introduction to spatial data analysis and various types of spatial data analysis operations in GIS. Introduction to GNSS; Introduction to GPS; GPS receivers; GPS positioning mode- point positioning & relative positioning (DGPS & RTK GPS); GPS accuracy and error sources, Integrating GPS data with GIS; Applications in earth system sciences.	

Text / Reference Books:

1. Lillisand, T. M. and Keifer, R. W. (2007) Remote sensing and image interpretation by John Willey and Sons, USA
2. Barrett, E. C. and Curtis L. F. (1999) Introduction to environmental remote sensing by Chapman and Hall Publishers, USA.
3. Joseph G. (2003) Fundamentals of remote sensing by Universities Press, Hyderabad.
4. Chang, Kang-taung (2002) Introduction to geographic information systems by Tata McGraw-Hill, USA.
5. Gupta, R.P. (1990) Remote Sensing Geology, by Springer Verlag.

Content Interaction Plan

Contact Hours	Topic
1-10	• History and Development of Remote Sensing, • Fundamental Principles of Remote Sensing, Electromagnetic radiation – characteristics, remote sensing regions and bands; • General orbital and sensor characteristics of remote sensing satellites; Spectra of common natural objects – soil, rock, water and vegetation. Elements of satellite image interpretation.
11-21	• Platforms- Satellite Orbits: Geostationary, Sun synchronous Satellites- Resolution: • Spatial Resolution, Spectral Resolution, Radiometric Resolution, Temporal Resolution, Multispectral Resolution. • Satellites & Sensors Landsat Series, SPOT Series, Indian Remote Sensing Satellites, Quick bird Satellite, World View, Geo Eye, ASTER.
22-33	• 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 earth Sciences. Case studies.
34-45	• Introduction and application of GIS, components of geographical information system (GIS), database structures in raster and vector and its comparison. • Spatial data analysis: introduction to spatial data analysis and various types of spatial data analysis operations in GIS. • Introduction to GNSS; Introduction to GPS; GPS receivers; GPS positioning mode- point positioning & relative positioning (DGPS & RTK GPS); GPS accuracy and error sources, • Integrating GPS data with GIS; Applications in earth system sciences.
T=15 Hours	Tutorials

Course Details			
Course Title: Oceanography			
Course Code	GEL81OE00604	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	First/Odd	**Contact Hours**	45 (L) + 15 (T) Hours
Course Type	Open Elective Interdisciplinary Course		
Nature of the Course	Theory		
Special Nature/ Category of the Course	Indian and World Knowledge		
Methods of Content Interaction	((*Lecture, Tutorials, presentations by students.)*		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives:

The Course aims to make:

- To the students well-versed with the basic concepts of Oceanography and applications in the field of Marine Geology.
- To understanding the physical, geological, chemical, biological features and processes of the oceans.
- To learn how ocean waters are studied to develop an appreciation for the diversity and importance of life in the oceans and to understand how oceanic processes, affect the global environment.

Course Learning Outcomes:

The students will develop capability to:

- describe the scientific method and apply it an oceanographic context
- describe Earth's hydrologic and atmospheric system and explain how they interact
- explain the theory of plate tectonics and how it explains the origin, distribution, and geological and physical features of the ocean basins
- demonstrate knowledge of the properties of seawater and apply methods for studying it
- demonstrate knowledge of the size, composition, origin, and distribution of common types of marine sediment
- explain the causes, locations, and behaviours of ocean waves, currents, and tides and their influence on coastal zones
- demonstrate knowledge of common marine organisms, their habitat, interaction and factors influencing productivity

Course Contents	Weightage (%)
Unit - I Introduction & Concept	**25** **12 lectures**
Introduction to Oceanography; Scope of Oceanography; Water and Ocean Structure. Geological Aspects of Oceans: Scientific Ocean Drilling - Major accomplishments; Biogenic Flux; Sampling of modern ocean biogenic flux; Sediment trap sampling. Plate Tectonics; Origin of oceans. Oceanic Topography; Distributional patterns of land and oceans; Depth zones and Hypsometric Curve; Submarine canyons; Bottom relief of oceans and the ocean floor.	
Unit- II Chemical and Physical Oceanography	**25** **11 Lectures**
Chemical Oceanography: Chemical composition of ocean waters; Gases Dissolved in Seawater; Factors affecting the concentration of gases in sea water; Oxygen minimum layer in the ocean. Physical Oceanography: Temperature of Sea Waters; Thermocline; Temperature and salinity distribution (horizontal and vertical) in ocean waters. Sea-Water Density; Concept of mixed layer; Pycnocline and water masses. Dynamics of Ocean Waters: Sea Waves; Tides – Origin, Types, Prediction. Oceanic Currents; Causes and Controlling factors; General Patterns of Circulation. Coriolis force and Ekman spiral; Upwelling, El Nino and La Nina.	
Unit- III Biological Oceanography	**25** **11 Lectures**
Biological oceanography: Oceans as Ecosystems; Marine Biota; Zonation of the sea. Energy flow: Food Chains and Food Webs; Mangroves and Estuarine Ecology. Coral Reefs: Formation, distribution, importance and bleaching; Marine Pollution. Climate change and Marine Ecosystem. Applications of benthic foraminiferal assemblages in identification of depth biotopes and estimation of paleodepth and in low oxygen environment of theocean. Application of planktic foraminiferal assemblages in identification of modern and ancient surface water mass and warm and mixed layer, thermocline and deep surface water of the modern oceans.	
Unit - IV Oceanic Resources and Distribution	**25** **11 Lectures**
Ocean Deposits, Nature, Distribution and Origin of Ocean Deposits. Oceanic Resources: Classification of oceanic resources; Mineral resources; Energy resources; Food resources; Depletion of marine resources; Management, and conservation of marine resources; Indian marine and submarine explorations. Deep ocean circulation, concept of thermohaline circulation, formation of bottom waters, water masses of the world oceans.	

Text / Reference Books:

1. David, Tolmazin (1985): Elements of Dynamic Oceanography, Allen and Unwin
2. **Garrison, Tom (2015)** *Oceanography: An Invitation to Marine Science, 9th Edition.* **Thomson Learning, Cengage Learning (ISBN** 9781305105164).
3. Grant, Gross M. (1977): Oceanography; A view of the Earth by. Prentice Hall.
4. Haq, B. U. &Boersma, A. (Eds.), (1978): Introduction to Marine Micropaleontology, Elsevier, New York, 250 p.

5. Saraswati Pratul Kumar, Srinivasan M. S. (2016): Micropaleontology – Principles and Applications, Springer.
6. Billeter, Paul and Given, Robert (2010): *The Endless Voyage: Study Guide, Intellecom*, 3rd Ed: Brooks/ Cole, Cengage Learning. (ISBN: 978-0-495-19070-7 or 0-495-19070-5). 4th ed: 9781506616131.
7. Kathal P. K., Rajiv Nigam, Abu Talib (2017): Micropaleontology and Its Applications Scientific Publishers (India).
8. Kennet, J. P. and Srinivasan, M. S. (1983): Neogene-Planktonic Foraminifera. Hutchison Ross Publ. Co., U. S. A.
9. Kennett and Srinivasan (1983): Neogene Planktonic Foraminifera: A phylogenetic Atlas, by, Hutchinson Ross, USA.
10. Murray, John, (2006): Ecology & Application of Benthic Foraminifera, Cambridge University Press.

Content Interaction Plan

Contact Hours	Topic
1 - 2	Introduction to Oceanography and scope of Oceanography, Water andOcean Structure.
3	Scientific Ocean Drilling - Major accomplishments
4 - 5	Biogenic Flux; Sampling of modern ocean biogenic flux; Sediment trap sampling
6 - 7	Plate Tectonics; Origin of oceans. Oceanic Topography; Distributional patterns of land and oceans
8 - 9	Depth zones and Hypsometric Curve; Submarine canyons
10 - 12	Bottom relief of oceans and the ocean floor.
13	Chemical composition of ocean waters
14 - 15	Gases Dissolved in Seawater; Factors affecting the concentration of gases in sea water; Oxygen minimum layer in the ocean.
16 - 17	Temperature and Salinityof Sea Waters; Thermocline; Temperature and Salinity distribution (horizontal and vertical) in ocean waters.
18	Sea-Water Density; Concept of mixed layer; Pycnocline and water masses.
19	Sea Waves; Tides: origin, types and prediction
20 - 21	Oceanic Currents; Causes and Controlling factors; General Patterns of Circulation.
22 - 23	Coriolis force and Ekman spiral; Upwelling, El Nino and La Nina.
24	Biological oceanography: Oceans as Ecosystems; Marine Biota; Zonation of the sea
25 - 26	Energy flow: Food Chains and Food Webs; Mangroves and Estuarine Ecology
27 - 28	Coral Reefs: Formation, distribution, importance and bleaching; Marine Pollution
29	Climate change and Marine Ecosystem
30 - 31	Applications of benthic foraminiferal assemblages in identification of depth biotopes and estimation of paleodepth and in low oxygen environment of theocean
32 - 33	Application of planktic foraminiferal assemblages in identification of modern and ancient surface water mass and warm and mixed layer, thermocline and deep surface water of the modern oceans
34 - 35	Ocean Deposits, Nature, Distribution and Origin of Ocean Deposits

36 - 37	Oceanic Resources: Classification of oceanic resources
38 - 39	Mineral resources; Energy resources; Food resources
40	Depletion of marine resources
41 - 42	Management, and conservation of marine resources
43	Indian marine and submarine explorations
44 - 45	Deep ocean circulation, concept of thermohaline circulation, formation of bottom waters, water masses of the world oceans
T=15 Hours	Tutorials

Course Details			
Course Title: Gemology			
Course Code	GEL81ME00800	**Credits**	0
L + T + P	1 + 1+ 0	**Course Duration**	One Semester
Semester	First/Odd	**Contact Hours**	15 (L) + 15 (T) Hours
Course Type	Mandatory Elective Non-Credit Course		
Nature of the Course	Theory		
Special Nature/ Category of the Course	Value Added, Indian Knowledge System/ Skill Based		
Methods of Content Interaction	(*Lecture, Tutorials, Group discussion, presentations by students)*		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives:

- To familiarize the students about characteristics of various type of gems and its distribution and characteristics.
- The course contents are expected to enable students of keen interest to learn more and encourage acquiring basic knowledge in the field

Course Learning Outcomes:

After successfully completion of course, the students would be able to:

- This course has been formulated in such a manner that students from all the streams get the basic idea about gemstones, their formation, identification and valuation etc.
- To understand the minerals, rocks and gemstones and their uses in Medical Sciences.

Course Contents	**Weightage (%)**
Unit -I Concept and Importance of Gemology	**20** **03 Lectures**
Introduction to Gemology – Relation to Mineralogy and Crystallography - Lithological association of Gemstones in India–What is a Gem: Precious and Semi-Precious Stones–Gem- bearing stratigraphic Units in India – Gemstone	

Resources of India.	
Unit- II Properties of Gems	**40** **06 Lectures**
Criteria for recognition of gemstones – Virtues of gemstones; Colours, Optical Properties, Hardness, Fractures, Inclusions, Zoning, Brittleness, Pleochroism, Clarity, Amenability for cutting and polishing, Processing of gemstones – Styles of Cutting; Cabochon cut, Rose cut, Brilliant cut, zircon cut, step, trap or emerald cut and mixed cuts.	
Unit- III Uses and types of Gems	**40** **06 Lectures**
Uses of gemstones in jewellery, medicine, health and customs –Important Gem Species: Diamond, Corundum, Ruby, Beryl, Chrysoberyl, Cat's Eye, Alexandrite, Topaz, Spinel, Garnets, Tourmaline, Peridot, Zircon, Varieties of Quartz Group – Sphene, Feldspar, Lapis Lazuli - Synthetic Gems.	

Text / Reference Books:

1. Karanth, R.V. (2000): Gem and gem industry in India, Memoir 45, Geological Society of India, Banglore.
2. Anderson, B.W (1990): Gem testing (10th edition), Butterworth Scientific, London.
3. Babu, T.M., (1998): Diamonds in India, Geological society of India, Bangalore
4. Hall, C. (1994): Gemstone, Dorling Kindesley, London.
5. Deer, W.A., Houre, R. A. and zussman, S. (1992). An Introduction to rock-forming minerals, ELBS, London.
6. Kerr, P.F. (1997): Optical mineralogy, 4th Ed. McGraw Hill Book &Co,New York,
7. Peter Read (1991): Gemology 2nd Ed., Butter worth –HeinemanuLtd.Lundu.
8. Peter Read: Gems 5th Ed. Butterworth, London
9. Richard Laddicoat (1987), Handbook of gem identification - G.I.A.
10. Santa Monica., Edward Gubelin (1986): Photo Atlas of Including GemStones – ABCEdition, Zurich, Gem Testing10th Ed.
11. Anderson, B.W. (1990): Gemstone Enhancement 2ndEdition, Butterworth
12. Scientific London.
13. Nassau, K. (1994): Gemstone Enhancement; Butterworths, London.
14. Webster, Robert, 1980: Gems, 5th Ed, Butterworths, London.
15. Hall, C., Gemstones.
16. Dorling Kindersley, (1994): Read, P. Gemology. Butterworth Heinemann,O' Donoghue, M. (1999): Identification of Gemstones.

Content Interaction Plan

Contact Hours	Topic
1	Introduction to Gemology – Relation to Mineralogy and Crystallography
2	Lithological association of Gemstones in India
3	What is a Gem: Precious and Semi-Precious Stones; Gem- bearing stratigraphic Units in India – Gemstone Resources of India
4	Criteria for recognition of gemstones – Virtues of gemstones
5 - 6	Colours, Optical Properties, Hardness, Fractures, Inclusions, Zoning, Brittleness, Pleochroism, Clarity, Amenability for cutting and polishing
7	Processing of gemstones – Styles of Cutting
8 - 9	Cabochon cut, Rose cut, Brilliant cut, zircon cut, step, trap or emerald cut and mixed cuts
10	Uses of gemstones in jewellery, medicine, health and customs
11	Important Gem Species:Diamond, Corundum, Ruby, Beryl, Chrysoberyl
12 - 13	Cat's Eye, Alexandrite, Topaz, Spinel, Garnets, Tourmaline, Peridot, Zircon
14 - 15	Varieties of Quartz Group – Sphene, Feldspar, Lapis Lazuli - Synthetic Gems
T=15 Hours	Tutorials

SEMESTER II (Total Credits = 20)			
Nature of Course	**Course Code**	**Name of Course**	**Credit (L+T+P)**
Discipline Based Core Course	GEL82DC04004	Marine Geology and Micropaleontology	3+0+1
Discipline Based Core Course	GEL82DC04104	Stratigraphy and Paleontology	3+0+1
Discipline Based Core Course (Skill Based)	GEL82DC01004	Research Methodology	3+1+0
Discipline Based Core Course (Vocational)	GEL82DC04204	Advance Remote Sensing and Its applications in Geology	2+1+1
Credits = 16			
Discipline Based Course Elective		Elective Basket III	4
Mandatory Elective Non-Credit Course		Elective Basket IV	0
Total Credits = 20			

Elective Basket III (Discipline Based Course Elective) (Any one)			
Nature of Course	**Course Code**	**Name of Course**	**Credit (L+T+P)**
Discipline Based Course Elective	GEL82DE04304	Geohazards and Disaster Risk Reduction	3+1+0
Discipline Based Course Elective	GEL82DE04404	Geophysics and Mineral Exploration	3+1+0
Discipline Based Course Elective	GEL82DE04504	Environmental and Engineering Geology	3+1+0
Credits = 04			

Elective Basket IV (Mandatory Elective Non-Credit Course)			
Nature of Course	**Course Code**	**Name of Course**	**Credit (L+T+P)**
Mandatory Elective Non-Credit Course	GEL82ME01700	Sustainable Development Goals (SDGs) and role of Geology	0

Course Details			
Course Title: Marine Geology and Micropaleontology			
Course Code	GEL82DC04004	**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	Second/Even	**Contact Hours**	45 (L) + 30 (P) Hours
Course Type	Discipline Based Core Course		
Nature of the Course	Theory cum practical		
Special Nature/ Category of the Course	Indian and World Knowledge		
Methods of Content Interaction	((*Lecture, Tutorials, presentations by students.)*		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives:

The course is aimed:

- ❖ To provide a comprehensive understanding of the marine environment, including its physical, chemical, biological, and geological aspects.
- ❖ To explore the interconnectedness between oceanographic processes, climate dynamics, and geological phenomena.
- ❖ To introduce students to microfossils studies and its applications in paleoenvironmental reconstruction, petroleum exploration, and geological studies.
- ❖ To familiarize students with field and laboratory used in marine science and micropaleontological research.
- ❖ To develop critical thinking and analytical skills in assessing the impact of human activities, climate change, and geological processes on marine ecosystems and geological formations.

Course Learning Outcomes:

By the end of this unit, students will be able to:

- ❖ Describe and explain key features and processes of the marine environment, including ocean basins, circulation patterns, chemistry, and marine biology.
- ❖ Analyze the interactions between oceanic processes, climate dynamics, and their impact on marine ecosystems and geological formations.
- ❖ Apply field and laboratory techniques in marine science and micropaleontological research, including sampling, treatment, and analysis of samples.
- ❖ Utilize micropaleontological methods in dating, biostratigraphy, and paleoenvironmental reconstruction, as well as in petroleum exploration and reservoir characterization.

- ❖ Evaluate the significance of microfossils as indicators of past environmental conditions, climate change, and geological events.
- ❖ Critically assess the human impact on marine ecosystems and geological formations, as well as future challenges and opportunities in oceanography and micropaleontology.

Course Contents	Weightage (%)
Unit - I Introduction to Marine Environment	**20** **11 lectures**
Understanding Ocean Basins: Introduction to Marine Environment; Ocean Basins and Features; Seafloor Topography; Continental Shelf, Slope, and Rise. Ocean Circulation and Currents: Ocean Circulation Patterns; Wind-driven Circulation; Thermohaline Circulation; Major Ocean Currents; Effects of Ocean Currents on Climate. Ocean Chemistry: Properties of Seawater; Salinity and Temperature; Dissolved Gases in the Ocean; Nutrients and Trace Elements; Ocean Acidification. Marine Biology: Marine Ecosystems; Plankton, Nekton, and Benthos; Marine Food Webs; Adaptations to Marine Environments; Human Impact on Marine Life.	
Unit- II Applied Oceanography and Introduction to Micropaleontology	**20** **11 Lectures**
Marine Geology: Plate Tectonics and Seafloor Spreading; Geological Processes in the Ocean; Sediment Types and Deposition; Marine Sedimentary Environments. Elementary idea on mineral resources of the ocean. Ocean and Climate Change: Ocean-Atmosphere Interactions; Ocean Warming and Sea Level Rise; Impact of Climate Change on Marine Ecosystems; Future Challenges and Opportunities in Oceanography. Introduction to Micropaleontology: Overview of micropaleontology and its subdisciplines; Scope and significance of micropaleontology. Environmental and Biotic Distribution: Types of environments and biotic distribution of microfossils; Microfossils as indicators of environmental conditions and paleoecology.	
Unit- III Techniques in Micropaleontology and Mineral Walled Microfossils	**20** **12 Lectures**
Field and Laboratory Techniques: Methods of sampling, treatment, and separation of microfossils from fossiliferous rocks; Application of scanning electron microscopy and mass spectrometry in micropaleontological studies. Dating and Biostratigraphy: Use of microfossils in dating, biozonation, and biostratigraphic correlation; Types of biozones and their significance. Micropaleontology in Petroleum Exploration: Role of micropaleontology in petroleum exploration; Applications of microfossils in reservoir characterization and stratigraphic analysis. Foraminifera: Living animal, habit, and life cycle; Morphology, wall composition, and classification; Taxonomic importance and applications.	
Unit - IV Mineral Walled Microfossils and Organic Walled Microfossils	**15**
Ostracoda: Living animal, life habit, and morphology; Classification, ecology, and stratigraphic distribution; Use of Ostracoda in petroleum exploration.	

Nannofossils: Introduction and significance; Sampling and separation methods; Calcareous Nannoplanktons: Living organism, habitat, and classification. Conodonts: Elementary idea, classification, and applications. Radiolaria, Diatom, and Silicoflagellate: Morphology, classification, and significance. Pteropoda; Calpionellids and Calcareous algae: Morphology, classification, and scope. Spores, Pollen, Dinoflagellates, and Acritarches: Morphology, classification, and applications.	**11 Lectures**

Unit – V Lab Experiments	
• Techniques of separation of microfossils from matrix; Preparation of micro-faunal slides of microfossils; • Study of important planktic foraminifera useful in surface water, paleoceanography and oceanic biostratigraphy; • Study of larger benthic foraminifera useful in Indian stratigraphy with special reference to Cenozoic petroliferous basins of India; • Ostracoda: Morphology, geological range, ecology and paleoecology of important groups of Ostracoda. • Nano-planktons: Study of SEM images; Identification of representatives of different groups of nannofossils in SEM photomicrographs. • Preparation of range charts of Foraminifera, Ostracoda and Nannofossils. • Ecological interpretation based on foraminiferal assemblages with special emphasis on conditions for oil formation.	**25** **30 Hours Lab Sessions**

Text/Reference Books

1. Aldrige, R. J. (1985). Paleobiology of Conodonts, (Ed.), British Micropaleontological Society
2. Alfred Traverse (1988). Paleopalynology, Unwin Hyman, USA.
3. Arnold (2002). Quaternary Environmental Micropaleontology (Ed. Simon K. Haslett), Oxford University Press, New York.
4. Billeter, Paul and Given, Robert (2010): *The Endless Voyage: Study Guide, Intellecom*, 3rd Ed: Brooks/ Cole, Cengage Learning.
5. Brander, Keith (2019): Climate Change and the Ocean, Cambridge University Press.
6. Clarkson, E. N. K. (1979 & 2002). Invertebrate Paleontology & Evolution, London Gorge Allen & Unwin.
7. Crasquin-Soleau, S. et. al. (Ed.) (2014): Ostracoda in the Earth Sciences, Cambridge University Press.
8. David, Tolmazin (1985): Elements of Dynamic Oceanography, Allen and Unwin
9. Garrison, Tom S. (2016): Oceanography: An Invitation to Marine Science, Cengage Learning.
10. Grant, Gross M. (1977): Oceanography; A view of the Earth by. Prentice Hall.
11. Haq, B. U. &Boersma, A. (Eds.), (1978): Introduction to Marine Micropaleontology, Elsevier, New York, 250 p.
12. Howard A. A. and Martin D. B. (2005). Microfossils (IInd Ed.) Blackwell Publishing Ltd.
13. Jones R.W. (1996). Micropaleontology in Petroleum exploration by Clarendon Press Oxford

14. Jones, Robert Wynn (2014): Foraminifera and their Application, Cambridge University Press.
15. Kathal P. K. (2012). Applied Geological Micropaleontology, Scientific Publishers (India)
16. Kathal P. K., Rajiv Nigam, Abu Talib (2017). Micropaleontology and Its Applications Scientific Publishers (India).
17. Knauss, John A. (1996): Introduction to Physical Oceanography, Waveland Press.
18. Levinton, Jeffrey S. (2007): Marine Biology: Function, Biodiversity, Ecology, Oxford University Press.
19. Loelich, A. R. (Jr.) & Tappan, J. (1988). Foraminifera Genera & Their Classification (v. 1 & 2), Van NostrandRenhold.
20. Murray, John, (2006). Ecology & Application of Benthic Foraminifera, Cambridge University Press.
21. Saraswati P. K. and Srinivasan M. S. (2016): Micropaleontology – Principles and Applications, Springer.
22. Sen Gupta, B. K. (1998). Modern Foraminifera, Kluwer Academic Publishers.
23. Simon K. Haslett (Ed.) (2002). Quaternary Environmental Micropaleontology Arnold; Oxford University Press, New York Year.
24. Sinha D. K. (2007). Micropaleontology: Applications in Stratigraphy and Paleoceanography. Narosa Publishing House, New Delhi
25. Summerhayes, Colin P. and Thorpe, Steve A. (1996): Marine Geology, Wiley-Blackwell.

Content Interaction Plan

Contact Hours	Topic
1 - 2	Introduction to Marine Environment; Ocean Basins and Features.
3	Seafloor Topography; Continental Shelf, Slope, and Rise.
4	Ocean Circulation Patterns; Wind-driven Circulation; Thermohaline Circulation.
5 - 6	Major Ocean Currents; Effects of Ocean Currents on Climate.
7 - 8	Properties of Seawater; Salinity and Temperature.
9 - 10	Dissolved Gases in the Ocean; Nutrients and Trace Elements; Ocean Acidification.
11	Marine Ecosystems; Plankton, Nekton, and Benthos; Marine Food Webs.
12	Plate Tectonics and Seafloor Spreading; Geological Processes in the Ocean.
13 - 14	Sediment Types and Deposition; Marine Sedimentary Environments; Elementary idea on mineral resources of the ocean.
15	Ocean-Atmosphere Interactions; Ocean Warming and Sea Level Rise.
16 - 17	Impact of Climate Change on Marine Ecosystems; Future Challenges and Opportunities in Oceanography.
18 - 19	Overview of micropaleontology and its subdisciplines; Scope and significance of micropaleontology.
21 - 22	Types of environments and biotic distribution of microfossils; Microfossils as indicators of environmental conditions and paleoecology.
23 - 24	Methods of sampling, treatment, and separation of microfossils from

	fossiliferous rocks
25 - 26	Application of scanning electron microscopy and mass spectrometry in micropaleontological studies.
27 - 28	Use of microfossils in dating, biozonation, and biostratigraphic correlation; Types of biozones and their significance.
29 - 30	Role of micropaleontology in petroleum exploration; Applications of microfossils in reservoir characterization and stratigraphic analysis.
31 - 34	Foraminifera: Living animal, habit, and life cycle; Morphology, wall composition, and classification; Taxonomic importance and applications.
35 - 36	Ostracoda: Living animal, life habit, and morphology; Classification, ecology, and stratigraphic distribution; Use of Ostracoda in petroleum exploration.
37 - 38	Nannofossils: Introduction and significance; Sampling and separation methods; Calcareous Nannoplanktons: Living organism, habitat, and classification.
39	Conodonts: Elementary idea, classification, and applications.
40 - 41	Radiolaria, Diatom, and Silicoflagellate: Morphology, classification, and significance.
42 - 43	Pteropoda; Calpionellids and Calcareous algae: Morphology, classification, and scope.
44 - 45	Spores, Pollen, Dinoflagellates, and Acritarches: Morphology, classification, and applications.

	List of Practicals
P=30 Hours	• Techniques of separation of microfossils from matrix; Preparation of micro-faunal slides of microfossils; • Study of important planktic foraminifera useful in surface water, paleoceanography and oceanic biostratigraphy; • Study of larger benthic foraminifera useful in Indian stratigraphy with special reference to Cenozoic petroliferous basins of India; • Ostracoda: Morphology, geological range, ecology and paleoecology of important groups of Ostracoda. • Nano-planktons: Study of SEM images; Identification of representatives of different groups of nannofossils in SEM photomicrographs. • Preparation of range charts of Foraminifera, Ostracoda and Nannofossils. • Ecological interpretation based on foraminiferal assemblages with special emphasis on conditions for oil formation.

Course Details			
Course Title: Stratigraphy and Paleontology			
Course Code	GEL82DC04104	**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	Second/Even	**Contact Hours**	45 (L) + 30 (P) Hours
Course Type	Discipline Based Core Course		
Nature of the Course	Theory cum Practical		
Special Nature/ Category of the Course	Core Course		
Methods of Content Interaction	(*Lecture, Tutorials, presentations by students.)*		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives

- The Course aims to make to the students well-versed with the strength of paleontological applications in the field of Geology.

Course Learning Outcomes

On successful completion of this course students should be able to:

- Demonstrate proficiency in common practical skills in palaeontology and an ability to evaluate, interpret and communicate scientific results obtained from fossil deposits.
- Comprehend fossil formation processes in different environments, and recognize the importance of studying taphonomic histories and stratigraphic contexts to ensure reliable interpretations of fossil records.
- Evaluate changes in diversity and paleoecology through time, and assess how key extinction and evolutionary events have been driven by major geological and paleoenvironmental change.
- Combine information from fossils and associated sedimentary archives to undertake multi-proxy interpretations of past environments, and explore the resource.
- Demonstrate an understanding of key geochronology techniques and modern analytical approaches used to contextualize and interpret fossil records.
- Critically debate and evaluate current topics or controversies in paleontology via group presentations and written reports.

Course Contents	Weightage (%)
Unit – I Origin of life and introduction to fossils	**20**
Scope of paleontology; Origin and evolution of life through age; species concept; trans-specific evolution, speciation, and radiation. Techniques in paleontology; binomial nomenclature, modern systematics. Elementary idea of Ichnofossils, classification and its applications. Brief on morphology and systematic and evolution of major invertebrates. Classification of fossil plants and broad characters of major plant groups. Plant fossils: Gondwana flora and their significance.	
Unit- II: A brief on vertebrate paleontology and application of fossils	**20**
Vertebrate paleontology: Origin of vertebrates. General characters and an outline classification, evolution of Fishes, Amphibians, Reptiles and Mammals. General characters, classification and evolution of Horse, Elephant and Man. Vertebrate fossil records of Siwaliks. A general account of Mesozoic vertebrates of India. Dinosaurs and their extinction. Use of paleontological data in stratigraphy, biostratigraphy, paleoecology, evolution, and sea level changes; Principle of paleobiogeography and paleoclimate. Principles of isotopic (oxygen, carbon, calcium, magnesium, strontium) studies of fossils and their application in paleoclimate, palaeo-oceanography and paleoenvironment.	
Unit- III Principle of stratigraphy and Archaean-Proterozoic stratigraphy of India	**20**
Stratigraphy, its relation with other branches of geology. Geological Time Scale. Introduction to Stratigraphic Code and Nomenclature. Economic importance of Pre-Cambrian successions of India.Archaean Stratigraphy of the Dharwar Craton, Baster Craton, Singbhum Craton, Bundelkhand Craton, Aravalli Craton. Stratigraphy of the Mobile Belts of India. Archaean-Proterozoic boundary.Stratigraphy of the Proterozoic Sedimentary basins/Purana formations in India and its economic significance.	
Unit – IV A brief on Paleozoic-Mesozoic and Cenozoic stratigraphy of India	**20**
Precambrian-Cambrian boundary. Stratigraphy of the marine Palaeozoic and Mesozoic rock formations of India; Concept of Gondwanaland; Permian/Triassic boundary, Classification, lithology, age, depositional characteristics, fauna and flora of Triassic, Jurassic and Cretaceous systems in principal basins of India.Marine Mesozoic Formations of India. Cretaceous/Tertiary boundary, Stratigraphy of Rajmahal Volcanics and Deccan Traps and Intertrappeans; Classification, depositional characteristics, fauna and flora of the Palaeogene and Neogene systems in their type localities and their equivalents in India; Epoch boundaries of the Cenozoic in India.	
Unit – V Lab Experiments	

• Brief morphology of different plant parts. Taxonomy, systematic position and distribution of common representative Indian plant genera. • Study of the morphological characters of some important Invertebrate Fossils belonging to Brachiopoda, Bivalvia, Gastropoda, Ammonoidea, Trilobita, Echinoidea and corals. • Morphological and systematic study of major vertebrates of India. • Study of the important fossils belonging to various formations of Indian Stratigraphy. • Study of rocks in hand specimens from known Indian stratigraphic horizons and type localities. • Tectonic framework of India: Exercises on geographical distribution of various successions belonging to Indian Stratigraphy. • Exercises on stratigraphic correlation and classification. • Study and understanding of plate-movements through important periods during Phanerozoic Eon. • Evolution of ocean systems during Phanerozoic.	**20**

Text & References

1. Andrews Jr., H.N. Studies in Palaeobotony. Wiley, New Yorks.
2. Arnold, C.A. (1947) An introduction to Palaeobotany, McGraw Hill
3. Babin Claude, 1980: Elements of Palaeontology. Johan Wiley & Sons.
4. Boardman, R.S., Cheetham, A.H. and Rowell, A.J. 1987: Fossil Invertebrates. Blackwell Science
5. Bromley R.G., 1996: Trace Fossils – Biology, Taphonomy and applications. Chapman & Hall.
6. Chester R.A., 1978: An Introduction to Paleobotany. Tata McGraw-Hill.
7. Clarkson, E.N.K. 1988: Invertebrate palaeontology and Evolution. IV Ed. Blackwell.
8. Danbar, C.O. and Rodgers, J. (1957) Principles of Stratigraphy. John Wiley & Sons.
9. Dodd, J.R. & Stenton, R.J. Palaeoecology-Concept and Applications.
10. Donald R. Prothero, 2003. Bringing Fossils to Life: An Introduction to Palaeobiology, McGraw-Hill Higher Education.
    Horowitz, A.S. & Potter, E.D. (1971) Introductory Petrography of Fossils. (Springer Verlag)
11. Jones, R.W. (2011) Application of Palaeontology: Techniques and case studies. Cambridge University Press.
12. Lehmann, U., Hillmer, G. 1983: Fossil Invertebrates. Cambridge University Press.
13. Mayr, E. (1971) Population, Species and Evolution (Harvard)
14. Michael Benton, 2004. Vertebrate Palaeontology, Wiley-Blackwell.
15. Nield, E.W. and Tucker V.C.T.: Palaeontology – An Introduction. Pergamon Press.
16. Raup, D.M. and Stanley, S.M. (1985) Principles of Palaeontology (CBS Publications)
17. Raymond C. Moore, Cecil G. Lalicker, Alfred G. Fischer: Invertebrate Fossils (Paperback). CBS Publisher and distributers
18. Seaward, A.C. (1991) Plant fossils, Today's & Tomorrow, New Delhi.
19. Smith, A.B. (1994) Systematics & Fossil Record – Documenting Evolutionary Patterns (Blackwell)

20. Strean, C.W. and Carroll, R.L. (1989) Palaeontology – the record of life (John Wiley)
21. Swnnerton, H.H. (1950) An outline of palaeontology.
22. Treatise on Invertebrate Palaeontology, Ed. Raymond C. Moore (complete series). The Geological Society of America and University of Kansa Press
23. Danbar, C. O. and Rodgers, J. (1957): Principles of Stratigraphy, John Wiley & Sons.
24. Naqvi, S. M. and Rogers, J.J.W. (1987): Precambrian Geology of India, Oxford Univ. Press.
25. Pomerol, C. (1982): The Cenozoic Era? Tertiary and Quaternary, Ellis Harwood Ltd.
26. Ramakrishnan, N. &Vaidyanandan, R. (2010): Geology of India, v. I & II, Geol. Soc. Ind.
27. Review of papers (1972): Stratigraphy of India, Rec. Geol. Surv. Ind., v. 101, pt. 2.
28. Weller, J. M. (1960): Stratigraphic Principles and Practice, Harper and Brothers.
29. Krishnan, M. S. (1982): Geology of India and Burma, 6 th Ed., CBS Pub. & Dis.
30. Pascoe, E. S. (1960): A Manual of Geology of India & Burma, I & II Govt. of India Pub.
31. Ravinder Kumar (2020) Fundamentals of Historical Geology and Stratigraphy of India, New Age International Private Limited
32. Sarkar, S. N. (1968): Precambrian Stratigraphy &Geochrnonology of Peninsular India, Dhanbad.
33. Wadia, D. N. (1967): Geology of India, McMillan & Co., London

Course Details			
Course Title: Research Methodology			
Course Code	GEL82DC01104	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	Second/Even	**Contact Hours**	45 (L) + 15 (T) Hours
Course Type	Discipline Based Core Course		
Nature of the Course	Theory		
Special Nature/ Category of the Course (*if applicable***)**	Introductory course on Research Methodology		
Methods of Content Interaction	Lecture, tutorials, group discussion, self-study, seminar, individual and group drills, assignments and presentation by students.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives:

- ❖ To make critical and independent inquiry in the geosciences including: the ability to gather and evaluate peer-reviewed literature; identify a research question; design and conduct a research plan to collect laboratory and/or field data; and interpret research results.
- ❖ To demonstrate competence in fundamental geological skills including: mineral, rock and soil identification; interpretation of topographic maps, geologic maps, and various forms of imagery; construction of geologic maps and cross sections.
- ❖ To develop students to make decisions on issues of local and global environmental significance based on an understanding of the interrelationships between humans and natural Earth systems

Course Learning Outcomes:

- ❖ The students will acquire knowledge on various modern techniques to find out rocks and minerals characteristics.
- ❖ The student will get well in knowledge on Remote Sensing, Geochemical, and Hydrological applications in different fields of Geology.
- ❖ The students will expertise in research and skills to design and conduct experiments, analyze data and interpret the results.

Course Contents	Weightage (%)
Unit - I Perspectives and getting started with scientific research	**20** **08 Lectures**
Science and technology, meaning and characteristic of research, importance and types of research activities, principles of quality research work, problems encountered in research, scientific attitude and temper, qualities of good researcher, contribution of Indian scientists in global research planning and	

designing of research, criteria and validity of good research, leadership in scientific research. How to conduct research survey (books, journals, electronic search engines likeSCOPUS, Web of Science, PubMed etc.)	
Unit- II Research in practice and science communication	**20** **07 Lectures**
Literature review, journals, conference proceedings, journal impact factor, citation index, research index, reading a scientific paper, seminar, conference and workshops, scientific paper, writing a scientific paper, communicating to a journal, writing a grant for funding, preparation of research presentation, presenting in power point, open presentation.	
Unit- III Research ethics	**10** **05 Lecture**
Research ethics, importance of ethics in research, ethics: values and principles, codes of ethics, research misconduct, dealing with research misconduct, research ethics committees, general ethics and ethical issues.	
Unit - IV Introduction to Research Methods and Analysis in Geosciences	**50** **25 Lecture**
Preparation for Field work, Field procedures in Geological mapping in Igneous, Sedimentary and metamorphic terrain, Methods used in sampling of rocks, minerals and fossils. Define statistics, the importance of statistics in geoscience, histograms, pie diagram, frequency distribution, mean, median and mode, variance, standard deviation,Correlation and Regression, Random variables, probability distribution: Discrete and continuous distribution, Normal distribution curve.The procedure of rock analysis in laboratory, Placer and study of Heavy minerals. Sedimentological techniques- Size and shape determination of grains in Clastic rocks, and their graphic representations. Paleontological and Micro paleontological techniques pertaining to microfossils. Remote Sensing and GIS techniques in Geosciences and earth resources mapping and Monitoring.	

Text Book / References

1. Stephenson, G., &Radmore, P. M. (1990). Advanced Mathematical Methods for Engineering and Science Students. Cambridge University Press.
2. Kothari, C. R. (2019). Research Methodology: Methods and Techniques. New Age International Publishers.
3. Chaddah, P. (2018). Ethics in Competitive Research: Do not get scooped; do not get plagiarized, India.
4. Muralidhar, K., Ghosh, A., Singhvi, A. K. (2019). Ethics in Science Education, Research and Governance. Indian National Science Academy (INSA), New Delhi.
5. Manual of Field Geology ByCromption.
6. Research Methodology_ Methods and Techniques-New Age Publications
7. Statistics and Data Analysis in Geology (3rd edition)-Wiley - John C. Davis - (2002
8. Research Methodology in Geology by Arnold LuwangUsham
9. Research Methodology, Pearson edition, New Delhi - Rajit Kumar, (2005)

Content Interaction Plan

Contact Hours	Topic

1-4	Science and technology, meaning and characteristic of research, importance and types of research activities, principles of quality research work, problems encountered in research, scientific attitude and temper.
5-8	Contribution of Indian scientists in global research planning and designing of research, criteria and validity of good research, leadership in scientific research. How to conduct research survey (books, journals, electronic search engines like SCOPUS, Web of Science, PubMed etc.)
9-11	Literature review, journals, conference proceedings, journal impact factor, citation index, research index, reading a scientific paper, seminar, conference and workshops,
12-15	scientific paper, writing a scientific paper, communicating to a journal, writing a grant for funding, preparation of research presentation, presenting in power point, open presentation
16 -18	Research ethics, importance of ethics in research, ethics: values and principles, codes of ethics, research misconduct.
19-20	Dealing with research misconduct, research ethics committees, general ethics and ethical issues.
21-28	Preparation for Field work, Field procedures in Geological mapping in Igneous, Sedimentary and metamorphic terrain, Methods used in sampling of rocks, minerals and fossils.
29-33	Procedures used in water and rock analysis in laboratory. Sedimentological techniques-Size and shape determination of grains in Clastic, rock
34-39	Graphic representations- placer and studies of Heavy mineral. Paleontological and Micropaleontological techniques pertaining to microfossils
40-45	Remote Sensing and GIS techniques in water resources, geomorphology, landscape evaluation, mineral targeting and structural mapping
T= 15 Hours	Tutorial

Course Details			
Course Title: Advance Remote Sensing and Its applications in Geology			
Course Code	GEL82DC01304	**Credits**	4
L + T + P	2+ 1+ 1	**Course Duration**	One Semester
Semester	Second/Even	**Contact Hours**	30 (L) + 15 (T) +30 (P) Hours
Course Type	Discipline Based Core Course		
Nature of the Course	Theory/Practical		
Special Nature/ Category of the Course (*if applicable***)**	Value and Skill Based		
Methods of Content Interaction	(*Lecture, Tutorials, Practical.)*		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades)		

	• 70% - End Term External Examination (University Examination)

Course Objectives:

- ❖ The advance remote sensing course is designed to understand the basic of advance satellite-based techniques and its applications in geomorphological, geological, structural, groundwater exploration, mining and mineral prospecting.

Course Learning Outcomes:

After successfully completion of course, the students would be able to

- ❖ To understand the basic of thermal and hyperspectral remote sensing.
- ❖ To understand the interpretation and classification of satellite data.
- ❖ To understand the information extraction form satellite data to map the geological features.
- ❖ Development of decision making and utility of satellite data in sustainable earth resource evaluation and management.
- ❖ To utilized the skills for advance research in the field of applied geology.

Course Contents	Weightage (%)
Unit - I Introduction and Principal of Remote Sensing Technology	**20** **10 Lectures**
History and Development of Remote Sensing, Fundamental Principles of Remote Sensing, Electromagnetic radiation – characteristics, General orbital and sensor characteristics of remote sensing satellites; Spectra of common natural objects – soil, rock, water and vegetation. Elements of satellite image interpretation. Platforms- Satellite Orbits: Geostationary, Sun synchronous Satellites- Resolution. Satellites & Sensors. Landsat Series, SPOT Series, Indian Remote Sensing Satellites, Quick bird Satellite, World View, Geo Eye, ASTER.	
Unit- II Hyperspectral, Thermal and Microwave Remote Sensing	**20** **10 Lectures**
Fundamental Concept of Thermal Remote Sensing, Physics of Thermal Remote Sensing, Thermal radiation principles and Factors affecting thermal images. Study of various types of thermal satellites. Microwave Remote sensing concepts: Backscattering, Range Direction, Azimuth Direction, Incident Angle, Depression Angle, Polarization, Dielectric Properties, Surface Roughness and Interpretation of microwave data and various microwave satellites. Hyperspectral remote sensing-Imaging spectrometry, principal of Hyperspectral remote sensing. Characteristics of hyperspectral data.	
Unit- III Satellite Image Processing	

Concept of 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.	**15** **5 Lectures**
Unit - IV Application of Remote Sensing in Earth Sciences	**15** **5 Lectures**
Remote sensing applications geological studies, identification of rocks, Minerals and geological structures. Applications of Remote Sensing in hydrocarbon exploration. Application of Geohazards mapping and monitoring. Applications of Remote Sensing in Mineral Targeting. Remote Sensing applications in climate change and UHI studies. Overview of Planetary Missions and remote sensing of planetary surfaces.	
Unit – V Lab Experiments	
• Geo-referencing of Toposheets and Satellite Images • Creation of subset, mosaicking and generation of FCC. • Satellite Image Classifications. • Spectral profiling of earth material and their analysis. • Study of landforms, lithology and structure and their interpretation. • Terrain Analysis from DEM.	**30** **30 Hours Lab Session**

Text / Reference Books:

1. Lillisand, T. M. and Keifer, R. W. (2007) Remote sensing and image interpretation. John Willey and Sons, USA
2. Barrett, E. C. and Curtis L. F., (1999) Introduction to environmental remote sensing by Chapman and Hall Publishers, USA.
3. Joseph G., (2003) Fundamentals of remote sensing by Universities Press, Hyderabad.
4. Chang, Kang-taung (2002) Introduction to geographic information systems by Tata McGraw-Hill, USA.
5. Gupta, R.P. (1990) Remote Sensing Geology. Springer Verlag.

Note: Students should go for recent research Publications for Case Studies.

Course Details			
Course Title: Geohazards and Disaster Risk Reduction			
Course Code	GEL82DE01304	**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	Second/Even	**Contact Hours**	45 (L) + 15 (T) Hours
Course Type	Discipline Based Course Elective		
Nature of the Course	Theory and knowledge		
Special Nature/ Category of the Course	Value based		
Methods of Content Interaction	(*Lecture, Tutorials, Group discussion, primary data collection & analysis, seminar, presentations by students, field work etc.)*		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives:

- To impart knowledge on concepts related to disaster, disaster risk reduction, disaster management
- To provide a systematic knowledge base on disaster typology, risk and vulnerability.
- To comprehend on approaches and measures of disaster management, preparedness and response and related policies, law and methods.
- To acquaint with the skills for planning and organizing disaster response

Course Learning Outcomes:

After successfully completion of course, the students would be able to

- Understand role of geologic processes in the assessment of natural hazards
- Formulate the plan for mitigation and predicting of natural hazards.
- Spatial correlation of natural hazards and role of anthropogenic activity.
- Understand the role of Govt and NGO in disaster management.

Course Contents	Weightage (%)

Unit - I Concept of Natural Hazards and Disasters	**30** **15 Lectures**
Introduction to natural hazards and disasters, Vulnerability, Resilience, Risks, Dimensions of natural and anthropogenic disasters. Coastal hazards, Earthquakes, Distribution, magnitude and intensity of earthquakes; Seismic hazard zonation. Tsunamis; Volcanoes; Wild fires; Oil spills; Urban hazards and disasters.	
Unit- II Application of Space Technology for Disaster Study	**25** **10 Lectures**
Floods –nature and frequency of flooding, flood hazards, urbanization and flooding, flood hydrographs. Mechanism of landslides, type of landslide, cyclones and storms. Deforestation and land degradation. Application of remote sensing & GIS in natural hazards monitoring & management. Urban Heat Island (UHI), Basic concept and impact study.	
Unit- III Disaster Management, Mitigation and Risk Reduction	**20** **10 Lectures**
Concepts and definitions of hazard, disaster, vulnerability and risk, disaster risk reduction, disaster management cycle, paradigm shift of Disaster Management. Disaster profile of India. Pre-disaster: risk assessment and vulnerability analysis, prevention & risk reduction, preparedness and response to disaster. Early warning system, capacity development, awareness, risk mapping and zonation. During-disaster: coordination and communication, evacuation, search and rescue emergency operation centre, relief and rehabilitation and response to psychological crises and stress. Post-disaster activities.	
Unit - IV Government Planning and Policies for Disaster Management	**25** **10 Lectures**
National institutional framework (NDRF, NDMA, SDMA, & NIDM, SIDM and other related Departments.), Natural Disaster Management Plan, Best practices in disaster management. Role of NGOs at local, state and national level. Geo-informatics in Disaster Management (RS & GIS, GPS). Land use planning and development for mitigating disaster - disaster resistant house construction. Disaster Risk Reduction (DRR) and Sendai Framework for Disaster Risk Reduction, Early Warning System and Advisories from Appropriate Agencies. Relevance of indigenous Knowledge, appropriate technology and Local resources.	

Text / Reference Books:

1. Bell, F. G. (1999). Geological Hazards, Routledge, London.
2. Bryant, E. (1985). Natural Hazards, Cambridge University Press.
3. KelIer, E. A. (1978). Environmental Geology, Bell and HowelI, USA.
4. Patwardhan, A.M. (1999). The Dynamic Earth System. Prentice Hall.
5. Smith, K. (1992). Environmental Hazards.Routledge, London.
6. Subramaniam, V. (2001). Textbook in Environmental Science, Narosa International.
7. Valdiya, X.S. (1987). Environmental Geology - Indian Context. Tata McGraw Hill

Content Interaction Plan

Contact Hours	Topic
1-10	• Introduction to natural hazards and disasters, natural and manmade; • Dimensions of natural and anthropogenic disasters. • Coastal hazards – tropical cyclone, coastal erosion, sea level changes, coastal zone management; • Earth quakes - Distribution, magnitude and intensity of earthquakes; • Tsunamis; Volcanoes; Wild fires; Oil spills; Urban hazards and disasters.
11-22	• Floods –nature and frequency of flooding, flood hazards, urbanization and flooding, flood hydrographs. • Mechanism of landslides, type of landslide, • Cyclones and storms. • Deforestation and land degradation. • Application of remote sensing & GIS in natural hazards monitoring & management. • Urban Heat Island (UHI), Basic concept and impact study.
23-36	• Concepts and definitions of hazard, disaster, vulnerability and risk, • Disaster risk reduction, disaster management cycle, paradigm shift of disaster Management. • Disaster profile of India. Pre-disaster: risk assessment and vulnerability analysis, prevention & risk reduction, preparedness and response to disaster. • Early warning system, capacity development, awareness, risk mapping and zonation. • During- disaster: coordination and communication, evacuation, search and rescue emergency operation centre, relief and rehabilitation and response to psychological crises and stress. • Post-disaster activities.
37-45	• National institutional framework (NDRF, NDMA, SDMA, & NIDM, SIDM and other related Departments.), • Natural Disaster Management Plan, Best practices in disaster management. • Role of NGOs at local, state and national level. • Geo-informatics in Disaster Management (RS &GIS, GPS). • Land use planning and development for mitigating disaster - disaster resistant house construction.
T=15	Tutorial

Course Details			
Course Title: Geophysics and Mineral Exploration			
Course Code	GEL82DE01404	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	Second/Even	**Contact Hours**	45 (L) + 15 (T) Hours
Course Type	Discipline Based Course Elective		
Nature of the Course	Theory		
Special Nature/ Category of the Course	Skill based		
Methods of Content Interaction	(*Lecture, Tutorials, Group discussion, assignments, presentations by students etc.)*		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives:

- This course aims to teach the students about the fundamentals of geophysics, principle of different geophysical exploration methods and their application in Earth Sciences.
- Furthermore, in this course students will learn geochemical, geobotanical exploration method, types of sampling, logging and drilling methods; Ore reserve calculation.

Course Learning Outcomes:

Upon completion of the course, students will be able to:

- Understand various geophysical methods and their working principles.
- This course will enhance the knowledge of students on geophysical, geochemical and geobotanical methods and make them capable to select the most suitable method for the exploration of earth materials and resources.

Course Contents	Weightage (%)
Unit - I Introduction	**25** **15 Lectures**
Introduction of Geophysics and its importance, Concept of seismic waves (body wave, surface wave), seismology and internal structure of the earth, variation of density, velocity, pressure, temperature, electrical and magnetic properties of the Earth; Seismic shadow zones (P and S waves shadow zones), Different discontinuities in the Earth's interior, P and S waves velocity variation from crust to the core, Lithostatic pressure calculation at crust-mantle boundary	

Unit- II Geophysical methods	**25** **15 Lectures**
Elementary knowledge of geophysical exploration methods, Gravity, gravity reduction, gravimeter, Magnetic, magnetism of the Earth and Earth's magnetic field, magnetometer, Seismic, Electrical, Wenner and Schlumberger resistivity configuration, Radiometric, and Ground Penetration Radar (GPR). Application of various geophysical methods in Earth Sciences.	
Unit- III Geochemical and Geobotanical surveys	**25** **15 Lectures**
Concept of Mineral Exploration, Selection of minerals for explorations; Criteria and guides for mineral search; Stages of mineral exploration; Field observations and field equipment; Types of sampling (e.g., pitting, trenching, channel, grab, and bulk sampling) Geochemical exploration: mobility of elements and their primary & secondary dispersion; Geochemical approaches, mapping and sample material; geochemical anomaly, pathfinder elements, introduction to geobotanical exploration method.	
Unit- IV Drilling and Well logging	**25** **15 Lectures**
Drilling: objectives of drilling, types of drilling (Rotary, Percussion and Diamond) for exploration and their advantages. Drilling fluid and its role, Geological and mineable ore reserves and their calculation. Geological modelling for mineral exploration.Elementary knowledge of Logging: Electric, Radioactive and Sonic logs, Application of logs in petrophysical analysis and facies analysis.	

Text / Reference Books:

1. Dobrin M.B. (1988). Introduction to Geophysical Prospecting. McGraw Hill
2. Gadallah, M. and Fisher, R. (2009). Exploration Geophysics. Springer-Verlag Berlin Heidelberg.
3. Lowrie W. (1997). Fundamentals of Geophysics. Cambridge University Press
4. Robinson E.S. (1988). Basic Exploration Geophysics. John Wiley & Sons
5. Telford, G.S., Geldart, L.P. and Sheriff, R.E. (1990). Applied Geophysics. Cambridge University Press.

Content Interaction Plan

Contact Hours	Topic
1-4	Introduction of Geophysics and its importance, Concept of seismic waves (body wave, surface wave), Detail information on seismic waves and their characteristics, Seismograph and seismogram, Seismic shadow zones (P and S waves shadow zones)
5 – 7	The internal structure of the Earth, Different discontinuities in the Earth's interior, P and S waves velocity variation from crust to the core, density, pressure and temperature variation within Earth's interior
8– 11	The basic introduction of different Geophysical exploration methods, Gravity method: Earth's gravitational field, Figure of the Earth, Concept of Geoid, the theoreticalvalue of gravity (g), gravity anomaly, factors affecting gravity reading
12-15	Gravity reduction: Latitude correction, Free-air correction,Bouguer correction, Terrain correction,Earth-tide correction,Isostatic correction, Bouguer and Free-Air anomalies, Gravity Instruments: Stable and unstable gravimeters, Application of gravity method in exploration
16-20	Introduction of the seismic method and its importance, Brief description of stress, strain and different types of elastic constants, P and S wave velocity in terms of elastic constant and density, Factors affecting seismic velocity, reflection and refraction survey of the seismic method with different examples
21-25	Principle of magnetic methods, magnetic anomaly, magnetism of the Earth and Earth's magnetic field, magnetic susceptibility, magnetism of rocks and minerals, Field instruments for magnetic measurement, application of magnetic method
26-30	Introduction of Electric methods, classification of electric methods, electrical properties of rocks and minerals, resistivity survey, self-potential methods, Ground Penetrating Radar (GPR),
31 –35	Concept of Mineral Exploration, Selection of minerals for explorations; Criteria and guides for mineral search; Stages of mineral exploration; Field observations and field equipment; Types of sampling (e.g., pitting, trenching, channel, grab, and bulk sampling)
36 –40	Geochemical exploration: mobility of elements and their primary & secondary dispersion; Geochemical approaches, mapping and sample material; geochemical anomaly, pathfinder elements, Introduction to geobotanical exploration method.
41 –45	Drilling: objectives of drilling, types of drilling for exploration and their advantages. Geological and mineable ore reserves and their calculation.Elementary knowledge of Logging: Electric, Radioactive and Sonic logs.
T=15	Tutorial

Course Details			
Course Title: Environmental and Engineering Geology			
Course Code	GEL82DE01504	**Credits**	4
L + T + P	3 + 1 +0	**Course Duration**	One Semester
Semester	Fourth/Even	**Contact Hours**	45(L) + 15 (T) Hours
Course Type	Discipline Based Course Elective		
Nature of the Course	Theory		
Special Nature/ Category of the Course (*if applicable***)**	Indian Knowledge System/Skill Based		
Methods of Content Interaction	(*Lecture, Tutorials, Practical and field work etc.)*		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives:

- To understand the interaction of humans with the geological environment,
- To provides the knowledge of various challenges of environmental geology and role of geologist to minimizing the environmental impact.
- To appreciate the importance of geology in civil engineering by going through case histories of failure of civil engineering constructions in the past.
- To introduce about minerals, rocks, their modes of formation and their physical and mechanical properties.
- To recognize geological structures in rock mass, their origin and their impact on civil engineering structures;
- To appreciate the importance of geo-explorations, geological maps and geological reports and develop an understanding for their utilization for safer, stable and economical civil structures.

Course Learning Outcomes:

The course, on completion, will definitely provide better capabilities:

- To understand the processes and principles of Engineering Geology &Geotechniques.
- To recognize the fundamentals of the Earth as a planet, earth's dynamic actions and their importance for civil engineering structures;
- To appreciate the usefulness and utilization of natural materials in civil engineering works; to broadly assess the dynamic actions of natural forces on civil engineering structures and recommend remedial measures;
- To analyse and interpret geological reports and information and the latest geological exploration methods for suitable site selection;

- ❖ To ascertain safe, stable and economical civil structures

- ❖ Describe common earth materials and their relationship to environmental hazards; and
- ❖ Explain how earth processes create hazards to life and property; and
- ❖ Describe the occurrence and formation of earth resources and significant environmental effects caused by their extraction, processing, and use.

Course Contents:	Weightage (%)
Unit - I Fundamental of Environmental Geology	**24** **10 Lectures**
Fundamental concepts of environmental geosciences, its scope and necessity; Definition, structure, composition and general characteristics of lithosphere, hydrosphere, atmosphere and biosphere. The interdisciplinary approach to environmental geology. Geological characteristics of various environmental regimes. Physiography, drainage, climate, soils and natural resources of India. Environmental Impact Assessment (EIA) and Environmental Protection Law. Application of Geology for sustainable development; Medical Geology; River pollution and Characteristics and problems.	
Unit- II Environmental Pollution and Management	**24** **10 Lectures**
Water pollution: types of water pollution, groundwater pollution sources, pathways and mechanism, attenuation processes, case histories of natural (arsenic and fluoride poisoning) and man-made water pollution; water logging, causes, effects and remedial measures, aquifers; declining groundwater tables, subsidence and compaction of aquifers; Soil pollution- sources, causes and effects; Soil pollution control measures; Air pollution: definition, terminology, sources and classification of air pollutants; effects of air pollution- acid rain, green house effects and ozone layer depletion; Air pollution control and management.	
Unit- III Scope and Properties of Geological Material, Dam and Tunneling	**24** **10 Lectures**
Role of engineering geology in civil construction and mining industry. Various stages of engineering geological investigations for civil engineering projects Engineering properties of rocks, behavior under loads, stress & strain, elasticity (elastic constants), residual stresses, rock discontinuity and parameters (RQD, Q & RMR); engineering classifications (NGI, ISRM & CSIR), physical characters of building stones, concrete and other aggregates. Engineering properties of soils. Dams and reservoirs: types and classification, investigations for the construction of dams and reservoir, spillways, dam foundation and reservoirs problems, Reservoir siltation; Geotechnical evaluations of tunnel alignments and transportation routes. Methods of tunneling; Classification of ground for tunneling purposes; various types of support.	
Unit - IV Bridges and Building	**28** **15 Lectures**
Geological and geotechnical consideration for transportation routes (Roads and railways), bridges and coastal barriers and canals. Buildings – foundations and their selection, types of piles, foundation problems	

and their improvement. Aseismic designing - calculation of safety factor (seismic coefficient), Seismic designs of buildings influence of geological condition on foundation and design of buildings. River training and flood control- river improvement for navigation, principles of flood control, control of abutment erosion.Mass movements with special emphasis on landslides and rock falls. Slope stabilization and protection measures.	

Text / Reference Books:

1. Beavis, F. C. (1985): Engineering Geology.
2. Bell, F. G. (1999): Geological Hazards, Routledge, London.
3. Bieniawski, Z. T. (1989): Engineering Rock Mass Classification, John Wiley.
4. Bryant, E. (1985): Natural Hazards, Cambridge University Press.
5. Goodman, R.E. (1980): Introduction to rock mechanics.
6. Jagger, J. C. and Cook, N. G. W. (1979): Fundamental of rock Mechanics, Champman& Hall.
7. Johnson, R. B. and DeGraff, J. V. (1988): Principles of Engineering Geology, John Wiley.
8. Valdia, K. S. (1987): Environmental Geology, Tata McGraw hills, New Delhi
9. Keller, A. E. (1978): Environmental Geology (5th Edt.) Charis and Merril Pub. Co.
10. Montgometry, C. W. (2016): Environmental Geology, Mc Graw Hall Global education Holding publishers
11. Legget, R. F. (1983): Handbook of geology in civil engineering, McGraw Hill, New York.
12. Schultz, J. R. & Cleaves, A. B. (1951): Geology in Engineering, John Willey & Sons, New York.
13. Schuster, R. I. &Krizek, R. J. (1978): Landslide analysis and control, Trans. Res. Board Spec. pub. 176 Nat. Acad. Sci. Washington D.C.
14. Vutukuri, V. S., Lama, R. D. and Saluja, S. S. (1974): Handbook on mechanical properties of rocks, Transtech Publications, Clausthal, Germany
15. Tonk, W. R. (1986): Environmental Geology, Oxford University Press, New York 1983

Content Interaction Plan

Contact Hours	Topic
1-10	Fundamental concepts of environmental geosciences, its scope and necessity; Definition, structure, composition and general characteristics of lithosphere, hydrosphere, atmosphere and biosphere; The interdisciplinary approach to environmental geology. Geological characteristics of various environmental regimes. Physiography, drainage, climate, soils and natural resources of India. Environmental Impact Assessment (EIA) and Environmental Protection Law. Application of Geology for sustainable development; Medical Geology; River

	pollution and Characteristics and problems.
11 – 20	Water pollution: types of water pollution, groundwater pollution sources, pathways and mechanism, attenuation processes, case histories of natural (arsenic and fluoride poisoning) and man-made water pollution; Water logging, causes, effects and remedial measures, aquifers; declining groundwater tables, subsidence and compaction of aquifers; Soil pollution- sources, causes and effects; Soil pollution control measures; Air pollution: definition, terminology, sources and classification of air pollutants; effects of air pollution- acid rain, green house effects and ozone layer depletion; Air pollution control and management.
21 – 25	Role of engineering geology in civil construction and mining industry; Various stages of engineering geological investigations for civil engineering projects Engineering properties of rocks, behavior under loads, stress & strain, elasticity (elastic constants), residual stresses, rock discontinuity and parameters (RQD, Q & RMR); Engineering classifications (NGI, ISRM & CSIR), physical characters of building stones, concrete and other aggregates. Engineering properties of soils.
26 - 30	Dams and reservoirs: types and classification, investigations for the construction of dams and reservoir, spillways, dam foundation and reservoirs problems, Reservoir siltation; Geotechnical evaluations of tunnel alignments and transportation routes. Methods of tunneling; Classification of ground for tunneling purposes; various types of support.
31-35	Geological and geotechnical consideration for transportation routes (Roads and railways); bridges and coastal barriers and canals.
36-45	Buildings – foundations and their selection, types of piles, foundation problems and their improvement; A seismic designing - calculation of safety factor (seismic coefficient), Seismic designs of buildings influence of geological condition on foundation and design of buildings; River training and flood control- river improvement for navigation, principles of flood control, control of abutment erosion; Mass movements with special emphasis on landslides and rock falls. Slope stabilization and protection measures.

Course Details			
Course Title: Sustainable Development Goals (SDG) and role of Geology			
Course Code	GEL82ME01600	**Credits**	0
L + T + P	2 + 0 + 0	**Course Duration**	One Semester
Semester	Second/Even	**Contact Hours**	30 (L) Hours
Course Type	Mandatory Elective Non-Credit Course		
Nature of the Course	Theory		
Special Nature/ Category of the Course (*if applicable*)	Value Added, Indian Knowledge System/		
Methods of Content Interaction	(*Lecture, Tutorials, Practical and field work etc.)*		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives:

- To familiarize the students about the sustainable development goals (SDG) and importance of Geology in SDG.

Course Learning Outcomes:

After successfully completion of course, the students would be able to,

- Understand the importance of Geology in Sustainable development goals,
- Understanding of Earth processes to ensure people, jobs and infrastructure to environmental change or geological hazards,
- To support sustainable development goals (SDG),
- Public participation and awareness for conservation natural resources.

Course Contents	Weightage (%)
Unit - I Introduction to sustainable development	
Introduction to sustainable development goals, its importance and need in the society. An overview of the 17 Sustainable Development Goals (SDG). Understanding and remediating contamination of our air, water and mineral resources. Explanation of the United Nations Conference on Sustainable Development Goals, with special reference to Quality Education, Climate Change, No poverty, Gender equality, affordable and clean energy, and peace justice and strong institutions. Effective understanding of sustainable energy of the earth as a whole, replacing the energy consumption to renewable energy. SDG in relation to Geological sciences.	**60** **18 Lectures**
Unit- II Sustainable Development Goals and Geology	
Environmental and biodiversity management and conservation. Mitigation against geohazards (hazards associated with earth processes earthquakes, volcanoes, landslides, avalanches, rock falls, soil creep, flood, drought and coastal hazards). Secure access to minerals and rock materials. Addressing climate change, disaster risk reduction, improved infrastructure and access to basic services.	**20** **06 Lectures**
Unit – III SDGs Awareness and Impact to Society	
Acknowledging the role of youth in sustainable development, organizations and governments, established strategies to raise youth's awareness and capacity for the SDGs. Sustainable Development Solutions Network (SDSN) Youth, for conducting peer-learning programmes to improve youth engagement and knowledge. Approaches to Sustainable Development: Community Capacity building Approach, industrial sector approach, integrated systems approach, human development and green account approach.	**20** **06 Lectures**

Text / Reference Books:

1. Global Goals, 2016, The Global Goals: http://www.globalgoals.org/ (accessedJanuary 2016).
2. Brilha, J. (2016) Inventory and Quantitative Assessment of Geosites and Geodiversity Sites: a Review. Geoheritage 8, 119–134. https://doi.org/10.1007/s12371-014-0139-3
3. Eder, W. (1999) "UNESCO GEOPARKS"- a new initiative for protection and sustainable development of the Earth's heritage. N JbGeolPaläont (Abh) 214(1/2):353–358
4. Henriques, M.H., Pena dos Reis, R., Brilha, J. and Mota, T. S. (2011) Geoconservation as an emerging geoscience. Geoheritage 3(2):117–128.

5. Cordani, U.G., 2000, The role of the earth sciences in a sustainable world:Episodes, v.23, no.3, pp. 155–162

Content Interaction Plan

Contact Hours	Topic
1-5	Introduction to sustainable development goals, its importance and need in the society. An overview of the 17 Sustainable Development Goals (SDG). Understanding and remediating contamination of our air, water and mineral resources.
6-10	Explanation of the United Nations Conference on Sustainable Development Goals, with special reference to Quality Education, Climate Change, No poverty, Gender equality, affordable and clean energy, and peace justice and strong institutions.
11 -12	Effective understanding of sustainable energy of the earth as a whole, replacing the energy consumption to renewable energy. SDG in relation to Geological sciences.
13-18	Environmental and biodiversity management and conservation. Mitigation against geohazards (hazards associated with earth processes earthquakes, volcanoes, landslides, avalanches, rock falls, soil creep, flood, drought and coastal hazards).
19 -22	Secure access to minerals and rock materials. Addressing climate change, disaster risk reduction, improved infrastructure and access to basic services.
23-27	Acknowledging the role of youth in sustainable development, organizations and governments, established strategies to raise youth's awareness and capacity for the SDGs. Sustainable Development Solutions Network (SDSN) Youth, for conducting peer-learning programmes to improve youth engagement and knowledge.
28 – 30	Approaches to Sustainable Development: Community Capacity building Approach, industrial sector approach, integrated systems approach, human development and green account approach.

SEMESTER III (Total Credits = 20)			
Nature of Course	**Course Code**	**Name of Course**	**Credit (L+T+P)**
Discipline Based Core Course	GEL91DC02004	Sedimentology	3+0+1
Discipline Based Core Course	GEL91DC04602	Geological Field	0+0+2
Discipline Based Core Course	GEL91DC02104	Hydrogeology	3+0+1
Discipline Based Core Course	GEL91DC04704	Ore and Mining Geology	3+1+0
Total Credit = 14			
Discipline Based Core Elective (Any one)			
Discipline Based Core Elective	GEL91DE04802	Geochemistry and Isotope Geology	2+0+0
Discipline Based Core Elective	GEL91DE04902	Cryosphere and Climate change	2+0+0
Discipline Based Core Elective	GEL91SW05002	Earth Science for Civil Engineering/River Engineering SWAYAM approved Course	2+0+0
Total Credits = 2			
Open Elective Interdisciplinary Course		Elective Basket V	4
Mandatory Elective Non-Credit Course		Elective Basket VI	0
Total Credits = 20			

Elective Basket V (Open Elective Interdisciplinary Course)			
Nature of Course	**Course Code**	**Name of Course**	**Credit (L+T+P)**
Open Elective Interdisciplinary Course	GEL91OE02604	Natural Hazard and Disaster Management	3+1+0

Elective Basket VI (Mandatory Elective Non-Credit Course)

Nature of Course	Course Code	Name of Course	Credit (L+T+P)
Mandatory Elective Non-Credit Course	GEL91ME02700	Geoheritages and Geoparks	0

Course Details			
Course Title: Sedimentology			
Course Code	GEL91DC01704	**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	Third/Odd	**Contact Hours**	45 (L) + 30 (P) Hours
Course Type	Discipline Based Core Course		
Nature of the Course	Theory cum Practical		
Special Nature/ Category of the Course	Indian Knowledge System/ Skill Based		
Methods of Content Interaction	(*Lecture, Tutorials, Group discussion, primary data collection & analysis, seminar, presentations by students, field work etc.)*		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives:

The Course aims to make to the students well-versed with the knowledge and skills necessary to:

- ❖ Describe, understand, and interpret sediments, and sedimentary rocks.
- ❖ Understand the story of life, the development of very important economic deposits (including petroleum, coal, and uranium), andthe development of a global climate favorable for the development of life.
- ❖ The ability to make careful observations, and from these interpret and understand modern and ancient sedimentary environments and stratigraphic successions.

Course Learning Outcomes:

The students will acquire better capability to:

- ❖ Visualize the processes and principles involved during the origin and evolution of the sedimentary rocks.
- ❖ Use precise geological terms in describing and discussing sedimentary structures, textures and processes.
- ❖ Identify the main types of sedimentary rocks e.g., limestones, conglomerates, sandstones, mudstones, evaporites, iron formations, *etc.*
- ❖ Interpret sedimentary processes on the basis of composition of the rock and structures.
- ❖ Identify the depositional environment (i.e., marine, continental, *etc.*) and sedimentary deposits that are characteristic of various types of sedimentary basins.

- ❖ The students will acquire a basis for further studies in sedimentology and sequence stratigraphy and can conduct fieldwork.

Course Contents	Weightage (%)
Unit - I Concept of sedimentology and sedimentary processes	**20** **11 Lectures**
Developments in sedimentology; Significance of Sedimentology; Origin of terrigenous clastic and non-clastic sediments; Weathering and its products- Physical and chemical weathering, soils and paleosols; Clastic transport and fluid mechanics in sedimentology: fluid flow in theory and in nature, Laminar vs. turbulent flow, Reynold's Numbers, Froude Number, Boundary layer effect, Particle entrainment, transport and deposition, sedimentary gravity flow; Concept of flow regimes and bedforms.	
Unit- II Sedimentary textures, structures its application	**20** **11 Lectures**
Sedimentary textures- types of textures, shape, size, fabric and surface textures, methods of textural analysis, textural parameters and their significance. Important bedforms and sedimentary structures- Primary (Depositional, Erosional, Penecontemporaneous deformational, biogenic) and post-depositional – their genesis and stratigraphic significance. Application of sedimentary structures in palaeo-current analysis.	
Unit- III Petrology of clastic and non-clastic rocks	**20** **12 Lectures**
Clastic sedimentary rocks: Classification, diagenesis, lithification and their petrogenesis of conglomerate, sandstone, siltstone and mudstone. Volcaniclastic sediments and their characteristics. Carbonate rocks: Sedimentary environments and controls on carbonate deposition, Carbonate Mineralogy, Allochemical and Orthochemical components. Classification of limestone, Diagenesis and lithification carbonate limestone, dolomitization and Dolomite problem. Study of evaporite, phosphorite, chert, iron and manganese rich sediments and rocks. Carbonaceous Sedimentary rocks.	
Unit - IV Sedimentary Basins and Depositional Environments	**15** **11 Lectures**
Sedimentary basin- Evolution and classification of sedimentary basins: tectonic and sedimentation; major sedimentary basins of India. Implication of facies in environmental interpretation and basin analysis. Concept of Sedimentary facies association models: Marine, Nonmarine, and Mixed Depositional Environment. Sedimentary facies and facies models with Indian analogues.	
Unit –V Lab Experiments	

• Exercise on grain size Analysis (Procedures, Cumulative curve, Histogram, Visher's curve and Statistical calculation); • Exercise on Shape analysis (Calculation and Classification). • Heavy mineral analysis (Procedure and identification); Insoluble residue analysis (Procedure and identification). • Megascopic and microscopic study of clastic (including volcanogenic), chemical and biochemical origin sedimentary rocks, and carbonaceous sedimentary rocks; • Sedimentary structure (identification and classification); • Paleocurrent analysis (rose diagram) and basin analysis calculation. • Fence diagram, preparation and interpretation. • Study of Vertical Profile Sections of some Selected Sedimentary Environment.	**25** **30 Hours lab Sessions**

Text / Reference Books:

1. Boggs, Sam (Jr.) (2006): Principles of Sedimentology and Stratigraphy 4nd Ed. Prentice Hall.
2. Pettijohn, F.J. (1975): Sedimentary Rocks (3rd Ed.), Harper and Row Publ., New Delhi.
3. Selley, R. C. (1976): An Introduction of Sedimentology. Academic Press London.
4. Selley, R. C. (2000): Applied Sedimentology, Academic Press.
5. Sengupta, S. M. (2007): Introduction of Sedimentology. 2nd Ed. CBS Pub., New Delhi.
6. Tucker, M. E. (1981): Sedimentary Petrology: an introduction. John Willey & Sons, New York.
7. Tucker, M.E. (1990): Carbonate Sedimentology, Blackwell Scientific Publication.
8. Babu, S. K. & Sinha, D. K. (1987): Sedimentary Petrology Practical, CBS Pub., N. Delhi.
9. Blatt, H. E., (1972): Sedimentary Petrology, 2nd Ed. W. H. Freeman & Co. New York.
10. Blatt, H., Middleton, G.V. and Murray, R.C. (1980): Origin of Sedimentary Rocks, Prentice-Hall Inc.
11. Collins, J.D., and Thompson, D.B. (1982): Sedimentary Structures, George Allen and Unwin, London.
12. Krumbein, W.C. and Sloss, L.L., (1963): Stratigraphy and Sedimentation. W.H. Freeman and Co., London.
13. Lindholm, R.C. (1987): A Practical Approach to Sedimentology, Allen and Unwin, London.
14. Miall, A.D. (2000): Principles of Basin Analysis, Springer-Verlag.
15. Reading, H.G. (1997): Sedimentary Environments and facies, Blackwell Scientific Publication.
16. Reineck, H.E. and Singh, I.B. (1973): Depositional Sedimentary Environments, Springer-Verlag.
17. Sukhtankar, R. K. (2004): Applied Sedimentology. 1st Ed. CBS Pub. & Dist., New Delhi.

Content Interaction Plan

Contact Hours	Topic
1 - 2	Developments in Sedimentology
3	Significance of Sedimentology
4	Origin of terrigenous clastic and non-clastic sediments
5 - 6	Weathering and its products-Physical and chemical weathering, soils and paleosols
7 - 9	Clastic transport and fluid mechanics in sedimentology: fluid flow in theory and in nature, Laminar vs. turbulent flow, Reynold's Numbers, Froude Number, Boundary layer effect, Particle entrainment, transport and deposition, sedimentary gravity flow
10- 11	Concept of flow regimes and bedforms
12 - 16	Sedimentary textures- types of textures, shape, size, fabric and surface textures, methods of textural analysis, textural parameters and their significance.
17 - 20	Important bedforms and sedimentary structures- Primary (Depositional, Erosional, Penecontemporaneous deformational, biogenic) and post-depositional – their genesis and stratigraphic significance
21 - 22	Application of sedimentary structures in palaeo-current analysis.
23 - 25	Clastic sedimentary rocks: Classification, diagenesis, lithification and their petrogenesis of conglomerate, sandstone, siltstone and mudstone.
26	Volcaniclastic sediments and their characteristics.
27 - 28	Carbonate rocks: Sedimentary environments and controls on carbonate deposition, Carbonate Mineralogy, Allochemical and Orthochemical components.
29 - 30	Classification of limestone, Diagenesis and lithification carbonate limestone, dolomitization and Dolomite problem.
31 - 32	Study of evaporite, phosphorite, chert, iron and manganese rich sediments and rocks.
33 - 34	Carbonaceous Sedimentary rocks.
35 - 37	Sedimentary basin- Evolution and classification of sedimentary basins: tectonic and sedimentation; major sedimentary basins of India.
38 - 39	Implication of facies in environmental interpretation and basin analysis.
40 - 43	Concept of Sedimentary facies association models: Marine, Nonmarine, and Mixed Depositional Environment.
44 - 45	Sedimentary facies and facies models with Indian analogues.
	List of Practicals

P=30Hours	• Exercise on grain size Analysis (Procedures, Cumulative curve, Histogram, Visher's curve and Statistical calculation); • Exercise on Shape analysis (Calculation and Classification). • Heavy mineral analysis (Procedure and identification); Insoluble residue analysis (Procedure and identification). • Megascopic and microscopic study of clastic (including volcanogenic), chemical and biochemical origin sedimentary rocks, and carbonaceous sedimentary rocks; • Sedimentary structure (identification and classification); • Paleocurrent analysis (rose diagram) and basin analysis calculation. • Fence diagram, preparation and interpretation. • Study of Vertical Profile Sections of some Selected Sedimentary Environment.

Course Details			
Course Title: Geological Field			
Course Code	GEL91DC01802	**Credits**	2
L + T + P	0 + 0 + 2	**Course Duration**	One Semester
Semester	Third/Odd	**Contact Hours**	2-Weeks field study
Course Type	Discipline Based Core Course		
Nature of the Course	Field Study /Training		
Special Nature/ Category of the Course	Skill Based		
Methods of Content Interaction	(*Group discussion, primary data collection & analysis, presentations by students, field work etc.)*		
Assessment and Evaluation	• 30% Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives:

- ❖ The Course aims to make to the students well-versed with the strength of geological field applications related to Applied Geology and industrial training.

Course Learning Outcomes:

The students will enable**:**

- ❖ To develop their understanding of different perspectives on social, ecological issues,
- ❖ To clarify and justify their own values whilst learning to acknowledge and respect other people's values.

- ❖ To develop their understanding of different perspectives on Economic Geology, Mineral Exploration other branch of Applied Geology including industrial visit, training etc.

Course Contents:

- ❖ A field report and viva-voce based on two weeks compulsory geological field survey / training to mines and places of geological importance (geological field work related to Economic Geology, Mineral Exploration, Mining Methods, Mineral Economics and other branch of Applied Geology), organized by the Department.
- ❖ Students will be sent to various governmental and non-governmental agencies/companies based on their interest for an in-hand experience for around 2weeks duration. After the completion of the field study and training a report will be submitted and evaluated by the examiners.

Course Details			
Course Title: Hydrogeology			
Course Code	GEL91DC01904	**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	Third/Odd	**Contact Hours**	45 (L) + 30 (P) Hours
Course Type	Discipline Based Core Course		
Nature of the Course	Theory cum Practical		
Special Nature/ Category of the Course (*if applicable***)**	Value Based / Skill Based		
Methods of Content Interaction	(*Lecture, Tutorials, Practical and field work etc.)*		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives:

- ❖ To familiarize the students, the basic hydrogeology including groundwater origin, occurrence and distribution in different geological formations.
- ❖ To familiarize the students with the various methods employed in the groundwater exploration, well hydraulics and water management.
- ❖ To familiarize the students about the physical and chemical attributes of water quality aspect.

Course Learning Outcomes:

After successfully completion of course, the students would be able to.

- ❖ Understand hydrologic cycle and its components, hydrologic properties of rock and method of their measurements.
- ❖ Understand basic concepts of well hydraulics including Darcy's law and groundwater flow equations.
- ❖ Understand methods of artificial recharge in varied hydrologic and geologic conditions and groundwater management.
- ❖ Understand various surface and sub-surface methods of groundwater exploration including Geological and geophysical and remote sensing.
- ❖ The students will learn about the groundwater chemistry.

Course Contents	Weightage (%)
Unit - I Occurrence and Distribution of groundwater	**30** **15 Lectures**
Introduction of water resources and current challenges. Controls of geology on groundwater occurrence, movement, and distribution; Classification of aquifers and aquifer systems; Mode of occurrence of groundwater in different geological formations and groundwater provinces of India. Concept of Darcy's law – validity of Darcy's law – Hydraulic conductivity, transmissivity, storage coefficient and specific capacity; Water table contour maps, specific yield, storage coefficient. Pump tests and evaluation of hydrologic properties. Determination of hydraulic conductivity. Groundwater level, its fluctuations and causes.	
Unit- II Methods of Groundwater Exploration	**10** **10 Lectures**
Surface and subsurface methods of groundwater exploration; Application of remote sensing in groundwater exploration; Collection of hydrogeological data and preparation of hydrographs; Selection of suitable site for well construction; Type and design of wells, methods of well construction, well completion and well development.	
Unit- III Groundwater Recharge and Management	**15** **10 Lectures**
Artificial recharge to groundwater and rainwater harvesting; Management of groundwater resources; Causative factors and their measurements. Artificial recharge of water - Recharging by surface water and rain water harvesting. Consumptive and conjunctive use of surface and ground water; problem of overexploitation; ground water legislation, Concept of watershed: Watershed characteristics and characterization. Indigenous techniques in water resources management.	
Unit – IV Groundwater Quality and Management	**15** **10 Lectures**
Groundwater quality and environmental aspects; Chemical characteristics of groundwater in relation to various uses – domestic, industrial and irrigation; Saline water intrusion in coastal and other aquifers, the Ghyben - Herzberg concept and its preventive measures. Concept of Groundwater quality Indexing (GWQI). Application of H and O isotopes in groundwater studies and artificial recharge of groundwater.	
Unit - V Practical Exercises	**30**
• Exercises on Water Table Maps and groundwater flow direction estimation.	

• Water level map creation using GIS software • Groundwater Water Quality Indexing (GWQI) map using GIS software. • Numerical problems on porosity, hydraulic conductivity, transmissivity, Storativity etc. • Plotting of Water Quality Data and Piper-plot, Wilcox plot etc.	**30 Hours Lab Sessions**

Text / Reference Books:

1. Hiscock, K, (2005) Hydrogeology Principles and Practice, Wiley-Blackwell.
2. Todd, D.K. (1988): Ground Water Hydrology, John Wiley &Sons,New York.
3. Davies, S.N. and Dc-West, R.J.N. (1966): Hydrogeology,John Wiley & Sons, New York.
4. Ground Water and Wells (1977): UOP, Johnson, Div. St. Paul. Min. USA
5. Raghunath, H.M. (1983): Ground Water, Wiley Eastern Ltd., Calcutta
6. Driscoll, F.G. (1988): Ground Water and Wells, UOP, Johnson Div. St. Paul. Min. USA
7. Fetter,C.W., Applied Hydrogeology (3rd edition),New York, Macmillan,1994
8. NandipatiSubbaRao, Hydrogeology: Problems with Solutions - Prentice Hall India
9. Karanth, K.R., 1987: Groundwater Assessment-Development and Management-Tata McGraw Hall

Content Interaction Plan

Contact Hours	Topic
1-3	Introduction to water resources and current challenges. Controls of geology on groundwater occurrence, movement, and distribution.
4 – 9	Classification of aquifers and aquifer systems; Mode of occurrence of groundwater in different geological formations and groundwater provinces of India
10 – 12	Concept of Darcy's law – validity of Darcy's law – Hydraulic conductivity, transmissivity, storage coefficient and specific capacity; Water table contour maps, specific yield, storage coefficient. Groundwater level, its fluctuations and causes.
12-15	Pump tests and evaluation of hydrologic properties,Determination of hydraulic conductivity.
16 –18	Surface and subsurface methods of groundwater exploration; Application of remote sensing in groundwater exploration.
19–22	Geophysical methods overview and application in groundwater exploration.
23-25	Collection of hydrogeological data and preparation of hydrographs; Selection of suitable site for well construction; Type and design of wells, methods of well construction, well completion and well development.
26-28	Artificial recharge to groundwater and rainwater harvesting; Management of groundwater resources; Conjunctive use of groundwater and surface water.

29-31	Concept of watershed: Watershed characteristics, importance of water resources; Technical aspects of artificial recharge structures;
32–35	Groundwater legislation; government policies problem of overexploitation; ground water legislation
36-40	Groundwater quality and environmental aspects; Chemical characteristics of groundwater in relation to various uses – domestic, industrial and irrigation; Saline water intrusion in coastal and other aquifers and its preventive measures; Environmental effects of over-exploitation of groundwater;
41- –45	Water logging problems; Causative factors of groundwater level fluctuations and environmental influences; Groundwater quality Indexing. Application of H and O isotopes in groundwater studies and artificial recharge of groundwater.
	List of Practical
P=30Hours	• Exercises on Water Table Maps and groundwater flow direction estimation. • Water level map creation using GIS software • Groundwater Water Quality Indexing (GWQI) map using GIS software. • Numerical problems on porosity, hydraulic conductivity, transmissivity, Storativity etc. • Plotting of Water Quality Data and Piper-plot, Wilcox plot etc.

Course Details			
Course Title: Ore Geology &Mining Geology			
Course Code	GEL91DC02004	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	Third/Odd	**Contact Hours**	45 (L) + 15 (T) Hours
Course Type	Discipline Based Core Course		
Nature of the Course	Theory		
Special Nature/ Category of the Course	Not Applicable		
Methods of Content Interaction	(*Lecture, Tutorials, Group discussion, presentations by students, field work etc.)*		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives

- ❖ The Course aims to make to the students well-versed with the strength of Mining Geology applications in the field of Geology.

Course Learning Outcomes

- ❖ The course definitely provides better capability to understand the processes and principles of Mining Geology.

Course Contents	Weightage (%)
Unit – I Ore genesis and its distribution	**25** **17 Lectures**
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- II Ore prospecting and Mining	**35** **20 Lectures**
Surface and subsurface indicators, Field parameters of mineral exploration; Mining terminology.Planning of field work; Mine examination; Surface and underground mapping. Samples: Introduction, principles, methods, types, applications, subsurface sampling, sampling reduction and related aspects. Basic factors of ore estimation; classification of ore reserves & resources, methods of estimation of different types of deposits. Developing & Mining: introduction to development a prospect; prospecting different features (shaft drift and tunnels, ventilation, illumination, transports, drainage).	
Unit- III Physical properties and Distribution of Ores	**15** **07 Lectures**
Physical and optical properties of ore minerals, Importance of minerals in national economy, Concepts of Strategic Critical and Essential minerals and their distribution in India, National Mineral Policy, Mineral concession rule and Law of Sea.	
Unit - IV Ore dressing	**25** **17 Lectures**
Mineral Processing: Definition; Ore Handling: Cleaning, Transportation, Stockpile, Weighing, Sampling, and In-Stream Analyzer, Particle Size Analysis; Comminution: Crushing and Grinding; Screening and Classification; Concentration: Leaching, Ore Sorting, Gravity Concentration, Magnetic Separation, Electrostatic Separation, Dense Medium Separation, Flotation, Dewatering, Tailing Management; Metallurgical Accounting: Plant Recovery, Ore-to-Concentrate Ratio, Enrichment Ratio, Metal Balancing, Milling Cost, Concentrate Valuation; Smelting and Refining; Ore to Concentrate and Metal.	

Text / Reference Books:

1. Arogyaswami, R. N. P. (1988). A course in Mining Geology, 2nd Ed., MohamPrimlani (Oxford & IBH Pub. Co.), New Delhi
2. Evans, A.M. (1992). Ore geology and industrial minerals. Blackwell Science.
3. Peters, W. C. (1987). Exploration and Mining Geology. 2nd Ed., John Wiely& Sons, New York.
4. Haldar, S. K. (2018). Mineral Exploration: Principles and Applications, 2ed Edition. Elsevier Publication.
5. Misra, K.C. (1999). Understanding mineral deposits. Kluwer Academic Publishers

6. Robb, L. (2004). Introduction to Ore-forming Processes. Blackwell Science, UK,384 p.
7. Clark, G.B. (1967). Elements of Mining, III ed. John Wiley

Content Interaction Plan

Contact Hours	Topic
1-12	Spatial and temporal distribution of ore deposits, 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
13-25	Surface and subsurface indicators, Field parameters of mineral exploration; Mining terminology. Planning of field work; Mine examination; Surface and underground mapping.Samples: Introduction, principles, methods, types, applications, subsurface sampling, sampling reduction and related aspects. Basic factors of ore estimation; classification of ore reserves & resources, methods of estimation of different types of deposits. Developing & Mining: introduction to development a prospect; prospecting different features (shaft drift and tunnels, ventilation, illumination, transports, drainage).
26-32	Physical and optical properties of ore minerals, Importance of minerals in national economy, Concepts of Strategic Critical and Essential minerals and their distribution in India, National Mineral Policy, Mineral concession rule and Law of Sea
33-45	Mineral Processing, Ore Handling: Cleaning, Transportation, Stockpile, Weighing, Sampling, and In-Stream Analyzer, Comminution: Crushing and Grinding; Screening and Classification; Concentration: Leaching, Ore Sorting, Gravity Concentration, Magnetic Separation, Electrostatic Separation, Dense Medium Separation, Flotation, Dewatering, Tailing Management; Metallurgical Accounting: Plant Recovery, Ore-to-Concentrate Ratio, Enrichment Ratio, Metal Balancing, Milling Cost, Smelting and Refining; Ore to Concentrate and Metal.
T=15	Tutorial

Course Details			
Course Title: Geochemistry and Isotope Geology			
Course Code	GEL91DE02102	**Credits**	2
L + T + P	2+ 0 + 0	**Course Duration**	One Semester
Semester	Third/Odd	**Contact Hours**	30 (L) Hours
Course Type	Discipline Based Core Elective		
Nature of the Course	Theory		

Special Nature/ Category of the Course	Skill and knowledge based
Methods of Content Interaction	(*Lecture, Tutorials, Group discussion, presentations by students, field work etc.)*
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)

Course Objectives:

The Course aims to make to the students well-versed with the strength:

- ❖ The course aims to give an introduction in how chemical principles are used to explain the mechanisms that control the large geological systems such as the Earth´s mantle, crust, ocean and atmosphere, and the formation of the solar system.

Course Learning Outcomes:

Upon successful completion of the course, students will be able to:

- ❖ To describe the composition of the Earth´s main geochemical reservoirs.
- ❖ To explain element fractionation and how this can be used to understand geochemical processes.
- ❖ To understand evolution of the early Earth from proto-planetary material and its differentiation to present day state.

Course Contents	Weightage (%)
Unit - I Fundamentals of Geochemistry	**60** **16 Lectures**
Principles of geochemistry. Cosmo chemistry, solar and stellar composition; The planet's composition and structure; Detailed study of meteorites; Lunar rocks; Cosmic abundance pattern. Primary geochemical differentiation of the earth; Geochemical classification of elements; Composition and structure of the earth and principles of distribution of elements in the cosmos; Distribution of elements in the earth. Meteorites, their classification, mineralogy, and origin. Earth in relation to the solar system and universe; composition of planets.	
Unit - II Isotope Geochemistry	
Explanation of isotopes with focus on radiogenic isotope systems. Basics of radioactive decay, half-lives and decay constants. Review of basic assumptions in radiometric dating. Rb-Sr, Sm-Nd, U-Pb, K-Ar and Ar-Ar.	**20** **07 Lectures**
Unit- III Geochemical cycle	**20** **07 Lectures**
Whole-rock and mineral isochrons. Significance of initial Sr and Nd isotope ratios in igneous rocks. Stable isotope geochemistry of carbon and oxygen and its applications to Geology. Concepts of geochemical cycle.	

Text / Reference Books:

1. Albarde Francis (2003). Geochemistry- Introduction. Cambridge University Press.
2. Bloss, F.D., (1971). Crystallography and Crystal Chemistry. Holt, Rinehart, and Winston, New York. Klein,
3. C. and Hurlbut, C.S. (1993). Manual of Mineralogy. John Wiley & Sons, New York.
4. Chris Riddle (1993). Analysis of geological materials. Marcel Dekker Inc.
5. Easton, A.J. (1972). Chemical analysis of sillicate rocks. Elsevier
6. Evans, R.C., (1964). Introduction to Crystal Chemistry. Cambridge Univ. Press
7. Faure, G. (1986). Stable Isotope Geochemistry. John Wiley & Sons.
8. Henderson, P. (1984). REE geochemistry. Elsevier.
9. Hoefs, J. (1980). Stable Isotope Geochemistry, Springer and Verlag.
10. Krauskopf, K.B. (1967). Introduction to Geochemistry. McGraw Hill.
11. Mason, B. and Moore, C.B. (1991). Introduction to Geochemistry, Wiley Eastern.
12. Rankama, K. and Sahama Th. G. (1950). Geochemistry. Univ. Chicago Press.
13. Rollinson, H.R. (1993). Using geochemical data: Evaluation, presentation, interpretation. Longman U.K.

Content Interaction Plan

Contact Hours	Topic
1-2	Principles of geochemistry. Cosmochemistry, solar and stellar composition
3 -4	The planet's composition and structure; Detailed study of meteorites
5-6	Lunar rocks; Cosmic abundance pattern.
7 - 8	Primary geochemical differentiation of the earth; Geochemical classification of elements.
9 - 10	Composition and structure of the earth and principles of distribution of elements in the cosmos.
11- 15	Earth in relation to the solar system and universe; composition of planets.
16 - 18	Explanation of isotopes with focus on radiogenic isotope systems.
19 - 20	Basics of radioactive decay, half-lives and decay constants.Review of basic assumptions in radiometric dating.
21 -25	Rb-Sr, Sm-Nd, U-Pb, K-Ar and Ar-Ar. Whole-rock and mineral isochrons.
26 -28	Significance of initial Sr and Nd isotope ratios in igneous rocks. Stable isotope geochemistry of carbon and oxygen and its applications to Geology.

29 - 30	Concepts of geochemical cycle.

Course Details			
Course Title: Cryosphere and Climate change			
Course Code	GEL91DE02202	**Credits**	2
L + T + P	2 + 0 + 0	**Course Duration**	One Semester
Semester	Third/Odd	**Contact Hours**	30 (L) Hours
Course Type	Discipline Based Core Elective		
Nature of the Course	Theory		
Special Nature/ Category of the Course (*if applicable***)**	Not Applicable		
Methods of Content Interaction	(*Lecture, Tutorials, Assignments, Group discussion, Presentation by students and Field work etc.)*		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives:

- ❖ To provide comprehensive knowledge about the geological activities during the Quaternary time period.
- ❖ To provide the different glacial stages and their significance during the different geological time periods.

Course Learning Outcomes:

After successful completion of the course, the students would be able to know

- ❖ Significance of the Quaternary period in the evolutionary history of the Earth and an overview of Quaternary events.
- ❖ Methods employed for dating of glacial sediments.
- ❖ Climate change and health of the glaciers at current scenario.

- ❖ Associated glaciogenic hazards and their mitigations.

Course Contents	Weightage (%)
Unit - I Introduction to Glaciology	**%**
Concept of Cryosphere and its importance, Concept of climate change at current prospective; Glacial terminology sediments transport and deposition by glaciers; sample collections; snout monitoring techniques, remote sensing and GIS applications in the study of glaciers and Mass balance study of glaciers.	**33** **10 Lectures**
Unit- II Different Glacial stages and climate change	**34**
Different techniques used for the dating of glacial deposits; Different glacial stages in geological past; Quaternary glacial and interglacial stages in India with different examples; Correlation of Quaternary glaciation of India with global records.	**10 Lectures**
Unit- III Glaciogenic hazards and Management	**33**
Health of the glaciers at current scenario: case study of different glaciers of Himalayan regions; Glaciogenic hazards: Concept of Glacial Lake Outburst Flood (GLOF) and Landslide Lake Outburst Flood (LLOF) case studies, their monitoring and mapping for mitigation; Snowavalanches their types; Mitigation of avalanches; Case study of Himalayan glaciers regarding their health and future challenges.	**10 Lectures**

Text / Reference Books:

1. Maherand Thompson 2000 Quaternary climates, environments and magnetism. Cambridge Univ. Press
2. Williams, D. et al. 1998 Quaternary Environments. Wiley&Sons.
3. Raina, V.K., Glaciers the Rivers of Ice 2005. Geological Society of India ISBN 10:8185867739
4. Raina,V.K. and Srivastava, D. “Glacier Atlas of India, 2008, Geological Society of India.
5. Bell, M. & Walker, M.J.C. (1992). Late Quaternary Environmental Change. Longman Scientific and Technical, New York.
6. Lowe, J.J. & Walker, M.J.C., (1997). Reconstructing Quaternary Environments Longman. ISBN 0-582- 100166-2.

Content Interaction Plan

Contact Hours	Topic
1-3	Concept of Cryosphere and its importance, Concept of climate change at current prospective
4 -7	Glacial terminology sediments transport and deposition by glaciers; sample collections
8-11	snout monitoring techniques, remote sensing and GIS applications in the study of glaciers and Mass balance study of glaciers
12 - 15	Different techniques used for the dating of glacial deposits; Different glacial stages in geological past;
16 - 19	Quaternary glacial and interglacial stages in India with different examples; Correlation of Quaternary glaciation of India with global records
20 - 23	Health of the glaciers at current scenario: case study of different glaciers of Himalayan regions; Glaciogenic hazards
24 - 26	Concept of Glacial Lake Outburst Flood (GLOF) and Landslide Lake Outburst Flood (LLOF) case studies, their monitoring and mapping for mitigation
27 - 30	Snowavalanches their types; Mitigation of avalanches; Case study of Himalayan glaciers regarding their health and future challenges

Course Details			
Course Title: Natural Hazards and Disaster Management			
Course Code	GEL91OE02404	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	Third/Odd	**Contact Hours**	45 (L) + 15 (T) Hours
Course Type	Open Elective Interdisciplinary Course		
Nature of the Course	Theory		
Special Nature/ Category of the Course (*if applicable***)**	Value Based		
Methods of Content Interaction	(*Lecture, Tutorials, Practical and field work etc.)*		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives:

- ❖ To impart knowledge on concepts related to disaster, disaster risk reduction, disaster management
- ❖ To provide a systematic knowledge base on disaster typology, risk and vulnerability.
- ❖ To comprehend on approaches and measures of disaster management, preparedness and response and related policies, law and methods.
- ❖ To acquaint with the skills for planning and organizing disaster response

Course Learning Outcomes:

After successfully completion of course, the students would be able to

- ❖ Understand role of geologic processes in the assessment of natural hazards
- ❖ Formulate the plan for mitigation and predicting of natural hazards.
- ❖ Spatial correlation of natural hazards and role of anthropogenic activity.
- ❖ Understand the role of Govt. and NGO in disaster management.

Course Contents	Weightage (%)
Unit - I Concept of Natural Hazards and Disasters	**30**
Introduction to natural hazards and disasters, Vulnerability, Resilience, Risks, Dimensions of natural and anthropogenic disasters. Coastal hazards, Earthquakes, Distribution, magnitude and intensity of earthquakes; Seismic hazard zonation. Tsunamis; Volcanoes; Wild fires; Oil spills; Urban hazards and disasters.	**15 Lectures**
Unit- II Application of Space Technology for Disaster study	**25**
Floods –nature and frequency of flooding, flood hazards, urbanization and flooding, flood hydrographs. Mechanism of landslides, type of landslide, cyclones and storms. Deforestation and land degradation. Application of remote sensing & GIS in natural hazards monitoring & management. Urban Heat Island (UHI), Basic concept and impact study. Concept of Glacial Lake outburst (GLOF), cause, consequences and related case studies.	**10 Lectures**
Unit- III Disaster Management and Mitigation	**20**
Concepts and definitions of hazard, disaster, vulnerability and risk, disaster risk reduction, disaster management cycle, paradigm shift of Disaster Management. Disaster profile of India. Pre-disaster: risk assessment and vulnerability analysis, prevention & risk reduction, preparedness and response to disaster. Early warning system, capacity development, awareness, risk mapping and zonation. During-disaster: coordination and communication, evacuation, search and rescue emergency operation center, relief and rehabilitation and response to psychological crises and stress. Post-disaster activities.	**10 Lectures**
Unit - IV Government Planning and Policies for Disaster Management	**25**
National institutional framework (NDRF, NDMA, SDMA, & NIDM, SIDM and other related Departments.), Natural Disaster Management Plan, Best practices in disaster management. Role of NGOs at local, state and national level. Geo-informatics in Disaster Management (RS &GIS, GPS). Land use planning and development for mitigating disaster - disaster resistant house construction. Disaster Risk Reduction (DRR) and Sendai Framework for Disaster Risk Reduction, Early Warning System and Advisories from Appropriate Agencies. Relevance of indigenous Knowledge, appropriate technology and Local resources.	**10 Lectures**

Text / Reference Books:

8. Bell, F. G. (1999). Geological Hazards, Routledge, London.
9. Bryant, E. (1985). Natural Hazards, Cambridge University Press.
10. KelIer, E. A. (1978). Environmental Geology, Bell and HowelI, USA.
11. Patwardhan, A.M. (1999). The Dynamic Earth System. Prentice Hall.
12. Smith, K. (1992). Environmental Hazards. Routledge, London.
13. Subramaniam, V. (2001). Textbook in Environmental Science, Narosa International.
14. Valdiya, X.S. (1987). Environmental Geology - Indian Context. Tata McGraw Hill

Content Interaction Plan

Contact Hours	Topic
1-10	• Introduction to natural hazards and disasters, natural and manmade; • Dimensions of natural and anthropogenic disasters. • Coastal hazards – tropical cyclone, coastal erosion, sea level changes, coastal zone management; • Earth quakes - Distribution, magnitude and intensity of earthquakes; • Tsunamis; Volcanoes; Wild fires; Oil spills; Urban hazards and disasters.
11-22	• Floods –nature and frequency of flooding, flood hazards, urbanization and flooding, flood hydrographs. • Mechanism of landslides, type of landslide, • Cyclones and storms. • Deforestation and land degradation. • Application of remote sensing & GIS in natural hazards monitoring & management. • Urban Heat Island (UHI), Basic concept and impact study.
23-36	• Concepts and definitions of hazard, disaster, vulnerability and risk, • Disaster risk reduction, disaster management cycle, paradigm shift of disaster Management. • Disaster profile of India. Pre-disaster: risk assessment and vulnerability analysis, prevention & risk reduction, preparedness and response to disaster. • Early warning system, capacity development, awareness, risk mapping and zonation. • During- disaster: coordination and communication, evacuation, search and rescue emergency operation centre, relief and rehabilitation and response to psychological crises and stress. • Post-disaster activities.
37-45	• National institutional framework (NDRF, NDMA, SDMA, & NIDM, SIDM and other related Departments.), • Natural Disaster Management Plan, Best practices in disaster management. • Role of NGOs at local, state and national level. • Geo-informatics in Disaster Management (RS &GIS, GPS). • Land use planning and development for mitigating disaster - disaster resistant house construction.
T=15	Tutorial

Course Details			
Course Title: Geoheritage and Geoparks			
Course Code	GEL91ME02500	**Credits**	0
L + T + P	1 + 1 + 0	**Course Duration**	One Semester
Semester	Third/Odd	**Contact Hours**	15 (L) + 15 (T) Hours
Course Type	Mandatory Elective Non-Credit Course		
Nature of the Course	Theory/Field		
Special Nature/ Category of the Course (*if applicable***)**	Value Added		
Methods of Content Interaction	(*Lecture, Tutorials, Practical and field work etc.)*		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives:

- To familiarize the students about the understanding of geoheritages and geoparks and its importance in Nation Building and awareness for conservation of geoheritages.

Course Learning Outcomes:

After successfully completion of course, the students would be able to

- Understand the importance of Geoheritages and geoparks.
- To support sustainable development goals (SDG)
- To support the jobs in the field of Geo-tourisms
- Public awareness for conservation of natural heritages

Course Contents	Weightage (%)
Unit - I Introduction to Geoheritage	**40**

Introduction and importance of Geodiversity, Geoheritage, Geo-conservation; Geoparks and Geo-tourism; History of the concept. Geological outcrops and society; Threats to geodiversity; Conservation, protection, maintenance of geological sites and related features of National importance; Conservation of geosites as a tool to protect geoheritage.	**08 Lectures**
Unit- II Geosites of India	**30**
Potential geoparks and geosites in India; Rajasthan, Odisha, Karnataka, Andhra Padesh, Madhya Pradesh, Telangana, Tamil Nadu, Kerala, Gujarat, Himachal Pradesh. UNESCO geoparks, Geopark networks across the globe; Geotourism and National geological Monuments.	**04 Lectures**
Unit- III Laws for Geoheritage Protection	**30**
Guidelines for selection of Geosites; Geoheritage laws, Role of local, state and national governments; Current status of Geoheritage protection in the country; Global geoheritage and protection laws.	**03 Lectures**

Text / Reference Books:

1. Brilha, J. (2016) Inventory and Quantitative Assessment of Geosites and Geodiversity Sites: a Review. Geoheritage 8, 119–134. https://doi.org/10.1007/s12371-014-0139-3
2. Eder, W. (1999) "UNESCO GEOPARKS"- a new initiative for protection and sustainable development of the Earth's heritage. N JbGeolPaläont (Abh) 214(1/2):353–358
3. Eder, W. and Patzak, M. (2004) Geoparks- geological attractions: a tool for public education, recreation and sustainable economic development. Episodes 27(3):162–164
4. Gray, J. M. (2008) Geodiversity: developing the paradigm. Proc GeolAssoc 119:287–298 Gray, J.M. (2013) Geodiversity: valuing and conserving abiotic nature, 2nd edn. John Wiley & Sons, Chichester
5. Gray, J. M. (2013) Geodiversity: Valuing and Conserving Abiotic Nature, 2nd ed. Wiley Blackwell,
6. Henriques, M. H., Pena dos Reis, R., Brilha, J. and Mota, T. S. (2011) Geoconservation as an emerging geoscience. Geoheritage 3(2):117–128
7. INTACH (2021) A monograph on Potential Geoparks in India. Indian National Trust for Art and Cultural Heritage (Ed. D. Rajasekhar Reddy). New Delhi. 266p.
8. Sharples, Chris (2002) Concepts and Principles of Geo-conservation. Published electronically on the Tasmanian Parks & Wildlife Service website.

Content Interaction Plan

Contact Hours	Topic
1-8	• Introduction and importance of Geodiversity, Geoheritage, Geo-conservation; Geoparks and Geo-tourism; • History of the concept. Geological outcrops and society; Threats to geodiversity; Conservation, protection, maintenance of geological sites and related features of National importance;

	• Conservation of geosites as a tool to protect geoheritage.
9-12	• Potential geoparks and geosites in India; Rajasthan, Odisha, Karnataka, Andhra Padesh, Madhya Pradesh, Telangana, Tamil Nadu, Kerala, Gujarat, Himachal Pradesh. • UNESCO geoparks, Geopark networks across the globe; Geotourism and National geological Monuments.
13-15	• Guidelines for selection of Geosites; • Geoheritage laws, Role of local, state and national governments; • Current status of Geoheritage protection in the country; • Global geoheritage and protection laws.
T=15 Hours	Tutorials

SEMESTER IV (Total Credits = 20)			
Nature of Course	**Course Code**	**Name of Course**	**Credit (L+T+P)**
Discipline Based Core Course	GEL92DC05120	Dissertation	20
Credits = 20			

Course Details			
Course Title: Dissertation			
Course Code	GEL92DC05120	**Credits**	20
L + T + P	0 + 0 + 20	**Course Duration**	One Semester
Semester	Fourth/Even	**Contact Hours**	
Course Type	Discipline Based Core Course		
Nature of the Course	Field work cum Research work		
Special Nature/ Category of the Course	Value Based, Skill Based		
Methods of Content Interaction	(*Primary data collection & analysis, seminar, presentations by students, field work etc.)*		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

During the IV Semester, the students shall undertake a Dissertation on any topic of applied Geology. The topic of Dissertation shall be assigned to the students based on the available specialization. Students can do the dissertation work in department under the supervision of

departmental faculty as well as students can go for dissertation in any research, academic and industry for the given timeline and they would be allotted an internal faculty in the department, who would act as their Dissertation Internal Supervisor. The students shall remain in contact with their Supervisor, for day-to-day progress of the work done by them. During the course of completion of the Dissertation work, the student will be required to complete various assignments given to them by their respective Supervisor, for the purpose of evaluation**.** The students will be required to submit the Dissertation by the date specified to them in the Fourth Semester. The Dissertation shall be of 100 Marks out of which, Marks will be on the basis of submitted Dissertation Work (Thesis), Monthly Progress Report (MPR), Feedback from external supervisor, Presentation followed by Viva-Voce Examination evaluated by panel of Internal and external examiners. CUSB will not provide any financial support for dissertation work conducted outside the department.