Central University of South Bihar

Integrated Bachelor's - Master's Degree Programme (Geology)

Multiple Entry and Exit

Syllabus

(Effective from Academic Session 2025-2026)

Department of Geology
School of Earth, Biological and Environment Sciences
Central University of South Bihar, Gaya-824236

B.Sc. (Geology)/ B.Sc. (Honours/ Research)/ Master of Science (Integrated) in Geology Multiple Entry and Exit

Vision Statement:

Be a nationally recognised department for excellence in research and education in the field of Geosciences.
To produce well-trained professional geoscientists to contribute for achieving the sustainable development Goals (SDGs).

Mission Statement:

- To conduct interdisciplinary, innovative, technologically advanced research that is widely translated and communicated for the benefit of society.
- To build the intellectual and human resources capacity through teaching, community service and research in geosciences.
- Prepare the next generation of geoscientists to conduct research, to find and develop natural resources, and to measure and respond to environmental change.
- To create awareness about the importance of Earth science study, natural resources and hazards among the public, students and scientific communities.

1. Introduction

The vision of the Integrated B.Sc. - M.Sc. course is to provide a comprehensive and interdisciplinary education inculcating a deep understanding in the Geological Sciences. The program aspires for lifelong learning through interdisciplinary approach for overall holistic development and to archive excellence in field.

Program Educational Objectives (PEO)

After five years of successful completion Integrated UG - PG Program in Geology, the student will be able to

PEO-1

Imparting geological knowledge and skills to gain employment in Industry, Academics and Research organizations and other service sectors.

PEO-2

To produce graduate - post graduates with knowledge and understanding of Geological Sciences and their applications in Sustainable Development Goals.

PEO-3

To produce skilled man power who are able to formulate, analyse, and solve issues in the of Geological Sciences.

PEO-4

To apply the acquired knowledge and skill to cater the needs of the academia, research and applies new knowledge for the betterment of society**.**

PEO-5

To inculcate the values of ethics and quality among students for providing constant productive services to the society.

Programme Outcomes (POs):

After going through the five-year Integrated UG - PG program in Geology, graduates will exhibit the capacity to:

1. **Disciplinary Knowledge**: Understand various aspects of Geology and apply tools and techniques for the betterment of their existence.
2. **Communication Skills:** Develop the verbal and written communication skills to convey the ideas clearly and concisely.
3. **Critical Thinking:** Capacity to generate hypothesis, design and conduct experiments, analyses the data and interprets, and report results.
4. **Problem Solving:** Design and execute process to find solutions for biological problems to meet the needs of society.
5. **Ethics:** Demonstrate and adherence to accepted standards of ethics and responsibilities.
6. **Reasoning:** Ability to analyse the scientific data critically and systematically and the ability to draw the objective unbiased conclusions.
7. **Creativity:** Ability to think out-of-the-box and innovate means to overcome challenges.
8. **Societal and Environmental Concern:** Appreciate and contribute to improve the quality of environment and sustainable utilization of earth resources.

2. Minimum Eligibility for Admission

Eligibility criteria for the B.Sc. - M.Sc. integrated course is given below: -

- Candidates must appear in CUET entrance Examination through common test.
- The candidate must pass the 10+2 or equivalent examination in science stream with the subject combination of Physics, Chemistry, Mathematics/Biology from any recognized Board / University with at least 50% marks for General /OBC/EWS and 45 % marks for SC/ST/PWD candidate
- Only those students having CGPA more than 7.5 throughout the previous semesters may undertake Research Project of 12 credits.

3. Different levels of Multiple Entry and Exit System and its credit requirements.

Admission through a multiple-level entry

Sl. No.	Entry Points	Basic Eligibility	Mode of Entrance
1	Semester 1	Std. 12 Certificate	Common University Entrance Test
2	Semester 3	40 Credits with a UG Certificate and 4	Counselling-cum-

		credits of skill enhancement Course	Interaction comprising 100 marks
3	Semester 5	80 Credits with a UG Diploma and 4 credits of skill enhancement Course	Counselling-cum-Interaction comprising 100 marks
4	Semester 7	120 Credits with a Degree of Bachelor in Science	Counselling-cum-Interaction comprising 100 marks
5	Semester 9	160 Credits with a Degree of Bachelor (Honours/Research)	Counselling-cum-Interaction comprising 100 marks

Award of Certificate/ Diploma/ Degree along with multiple Exit Options

Sl. No.	**Exit Points**	**Qualification Title**	**NHEQF Level**
1	After completion of Semesters 1 & 2	UG Certificate in (Basic Geology)	5
2	After completion of Semesters 1,2,3 & 4	UG Diploma in (Basic Geology)	6
3	After completion of Semester 1,2,3,4,5 & 6	Bachelor of Science (Geology)	7
4	After completion of Semesters 1,2,3,4,5,6,7 & 8	Bachelor of Science (Honours/Research)	8
5	After completion of Semesters 1,2,3,4,5,6,7,8,9 & 10	Master of Science (Integrated) in Geology	9

UG CERTIFICATE COURSE IN GEOLOGY (FIRST YEAR)

SEMESTER I				
Course Types	**Course Code**	**Name of Course**	**(L+T+P)**	**Credits**
Major Course	GEL51MJ00104	Mineralogy	3+0+1	4
Minor Course		From Chemistry/Environmental Science/Physics/Maths/Statistics / Computer Sciences/ Biological Sciences/ SWAYAM courses		4
Multidisciplinary Course (MD)		From other Departments / SWAYAM courses		3
Skill Enhancement Course (SEC)	GEL51SE00203	Tools and Techniques used in Geological Sciences	1+1+1	3
Value Added Course (VAC)	GEL51VA00302	Indian Contributors in Earth Sciences	2+0+0	2
Value Added Course (VAC)		Courses offered by other Departments		2
Ability Enhancement Course (AEC)		University level offered Courses		2
	Minimum Credits required for Semester I			**20**

Courses offered for students of other Departments

Course Types	**Course Code**	**Name of Course**	**(L+T+P)**	**Credits**
Minor Course	GEL51MJ00104	Mineralogy	3+0+1	4
Multidisciplinary Course (MD)	GEL51MD00403	Earth System Science	2+1+0	3

Course Title: Mineralogy

Course Code	GEL51MJ00104	**Credits**	4
L + T + P	3+0+1	**Course Duration**	One Semester
Semester	One/Odd	**Contact Hours**	45 (L) + 30 (P) Hours
Course Type	Major Course		
Nature of the Course	Theory/Practical		
Special Nature/ Category of the Course (*if applicable*)	Concept and Skill Based		
Methods of Content Interaction	Lecture, Group discussion; Self-study, Seminar		
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.

Course Learning Outcomes:

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

- ❖ Identify and classify different rock-forming silicate minerals; study the physical and optical properties of minerals.
- ❖ Learn to handle petrological microscope, understand crystal systems and symmetry elements in crystallography; characterize isomorphs and polymorphs minerals.

Course Contents (Mineralogy)	Weightage (%)
Unit-I Introduction of Minerals	**20** **12 Lectures**
Definition of mineral, crystalline and amorphous, mineraloids; Chemical classification of minerals, Types of bonding in minerals, Minerals in the Earth Crust with examples, Gemstone minerals, Importance of minerals in the various field.	
Unit- II Classification and Properties of Minerals	**20** **12 Lectures**
Anions and cations, coordination number, Radius ratio, Silicon tetrahedron, Classification of silicate minerals, Physical properties of minerals: form, colour,	

streak, hardness, specific gravity, lustre, cleavage, fracture, tenacity, magnetism and diaphaneity properties, Moho's scale of hardness, polymorphs and isomorphs of minerals.	
Unit- III Basic Crystallography	**15**
Define crystal, crystal lattice, crystal structure, faces, edges, solid angle, zones, Euler's formula, Interfacial angle of crystals, crystal forms; Open and closed crystal forms and their examples; Crystallographic axes and angle, Classification of different crystal systems; Examples of minerals from each crystal system; concept of symmetry elements.	**9 Lectures**
Unit - IV Interaction of Light and Minerals	**20**
Interaction of light with minerals, Ordinary and polarized light, Reflection and refraction of light, critical angle, total internal reflection, Refractive index and Becke's line effect, Components of petrological microscope and its working, Nicol Prism, isotropic and anisotropic minerals, optical properties of minerals.	**12 Lectures**
Unit –V Lab Experiments	**25**
• Megascopic study of common rock-forming minerals in hand specimens and their identification. • Learn to determine the hardness, streak, specific gravity and other physical properties of minerals. • Study of crystal models, identify crystallographic axes, faces and determine the axis, plane and centre of symmetry in crystals • Study optical properties of common rock-forming minerals under microscopic. • Learn types of extinction in minerals and measure the extinction angle of the minerals.	**30 Hours Lab Sessions**

Text & Reference Books

1. Dana, E.S. and Ford, W.E. (2002). A textbook of Mineralogy (Reprint).
2. Deer, W. A., Howie, R. A. and Zussman, J. (1966). An Introduction to the Rock-Forming Minerals. The Mineralogical Society, London.
3. Flint, F. (1964). Essentials of Crystallography. Peace Pub., Russia.
4. Kerr, P.F. (1977). Optical Mineralogy. McGraw Hill.
5. Nesse, D.W. (1991). Introduction to Optical Mineralogy, Oxford University
6. Nesse, D.W. (1999). Introduction to Mineralogy, Oxford University Press
7. Perkins, D. (1998). Mineralogy. Pearson Education
8. Sharma, R.S. and Sharma, A. (2013). Crystallography and Mineralogy. Geological Society of India.

Content interaction plan

Contact Hours	Topic
1-5	Define Minerals, crystalline and amorphous, mineraloids; Chemical classification of minerals, Types of bonding in minerals, Minerals in the Earth Crust, Gemstone minerals, Importance of minerals
6 – 9	Define coordination number, Radius ratio, Silicon tetrahedron, Brief introduction of silicate minerals classification
10 – 15	Discuss the physical properties of minerals: form, colour, streak, hardness, specific gravity, lusture, cleavage, fracture, tenacity, magnetism and diaphaneity properties, Moho's scale of hardness, polymorphs and isomorphs of minerals
16-21	What is crystal? Define crystal lattice, crystal structure, faces, edges, solid angle, zones, Euler's formula, Interfacial angle of crystals,
22 –27	Crystal forms; Open and closed crystal forms; Crystallographic axes and angle, Classification of different crystal systems; the concept of symmetry elements: Axis, plane and centre of symmetry in the crystal.
28 –35	Interaction of light with minerals, Ordinary and polarized light, Reflection and refraction of light, critical angle, total internal reflection, Refractive index and Becke's line effect
36-40	Components of petrological microscope and its working, Nicol Prism, polarizer, analyser and Bertrand lens, plane polarized and cross-polarized light, isotropic and anisotropic minerals,
41-45	Optical properties of minerals: colour, relief, pleochroism, twinkling, cleavage/fracture, alteration, extinction, interference colour, birefringence etc.
P= 30 Hours	**List of Practical** • Megascopic study of common rock-forming minerals in hand specimens and their identification. • Learn to determine the hardness, streak, specific gravity and other physical properties of minerals. • Study of crystal models, identify crystallographic axes, faces and determine the axis, plane and centre of symmetry in crystals • Study optical properties of common rock-forming minerals under microscopic. • Learn types of extinction in minerals and measure the extinction angle of the minerals.

Course Title: Tools and Techniques used in Geological Sciences

Course Code	GEL51SE00203	**Credits**	3
L + T + P	1 + 1 + 1	**Course Duration**	One Semester
Semester	First/Odd	**Contact Hours**	15 (L)+ 15 (T)+ 30 (P) Hours
Course Type	Skill Enhancement Course (SEC)		
Nature of the Course	Theory/Practical		
Special Nature/ Category of the Course (*if applicable*)	Concept and Skill Based		
Methods of Content Interaction	Lecture, Group discussion; Self-study		
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 basic concepts map, their types and its importance in geology and other branches.

- The course is aimed to enable the students to understand about the science of cartography (map making) and the how its help to decipher the detail 3Dimensional information of any area/region of the world on plain paper in 2 Dimension.

Course Learning Outcomes:

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

- Understand the terminology, symbology and application of cartography in modern science to solve the various problems.
- Mapping is one of the major parts of disaster risk reduction (DRR) at current scenario. This course will definitely help to produce the skill persons that can help to manage the disaster through monitoring and mapping.

Course contents (Tools and techniques used in geological sciences)	Weightage (%)
Unit I Basic Concept of Map and its Components	
Concept of Map; Important component of maps; Classification of maps, Scale, symbols and Legends, Symbol and Signs used on maps, Introduction to Topographical map, Geological maps, Geomorphological maps, Determination of latitude and longitude from toposheet, Grid system, Concept of Contour line and their significances.	**35** **08 Lectures**
Unit II Identification and Interpretation of various Landforms on Map	
Interpretation of various geomorphic landforms and different drainage patterns on toposheet, Map exercise related to plotting of major mountain ranges, lakes and rivers of India & seismic data on map, Preparation of cross section profile, Slope Calculation, Preparation of contour map.	**30** **07 Lectures**
Unit III Lab exercise on Toposheets and Images	
Hands on practice and various exercise on Toposheets, Satellite images, Aerial photos etc.	**35** **30 Hours Lab Sessions**

Content interaction plan

Contact Hours	Topic
1-3	Concept of Map; Important component of maps; Classification of maps, Scale, symbols and Legends, Symbol and Signs used on maps.
4 – 8	Introduction to Topographical map, Geological maps, Geomorphological maps, Determination of latitude and longitude from toposheet, Grid system, Concept of Contour line and their significances.
9 – 11	Interpretation of various geomorphic landforms and different drainage patterns on toposheet.
12-15	Map exercise related to plotting of major mountain ranges, lakes and rivers of India & seismic data on map, Preparation of cross section profile, Slope Calculation, Preparation of contour map.
T=15 Hours	Tutorials
P= 30 Hours	**List of Practical** • Hands-on Practice on Toposheets. • Hands-on Practice on Satellite images, • Hands-on Practice on Aerial photos

Course Title: Indian Contributors in Earth Sciences

Course Code	GEL51VA00302	**Credits**	2
L + T + P	2+ 0 +0	**Course Duration**	One Semester
Semester	First/Odd	**Contact Hours**	30 (L) Hours
Course Type	Value Added Course		
Nature of the Course	Theory		
Special Nature/ Category of the Course (*if applicable*)	Indian Knowledge System		
Methods of Content Interaction	Lecture, Group discussion; Self-study, Seminar		
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 history of Geology and contribution certain Indian and British geologist in the geological knowledge system of India.

Course Learning Outcomes:

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

- ❖ Understand the stages of geological studies in the past.
- ❖ Understand the contribution of Indian and British geologist in the geological knowledge system of India.
- ❖ Apprise the relationship between Indian mythology and geology.
- ❖ Appreciate the contribution of certain Indian geological organization in the field of nation building and basic research.

Course Contents (Indian Contributors in Earth Sciences)	Weightage (%)
Unit – I Introduction to Geoscience and IKS	**30** **10 Lectures**
A brief study on the Geo-mythology of India. Geoscience as a part of Indian knowledge system and a brief historical account on geological studies in the past. Contribution of pioneer Indian and British geologist in the Geological knowledge of India.	
Unit- II Major Geological Institute and their Contributions	**42** **12 Lectures**
Understanding the major geological institutions and their roles and contributions in nation building: Geological Survey of India, ONGC, CGWB, Wadia Institute of Himalayan Geology, Birbal Sahni Institutes of Paleoscience, NGRI, PRL, ISRO, AMD, NRSC, IIRS, NCESS, NIO, NCPOR, Indian Institute of Geomagnetism, SJVN, NHPC, Coal India Limited, MECL, NHPC, etc. and other institutions. Geological Society of India, INSA, Indian Geological Congress, Indian Geophyical Union, their roles in nation building and basic research. Major awards by Government of India, societies and institutions in the field of Earth Sciences.	
Unit- III Scope of Geology and Contribution of Contemporary Eminent Geologists	**28** **08 Lectures**
Scope, prospects and challenges in Geology as a multidisciplinary Science. Recent advancement in geology and Geoscience. Understanding the contribution of eminent geologists in contemporary India.	

Text / Reference Books:

References:

1. Barbara Leigh Ransom, Sonya Wainwright and Barbara Ransom, 2001. Recent Advances and Issues in the Geological Sciences. Oryx Press.
2. Institute for Career Research 2018. Careers in Geology: Geosciences. Createspace Independent Publishing Platform.
3. Dr. V.M. Rokade, 2022. Recent Advances in Geology and Earth Sciences (Volume - 2). AkiNik Publications.
4. O'Hara, Kieran D. (2018). A Brief History of Geology. Cambridge, England: Cambridge University Press.
5. KS Valdiya 2012. Geography, Peoples and Geodynamics of India In Puranas and Epics: A Geologist's Interpretation. ARYAN BOOKS INTERNATIONAL.
6. By Dr. Binod Bihari Satpath HISTORY OF SCIENCE AND TECHNOLOGY IN INDIA
7. Martin J.S. Rudwick, 2018.The New Science of GeologyStudies in the Earth Sciences in the Age of Revolution. Routledge, 336 Pages,ISBN 9781138382503.

8. Tolman, Aja B., "Geologists and the British Raj, 1870-1910" (2016). All Graduate Theses and Dissertations. 4989. https://digitalcommons.usu.edu/etd/4989
9. Geological Pioneers - Edinburgh Geological Society (edinburghgeolsoc.org)
10. Geology | Birbal Sahni Institute of Palaeosciences (bsip.res.in)
11. https://www.ias.ac.in/article/fulltext/reso/008/02/0065-0075

Content Interaction Plan

Contact Hours	Topic
1-6	A brief study on the Geo-mythology of India. Geoscience as a part of Indian knowledge system and a brief historical account on geological studies in the past.
7– 10	Contribution of pioneer Indian and British geologist in the Geological knowledge of India
11 – 16	Understanding the major geological institutions and their roles and contributions in nation building: Geological Survey of India, ONGC, CGWB, Wadia Institute of Himalayan Geology, Birbal Sahni Institutes of Paleoscience, NGRI, PRL, ISRO, AMD, NRSC, IIRS, NCESS, NIO, NCPOR, Indian Institute of Geomagnetism, SJVN, NHPC, Coal India Limited, MECL, NHPC, etc.
17-20	Geological Society of India, INSA, Indian Geological Congress, Indian Geophyical Union, their roles in nation building and basic research.
21-22	Major awards by Government of India, societies and institutions in the field of Earth Sciences
23 –24	Scope, prospects and challenges in Geology as a multidisciplinary Science.
25-28	Recent advancement in geology and Geoscience.
29 –30	Understanding the contribution of eminent geologists in contemporary India.

Course Title: Earth System Science

Course Code	GEL51VA00403	**Credits**	3
L + T + P	2 + 1 + 0	**Course Duration**	One Semester
Semester	First/Odd	**Contact Hours**	30 (L)+15 (T) Hours
Course Type	Multidisciplinary Course		
Nature of the Course	Theory		
Special Nature/ Category of the Course (*if applicable*)	Concept and Skill Based		
Methods of Content Interaction	Lecture, Group discussion; Self-study, Seminar		

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 basics about Earth Science and its importance at current prospective.

- ❖ The course is aimed to enable the students to understand about the Universe, Solar system, and Earth and governing interior and exterior earth processes that crafted the various scenic landforms on Earth surface.

Course Learning Outcomes:

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

- ❖ Understand the what is earth science and how it differs from the other branches.
- ❖ Systematically understand various govern surface and subsurface earth's processes and how these processes responsible for the formation of various landforms and associated features.

Course Contents (Earth System Science)	Weightage (%)
Unit – I Introduction to Earth Science	**30** **08 Lectures**
Introduction about the Earth Science and their branches, Importance of Earth Science at current scenario, General characteristics and origin of the Universe, Solar System and its planets. The terrestrial and Jovian planets. Meteorites and Asteroids. Earth in the solar system - origin, size, shape, mass, density, rotational and revolution parameters. Origin of atmosphere, ocean and life.	
Unit- II Earth and their Components	**20** **07 Lectures**
Earth and its different layers: lithosphere, asthenosphere, mantle and core. Earthquake and earthquake belts: seismic waves and internal constitution of the Earth. Volcanoes and volcanism, distribution of volcanoes. Concept of isostasy. Convection in Earth's core and production of its magnetic field. Geothermal gradient and internal heat of the Earth.	
Unit- III Earth's Surface and Subsurface Processes (Ancient and Modern concepts)	**20** **07 Lectures**
Historical development of the concept of continental drift and plate tectonics. Plates and plate boundaries. Geodynamic elements of Earth: mid oceanic ridges, trenches, transform faults and island arcs. Plate tectonics: mountain belts and rift valleys. Soils: types, soil profile, processes of formation of soil.	
Unit- IV Changes on Earth through Time and their Records	**30** **08 Lectures**
Nature of stratigraphic records. Fundamental laws of stratigraphy: laws of superposition and faunal succession. Absolute and relative time in Geology. Concept of time and geological time scale, Concept of radiometric dating. Radiometric dating of rocks and minerals: U-Pb, Pb-Pb, K-Ar, Rb-Sr, Sm-Nd methods. Concepts of neptunism, plutonism, uniformitarianism, and catastrophism.	

Text / Reference Books:

1. Duff, P. M. D. and Duff, D. (Eds.) (1993). Holmes' principles of physical geology. Taylor and Francis.
2. Emiliani, C. (1992). Planet Earth: cosmology, geology, and the evolution of life and environment. Cambridge University Press.
3. Gross, M. G. (1977). Oceanography: A view of the earth.
4. Tarback, E. J. and Lutgens, F.K. (2006). Earth Science. Pearson Prentice Hall, New Jersey.
5. Grotzinger, J., Jordan, T.H., Press, F and Siever, R. (2007) Understanding Earth (Fifth Edition). W. H. Freeman and company, New York.

Content Interaction Plan

Contact Hours	Topic
1-6	Introduction about the Earth Science and their branches, Importance of Earth Science at current scenario, General characteristics and origin of the Universe, Solar System and its planets.
7-11	The terrestrial and Jovian planets. Meteorites and Asteroids. Earth in the solar system - origin, size, shape, mass, density, rotational and revolution parameters. Origin of atmosphere, ocean and life.
12-14	Earth and its different layers: lithosphere, asthenosphere, mantle and core. Earthquake and earthquake belts: seismic waves and internal constitution of the Earth.
15-17	Volcanoes and volcanism, distribution of volcanoes. Concept of isostasy. Convection in Earth's core and production of its magnetic field. Geothermal gradient and internal heat of the Earth.
18-20	Historical development of the concept of continental drift and plate tectonics. Plates and plate boundaries.
21-23	Geodynamic elements of Earth: mid oceanic ridges, trenches, transform faults and island arcs. Plate tectonics: mountain belts and rift valleys.
24-25	Soils: types, soil profile, processes of formation of soil.
26-27	Nature of stratigraphic records. Fundamental laws of stratigraphy: laws of superposition and faunal succession. Absolute and relative time in Geology.
28-30	Concept of time and geological time scale, Concept of radiometric dating. Radiometric dating of rocks and minerals: U-Pb, Pb-Pb, K-Ar, Rb-Sr, Sm-Nd methods. Concepts of neptunism, plutonism, uniformitarianism, and catastrophism.
T = 15 Hours	Tutorial

SEMESTER II				
Course Types	**Course Code**	**Name of Course**	**(L+T+P)**	**Credits**
Major Course	GEL52MJ00504	Introduction to Geological Sciences	3+1+0	4
Minor Course		From Chemistry/Environmental Science/Physics/Maths/Statistics / Computer Sciences/ Biological Sciences/ SWAYAM courses		4
Multidisciplinary Course (MD)		From other Departments / SWAYAM courses		3
Skill Enhancement Course (SEC)	GEL52SE00603	Surveying and Mapping Techniques	1+0+2	3
Value Added Course (VAC)	GEL52VA00702	Sustainable Development Goals (SDGs)	2+0+0	2
Value Added Course (VAC)		Courses offered by other Departments		2
Ability Enhancement Course (AEC)		University level offered Courses		2
Minimum Credits required for Semester II				**20**
After Two Semesters Summer Vacation (6-8 weeks) Summer Internship				4

Courses offered for students of other Departments

Course Types	**Course Code**	**Name of Course**	**(L+T+P)**	**Credits**
Minor Course	GEL52MJ00504	Introduction to Geological Sciences	3+1+0	4
Multidisciplinary Course (MD)	GEL52MD00803	Natural Resource Management	2+1+0	3

Course Title: Introduction to Geological Sciences

Course Code	GEL52MJ00504	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	Second/Even	**Contact Hours**	45 (L)+15 (T) Hours
Course Type	Major Course		
Nature of the Course	Theory		
Special Nature/ Category of the Course (*if applicable*)	Concept and Skill Based		
Methods of Content Interaction	Lecture, Group discussion; Self-study, Seminar		
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 about basics and importance of Geological science.

- ❖ The course is aimed to enable the students to understand about the geology and geological processes that crafted the various scenic landforms on Earth surface.

Course Learning Outcomes:

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

- ❖ Understand the what is geology and how it differs from the other branches
- ❖ Systematically understand various govern surface and subsurface earth's processes and how these processes responsible for the formation of various landforms and associated features.

Course Contents	Weightage (%)
Unit – I Introduction to Geological Science	**30** **16 Lectures**
Introduction to geological sciences, scopes and subdivisions; origin and age of the Earth; shape, size, mass, density, magnetism and orbital parameters of the Earth; internal structure of the Earth. Earth as a natural magnet, Paleo magnetism and polar reversals. Introduction to the concept of geological time scale.	
Unit- II Fundamental of Geological Processes	**26** **13 Lectures**
Concept of landforms and related geological processes; Endogenic processes: volcano and volcanism - their types and distribution; earthquakes – definition, focus, epicentre, magnitude, intensity, causes of earthquakes, properties and propagation of seismic waves, earthquake belts, earthquake zones of India, strategy of mitigation.	
Unit- III Geological Process and associated Landforms	**22** **08 Lectures**
Exogenic processes: Weathering, controlling factors of weathering, type of weathering processes (mechanical, chemical, biological), importance of weathering; Erosion, transportation and deposition by water (surface and subsurface), wind, glaciers, and their related landforms.	

Unit- IV Modern concepts of Geological Processes	22 08 Lectures
Concept of plate tectonics, sea-floor spreading and continental drift Geodynamic elements of Earth- Mid Oceanic Ridges, trenches, transform faults and island arcs; Concept of orogeny and epeirogeny; Concept of Isostasy; mass movements - mechanism, factors and triggers, classification of mass movement.	

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. Duff, P. M. D. and Duff, D. (Eds.) (1993). Holmes' principles of physical geology. Taylor and Francis.
4. Halis, J.R. (1983). Applied Geomorphology.
5. Shroder J. F. Treatise on Geomorphology. Academic Press Hall, London.
6. Edward A. Keller and Nicholas (1996) Active Tectonics: Earthquakes, Uplift and Landscape - Pinter, Prentice Hall
7. Richard John Huggett and Routledge (2011) Fundamentals of Geomorphology. Routledge CRC Press

Content Interaction Plan

Contact Hours	Topic
1-8	Introduction to geological sciences, scopes and subdivisions; origin and age of the Earth; shape, size, mass, density, magnetism and orbital parameters of the Earth; internal structure of the Earth
9-11	Earth as a natural magnet, Paleo magnetism and polar reversals. Introduction to the concept of geological time scale
12-16	Concept of landforms and related geological processes; theory of landscape evolution; Endogenic processes: volcano and volcanism - their types and distribution
17-22	earthquakes – definition, focus, epicentre, magnitude, intensity, causes of earthquakes, properties and propagation of seismic waves, earthquake belts, earthquake zones of India, strategy of mitigation.
23-28	Exogenic processes: Weathering, controlling factors of weathering, type of weathering processes (mechanical, chemical, biological), and importance of weathering.
29-34	Erosion, transportation and deposition by water (surface and subsurface), wind, glaciers, and their related landforms
35-41	Concept of plate tectonics, sea-floor spreading and continental drift Geodynamic elements of Earth- Mid Oceanic Ridges, trenches, transform faults and island arcs.
42-45	Concept of orogeny and epeirogeny; Concept of Isostasy; mass movements - mechanism, factors and triggers, classification of mass movement.
T = 15 Hours	Tutorial

Course Title: Surveying and Mapping Techniques

Course Code	GEL52SE00603	**Credits**	3
L + T + P	1 + 0+ 2	**Course Duration**	One Semester
Semester	Second/Even	**Contact Hours**	15 (L) + 60 (P) Hours
Course Type	Skill Enhancement Course (SEC)		
Nature of the Course	Practical/Theory		
Special Nature/ Category of the Course	Not applicable		
Methods of Content Interaction	(*Lecture, 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 provide comprehensive knowledge about the Total Station, Global Positioning System (GPS) and Stereoscope instruments and their applications in various field.
- Field "in and around" Gaya region will provide the detail knowledge about lithology and topography of the region.

Course Learning Outcomes:

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

- Determine coordinates for given location
- Calculate the area of a given land.
- Display contour map of a given area.
- Perform the survey of existing road alignment/Intersection
- Perform the geotechnical survey in
- Collect Ground Control Point (GCP) at various locations

Course Contents (Surveying and Mapping Techniques)	Weightage (%)
Unit – I Introduction of Surveying and Mapping with Total Station	**33** **05 Lectures**
Basic of Total Station and their applications; Measurement of sloping distance, horizontal angle and vertical angle of remote object using total station (using Direct and Prism both); Measurement of an area of remote object using total station; Volume calculation using total station; Measurement of remote height of an object using total station; Data transfer from total station to computer; Surveying existing road using total station; Mini Group Project.	
Unit- II Global Positing System	

Fundamentals of Global Positing System (GPS); Collecting coordinates (ground control point) using GPS; Application and Importance of GPS at current scenario; Mini Group Project.	**32** **04 Lectures**
Unit- III Aerial Photographs and Photogrammetry	
Fundamentals of Aerial photographs and Photogrammetry; Hands on practice on Aerial photographs of various terrain using stereoscope (Pocket and Mirror); Local field visit Gaya and surrounding areas.	**35** **06 Lectures**

Course Title: Sustainable Development Goals (SDGs)

Course Code	GEL52VA00702	**Credits**	2
L + T + P	2 + 0+ 0	**Course Duration**	One Semester
Semester	Second/Even	**Contact Hours**	30 (L) Hours
Course Type	Value Added Course (VAC)		
Nature of the Course	Theory		
Special Nature/ Category of the Course	Knowledge based		
Methods of Content Interaction	(*Lecture, 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 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 (Sustainable Development Goals)	Weightage (%)
Unit – I Introduction to Sustainable Development Goals	

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.	**40** **12 Lectures**
Unit- II Environmental Issues and Management	
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.	**30** **09 Lectures**
Unit- III General Awareness and Societal Impact	
Sustainable Development Solutions Network (SDSN) Youth, for conducting peer-learning programmes to improve youth engagement and knowledge. Acknowledging the role of youth in sustainable development, organizations and governments, established strategies to raise youth's awareness and capacity for the SDGs. Approaches to Sustainable Development: Community Capacity building Approach, industrial sector approach, integrated systems approach, human development and green account approach.	**30** **09 Lectures**

Text / Reference Books:

1. Global Goals, 2016, The Global Goals: http://www.globalgoals.org/ (accessed January 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 Jb GeolPaläont (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	Sustainable Development Solutions Network (SDSN) Youth, for conducting peer-learning programmes to improve youth engagement and knowledge. Acknowledging the role of youth in sustainable development, organizations and governments, established strategies to raise youth's awareness and capacity for the SDGs.
28 – 30	Approaches to Sustainable Development: Community Capacity building Approach, industrial sector approach, integrated systems approach, human development and green account approach.

Course Title: Natural Resource Management

Course Code	GEL52MD00803	**Credits**	3
L + T + P	2 + 1 + 0	**Course Duration**	One Semester
Semester	Two/Even	**Contact Hours**	30 (L)+15 (T) Hours
Course Type	Multidisciplinary course		
Nature of the Course	Theory		
Special Nature/ Category of the Course (*if applicable***)**	Concept and Skill Based		
Methods of Content Interaction	Lecture, Group discussion; Self-study, Seminar		
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 to introduce this course are;

- ❖ To educate students on the principles and practices needed to sustainably utilize and conserve natural resources like land, water, soil, minerals, and energy, ensuring their availability for present and future generations.
- ❖ To explore various management techniques for different resource types, including conservation, restoration, mitigation, and utilization strategies.

Course Learning Outcomes:

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

- ❖ Understand an overview of the various natural resources
- ❖ Know the resource degradation problem

- ❖ Be familiar with issues and conservation of natural resources

Course Contents (Natural Resource Management)	Weightage (%)
Unit – I Introduction to Natural Resource Management	**30** **10 Lectures**
Concept of natural resources; Scopes of natural resource management; Types of natural resources (Renewal and non-renewal resources); Factors influencing natural resources; Land Resources: Land use and land cover, land use change, drivers of land use change, impact of land use change on environment; Soil resource: soil types, profile and composition, degradation of land and soil.	
Unit- II Mineral Resources and its Distribution	**20** **06 Lectures**
Mineral resources: types (metallic and non-metallic minerals) and distribution of mineral resources, importance of mineral resources, Rapid depletion, wastage, environmental pollution, Major mineral resources, their status, distribution and extraction in India.	
Unit- III Introduction to Water Resources and its Managements	**25** **07 Lectures**
Water resources type: surface water, subsurface water; Causes of water resource depletion: Use and over use of water resources; Methods for managing water resources: Ground water recharging, rainwater harvesting; Watershed management: Concept and objectives, land use planning, flood control; Wetlands: definition, importance and classification.	
Unit- IV Energy Resources	**25** **07 Lectures**
Energy resources definition, types and potentials of renewable (solar, wind power, hydropower, biomass, geothermal, tidal, etc.) and non-renewable (coal, oil and natural gas) energy resources; Causes and ecological and economic effects of rapid consumption of fossil fuels; Status of energy availability and use in India; Use of alternate energy sources; Impacts of climate change on natural resource.	

Text / Reference Books:

1. Agarwal, K.M., Sikdar, P.K., Deb., S.C. 2005. A Text Book of Environment. Macmillan India Limited.
2. Khadka, N.B. 2008. Natural Resource and Conservation.
3. Klee, G.A. 1991. Conservation of Natural Resources. New Jersey: Prentice Hall Publ. Co.
4. Peter, M., Dixit, A. and Athukorala, K. (edited). 2007. Integrated Water Resources Management: Global Theory, Emerging Practice and Local need. Sage Publication.
5. Ramade, F. 1984. Ecology of Natural Resources. John Wiley & Sons Ltd. Ristinin, R.A. and Kraushaar, J.J. 2006. Energy and Environment. New York: John Wiley and Sons, Inc.
6. Francois Ramade 1984. Ecology of Natural Resources. John Wiley & Sons Ltd.

Content Interaction Plan

Contact Hours	Topic
1-4	Concept of natural resources; Scopes of natural resource management; Types of natural resources (Renewal and non-renewal resources); Factors influencing natural resources.
5-7	Land Resources: Land use and land cover, land use change, drivers of land use change, impact of land use change on environment.
8-10	Soil resource: soil types, profile and composition, degradation of land and soil.
11-13	Mineral resources: types (metallic and non-metallic minerals) and distribution of mineral resources.
14-16	Importance of mineral resources, Rapid depletion, wastage, environmental pollution, Major mineral resources, their status, distribution and extraction in India.
17-19	Water resources type: surface water, subsurface water; Causes of water resource depletion: Use and over use of water resources.
20-21	Methods for managing water resources: Ground water recharging, rainwater harvesting
22-23	Watershed management: Concept and objectives, land use planning, flood control; Wetlands: definition, importance and classification.
24-26	Energy resources definition, types and potentials of renewable (solar, wind power, hydropower, biomass, geothermal, tidal, etc.) and non-renewable (coal, oil and natural gas) energy resources.
27-28	Causes and ecological and economic effects of rapid consumption of fossil fuels; Status of energy availability and use in India
29-30	Use of alternate energy sources; Impacts of climate change on natural resource.
T = 15 Hours	Tutorial

UG DIPLOMA COURSE IN GEOLOGY (SECOND YEAR)

SEMESTER III				
Course Types	**Course Code**	**Name of Course**	**(L+T+P)**	**Credits**
Major Course	GEL61MJ00904	Petrology	3+0+1	4
Major Course	GEL61MJ01004	Elements of Geochemistry	3+1+0	4
Minor Course		From Chemistry/Environmental Science/Physics/Maths/Statistics / Computer Sciences/ Biological Sciences/ SWAYAM courses		4
Multidisciplinary Course (MD)		From other Departments / SWAYAM courses		3
Skill Enhancement Course (SEC)	GEL61SE01103	Gemology	2+1+0	3
Ability Enhancement Course (AEC)		University level offered Courses		2
Minimum Credits required for Semester III				**20**

Courses offered for students of other Departments

Course Types	**Course Code**	**Name of Course**	**(L+T+P)**	**Credits**
Minor Course	GEL61MJ01004	Elements of Geochemistry	3+1+0	4
Multidisciplinary Course (MD)	GEL61MD01203	Geodiversity-Geoheritage-Geopark	2+1+0	3

Course Title: Petrology

Course Code	GEL61MJ00904	**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	Three/Odd	**Contact Hours**	45 (L) Hours + 30 (P) Hours
Course Type	Major Course		
Nature of the Course	Theory/Practical		
Special Nature/ Category of the Course	Knowledge and Skill based		
Methods of Content Interaction	(*Lecture, Group discussion, primary data collection & analysis, seminar, 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:

- Introduce the diversity of sedimentary rocks and their significance in the geological record.
- Explain the processes of weathering and sediment production, and how they contribute to the formation of sedimentary rocks.
- Classify sedimentary rocks based on their origin, composition, and texture.
- Identify and Introduce Igneous and Metamorphic rocks.
- Understand carbonate rocks, their depositional environments, mineralogy, and classification.

Course Learning Outcomes:

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

- Describe the main types of sedimentary rocks and their roles in recording Earth's history.
- Explain the significance of weathering in the rock cycle and its products.
- Classify sedimentary rocks using established classification schemes.
- Recognize and interpret various sedimentary structures and their implications for past environmental conditions.
- Analyze siliciclastic rocks (including volcaniclastic) to infer their provenance and depositional processes.
- Distinguish between different types of carbonate rocks and their formation environments.
- Evaluate the formation conditions of special sedimentary, Igneous and Metamorphic rocks and their economic importance.
- Apply knowledge of sedimentary rocks to solve geological problems in the field and laboratory settings.
- Integrate concepts from sedimentology with other geological disciplines to provide a comprehensive understanding of Earth's processes.

Course Contents (Petrology)	**Weightage (%)**
Unit - I Introduction to Sedimentary rock	**15** **10 Lectures**
Introduction to sedimentary rocks; Origin of sedimentary rocks - weathering and its products. Classification of Sedimentary Rocks. Sedimentary structures - physical, chemical and biological.	

Siliciclastic rocks: Conglomerates, sandstones, mud rocks (texture, composition, classification and origin and occurrence). Volcaniclastic sediments and their characteristics.	
Unit- II Types of Sedimentary rock	**15** **10 Lectures**
Carbonate rocks: Sedimentary environments and controls on carbonate deposition, Carbonate Mineralogy, Allochemical and Orthochemical components. Classification of limestone and dolomite. Study of evaporite, phosphorite, chert, iron and manganese rich sediments and rocks. Carbonaceous Sedimentary rocks.	
Unit - III Introduction to Igneous and Metamorphic rocks	**20** **15 Lectures**
Introduction to Igneous rocks, thermal structure of the earth, mantle composition and mantle heterogeneities. Magma generation in various plate tectonics of the earth. Petrology, partial melting and fractional crystallization of mantle composition. Primitive magma enriched and depleted mantle mineralogy. Magma mixing and magma mingling. Types of metamorphic and classification based on metamorphic facies. Classification based on geological setting. Isograd and reaction isograd. Field observations, petrographic classification of common metamorphic rocks. Plate tectonics and metamorphic facies series. Significance of metamorphic rocks and limits of metamorphism.	
Unit - IV Textures of Igneous and Metamorphic rocks	**20** **10 Lectures**
Primary and secondary textures in igneous rocks. Petrology and petrogenesis of major igneous rock types, giving Indian examples; Ultramafic, Basaltic, Granitic, Alkaline, Ophiolite, Carbonatite and Layered igneous rocks. Igneous rocks associated with convergent plate boundaries, continental flood basalt and large igneous provinces, ophiolite, granites and basalts, continental rift associations. Textures of metamorphic rocks. Mineral assemblages, equilibrium/reaction textures. Mineralogical phase rules of closed and open system; Nature of Metamorphic reactions; Effect of metamorphism: Phase diagram and graphic representation of mineral assemblages: Prograde and retrograde metamorphism.	
Unit - V Lab Experiment	**30** **30 Hours Lab Sessions**
• Identification of sedimentary rocks in hand specimen and thin section. • Sedimentary structure (identification and classification). • Inspect key textural/micro structural features of metamorphic rocks in hand specimen as well as under the microscope. • Megascopic hand specimens' study of different Igneous and Metamorphic rocks • Petrological calculations: calculation of mineral formulae, CIPW Norms calculation and interpretation. Assign a name to metamorphic rock on the basis of its mineralogical and textural characteristics, and appreciate the environment(s) of formation.	

Suggested Reading:

- D.R. Prothero, 2013, Sedimentary Geology: An Introduction to Sedimentary Rocks and Stratigraphy. W. H. Freeman; Third edition
- H.G. Reading, 2009, Sedimentary Environments: Processes, Facies and Stratigraphy. John Wiley & Sons.
- S.M. Sengupta, 2018, Introduction to Sedimentology. CBS Publishers & Distributors Pvt. Ltd.
- M. R. Leeder, 2009, Sedimentology and Sedimentary Basins: from Turbulence to Tectonics. John Wiley & Sons.
- N.W. Gokhale, 2017, Fundamentals of Sedimentary Rocks. CBS Publishers & Distributors Pvt. Ltd.
- H.E. Reineck, and I. B. Singh, 1980, Depositional Sedimentary Environments: With Reference toTerrigenous Clastics, Springer.
- J.D. Collinson, and D.B. Thompson, 1988, Sedimentary Structures, Unwin Hyman, London.
- D. R. Prothero, F. Schwab, 2004, Sedimentary Geology, Freeman
- D.S. Singh, 2018, Indian Rivers: Socio-economic aspects, Springer.
- M.E. Tucker, 2006, Sedimentary Petrology. Blackwell Publishing.

1. Best, Myron G., 2002. Igneous and Metamorphic Petrology, Blackwell Science.
2. Bose, M.K., 1997. Igneous Petrology, World Press, Kolkata.
3. Cox, K.G., Bell, J.D. and Pankhurst, R.J., 1993.The Interpretation of Igneous Rocks. Champman & Hall, London.
4. Mc Birney, 1994. Igneous Petrology, CBS Publishers, Delhi
5. Phillpotts, A.R., 1994. Principles of Igneous and Metamorphic Petrology, Prentice Hall of India.
6. Powell, R. 1978. Equilibrium thermodynamics in Petrology: An Introduction, Harper & Row Publishers, London.
7.

1. Bucher, K. and Grapes, R., 2010. Petrogenesis of Metamorphic Rocks, Springer.
2. Kerr, P.F. (1959). Optical Mineralogy, McGraw Hill Book Company Inc., New York.
3. Philpotts, A.R. (1994). Principles of Igneous and Metamorphic Petrology, Prentice Hall.
4. Powell, R. (1978). Equilibrium thermodynamics in Petrology: An Introduction, Harper and Row Publ., London.

Contact Hours	Topic
1	Introduction to sedimentary rocks
2	Origin of sedimentary rocks - weathering and its products.
3	Classification of Sedimentary Rocks.
4	Sedimentary structures - physical, chemical and biological.
5 - 7	Siliciclastic rocks: Conglomerates, sandstones, mudrocks (texture, composition, classification and origin and occurrence). Volcaniclastic sediments and their characteristics.
8	Carbonate rocks: Limestone and Dolomites
9 – 10	Sedimentary environments and controls on carbonate deposition, Carbonate Mineralogy, Allochemical and Orthochemical components.
11	Classification of limestone and dolomite.
12 – 14	Study of evaporite, phosphorite, chert, iron and manganese rich sediments and rocks.
15	Carbonaceous Sedimentary rocks.

16-17	Introduction to Igneous rocks, thermal structure of the earth, mantle composition and mantle heterogeneities. Magma generation in various plate tectonics of the earth.
18-22	Petrology, partial melting and fractional crystallization of mantle composition. Primitive magma enriched and depleted mantle mineralogy. Magma mixing and magma mingling.Types of metamorphic and classification based on metamorphic facies.
23-26	Classification based on geological setting. Isograd and reaction isograd. Field observations, petrographic classification of common metamorphic rocks. Plate tectonics and metamorphic facies series. Significance of metamorphic rocks and limits of metamorphism.
27-32	Primary and secondary textures in igneous rocks. Petrology and petrogenesis of major igneous rock types, giving Indian examples; Ultramafic, Basaltic, Granitic, Alkaline, Ophiolite, Carbonatite and Layered igneous rocks.
33-40	Igneous rocks associated with convergent plate boundaries, continental flood basalt and large igneous provinces, ophiolite, granites and basalts, continental rift associations. Textures of metamorphic rocks. Mineral assemblages, equilibrium/reaction textures. Mineralogical phase rules of closed and open system;
41-45	Nature of Metamorphic reactions; Effect of metamorphism: Phase diagram and graphic representation of mineral assemblages: Prograde and retrograde metamorphism.
P= 30 Hours	**List of Practical** • Identification of sedimentary rocks in hand specimen and thin section. • Sedimentary structure (identification and classification). • Inspect key textural/micro structural features of metamorphic rocks in hand specimen as well as under the microscope. • Megascopic hand specimens' study of different Igneous and Metamorphic rocks. • Petrological calculations: calculation of mineral formulae, CIPW Norms calculation and interpretation. Assign a name to metamorphic rock on the basis of its mineralogical and textural characteristics, and appreciate the environment(s) of formation.

Course Title: Elements of Geochemistry

Course Code	GEL61MJ01004	**Credits**	4
L + T + P	3+ 1 + 0	**Course Duration**	One Semester
Semester	Sixth/Even	**Contact Hours**	45 (L) Hours + 15 (Tutorial)
Course Type	Major Course		
Nature of the Course	Theory		
Special Nature/ Category of the Course	Skill based		
Methods of Content Interaction	(*Lecture, Group discussion, primary data collection & analysis, seminar, 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:

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 (Elements of Geochemistry)	Weightage (%)
Unit - I Introduction to Geochemistry	**40** **15 Lectures**
Principles of geochemistry. Cosmochemistry, 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.	
Unit- II Elemental Composition of the Earth	**20** **10 Lectures**
Distribution of elements in the earth. Meteorites, their classification, mineralogy, and origin. Earth in relation to the solar system and universe; composition of planets. Thermodynamics and crystal chemistry; Periodic Table of elements and ionic substitution in minerals; principles of crystal structure. Minor and trace elements during magmatic crystallization.	
Unit- III Rare Earth Elements	**20** **10 Lectures**
Significance of REEs in igneous petrology and their importance in fractional crystallization during magmatic/partial melting. Geochemistry of mafic rocks. Partition coefficients. Behaviour of major and trace including rare earth elements during partial melting of crustal and mantle reservoirs, magmatic crystallization and their application in petrogenesis and as tectonic discriminants.	
Unit - IV Geochemical Cycle	**20** **10 Lectures**
Element partitioning in mineral/rock formation and concept of distribution coefficient. Near surface geochemical environment; Principles of mass transport and rock- cycle; Chemical weathering of minerals and rocks. Sampling procedures and introduction to analytical techniques used in geochemistry. Geochemical processes involved in rock weathering and soil formation; Principles of ionic substitution in minerals.	

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 silicate rocks. Elsevier
6. Evans, R.C., (1964). Introduction to Crystal Chemistry. Cambridge Univ. Press
7. Henderson, P. (1984). REE geochemistry. Elsevier.
8. Hoefs, J. (1980). Stable Isotope Geochemistry, Springer and Verlag.
9. Krauskopf, K.B. (1967). Introduction to Geochemistry. McGraw Hill.
10. Mason, B. and Moore, C.B. (1991). Introduction to Geochemistry, Wiley Eastern.
11. Rankama, K. and Sahama Th. G. (1950). Geochemistry. Univ. Chicago Press.
12. Rollinson, H.R. (1993). Using geochemical data: Evaluation, presentation, interpretation. Longman U.K.

Content Interaction Plan

Contact Hours	Topic
1-8	Principles of geochemistry. Cosmochemistry, solar and stellar composition; The planet's composition and structure; Detailed study of meteorites; Lunar rocks; Cosmic abundance pattern.
9-12	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.
13-20	Distribution of elements in the earth. Meteorites, their classification, mineralogy, and origin. Earth in relation to the solar system and universe; composition of planets. Thermodynamics and crystal chemistry;
21 - 25	Periodic Table of elements and ionic substitution in minerals; principles of crystal structure. Minor and trace elements during magmatic crystallization. Significance of REEs in igneous petrology and their importance in fractional crystallization during magmatic/partial melting.
26 - 30	Geochemistry of mafic rocks. Partition coefficients. Behaviour of major and trace including rare earth elements during partial melting of crustal and mantle reservoirs, magmatic crystallization and their application in petrogenesis and as tectonic discriminants.
31- 35	Element partitioning in mineral/rock formation and concept of distribution coefficient. Near surface geochemical environment; Principles of mass transport and rock- cycle;
36- 40	Chemical weathering of minerals and rocks. Sampling procedures and introduction to analytical techniques used in geochemistry.
41- 45	Geochemical processes involved in rock weathering and soil formation; Principles of ionic substitution in minerals.
T = 15 Hours	Tutorial

Course Title: Gemology

Course Code	GEL61SE01103	**Credits**	3
L + T + P	2 + 1+ 0	**Course Duration**	One Semester
Semester	Three/Even	**Contact Hours**	30 (L) + 15 (T) Hours
Course Type	VAC		
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:

The Course aims to:

- Provide a comprehensive understanding of gemology, focusing on India's contribution, the chemical and physical properties of gemstones, and their significance.
- Educate on gemstone valuation using the 4 Cs (Colour, Clarity, Carat, Cut), and the distinction between minerals and gemstones.
- Explore the classification of gemstones, including precious and semi-precious stones, and their geological associations in India.
- Develop skills in gemstone identification, processing, and analysis, covering natural, cultured, synthetic, and treated varieties, and their cultural and therapeutic impacts.

Course Learning Outcomes:

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

- Demonstrate knowledge of gemology fundamentals, including the historical significance, mineral identification, and India's role in the field.
- Evaluate and differentiate gemstones using the 4 Cs (Colour, Clarity, Carat, Cut), and classify them into precious, semi-precious, and other categories.
- Master gemstone classification, cutting techniques, treatments, and understand the impact of gemstones in astrology, healing, and cultural traditions.
- Identify and assess synthetic, treated, and natural gemstones, and apply gemstones in various domains like jewelry, medicine, and research.

Course Contents (Gemology)	Weightage (%)
Unit - I Concept and Importance of Gemology	**30** **04 Lectures**
Gemology: fundamental concepts; History of gemology: India as a leader. Gemstones: Basic qualities of gemstones; The 4 Cs: Colour, Clarity, Carat and Cut; Differences and similarities between Minerals and Gemstones; Gemstone	

classification; precious gemstones and semi-precious gemstones. Lithological association of Gemstones in India. Gemstones bearing stratigraphic Units in India; Gemstone Resources of India.	
Unit-II Properties of Gems	**30** **04 Lectures**
Gemstone Varieties: Natural, Cultured and imitation; Synthetic and stimulant Gemstones; Weights and measures; Treatments and Enhancements. 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** **07 Lectures**
Valuation of Gemstones; Utility of Gemstones. Gemstones and their impact: Gemstone and Astrology; Crystal Healing; Birthstones and their significance. Applications of Gemstones: Uses in Jewellery; Uses in Medicine and Health; Role in Customs and Traditions. Important Gem Species: Diamond, Corundum (Ruby and Sapphire), Beryl (Emerald), Chrysoberyl (Cat's Eye and Alexandrite), Topaz, Spinel, Garnets, Tourmaline, Peridot, Zircon, Quartz Group Varieties (Opal, Amethyst, Citrine, etc.), Sphene, Feldspar, Lapis Lazuli, Aquamarine, Pearl, Turquoise, Tanzanite. Synthetic and Treated Gems: Identification and Valuation, Comparison with Natural Counterparts.	

Text / Reference Books:

1. A.M. Zaitsev, 2001, Optical Properties of Diamond: A Data Handbook. Springer, Berlin, New York.
2. Anderson, B.W (1990): Gem testing (10th edition), Butterworth Scientific, London.
3. Anderson, B.W. (1990): Gemstone Enhancement 2ndEdition, Butterworth, Scientific London.
4. Babu, T.M., (1998): Diamonds in India, Geological society of India, Bangalore.
5. Dorling Kindersley, (1994): Read, P. Gemology. Butterworth Heinemann,O' Donoghue, M. (1999): Identification of Gemstones.
6. E. Strack, 2006, Pearls. Stuttgart, RühleDiebener, Germany.
7. G. Davies, 1984, Diamond. A. Hilger, Bristol.
8. Gem Reference Guide, 1993, Gemological Institute of America, Santa Monica, CA.
9. Gems &Gemology in Review: Coloured Diamonds, 2006. Gemological Institute of America, Carlsbad, CA.
10. Hall, C. (1994): Gemstone, Dorling Kindesley, London.
11. J.E. Field, 1992, Properties of natural and synthetic diamond. Academic Press, London, New York.
12. Karanth, R.V. (2000): Gem and gem industry in India, Memoir 45, GeologicalSocietyof India, Banglore.
13. Kerr, P.F. (1997): Optical mineralogy, 4th Ed. McGraw Hill Book &Co,New York.
14. M. C. Pedersen, 2010, Gem and Ornamental Materials of Organic Origin. NAG Press, London.
15. Nassau, K. (1994): Gemstone Enhancement; Butterworths, London.
16. Peter Read (1991): Gemology 2nd Ed., Butter worth –HeinemanuLtd.Lundu.
17. Richard Laddicoat (1987), Handbook of gem identification - G.I.A.

18. Santa Monica., Edward Gubelin (1986): Photo Atlas of Including GemStones – ABCEdition, Zurich, Gem Testing10th Ed.

Content Interaction Plan

Contact Hours	Topic
1-3	Gemology: fundamental concepts; History of gemology: India as a leader
4-6	Gemstones: Basic qualities of gemstones; The 4 Cs: Colour, Clarity, Carat and Cut
7-9	Differences and similarities between Minerals and Gemstones; Gemstone classification; precious gemstones and semi-precious gemstones.
10-12	Lithological association of Gemstones in India. Gemstones bearing stratigraphic Units in India; Gemstone Resources of India.
13-15	Gemstone Varieties: Natural, Cultured and imitation; Synthetic and stimulant Gemstones
16-19	Weights and measures; Treatments and Enhancements.
20-22	Criteria for recognition of gemstones – Virtues of gemstones; Colours, Optical Properties, Hardness, Fractures, Inclusions, Zoning, Brittleness, Pleochroism, Clarity, Amenability for cutting and polishing.
23-24	Processing of gemstones – Styles of Cutting; Cabochon cut, Rose cut, Brilliant cut, zircon cut, step, trap or emerald cut and mixed cuts.
24-26	Valuation of Gemstones; Utility of Gemstones. Gemstones and their impact: Gemstone and Astrology; Crystal Healing; Birthstones and their significance.
27	Applications of Gemstones: Uses in Jewellery; Uses in Medicine and Health; Role in Customs and Traditions.
28-29	Important Gem Species: Diamond, Corundum (Ruby and Sapphire), Beryl (Emerald), Chrysoberyl (Cat's Eye and Alexandrite), Topaz, Spinel, Garnets, Tourmaline, Peridot, Zircon, Quartz Group Varieties (Opal, Amethyst, Citrine, etc.), Sphene, Feldspar, Lapis Lazuli, Aquamarine, Pearl, Turquoise, Tanzanite.
30	Synthetic and Treated Gems: Identification and Valuation, Comparison with Natural Counterparts.
T=15 Hours	Tutorials

Course Title: Geodiversity-Geoheritage-Geopark

Course Code	GEL61MD01203	**Credits**	3
L + T + P	2 + 1 + 0	**Course Duration**	One Semester
Semester	Three/Odd	**Contact Hours**	30 (L) + 15 (T) Hours
Course Type	Multidisciplinary Elective Course		
Nature of the Course	Theory		
Special Nature/ Category of the Course (*if applicable*)	Value Added, IKS		
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 (Geodiversity-Geoheritage-Geopark)	Weightage (%)
Unit – I Introduction to Geoheritage and Its Importance	**40** **14 Lectures**
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. UNESCO guidelines on Geoheritage and conservation, assessment and valuation of geoheritage resources. Methods for assessing and mapping geoheritage resources.	
Unit - II Potential Geoheritage sites of India	**30** **08 Lectures**
Concept of Geopark, Geopark through Geotourism, Employment opportunities and economic developments through Geotourism. Potential geoparks and geosites in India; Rajasthan, Odisha, Karnataka, Andhra Padesh, Madhya Pradesh, Telangana, Tamil Nadu, Kerala, Gujarat, Himachal Pradesh. Geotourism and National geological Monuments. Education for geoheritage and geotourism.	

Emerging technology, challenges and opportunities in geoheritage conservation and management.	
Unit - III Conservation and Protection of Geoheritage	**30** **08 Lectures**
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.	

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 Geol Assoc 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
1-14	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.
15-22	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.
23-30	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.
T = 15 Hours	Tutorial including presentation and case studies

SEMESTER IV				
Course Types	**Course Code**	**Name of Course**	**(L+T+P)**	**Credits**
Major Course	GEL62MJ01304	Palaeontology	3+0+1	4
Major Course	GEL62MJ01404	Structural Geology	3+0+1	4
Major Course	GEL62MJ01504	Introduction of Geospatial Technology	2+0+2	4
Major Course	GEL62MJ01602	Geohazards and Disaster Risk Reduction	2+0+0	2
Minor Course		From Chemistry/Environmental Science/Physics/Maths/Statistics / Computer Sciences/ Biological Sciences/ SWAYAM courses		4
Ability Enhancement Course (AEC)		University level offered Courses		2
Minimum Credits required for Semester IV				**20**
After Two Semesters Summer Vacation (6-8 weeks) Summer Internship				4

Courses offered for students of other Departments

Course Types	**Course Code**	**Name of Course**	**(L+T+P)**	**Credits**
Minor Course	GEL62MJ01304	Palaeontology	3+0+1	4

Course Title: Paleontology

Course Code	GEL62MJ01304	**Credits**	4
L + T + P	3 + 0+ 1	**Course Duration**	One Semester
Semester	Four/Even	**Contact Hours**	45 (L) + 30 (P) Hours
Course Type	Discipline Based Course Elective		
Nature of the Course	Theory/Practical		
Special Nature/ Category of the Course	Value Based, Indian Knowledge System		
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 strength of paleontological knowledges 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.
- Critically debate and evaluate current topics or controversies in paleontology via group presentations and written reports.

Course Contents (Paleontology)	Weightage (%)
Unit - I Origin of life and introduction of Palaeontology	**15** **10 Lectures**
Scope of paleontology; Origin and evolution of life through age; species concept; trans-specific evolution, speciation, and radiation. Fossilization process and fossil record. Modes of preservation. Techniques in paleontology; binomial nomenclature, modern systematics.	
Unit- II Introduction to Invertebrate fossils	**15** **10 Lectures**
Brief introduction to invertebrate palaeontology: A detailed study of the morphology and geological distribution of Bivalvia, Gastropoda, Brachiopoda, Cephalopoda, Trilobites, Echnoids and Corals with their biostratigraphic and palaeobiogeographic significance.	
Unit- III Introduction to Plant fossil	

Classification of fossil plants and broad characters of major plant groups. Brief morphology of different plant parts. Taxonomy, systematic position and distribution of common representative Indian plant genera. Plant fossils: Gondwana flora and their significance.	**15** **10 Lectures**
Unit- IV Introduction to Vertebrate fossil	
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.	**25** **15 Lectures**
Unit- V Lab Experiments	
• Classification of fossil plants and broad characters of major plant groups. • 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. • Determination of valves and dental formula of Heterodont Bivalves. Shell petrography of Bivalves and Brachiopods. • Study of an assorted group of trace fossils. • Study of ammonoid suture pattern, coiling, whorl section and ontogenic variation; exercises in ammonoid heterochrony.	**30** **30 Hours Lab Sessions**

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.
11. Horowitz, A.S. & Potter, E.D. (1971) Introductory Petrography of Fossils. (Springer Verlag)
12. Jones, R.W. (2011) Application of Palaeontology: Techniques and case studies. Cambridge University Press.
13. Lehmann, U., Hillmer, G. 1983: Fossil Invertebrates. Cambridge University Press.
14. Mayr, E. (1971) Population, Species and Evolution (Harvard)
15. Michael Benton, 2004. Vertebrate Palaeontology, Wiley-Blackwell.
16. Nield, E.W. and Tucker V.C.T.: Palaeontology – An Introduction. Pergamon Press.
17. Raup, D.M. and Stanley, S.M. (1985) Principles of Palaeontology (CBS Publications)
18. Raymond C. Moore, Cecil G. Lalicker, Alfred G. Fischer: Invertebrate Fossils (Paperback). CBS Publisher and distributers
19. Seaward, A.C. (1991) Plant fossils, Today's & Tomorrow, New Delhi.

20. Smith, A.B. (1994) Systematics & Fossil Record – Documenting Evolutionary Patterns (Blackwell)
21. Strean, C.W. and Carroll, R.L. (1989) Palaeontology – the record of life (John Wiley)
22. Swnnerton, H.H. (1950) An outline of palaeontology.
23. Treatise on Invertebrate Palaeontology, Ed. Raymond C. Moore (complete series). The Geological Society of America and University of Kansa Press

Content Interaction Plan

Contact Hours	Topic
1-10	Scope of paleontology; Origin and evolution of life through age; species concept; trans-specific evolution, speciation, and radiation. Fossilization process and fossil record. Modes of preservation. Techniques in paleontology; binomial nomenclature, modern systematics.
11-20	Brief introduction to invertebrate palaeontology: A detailed study of the morphology and geological distribution of Bivalvia, Gastropoda, Brachiopoda, Cephalopoda, Trilobites, Echnoids and Corals with their biostratigraphic and palaeobiogeographic significance.
21-23	Classification of fossil plants and broad characters of major plant groups.
24-26	Brief morphology of different plant parts.
27-32	Taxonomy, systematic position and distribution of common representative Indian plant genera.
33-35	Plant fossils: Gondwana flora and their significance.
36-40	Vertebrate paleontology: Origin of vertebrates. General characters and an outline classification, evolution of Fishes, Amphibians, Reptiles and Mammals.
41-42	General characters, classification and evolution of Horse, Elephant and Man.
43-45	Vertebrate fossil records of Siwaliks. A general account of Mesozoic vertebrates of India. Dinosaurs and their extinction.
P= 30 Hours	**List of Practical** • Classification of fossil plants and broad characters of major plant groups. • 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. • Determination of valves and dental formula of Heterodont Bivalves. Shell petrography of Bivalves and Brachiopods. • Study of an assorted group of trace fossils. • Study of ammonoid suture pattern, coiling, whorl section and ontogenic variation; exercises in ammonoid heterochrony.

Course Title: Structural Geology

Course Code	GEL62MJ01404	**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	Four/Even	**Contact Hours**	45 (L) + 30 (P) Hours
Course Type	Discipline Based Core Course		
Nature of the Course	Theory/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 Course aims to make:

- **Understand the fundamental concepts** of geological structures and their classifications.
- **Comprehend the forces** and stresses that affect Earth's crust, including two-dimensional and three-dimensional stress fields.
- **Analyse stress and deformation** in geological materials using Mohr diagrams and tensor mathematics.
- **Explore the principles of rheology** and its application to the lithosphere, including the study of strain rates, flow laws, and rheological models.
- **Examine the processes and outcomes** of brittle and ductile deformation in geologic materials.
- **Investigate the mechanics of plate tectonics**, including the various types of tectonic movements and their effects on the Earth's surface.

Course Learning Outcomes:

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

- **Identify and classify** primary and micro-geological structures. **Construct and interpret Mohr diagrams** for stress analysis and understand the concept of stress tensors.
- **Describe the mechanical behaviour** of isotropic and anisotropic materials under different stress conditions.
- **Evaluate the factors** influencing rock deformation, including temperature, pressure, and time-dependent processes like creep.
- **Analyse fault systems**, folds, and other structural features to infer the stress history and tectonic evolution of a region.
- **Apply knowledge of rheology** to understand the long-term stability and flow behaviour of the Earth's lithosphere.
- **Synthesize information** from various geological indicators to assess the kinematics and dynamics of deformation.

- **Interpret geological maps** and cross-sections to recognize and understand the significance of lineaments, joints, and shear zones.
- **Predict the potential for natural hazards** based on the understanding of faulting and folding mechanisms.
- **Integrate plate tectonic theory** with geological observations to explain the formation of mountain ranges, ocean basins, and other major geologic features.

Course Contents (Structural Geology)	Weightage (%)
Unit - I Introduction to structural Geology	**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; 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, rheology of the lithosphere.	
Unit- II Introduction to Brittle deformation	**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 Introduction to fold, foliation, Lineation and shear zone	**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 Deformation and 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- V 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 Gautam Mitra (1988). Basic Methods of Structural Geology. Prentice Hall.
15. Sudipta Sengupta (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; principal planes and principal stresses;
4 – 8	Mohr diagram for stress; stress tensor; deformation and strain: homogeneous and inhomogeneous deformation, strain path, strain quantities;
8 – 12	rheology: strain rate, the creep curve, steady-state flow, transient flow, isotropic and anisotropic materials, 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 controlling deformation of 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.
P = 30 hours	**List of Practical** • 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 Title: Introduction of Geospatial Technology

Course Code	GEL62MJ01504	**Credits**	4
L + T + P	2 + 0 + 2	**Course Duration**	One Semester
Semester	Four/Even	**Contact Hours**	30(L) + 60(P) Hours
Course Type	Major Course		
Nature of the Course	Theory/Practical		
Special Nature/ Category of the Course (*if applicable*)	Skill Based		
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 (Introduction of Geospatial Technology)	Weightage (%)
Unit – I Principle of Remote Sensing	**30** **12 Lectures**
History and Development of Remote Sensing, Fundamental Principles of Remote Sensing, Electromagnetic radiation – characteristics, remote sensing regions and bands. Properties of EMR; Atmospheric windows; Perturbing effects of the atmosphere. 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 Sensor	**10** **05 Lectures**
Platforms- Satellite Orbits: Geostationary, Sun synchronous Satellites- Resolution: Spatial Resolution, Spectral Resolution, Radiometric Resolution, Temporal Resolution, and Multispectral Resolution. IRS, Landsat and SPOT series and High-resolution satellites IKONOS, Cartosat, Quickbird, OrbView, GeoEye, WorldView; Other latest earth resource satellites.	
Unit- III Digital Image Processing	**10** **05 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 Fundamental of GIS and GNSS	**25** **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.	
Unit – V Lab Experiments	

• Satellite data and toposheet downloading from various sources. • Georeferencing of Toposheet and Satellite Images • Mosaicking, Sub-setting and creation of FCC • Satellite Image Classifications (Supervised and Unsupervised). • Satellite Image Interpretation (Visual and Digital) • Digitizing (Point, Line, Polygon) and Database Creation • Construction of topology, Error identification, error correction and reconstruction of topology. • Entry of non- spatial data and linking of spatial and non- spatial data. • Buffer analysis. • Map composition and representation.	**25** **60 Hours Lab Sessions**

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
1-12	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.
13-17	Platforms- Satellite Orbits: Geostationary, Sun synchronous Satellites Resolution and its types. IRS, Landsat and SPOT series; High-resolution satellites – IKONOS, Cartosat, Quickbird, OrbView, GeoEye, WorldView; Other latest earth resource satellites.
18-22	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.
23-30	Introduction and application of GIS, components of geographical information system (GIS), database structures in raster and vector and its comparison. National Geospatial Policy 2022, its significance and related Concerns.

	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.
P = 60 hours	**List of Practical** • Satellite data and toposheet downloading from various sources. • Georeferencing of Toposheet and Satellite Images • Mosaicking, Sub-setting and creation of FCC • Satellite Image Classifications (Supervised and Unsupervised). • Satellite Image Interpretation (Visual and Digital) • Digitizing (Point, Line, Polygon) and Database Creation • Construction of topology, Error identification, error correction and reconstruction of topology. • Entry of non- spatial data and linking of spatial and non- spatial data. • Buffer analysis. • Map composition and representation.

Course Title: Geohazards and Disaster Risk Reduction

Course Code	GEL62MJ01602	**Credits**	2
L + T + P	2 + 0 + 0	**Course Duration**	One Semester
Semester	Four/Even	**Contact Hours**	30 (L) Hours
Course Type	Major Course		
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 (Course Title: Geohazards and Disaster Risk Reduction)	Weightage (%)
Unit - I Concept of Natural Hazards, Disasters and Catastrophism	**40** **12 Lectures**
Introduction to natural hazards, disasters, catastrophic; Terminology used in hazards and disasters; Earthquakes, Distribution, magnitude and intensity of earthquakes, Seismic hazard zonation; Volcano; Landslide; Tsunami; Coastal hazards; Wild fires; Oil spills; Cyclones and storms; Deforestation and land degradation; Urban Heat Island (UHI).	
Unit- II Major Disaster of Bihar their Mitigation and Managements	**35** **10 Lectures**
Floods and their types, possible causes and preventive measures to manage the different types of floods; Major Disaster profile of Bihar: Flood, Lighting, Drought, Land subsidence, Water contamination; United Nation office for Disaster Risk Reduction (UNDRR) and their various programmes to manage the disaster; paradigm shift in Disaster Management; Concept of Disaster Risk Reduction (DRR) and their various measures to manage the disaster.	
Unit- III Government Planning and Policies for Disaster Management	**25** **08 Lectures**
National institutional framework to manage the disaster: NDMA, DDMA, SDMA, NIDM, NDRF, MoES and other related departments; Disaster Management Act and Natural Disaster Management Plan; Best practices in disaster management; Role of NGOs at local, state and national level to manage the disaster; Relevance of indigenous Knowledge, appropriate technology and Local resources, to manage the disaster.	

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
1-12	Introduction to natural hazards, disasters, catastrophic; Terminology used in hazards and disasters; Earthquakes, Distribution, magnitude and intensity of earthquakes, Seismic hazard

	zonation; Volcano; Landslide; Tsunami; Coastal hazards; Wild fires; Oil spills; Cyclones and storms; Deforestation and land degradation; Urban Heat Island (UHI).
13-22	Floods and their types, possible causes and preventive measures to manage the different types of floods; Major Disaster profile of Bihar: Flood, Lighting, Drought, Land subsidence, Water contamination; United Nation office for Disaster Risk Reduction (UNDRR) and their various programmes to manage the disaster; paradigm shift in Disaster Management; Concept of Disaster Risk Reduction (DRR) and their various measures to manage the disaster.
23-30	National institutional framework to manage the disaster: NDMA, DDMA, SDMA, NIDM, NDRF, MoES and other related departments; Disaster Management Act and Natural Disaster Management Plan; Best practices in disaster management; Role of NGOs at local, state and national level to manage the disaster; Relevance of indigenous Knowledge, appropriate technology and Local resources, to manage the disaster.

BACHELOR OF SCIENCE IN GEOLOGY (THIRD YEAR)

SEMESTER V				
Course Types	**Course Code**	**Name of Course**	**(L+T+P)**	**Credits**
Major Course	GEL71MJ01704	Marine Geology and Micropaleontology	3+0+1	4
Major Course	GEL71MJ01804	Indian Stratigraphy	3+0+1	4
Major Course	GEL71MJ01904	Economic Geology	3+0+1	4
Major Course	GEL71MJ02002	Applied Geomorphology	2+0+0	2
Major Course	GEL71MJ02102	Internship/Seminar	0+0+2	2
Minor Course		From Chemistry/Environmental Science/Physics/Maths/Statistics / Computer Sciences/ Biological Sciences/ SWAYAM courses		4
Minimum Credits required for Semester V				**20**

Courses offered for students of other Departments

Course Types	**Course Code**	**Name of Course**	**(L+T+P)**	**Credits**
Minor Course	GEL71MJ01704	Marine Geology and Micropaleontology	3+0+1	4

Course Title: Marine Geology and Micropaleontology

Course Code	GEL71MJ01704	**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	Five/Odd	**Contact Hours**	45 (L) + 30 (P) Hours
Course Type	Major Course		
Nature of the Course	Theory/Practical		
Special Nature/ Category of the Course	Applications Based Course		
Methods of Content Interaction	(*Lecture, Tutorials, 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 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 (Marine Geology and Micropaleontology)	Weightage (%)
Unit - I Introduction to Marine Environment	**18** **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; Oxygen minimum layer in the ocean.	
Unit- II Applied Oceanography and Introduction to Micropaleontology	**18** **11 Lectures**
Marine Biology: Marine Ecosystems; Plankton, Nekton, and Benthos; Marine Food Webs; Adaptations to Marine Environments; Human Impact on Marine Life. Marine Geology: Geological Processes in the Ocean; Sediment Types and Deposition; Marine Sedimentary Environments. 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. 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.	
Unit- III Techniques in Micropaleontology and Mineral Walled Microfossils	**21** **12 Lectures**
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. Foraminifera: Basic morphology, wall composition, and classification and applications. Ostracoda: Basic morphology; Classification and stratigraphic distribution.	
Unit - IV Mineral Walled Microfossils and Organic Walled Microfossils	**18** **11 Lectures**
Nannofossils: Introduction and significance; Calcareous Nannoplanktons: Morphology and classification. Radiolaria, Diatom, and Silicoflagellate: Basic Morphology, and significance. Calcareous algae: Morphology, classification, and scope. Spores, Pollen, Dinoflagellates, and Acritarches: Morphology, classification, and applications.	
Unit – V Lab Experiments	**25**

• 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.	**30 Hours Lab Sessions**

Text/Reference Books

1. Alfred Traverse (1988). Paleopalynology, Unwin Hyman, USA.
2. Brander, Keith (2019): Climate Change and the Ocean, Cambridge University Press.
3. Crasquin-Soleau, S. et. al. (Ed.) (2014): Ostracoda in the Earth Sciences, Cambridge University Press.
4. David, Tolmazin (1985): Elements of Dynamic Oceanography, Allen and Unwin
5. Garrison, Tom S. (2016): Oceanography: An Invitation to Marine Science, Cengage Learning.
6. Haq, B. U. & Boersma, A. (Eds.), (1978): Introduction to Marine Micropaleontology, Elsevier, New York, 250 p.
7. Howard A. A. and Martin D. B. (2005). Microfossils (IInd Ed.) Blackwell Publishing Ltd.
8. Jones, Robert Wynn (2014): Foraminifera and their Application, Cambridge University Press.
9. Kathal P. K. (2012). Applied Geological Micropaleontology, Scientific Publishers (India)
10. Murray, John, (2006). Ecology & Application of Benthic Foraminifera, Cambridge University Press.
11. Saraswati P. K. and Srinivasan M. S. (2016): Micropaleontology – Principles and Applications, Springer.

Content Interaction Plan

Contact Hours	Topic
1 – 3	Introduction to Marine Environment; Ocean Basins and Features; Seafloor Topography; Continental Shelf, Slope, and Rise.
4 – 5	Ocean Circulation Patterns; Wind-driven Circulation; Thermohaline Circulation.
6 – 7	Major Ocean Currents; Effects of Ocean Currents on Climate.
8 – 9	Properties of Seawater; Salinity and Temperature.
10 - 11	Dissolved Gases in the Ocean; Nutrients and Trace Elements; Ocean Acidification; Oxygen minimum layer in the ocean.
12 - 13	Marine Ecosystems; Plankton, Nekton, and Benthos; Marine Food Webs; Adaptations to Marine Environments; Human Impact on Marine Life.

14 - 16	Geological Processes in the Ocean; Sediment Types and Deposition; Marine Sedimentary Environments.
17 - 18	Oceanic Resources: Classification of oceanic resources; Mineral resources; Energy resources; Food resources; Depletion of marine resources; Management, and conservation of marine resources;
19 - 20	Indian marine and submarine explorations; Ocean and Climate Change: Ocean-Atmosphere Interactions; Ocean Warming and Sea Level Rise.
21 - 22	Impact of Climate Change on Marine Ecosystems; Future Challenges and Opportunities in Oceanography.
23 - 24	Introduction to Micropaleontology: Overview of micropaleontology and its subdisciplines; Scope and significance of micropaleontology.
25 - 27	Environmental and Biotic Distribution: Types of environments and biotic distribution of microfossils.
28 - 31	Foraminifera: Basic morphology, wall composition, and classification and applications.
32 - 34	Ostracoda: Basic morphology; Classification and stratigraphic distribution.
35 - 37	Nannofossils: Introduction and significance; Calcareous Nannoplanktons: Morphology and classification.
38 - 40	Radiolaria, Diatom, and Silicoflagellate: Basic Morphology, and significance; Calcareous algae: Morphology, classification, and scope.
41 - 42	Spores & Pollen: Morphology, classification, and applications.
43 - 45	Dinoflagellates, and Acritarches: Morphology, classification, and applications.
P = 30 Hours	**List of Practical**
	• 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 Title: Indian Stratigraphy

Course Code	GEL71MJ01804	**Credits**	4
L + T + P	3+ 0 +1	**Course Duration**	One Semester
Semester	Five/Odd	**Contact Hours**	45(L) + 30(P) Hours
Course Type	Major Course		
Nature of the Course	Theory/Practical		
Special Nature/ Category of the Course	Discipline enrichment core course; Indian Knowledge System		
Methods of Content Interaction	(*Lecture, Tutorials, Group discussion, 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 is being proliferated with a view to establish a firm and profound understanding of the Precambrian rocks and Phanerozoic rocks exposed in different parts of India and its correlation with the isochronous rocks exposed elsewhere.

Course Learning Outcomes:

The manifestation of the course, if completed successfully can be reflected in the form of an insight as:

- To know how the earth has behaved during Precambrian Era that in turn covers more than 90% of the geological time. It also enables the students to link events and to correlate them at several scales.
- To know how the earth has behaved during Phanerozoic Era that in turn covers significant part of the geological time. It also enables the students to link events and to correlate them at several scales.

Course Contents (Indian Stratigraphy)	Weightage (%)
Unit - I Introduction to stratigraphy, Precambrian Stratigraphy and Mobile Belts of India	**18** **11 Lectures**
Stratigraphy, its relation with other branches of geology. Geological Time Scale. Introduction to Stratigraphic Code and Nomenclature. Tectonic framework of India. Economic importance of Pre-Cambrian successions of India. Archaean Stratigraphy of the Dharwar Craton, Baster Craton, Singbhum Craton, Bundelkhand Craton, Aravalli Craton. Precambrian of Extra Peninsular region. Stratigraphy of the Mobile Belts of India.	
Unit- II Archaean Proterozoic Basins of India	**18** **11 Lectures**
Archaean-Proterozoic boundary. Stratigraphy of the Proterozoic Sedimentary basins/Purana formations in India: Delhi-Aravalli	

Supergroup, Singbhum-Kolhan Group, Cuddapah-Kurnool, Kaladgi-Bhima-Badami, Pranhita-Godavari (Pakhal&Sullavai), Mahakoshal - Bijawar -Gwalior, DongarhgarhSupergroup. Marwar, Abujhmar-Indravati, Vindhyans- Chattisgarh- Singhora Supergroups.	
Unit- III Palaeozoic Stratigraphy of India	**18** **11 Lectures**
Precambrian-Cambrian boundary. Palaeozoic of Salt Range and their age. Marine Palaeozoic rocks of Tethys and Lesser Himalayas with fossils. Marine Palaeozoic rocks of Peninsular India with fossils. Permian Triassic boundary. Marine Mesozoic Formations of Tethyan and Lesser Himalayas with fossils. Marine Mesozoic rocks of Peninsula, and Andaman and Nicobar Island with fossils.	
Unit - IV Mesozoic and Cenozoic Stratigraphy of India	**21** **12 Lectures**
Concept of Gondwanaland. Classification, lithology, age, correlation, and fossils of Gondwana Supergroup. Cretaceous-Tertiary boundary. Stratigraphy of Rajmahal Volcanics and Deccan Traps and Intertrappeans. Sabathu, Dagshai and Kasauli Formations. Assam Cenozoics. Siwalik Group, Karaikal Beds, Warkala Beds and Coastal formations. Tectonic evolution of Indo-Gangetic Plain. Quaternary Stratigraphy and dating methods.	
Unit - V Lab Experiments	**25** **30 Hours Lab Sessions**
• Study of rocks in hand specimens from known Indian stratigraphic horizons and type localities. • Study of the important fossils belonging to various formations of Indian Stratigraphy. • Exercises on geographical distribution of various successions belonging to Indian Stratigraphy. • Exercises on stratigraphic correlation and classification. • Exercises on Seismic and magneto-stratigraphic interpretations. • Study and understanding of plate movements through important periods during Phanerozoic Eon. • Evolution of ocean systems during Phanerozoic.	

Text & Reference Book

1. Krishnan, M. S. (2017). Geology of India and Burma. 6th Edition. CBS Pub. & Dis.
2. Naqvi, S. M. and Rogers, J.J.W. (1987). Precambrian Geology of India. Oxford Univ. Press.
3. Pascoe, E. S. (1960). A Manual of Geology of India & Burma. Volume I & II Govt. of India Pub.
4. Pomerol, C. (1982). The Cenozoic Era? Tertiary and Quaternary. Ellis Harwood Ltd.
5. Ramakrishnan, N. &Vaidyanandan, R. (2010). Geology of India, v. I & II. Geol. Soc. Ind.
6. Kumar, R. (2020). Fundamentals of Historical Geology and Stratigraphy of India. New Age International Private Limited.
7. Wadia, D. N. (1967). Geology of India. McMillan & Co., London.
8. Weller, J. M. (1960). Stratigraphic Principles and Practice. Harper and Brothers.

Content Interaction Plan

Contact Hours	Topic
1-3	Stratigraphy, its relation with other branches of geology. Geological Time Scale. Introduction to Stratigraphic Code and Nomenclature.
4 – 8	Tectonic framework of India. Economic importance of Pre-Cambrian successions of India. Archaean Stratigraphy of the Dharwar Craton. Baster Craton,
8 – 12	Singbhum Craton, Bundelkhand Craton, Aravalli Craton. Precambrian of Extra Peninsular region. Stratigraphy of the Mobile Belts of India.
12-15	Archaean-Proterozoic boundary. Stratigraphy of the Proterozoic Sedimentary basins/Purana formations in India: Delhi-Aravalli Supergroup,
16 –18	Singbhum-Kolhan Group, Cuddapah-Kurnool, Kaladgi- Bhima-Badami, Pranhita-Godavari (Pakhal&Sullavai),
19 –22	Mahakoshal -Bijawar -Gwalior, Dongarhgarh Supergroup. Marwar, Abujhmar- Indravati,
23-24	Vindhyans- Chattisgarh- Singhora Supergroups.
25-30	Precambrian-Cambrian boundary. Palaeozoic of Salt Range and their age. Marine Palaeozoic rocks of Tethys and Lesser Himalayas with fossils.
31-33	Marine Palaeozoic rocks of Peninsular India with fossils. Permian Triassic boundary. Marine Mesozoic Formations of Tethyan and Lesser Himalayas with fossils. Marine Mesozoic rocks of Peninsula, and Andaman and Nicobar Island with fossils
34 –36	Concept of Gondwanaland. Classification, lithology, age, correlation, and fossils of Gondwana Supergroup. Cretaceous-Tertiary boundary.
37 –39	Stratigraphy of RajmahalVolcanics and Deccan Traps and Intertrappeans. Sabathu, Dagshai and Kasauli Formations.
40 –45	Assam Cenozoics. Siwalik Group, Karaikal Beds, Warkala Beds and Coastal formations. Tectonic evolution of Indo-Gangetic Plain. Quaternary Stratigraphy and dating methods.
P= 30 Hours	**List of Practical**
	• Study of rocks in hand specimens from known Indian stratigraphic horizons and type localities. • Study of the important fossils belonging to various formations of Indian Stratigraphy. • Exercises on geographical distribution of various successions belonging to Indian Stratigraphy. • Exercises on stratigraphic correlation and classification. • Exercises on Seismic and magneto-stratigraphic interpretations. • Study and understanding of plate movements through important periods during Phanerozoic Eon. • Evolution of ocean systems during Phanerozoic.

Course Title: Economic Geology

Course Code	GEL71MJ01904	**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	Five/Odd	**Contact Hours**	45(L) + 30(P) Hours
Course Type	Major Course		
Nature of the Course	Theory/Practical		
Special Nature/ Category of the Course (*if applicable*)	Concept and Skill Based		
Methods of Content Interaction	Lecture, Group discussion; Self-study, Seminar		
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 with the knowledge of economic minerals and their distribution

Course Learning Outcomes

- The course definitely provides the better capability to understand the basic concepts of the processes of the formation of the ore deposits and types of ore deposits, mode of occurrences and distribution of metallic and industrial minerals in India and various parts of the world.

Course Contents (Economic Geology)	Weightage (%)
Unit – I Mineral deposits and Ore Forming Processes	**20** **12 Lectures**
Definition of ore, ore mineral and gangue, tenor, cut-off grade, and concentration factor. Mineral deposits, Epigenetic and syngenetic mineral deposits, Ore forming processes, magmatic deposits (Early and Late magmatic deposits), sedimentary deposits, residual and mechanical concentration, placer deposits, Gossan, Oxidation and supergene enrichment, metamorphosed deposits, Evaporites; Mineral deposits associated with different rocks.	
Unit- II Ore Deposits and Controls of Ore Localization	**20** **12 Lectures**
Spatial and temporal distribution of ore deposits: Metallogenic epoch and province, Ore deposits and Plate Tectonics. Mode of occurrence of ore deposits: – morphology and relationship of host rocks. Textures of ores and their genetic significance. Hydrothermal deposits and their classification, Wall-rock alteration. Structural, physico-chemical and stratigraphic controls of ore localization, Skarn deposits, SEDEX and VHMS deposits, Stratiform and strata-bound deposits.	
Unit- III Mineral Resource and ore Reserve	

Physical and optical properties of ore minerals, Mineral resource and ore reserve, classification of mineral resource and reserves, calculation of reserve (tonnage) and metal content, Basic factors of ore estimation, methods of ore reserve estimation.	**15** **09 Lectures**
Unit – IV Distribution and Importance of Mineral Deposits	**20** **12 Lectures**
Indian distribution of mineral deposits (metallic and industrial) with mode of occurrence and host rock types; Uses of metallic and industrial 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, Mineral prosperity of Bihar.	
Unit -V Lab Experiments	**25** **30 Hours Lab sessions**
• Identification of economic minerals in hand specimen. • Study the optical properties of ore minerals in reflected light and their identification in polished sections. • Study of ore textures and interpretation of paragenesis. • Drawing of maps showing the distribution of important metallic and industrial mineral deposits.	

Text / Reference Books:

1. Evans, A.M. (1992). Ore geology and industrial minerals. Blackwell Science.
2. Haldar, S. K. (2018). Mineral Exploration: Principles and Applications, 2nd Edition. Elsevier Publication.
3. Misra, K.C. (1999). Understanding mineral deposits. Kluwer Academic Publishers
4. Robb, L. (2004). Introduction to Ore-forming Processes. Blackwell Science, UK,384 p.
5. Jensen, M.L. & Bateman, A.M. (1981). Economic mineral deposits. John Wiley & Sons, New York.
6. Marshall, D.D., Anglin, C.D. and Mumin, A.H. (2004). Ore mineral atlas. St. John's, Nfld.: Geological Association of Canada, Mineral Deposits Division.
7. Prasad, U. (2006). Economic Geology: Economic Mineral Deposits. CBS Publications.
8. Short, M.N. (1948). Microscopic determination of the ore minerals (Vol. 914). US Government Printing Office.

Content Interaction Plan

Contact Hours	Topic
1-5	Definition of ore, ore mineral and gangue, tenor, cut-off grade, and concentration factor. Mineral deposits, Epigenetic and syngenetic mineral deposits, Ore forming processes, magmatic deposits (Early and Late magmatic deposits)
6 – 10	Sedimentary deposits, residual and mechanical concentration, placer deposits, Gossan, Oxidation and supergene enrichment, metamorphosed deposits, Evaporites; Mineral deposits associated with different rocks

11 – 15	Spatial and temporal distribution of ore deposits: Metallogenic epoch and province, Ore deposits and Plate Tectonics.
16 – 20	Mode of occurrence of ore deposits: – morphology and relationship of host rocks. Textures of ores and their genetic significance. Hydrothermal deposits and their classification,
21-25	Wall-rock alteration. Structural, physico-chemical and stratigraphic controls of ore localization, Skarn deposits, SEDEX and VHMS deposits, Stratiform and strata-bound deposits
26 –31	Physical and optical properties of ore minerals, Mineral resource and ore reserve, classification of mineral resource and reserves
32 –35	calculation of reserve (tonnage) and metal content, Basic factors of ore estimation, methods of ore reserve estimation
36 –40	Indian distribution of mineral deposits (metallic and industrial) with mode of occurrence and host rock types; Uses of metallic and industrial minerals; Importance of minerals in national economy
41-45	Concepts of Strategic, Critical and Essential minerals and their distribution in India, National Mineral Policy, Mineral concession rule and Law of Sea, Mineral prosperity of Bihar
P=30 Hours	**List of Practical** • Identification of economic minerals in hand specimen. • Study the optical properties of ore minerals in reflected light and their identification in polished sections. • Study of ore textures and interpretation of paragenesis. • Drawing of maps showing the distribution of important metallic and industrial mineral deposits.

Course Title: Applied Geomorphology

Course Code	GEL71MJ02002	**Credits**	2
L + T + P	2 + 0 +0	**Course Duration**	One Semester
Semester	Five/Odd	**Contact Hours**	30 (L) Hours
Course Type	Major Course		
Nature of the Course	Theory		
Special Nature/ Category of the Course (*if applicable***)**	Concept and Applied 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:

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 land forms 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 (Applied Geomorphology)	Weightage (%)
Unit – I Geomorphological Processes and associated Landforms	**40** **12 Lectures**
The fundamental concept of Applied Geomorphology and their significance; Basic concepts of landform evolution; Geomorphological Processes and Landforms: Fluvial processes and landforms, Aeolian processes and landforms, Glacial and Periglacial processes and landforms, Coastal processes and landforms, Karst and speleology.	
Unit- II Drainage Basin and their Characteristics	**30** **09 Lectures**
Drainage Basin: Network Characteristics, Morphology, Phases of drainage network; Geomorphic application in soil studies- Weathering, Profile of weathering, Various type of weathering formation, Soil as a product of weathering, its formation, Vertical zonation and major soil groups.	
Unit- III Applications of Geomorphology in various Sectors	**30** **09 Lectures**
Application of Geomorphology in Mineral Prospecting; Civil Engineering projects construction of dam, roads and tunnels and their impact; Strategic and Military purposes; Land use planning; Hazard and risk studies; Environmental studies; Coastal management; Surface and Subsurface Hydrology; Urban Hydrology.	

Text / Reference Books:

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

Content Interaction Plan

Contact Hours	Topic
1-12	The fundamental concept of Applied Geomorphology and their significance; Basic concepts of landform evolution; Geomorphological Processes and Landforms: Fluvial processes and landforms, Aeolian processes and landforms, Glacial and Periglacial processes and landforms, Coastal processes and landforms, Karst and speleology.
13 – 21	Drainage Basin: Network Characteristics, Morphology, Phases of drainage network; Geomorphic application in soil studies- Weathering, Profile of weathering, Various type of weathering formation, Soil as a product of weathering, its formation, Vertical zonation and major soil groups.
22 – 30	Application of Geomorphology in Mineral Prospecting; Civil Engineering projects construction of dam, roads and tunnels and their impact; Strategic and Military purposes; Land use planning; Hazard and risk studies; Environmental studies; Coastal management; Surface and Subsurface Hydrology; Urban Hydrology.

Course Title: Internship/ Seminar

Course Code	GEL71MJ02102	**Credits**	2
L + T + P	1+ 1 +0	**Course Duration**	One Semester
Semester	Fifth/Odd	**Contact Hours**	15(L) + 30(P) Hours
Course Type	Multidisciplinary Course		
Nature of the Course	Theory/Practical		
Special Nature/ Category of the Course (*if applicable*)	Skill Based		
Methods of Content Interaction	Lecture, Group discussion; Self-study, Seminar, presentation		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

One seminar with power point presentation will be delivered by the student on any theme of his or her area of research interest, which will include all sequences of research, development of communication skill and presentation analysis. In this work faculty will review the students throughout the semester and give the topics for presentation.

SEMESTER VI				
Course Types	**Course Code**	**Name of Course**	**(L+T+P)**	**Credits**
Major Course	GEL72MJ02204	Research Methodology	3+1+0	4
Major Course	GEL72MJ02304	Geophysical Techniques	3+1+0	4
Major Course	GEL72MJ02404	Hydrogeology	3+0+1	4
Major Course	GEL72MJ02504	Field Geology and Field Training	2+0+2	4
Minor Course		From Chemistry/Environmental Science/Physics/Maths/Statistics / Computer Sciences/ Biological Sciences/ SWAYAM courses		4
Minimum Credits required for Semester VI				**20**

Courses offered for students of other Departments

Course Types	**Course Code**	**Name of Course**	**(L+T+P)**	**Credits**
Minor Course	GEL72MJ02304	Geophysical Techniques	3+1+0	4

Course Title: Research Methodology

Course Code	GEL72MJ02204	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	Six/Even	**Contact Hours**	45 (L) + 15 (T) Hours
Course Type	Major 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, 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 (Research Methodology)	Weightage (%)
Unit - I Introduction of Research Methods and Problems	**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 like SCOPUS, Web of Science, PubMed etc.)	
Unit- II Literature Review	**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 Lectures**
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 Field and Laboratory Techniques in Geological Study	**50** **25 Lectures**
Preparation for Field work, Field procedures in Geological mapping in Igneous, Sedimentary and metamorphic terrain, Methods used in sampling of rocks, minerals and fossils. Procedures used in water and rock analysis in laboratory. Sedimentological techniques-Size and shape determination of grains in Clastic, rocks and their graphic representations- placer and studies of Heavy mineral. Paleontological and Micropaleontological techniques pertaining to microfossils. Remote Sensing and GIS techniques in water resources, geomorphology, landscape evaluation, mineral targeting and structural mapping.	

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 Luwang Usham
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 Title: Geophysical Techniques

Course Code	GEL72MJ02304	**Credits**	4
L + T + P	3+ 1 + 0	**Course Duration**	One Semester
Semester	Six/Even	**Contact Hours**	45(L) + 15(T) Hours
Course Type	Major Course		
Nature of the Course	Theory		
Special Nature/ Category of the Course (*if applicable*)	Concept and Skill Based		
Methods of Content Interaction	Lecture, Group discussion; Self-study, Seminar		
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 the course is to signify the role of geophysics in Earth's interior and introduce the various geophysical methods used in exploration.

Course Learning Outcomes

- After successful completion of the course students will learn about the geophysical exploration methods and their importance.

Course Contents (Geophysical techniques)	Weightage (%)
Unit –I Seismic waves and Earth's interior	**25** **15 Lectures**
Introduction of Geophysics and its importance, Concept of seismic waves (body wave, surface wave), Detail information on seismic waves and their characteristics, seismology, seismic waves role in earthquake, 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, density, pressure and temperature variation within Earth's interior, Lithostatic pressure calculation at crust-mantle boundary.	
Unit- II Gravity method	**25** **15 Lectures**
The basic introduction of different Geophysical exploration methods, Gravity method: Earth's gravitational field, Figure of the Earth, Concept of Geoid, the theoretical value of gravity (g), Densities of rocks; Gravity units, gravity anomaly, measurement of gravity.	
Unit- III Magnetic and Seismic method	**30** **20 Lectures**
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, 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, Elementary working principle of seismic method.	
Unit - IV Electrical method	**20** **10 Lectures**
Introduction and classification of electrical methods, electrical properties of rocks and minerals, Concept of Ohm law, conductivity, resistivity, current and potential electrodes, Importance of resistivity survey.	

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
1-5	Introduction of Geophysics and its importance, Concept of seismic waves (body wave, surface wave), Detail information on seismic waves and their characteristics, seismology, seismic waves role in earthquake, Seismic shadow zones (P and S waves shadow zones),
6– 9	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, Lithostatic pressure calculation at crust-mantle boundary
10 – 14	The basic introduction of different Geophysical exploration methods, Gravity method: Earth's gravitational field, Figure of the Earth,
15 – 20	Concept of Geoid, the theoretical value of gravity (g), Densities of rocks; Gravity units, gravity anomaly, measurement of gravity
21-27	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
28 –37	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, Elementary working principle of seismic method
38 –45	Introduction and classification of electrical methods, electrical properties of rocks and minerals, Concept of Ohm law, conductivity, resistivity, current and potential electrodes, Importance of resistivity survey
T=15 Hours	Tutorial

Course Title: Hydrogeology

Course Code	GEL72MJ02404	**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	Six/Even	**Contact Hours**	45 (L) + 30 (P) Hours
Course Type	Major Course		
Nature of the Course	Theory/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 (Hydrogeology)	Weightage (%)
Unit - I Groundwater movement, Occurrence and Distribution	**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 through various methods for steady and unsteady flow. Determination of hydraulic conductivity. Groundwater level, its fluctuations and causes.	
Unit- II Groundwater Exploration and Well Hydraulics	**15** **10 Lectures**
Surface and subsurface methods of groundwater exploration; Remote sensing techniques in groundwater exploration, Selection of suitable site for well construction; Type and design of wells, methods of well construction, well completion and well development. Environmental effects of over-exploitation of groundwater.	
Unit- III Groundwater Recharge and its Management	**15** **10 Lectures**
concepts of artificial recharge methods; design of artificial recharge structures. Artificial recharge to groundwater and rainwater harvesting. Management of groundwater resources, Conjunctive use of groundwater and surface water; Concept of watershed: Watershed characteristics, importance of water resources; Technical aspects of artificial recharge structures; Groundwater legislation; government policies problem of overexploitation; ground water legislation.	
Unit - IV Groundwater Quality and its 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 Lab Experiments	**25** **30 Hours Lab Sessions**
• Exercises on Water Table Maps and groundwater flow direction estimation. • Water level map creation using GIS software • Groundwater Water Quality Indexing (GWQI) using GIS software. • Numerical problems on porosity, hydraulic conductivity, transmissivity, Storativity etc. • Plotting of Water Quality Data and Piper-plot, Wilcox plot etc.	

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. Nandipati Subba Rao, 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 through various methods for steady and unsteady flow. 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.
P= 30 hours	**List of Practical** • Exercises on Water Table Maps and groundwater flow direction estimation. • Water level map creation using GIS software • Groundwater Water Quality Indexing (GWQI) using GIS software. • Numerical problems on porosity, hydraulic conductivity, transmissivity, Storativity etc. • Plotting of Water Quality Data and Piper-plot, Wilcox plot etc.

Course Title: Field Geology and Field Training

Course Code	GEL72MJ02504	**Credits**	4
L + T + P	2 + 0 + 2	**Course Duration**	One Semester
Semester	Six/Even	**Contact Hours**	30 (L) + 2-Weeks field study
Course Type	Major 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 is aimed:

- To impart an elementary understanding of surveying and levelling techniques.
- To facilitate the study and interpretation of toposheets, with a special emphasis on the Gaya town area.
- To develop skills in Plane Table surveying and levelling using a dumpy level.
- To train students in the measurement of horizontal and vertical angles using a theodolite.
- To educate on the application of Global Positioning System (GPS) for self-location and traverse mapping.
- To provide practical experience in surveying with Total Station equipment.
- To prepare students for conducting and reporting on geological fieldwork through a compulsory field course.

Course Learning Outcomes:

By the end of the course, students will be able to:

- Demonstrate a foundational understanding of surveying and levelling principles.
- Analyse and utilize toposheets for surveying urban and rural landscapes, particularly focusing on Gaya town.
- Conduct Plane Table surveying and levelling tasks with competence.
- Accurately measure horizontal and vertical angles using theodolite in various surveying projects.
- Apply GPS technology for precise self-location and in creating traverse maps.
- Operate Total Station surveying instruments and interpret the data collected effectively.
- Produce comprehensive field reports and articulate their findings in viva-voce examinations.
- Engage in geological fieldwork, including mapping and surveying, and apply classroom knowledge to real-world scenarios.
- Gain practical experience in geological surveying related to Economic Geology, Mineral Exploration, and Mining Methods.
- Acquire hands-on industry experience by working with governmental and non-governmental agencies/companies, enhancing their professional skills and industry readiness.

Course Contents (Field Geology and Field Training)	Weightage (%)
Unit – I Introduction to Field Geology and Instruments	**40** **12 Lectures**
Introduction to field geology, Objectives of field work, Importance of field safety. The Field Notebook: Purpose of Field Notes, Field Notebook Layout, Field Sketches. Written Notes: Recording Data. Scale of observation: Regional context, Whole exposure, Hand specimens. Instruments used in field: GPS, Brunton compass, Geological Hammer & altimeter. Parts, functions and use of Brunton compass, GPS. Preparedness for field survey: Base map, Geological maps, toposheets and Indian numbering system, Reading toposheets, interpretation of contour patterns.	
Unit- II Concepts and Principles of Field	**30** **09 Lectures**
Concept of dip and strike, Recording orientation of planar and linear features. Reporting orientation data: Azimuth, Quadrant reading. Establishment of relative ages: cross-cut relations, xenoliths.Recognition of folds, faults and unconformities in the field. Measuring thickness of inclined strata. Locating position on toposheet and concept of forward bearing and backward bearing. Field Report writing. Observations and recording of important field information. Recording features of sedimentary, Igneous and Metamorphic Rocks. Importance of field photographs. Sampling. Recording Palaeontological information: Sampling.	
Unit- III Field Techniques and Practices	**30** **09 Lectures**
Mapping techniques: traverse mapping, contact mapping, exposure mapping. Map symbols. Structural measurements and notations**,** Brittle structures: Faults, joints and veins, Ductile structures: Shear zones, foliations and folds. Elementary idea of surveying and levelling. Study of toposheet, especially of area covering Gaya town. Plane Table surveying; Levelling with dumpy level. Measurement of horizontal and vertical angles with theodolite.	

Geological Field Work

A field report and *viva-voce* based on the two to three weeks compulsory course in geological mapping in the Geological field work organized by the Department.

OR

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.

OR

Students will be sent to various governmental and non-governmental agencies/companies based on their interest for an in-hand experience for 2-3 weeks' duration. After the completion of the field study and training a report will be submitted and evaluated based on viva-voce.

Text/Reference Books

1. McClay, K.R. 2013. Mapping of Geological Structures (Geological Society of London Handbook). John Wiley and Sons, 168p.
2. Angela L. Coe, Tom W. Argles, David A. Rothery, Robert A. Spicer, 2010.Geological Field Techniques**,** Edited by Angela L. Coe.A John Wiley & Sons, Ltd., Publication.

3. Roger Marjoribanks, 2010. Geological Methods in Mineral Exploration and Mining, Springer Verlag, Hiedelberg. 238pp.

BACHELOR OF SCIENCE (HONOURS) IN GEOLOGY (FOURTH YEAR)

SEMESTER VII				
Course Types	**Course Code**	**Name of Course**	**(L+T+P)**	**Credits**
Major Course	GEL81MJ02604	Igneous & Metamorphic Petrology	3+0+1	4
Major Course	GEL81MJ02704	Advanced Remote Sensing & Its Applications in Geosciences	2+1+1	4
Major Course	GEL81MJ02804	Advanced Mineralogy	3+0+1	4
Major Course	GEL81MJ02904	Sedimentology and Sequence Stratigraphy	3+0+1	4
Minor Course		From Chemistry/Environmental Science/Physics/Maths/Statistics / Computer Sciences/ Biological Sciences/ SWAYAM courses		4
Minimum Credits required for Semester VII				**20**

Courses offered for students of other Departments

Course Types	**Course Code**	**Name of Course**	**(L+T+P)**	**Credits**
Minor Course	GEL81MJ02804	Advanced Mineralogy	3+0+1	4

Course Title: Igneous and Metamorphic Petrology

Course Code	GEL81MJ02604	**Credits**	4
L + T + P	3+ 0 + 1	**Course Duration**	One Semester
Semester	Seven/Odd	**Contact Hours**	45 (L) + 30 (P) Hours
Course Type	Major Course		
Nature of the Course	Theory/Practical		
Special Nature/ Category of the Course	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:

- ❖ 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 and 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, especially the orogenic events.

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 proceed to study how these minerals occur and interact in magmatic rocks.

Course Contents (Igneous and Metamorphic Petrology)	**Weightage (%)**
Unit - I Introduction to Igneous and Metamorphic rocks	**18** **10 Lectures**
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; 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; Overview of different types of metamorphism; Factors controlling transformations, 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	**18**
The IUGS mineralogical based classification and nomenclature scheme for phaneritic and aphanitic igneous rocks; Classification of quartz-bearing plutonic	

rocks in the IUGS scheme; Brief introduction to feldspathoid-bearing plutonic 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.	**10 Lectures**
Unit- III Phase rule in Melting and Crystallization	**21** **15 Lectures**
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) Forsterite Silica (e) Diopside-Albite-Anorthite (f) Diopside-Forsterite-silica; Crystallization of granitic magma in relation to Quartz Orthoclase-Aalbite-Anorthite-H2O system. 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.	
Unit - IV Instrumental Concept in rock studies	**18** **10 Lectures**
Introduction to the main analytical methods for geochemical analysis of igneous rocks. XRF, ICPMS, TIMS, Electron microprobe and ion probes; Laser ablation analysis for geochronology and mineral analysis; Discussion of detection limits, analytical precision and accuracy of analyses. Metamorphic facies and facies series, combinatorial formula and Schreinemakers rules, Mineral formula calculation, geothermobarometry, Medium to high pressure (zeolite facies, green schist facies, amphibolite facies and granulite facies) with special reference to characteristic minerals; Petrogenetic grid and pseudosections, Characterization of metamorphic fluids and mineral-fluid equilibria, Time scales of metamorphism, metasomatism, migmatites, Metamorphic field gradient and P-T-t paths. Spatial link between magmatism, metamorphism and tectonics: Concept of orogenic tectonic setting.	
Unit – V Lab Experiments	**25** **30 Hours Lab Sessions**
• Major oxides and trace element analysis. Interpretation of Application of different computer software's for understanding of different setup of igneous rocks. • Partial melting, co-efficient distribution value calculations • Trace elements, REEs diagram to interpret the igneous rock types. • Bulk composition specific plotting of mineral assemblages; ACF, AFM and AKF diagrams; inferring metamorphic reactions from topology changes. • Inferring metamorphic evolution and geodynamic implications of metamorphic assemblages.	

Text / Reference Books

1. Best, Myron G., 2002. Igneous and Metamorphic Petrology, Blackwell Science.
2. Bose, M.K., 1997. Igneous Petrology, World Press, Kolkata.

3. Cox, K.G., Bell, J.D. and Pankhurst, R.J., 1993.The Interpretation of Igneous Rocks. Champman & Hall, London.
4. Mc Birney, 1994. Igneous Petrology, CBS Publishers, Delhi
5. Phillpotts, A.R., 1994. Principles of Igneous and Metamorphic Petrology, Prentice Hall of India.
6. Powell, R. 1978. Equilibrium thermodynamics in Petrology: An Introduction, Harper & Row Publishers, London.
7. Bucher, K. and Grapes, R., 2010. Petrogenesis of Metamorphic Rocks, Springer.
8. Kerr, P.F. (1959). Optical Mineralogy, McGraw Hill Book Company Inc., New York.
9. Philpotts, A.R. (1994). Principles of Igneous and Metamorphic Petrology, Prentice Hall.
10. Powell, R. (1978). Equilibrium thermodynamics in Petrology: An Introduction, Harper and Row Publ., London.
11. Rastogy, R.P. and Mishra, R.R. (1993). An Introduction to Chemical Thermodynamics, Vikash Publishing House.
12. Spear, F. S. (1993). Mineralogical Phase Equilibria and pressure – temperature – time Paths, Mineralogical Society of America.
13. Winter, J.D. (2001). An introduction to Igneous and Metamorphic Petrology, Prentice Hall. Wood, B.J. and Fraser, D.G. (1976). Elementary Thermodynamics for Geologists, Oxford University Press, London.
14. Yardley, B.W.D., Mackenzie, W.S. and Guilford, C. (1995). Atlas of Metamorphic Rocks and their textures, Longman Scientific and Technical, England.
15. Yardlley, B.W.D. (1989). An introduction to Metamorphic Petrology, Longman Scientific and Technical, New York.

Content Interaction Plan

Contact Hours	Topic
1- 3	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. 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.
4–5	Overview of different types of metamorphism; Factors controlling transformations, Heat flow, Minerals as pure and impure phases, Textures of contact and regional metamorphism, Tectonic context of metamorphic transformations.
6 – 7	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,
8 – 10	(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.
11 – 15	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);
16-19	Crystal fractionation (equilibrium and fractional (Rayleigh) crystallization); Contamination (AFC process) and dynamic melting of magma.

20 – 25	Introduction to the main analytical methods for geochemical analysis of igneous rocks. XRF, ICPMS, TIMS, Electron microprobe and ion probes.
26 – 30	Laser ablation analysis for geochronology and mineral analysis. Discussion of detection limits, analytical precision and accuracy of analyses.
31 – 33	Metamorphic facies and facies series, combinatorial formula and Schreinemakers rules, Mineral formula calculation, geothermobarometry,
34 – 36	Medium to high pressure (zeolite facies, green schist facies, amphibolite facies and granulite facies) with special reference to characteristic minerals;
37 -40	Petrogenetic grid and pseudosections, Characterization of metamorphic fluids and mineral-fluid equilibria,
41 – 45	Time scales of metamorphism, metasomatism, migmatites, Metamorphic field gradient and P-T-t paths. Spatial link between magmatism, metamorphism and tectonics: Concept of orogenic tectonic setting.
P= 30 hours	**List of Practical** • Major oxides and trace element analysis. Interpretation of Application of different computer software's for understanding of different setup of igneous rocks. • Partial melting, co-efficient distribution value calculations • Trace elements, REEs diagram to interpret the igneous rock types. • Bulk composition specific plotting of mineral assemblages; ACF, AFM and AKF diagrams; inferring metamorphic reactions from topology changes. • Inferring metamorphic evolution and geodynamic implications of metamorphic assemblages.

Course Title: Advance Remote Sensing and Its Applications in Geosciences

Course Code	GEL81MJ0270 4	**Credits**	4
L + T + P	2+ 1+ 1	**Course Duration**	One Semester
Semester	Seven /Odd	**Contact Hours**	30(L) + 15(T) +30(P) Hours
Course Type	Major 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 (Advance Remote Sensing and Its Applications in Geosciences)	**Weightage (%)**
Unit – I Concept of Thermal Remote Sensing	**30** **09 Lectures**
Fundamental Concept of Thermal Remote Sensing, Physics of Thermal Remote Sensing, Thermal radiation principles, thermal process and properties, Characteristics of thermal IR images and Factors affecting thermal images. Study of various types of thermal satellites and their characteristics such as Landsat, ASTER, MODIS, interpretation of thermal sensors and information extraction from thermal imagery. Spectral signatures of variety of surface materials.	
Unit- II Hyperspectral and Microwave Remote Sensing	**15** **07 Lectures**
Hyperspectral remote sensing-Imaging spectrometry, principal of Hyperspectral remote sensing. Characteristics of hyperspectral data, spectral signatures and spectral libraries. Various satellite in hyperspectral Series and Availability of data. 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. Sentinel, RADARSAT, RISAT satellites characteristics.	
Unit- III Application of Applied Remote Sensing in Earth Sciences	**15** **07 Lectures**
Applications of Thermal, Microwave and Hyperspectral Remote Sensing in Mineral Targeting. Remote Sensing applications in climate change and UHI studies. Remote Sensing applications in Hydrology and Water quality mapping. Study of various recent case studies.	
Unit - IV Application of Applied Remote Sensing in Earth Sciences	**15** **07 Lectures**
Microwave and Hyperspectral remote sensing applications geological studies, identification of rocks, Minerals and geological structures. Applications of Remote Sensing in hydrocarbon exploration and environmental geology, geohazards mapping and monitoring. Study of various recent case studies.	
Unit- V Lab Experiments	
• Visual interpretation of satellite images to study the geomorphology, lithology, geology and structure, surface water, snow etc. • Digital Terrain Modeling and development of various terrain product. • Working on GEE platform • Geomorphic and Structural mapping from satellite data· • Spectral profiling of earth material and their analysis.	**25** **30 Hours Lab Sessions**

• Development of various satellite derived indices.	

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.

Content Interaction Plan

Contact Hours	Topic
1-5	Fundamental Concept of Thermal Remote Sensing, Physics of Thermal Remote Sensing, Thermal radiation principles, thermal process and properties, Characteristics of thermal IR images and Factors affecting thermal images.
6-8	Landsat, Sentinel Satellite, ASTER, MODIS satellite and their characteristics.
9-12	Interpretation of thermal sensors and information extraction from thermal imagery. Spectral signatures of variety of surface materials.
13-18	Hyperspectral remote sensing-Imaging spectrometry, Characteristics of hyperspectral data, reflection and absorption processes, causes of absorption, spectral signatures and spectral libraries.
19 -22	Microwave Remote sensing concepts: Properties and principles of microwave data, Polarization, Dielectric Properties, Surface Roughness and Interpretation of microwave data and various microwave satellites
22-25	Concept of Digital image processing techniques: radiometric and geometric corrections. Image registration and correction, basic concept of geocoding, Digital image classification and
26-28	Image enhancement, spatial filtering, band ratioing, FCCs, principal component analysis, HIS and NDVI images. Supervised and unsupervised classification. Thermal and Hyperspectral remote sensing applications geological studies, identification of rocks, Minerals and geological structures.
28-30	Applications of Remote Sensing in hydrocarbon exploration and environmental geology, geohazards mapping and monitoring. Applications of thermal and Hyperspectral Remote Sensing Mineral Targeting. Remote Sensing applications in climate change and UHI. Remote Sensing applications in Hydrology and Water quality mapping.
T = 15 Hours	Tutorial, field work and recent research paper review and presentation.
P = 30 Hours	**List of Practical** • Visual interpretation of satellite images to study the geomorphology, lithology, geology and structure, surface water, snow etc. • Digital Terrain Modeling and development of various terrain products. • Geomorphic mapping and Structural mapping from satellite data· • Hydrogeomorphological mapping and interpretation • Spectral profiling of earth material and their analysis. • Development of various satellite derived indices.

Course Title: Advanced Mineralogy

Course Code	GEL81MJ02804	**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	Seven/Odd	**Contact Hours**	45 (L) + 30 (P)Hours
Course Type	Discipline Based Core Course		

Nature of the Course	Theory/Practical
Special Nature/ Category of the Course (*if applicable*)	Concept and Skill based
Methods of Content Interaction	Lecture, Group discussion; Self-study, Seminar
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 the course is

- ❖ To introduce the structure, composition and properties of major rock-forming mineral groups and their occurrence in different rocks.
- ❖ Symmetry elements, 32 crystal class, mineral stability and optical mineralogy

Course Learning Outcomes:

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

- ❖ Classify different rock-forming silicate minerals;
- ❖ Identify minerals in thin sections, Determine sign of elongation and optic sign of the minerals.

Course Contents (Advanced Mineralogy)	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, properties, pressure-temperature stability, modes of occurrence and alterations: Nesosilicates/Orthosilicates: Olivine Group, Garnet Group, Aluminosilicate Group, Zircon; Sorosilicates: Epidote Group; Cyclosilicates: Beryl, Tourmaline; Inosilicates; Pyroxene Group; Amphibole Group; Phyllosilicates: Clay minerals, Mica Group, Chlorite, Serpentine; Tectosilicate: Quartz, Feldspar, Feldspathoid, Zeolite minerals; Introduction of Oxides, Carbonates, Phosphates and Sulphide minerals.	
Unit- II Crystallography	**20** **12 Lectures**
External and internal symmetry, types of symmetry possible in minerals, 32 crystals classes and description of the different classes; concept of Space groups; Miller indices; Hermann Mauguin notation, Different types of crystal projections-spherical and stereographic projections and their uses, Twinning in crystals, Laws of twinning, common types of twins and their examples in minerals.	
Unit- III Mineral Stability and Colour	**15** **09 Lectures**
Mineral stability with emphasis on solid solution, Gibb's phase rule, phase diagrams, exsolution and order, Polymorphism and Isomorphism; crystal defects and chemistry: colour, cause and enhancement techniques, thin section preparation for mineral studies, mineral formula recalculation	
Unit - IV Optical Mineralogy	

Behaviour of light in minerals, Double refraction, Optic axis, Uniaxial and biaxial minerals, Retardation, Birefringence, Interference of light, Interference colour, Order of Interference colour, Michael Levy's chart, determine birefringence, Optical Indicatrix: uniaxial and biaxial indicatrix, Scheme of pleochroism, Optical accessory plates (mica, gypum and quartz), Sign of elongation,Conoscopic and orthoscopic light view, Interference figure: Isogyre, isochromes, melatope; Determination of Optic sign	**20** **12 Lectures**
Unit -V Lab Experiments • Identify minerals under microscopes by studying their optical properties in plane-polarized and cross-polarized light. • Learn how to identify opaque minerals, glass and isotropic minerals. • Determine the sign of elongation of minerals under microscope. • Optic sign determination of the minerals using accessory plates. • Recalculation of mineral formula based on given oxygen and oxide weight (%) data from EPMA analysis. • Determination of Anorthite content in Plagioclase feldspar.	**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
1-3	Introduction of Silicate group minerals and their classification, discuss silicates minerals in terms of formula, Si:O ratio, crystal system and elemental substitution
4 – 8	Structure and properties of Nesosilicate minerals: Olivine Group, Garnet Group, Aluminosilicate Group; Zircon and Sorosilicates minerals: Epidote Group;
9 – 16	Explanation of Cyclosilicates: Beryl, Tourmaline, Inosilicates; Pyroxene Group; Amphibole Group and Phyllosilicates Group minerals: Clay minerals, Mica Group, Chlorite, Serpentine
17-19	Tectosilicate: Quartz, Feldspar, Feldspathoid minerals. Brief introduction of Oxides, Carbonates, Phosphates and Sulphide minerals.

20 –25	Types of symmetry possible in minerals, 32 crystals classes and description of the different classes; concept of Space groups.
26 –31	Miller indices; Hermann Mauguin notation, Different types of crystal projections-spherical and stereographic projections and their uses, Twinning in crystals, Laws of twinning, common types of twins and their examples in minerals.
32-34	Mineral stability with emphasis on solid solution, Gibbs phase rule, phase diagrams, exsolution and order, Polymorphism and Isomorphism; crystal defects and chemistry: colour, cause and enhancement techniques, thin section preparation for mineral studies.
35-38	Polymorphism and Isomorphism; crystal defects and chemistry: colour, cause and enhancement techniques, thin section preparation for mineral studies.
39-41	Behaviour of light in minerals, Double refraction, Optic axis, Uniaxial and biaxial minerals, Retardation, Birefringence, Interference of light, Interference colour, Order of Interference colour, Michael Levy's chart, determine birefringence,
42-45	Optical Indicatrix: uniaxial and biaxial indicatrix, Scheme of pleochroism, Optical accessory plates (mica, gypsum and quartz), Sign of elongation, Conoscopic and orthoscopic light view, Interference figure: Isogyre, isochromes, melatope; Determination of Optic sign.
P = 30 Hours	**List of Practical** • Identify minerals under microscopes by studying their optical properties in plane-polarized and cross-polarized light. • Learn how to identify opaque minerals, glass and isotropic minerals. • Determine the sign of elongation of minerals under microscope. • Optic sign determination of the minerals using accessory plates. • Recalculation of mineral formula based on given oxygen and oxide weight (%) data from EPMA analysis. • Determination of Anorthite content in Plagioclase feldspar.

Course Title: Sedimentology and Sequence Stratigraphy

Course Code	GEL81MJ02904	**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	Seven/Odd	**Contact Hours**	45 (L) + 30 (P) Hours
Course Type	Major Course		
Nature of the Course	Theory/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 is aimed:

- To understand the development and significance of sedimentology.
- To learn about the origin and classification of terrigenous clastic and non-clastic sediments.
- To comprehend the principles of fluid mechanics in sedimentology, including flow regimes and bedforms.
- To explore the processes of diagenesis and lithification in siliclastic and carbonate rocks.
- To examine sedimentary textures and structures, their analysis, and stratigraphic significance.
- To apply knowledge of sedimentary structures in palaeo-current analysis.
- To study the evolution and classification of sedimentary basins and their implications in facies analysis.
- To understand the environmental interpretation of sedimentary facies and their models with a focus on Indian analogues.

Course Learning Outcomes:

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

- Describe the historical developments and the importance of sedimentology in geological sciences.
- Classify different types of sediments and understand their origins and depositional environments.
- Explain the concepts of fluid flow, including laminar and turbulent flow, and the significance of Reynold's and Froude Numbers.
- Analyze the boundary layer effects, particle entrainment, transport, and deposition processes.
- Identify various bedforms and understand the conditions under which they form.
- Discuss the diagenetic processes that lead to the lithification of siliclastic and carbonate rocks.
- Interpret sedimentary textures and structures and their applications in geological history and palaeo-current analysis.
- Evaluate the evolution of sedimentary basins and the role of tectonics and sedimentation in their development.
- Apply facies association models to real-world scenarios, particularly in the context of Indian sedimentary environments.

Course Contents (Sedimentology and Sequence Stratigraphy)	**Weightage (%)**
Unit - I Concepts of sedimentology and sedimentary processes	**21** **12 Lectures**
Developments in sedimentology; Significance of Sedimentology; Origin of terrigenous clastic and non-clastic sediments; 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. Diagenesis and lithification siliciclastic rocks	
Unit- II Sedimentary textures, structures its application	**18** **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. Diagenesis and lithification carbonate limestone, dolomitization and Dolomite problem.	
Unit- III Petrology of clastic and non-clastic rocks	**18** **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 - IV Sedimentary Basins and Depositional Environments	**18** **11 Lectures**
Introduction –Sequence Stratigraphy—An Overview, Approach. Methods of Sequence Stratigraphic Analysis –Facies analysis; Accommodation and Shoreline Shifts. Sequence stratigraphic Surfaces - Transgressive surface, Maximum flooding surface. Systems Tracts – High Stand Systems Tract. Falling-stage Systems Tract, Low stand Systems Tract, Transgressive Systems Tract, Regressive Systems Tract. Hierarchy of Sequences and Sequence Boundaries. Sequence Models - types of stratigraphic sequences, sequences in Fluvial Systems, sequences in Coastal to Shallow-Water Clastic Systems, sequences in Deep-Water Clastic Systems, Sequences in Carbonate Systems.	
Unit -V Lab Experiments	**25** **30 Hours Lab Sessions**
• 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.	

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; Significance of Sedimentology
3 - 4	Origin of terrigenous clastic and non-clastic sediments; Soils and paleosols;
5 - 6	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,
7 - 8	Particle entrainment, transport and deposition, sedimentary gravity flow;
9 - 10	Concept of flow regimes and bedforms.
11 - 12	Diagenesis and lithification siliciclastic rocks
13 - 15	Sedimentary textures- types of textures, shape, size, fabric and surface textures, methods of textural analysis, textural parameters and their significance.
16 - 18	Important bedforms and sedimentary structures- Primary (Depositional, Erosional, Penecontemporaneous deformational, biogenic) and post-depositional – their genesis and stratigraphic significance.
19 – 20	Application of sedimentary structures in palaeo-current analysis.
21 - 23	Diagenesis and lithification carbonate limestone, dolomitization and Dolomite problem.
24 – 27	Sedimentary basin- Evolution and classification of sedimentary basins; tectonic and sedimentation; major sedimentary basins of India.
28 - 30	Implication of facies in environmental interpretation and basin analysis.
31 – 34	Concept of Sedimentary facies association models: Marine, Nonmarine, and Mixed Depositional Environment. Sedimentary facies and facies models with Indian analogues.
35-37	Introduction –Sequence Stratigraphy—An Overview, Approach. Methods of Sequence Stratigraphic Analysis –Facies analysis
38-42	Accommodation and Shoreline Shifts. Sequence stratigraphic Surfaces - Transgressive surface, Maximum flooding surface. Systems Tracts – High Stand Systems Tract. Falling-stage Systems Tract, Low stand Systems Tract, Transgressive Systems Tract, Regressive Systems Tract.

42-45	Hierarchy of Sequences and Sequence Boundaries. Sequence Models - types of stratigraphic sequences, sequences in Fluvial Systems, sequences in Coastal to Shallow-Water Clastic Systems, sequences in Deep-Water Clastic Systems, Sequences in Carbonate Systems.
P = 30 Hours	**List of Practical**
	• 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.

SEMESTER VIII				
Course Types	**Course Code**	**Name of Course**	**(L+T+P)**	**Credits**
Major Course	GEL82MJ03004	Engineering Geology	3+1+0	4*
Major Course	GEL82MJ03104	Environmental and Medical Geology	3+1+0	4*
Major Course	GEL82MJ03204	Statistics and Computer Applications in Geology	1+1+2	4*
Major Course	GEL82MJ03304	Mining Geology and Energy	3+1+0	4*
Major Course	GEL82MJ03404	Climatology	3+1+0	4*
Major Course	GEL82MJ03504	Application of Geospatial Technology in Water Resources Management	2+1+1	4*
Minor Course		From Chemistry/Environmental Science/Physics/Maths/Statistics / Computer Sciences/ Biological Sciences/ SWAYAM courses		4
Minimum Credits required for Semester VIII				**20**

*All the major courses offered in VIII semester are Discipline Based Core Elective (DE) in nature and student can choose 4 courses as per your interest from the provided major course basket and one 4 credit course from other departments.

Courses offered for students of other Departments

Course Types	**Course Code**	**Name of Course**	**(L+T+P)**	**Credits**

Minor Course	GEL82MJ03004	Engineering Geology	3+1+0	4

Course Title: Engineering Geology

Course Code	GEL82MJ03004	**Credits**	4
L + T + P	3+ 1 + 0	**Course Duration**	One Semester
Semester	Eight/Even	**Contact Hours**	45 (L) + 15 (T) Hours
Course Type	Major Course		
Nature of the Course	Theory		
Special Nature/ Category of the Course	Value Based and Skill 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 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 (Engineering Geology)	Weightage (%)
Unit - I: Scope of Engineering Geology and Engineering properties of rocks	**30** **12 Lectures**
Geotechnical engineering and environmental geo-technology: Introduction and scope, recent trends & developments. Engineering properties of rocks, behaviour under loads, stress & strain, elasticity (elastic constants), residual stresses, rock discontinuity and parameters (RQD, Q & RMR), geotechnical logging charts, engineering classifications (NGI, ISRM & CSIR), physical characters of building stones, concrete and other aggregates. Engineering properties of soils-soil profile, grading, index properties, consistency limits, influence of clay minerals, liquefaction, behaviour under loads, effective, neutral and total stresses, theories of failure, engineering classification, expansive pressure, consolidation and compressibility.	
Unit- II Engineering projects of Dam, Tunnel, Bridge and Canal	**25** **12 Lectures**
Dams and reservoirs: types and classification, investigations for the construction of dams and reservoir, spillways etc. Foundation rock and abutment problems-abatement technology, reservoir area problems, bearing strength of foundation rocks/soils and their improvement. Tunnels- types, tunnelling in hard and soft grounds, investigations for tunnel alignment, tunnel support design, tunnel linings, TBM, case studies. Bridges: Types, abutment and foundation problems across river and valley crossing, geological investigations for construction of bridges. Canals-types, investigations for canals, drains and linings, problems and their control, river interlinking projects in India.	
Unit- III Building foundation, Aseismic designs and flood control	**25** **12 Lectures**
Buildings– foundations and their selection, types of piles, foundation problems and their improvement. Aseismic designing - calculation of safety factor (seismic coefficient), earthquake resistance design, geo-radars. River training and flood control- river improvement for navigation, principles of flood control, control of abutment erosion.	
Unit – IV Engineering problems and geotechnical consideration	**20** **09 Lectures**
Mass movements with special emphasis on landslides and rock falls. Slope stabilization and protection measures. Geological consideration for evaluation of dams and reservoir sites. Reservoir siltation. Geotechnical evaluation of tunnel alignments, Methods of tunnelling, classification of ground for tunnelling purposes, various types of support. Geotechnical consideration for transportation routes (Roads and railways) Geotechnical investigations for bridges and coastal barriers.	

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. Schuster, R. I. &Krizek, R. J. (1978): Landslides analysis and control, Trans. Res. Board Spec. pub. 176 Nat. Acad. Sci. Washington D.C.
13. Vutukuri, V. S., Lama, R. D. and Saluja, S. S. (1974): Handbook on mechanical properties of rocks, Transtech Publications, Clausthal, Germany.
14. Tonk, W. R. (1986): Environmental Geology, Oxford University Press, New York.

Content Interaction Plan

Contact Hours	Topic
1-10	Geotechnical engineering and environmental geo-technology: Introduction and scope, recent trends & developments. Engineering properties of rocks, behaviour under loads, stress & strain, elasticity (elastic constants), residual stresses, rock discontinuity and parameters (RQD, Q & RMR), geotechnical logging charts, engineering classifications (NGI, ISRM & CSIR), physical characters of building stones, concrete and other aggregates.
11 – 18	Engineering properties of soils- soil profile, grading, index properties, consistency limits, influence of clay minerals, liquefaction, behaviour under loads, effective, neutral and total stresses, theories of failure, engineering classification, expansive pressure, consolidation and compressibility.
19–25	Dams and reservoirs: types and classification, investigations for the construction of dams and reservoir, spillways etc. Foundation rock and abutment problems- abatement technology, reservoir area problems, bearing strength of foundation rocks/soils and their improvement. Tunnels- types, tunneling in hard and soft grounds, investigations for tunnel alignment, tunnel support design. Tunnel linings, TBM, case studies. Bridges: Types, abutment and foundation problems across river and valley crossing, geological investigations for construction of bridges.
26-30	Canals-types, investigations for canals, drains and linings, problems and their control, river interlinking projects in India. Buildings– foundations and their selection, types of piles, foundation problems and their improvement.
	Aseismic designing - calculation of safety factor (seismic coefficient), earthquake resistance design, geo-radars. River training and flood control- river improvement for navigation, principles of flood control, control of abutment erosion.

31-38	Mass movements with special emphasis on landslides and rock falls. Slope stabilization and protection measures, Geological consideration for evaluation of dams and reservoir sites. Reservoir siltation study. Geotechnical evaluation of tunnel alignments, Methods of tunneling, classification of ground for tunneling purposes, various types of support Geotechnical consideration for transportation routes (Roads and railways) Geotechnical investigations for bridges and coastal barriers.
39-45	Buildings– foundations and their selection, types of piles, foundation problems and their improvement. Aseismic designing - calculation of safety factor (seismic coefficient), earthquake resistance design, geo-radars. River training and flood control- river improvement for navigation, principles of flood control, control of abutment erosion.
T = 15 Hours	Tutorial

Course Title: Environmental and Medical Geology

Course Code	GEL82MJ03104	**Credits**	4
L + T + P	3 + 1 +0	**Course Duration**	One Semester
Semester	Eight/Even	**Contact Hours**	45 (L) + 15 (T) Hours
Course Type	Major Course		
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:

- ❖ The main objective of this course to understand the interaction of humans with the geological environment,
- ❖ Familiarize the students to various challenges of environmental geology and understand the role of geologist to minimizing the environmental impact of various activity.

Course Learning Outcomes:

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

- ❖ Basic Concepts of environmental geology and its role in sustainable development and management.
- ❖ Understand the role of geology in natural resource mapping and mitigating the environmental pollution to support the Sustainable development goal (SDG).

Course Contents (Environmental and Medical Geology)	Weightage (%)
Unit – I Concept and Scope of Environmental Geology	

Fundamental concepts of environmental geology, its scope and necessity; natural hazards: earthquakes, volcanic activity, floods, landslides and coastal hazards. 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; River pollution and Characteristics and problems.	**30** **12 Lectures**
Unit- II Various type of Pollution	
Water pollution: types of water pollution, groundwater pollution sources, pathways and mechanism, attenuation processes, case histories of natural and man-made water pollution; water logging, causes, effects and remedial measures; declining groundwater tables, subsidence and compaction of aquifers; Soil pollution- sources, causes, effects, and 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.	**30** **12 Lectures**
Unit- III Introduction and Scope of Medical geology	
Introduction to medical geology and terminology; Minerals in medical geology; Geogenic distribution and abundance of elements; anthropogenic sources of elements; Essential and Non-essential elements with reference to human health; Major, minor and trace elements of human body; Micronutrient Deficiencies in Soils, Crops and Health of Humans.	**22** **11 Lectures**
Unit – IV Pollutants Mapping and Human Health Risk Assessment	
Trace element deficiency and toxicity health effects: Arsenic, Cadmium, Lead, Mercury, Radon, Fluoride and Selenium; Health hazards associated with volcanic eruptions; carcinogenic associations with coal and fibrous minerals; geological effects on animal health; geophagy; Geospatial technology in Human Health Studies.	**18** **10 Lectures**

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
1-12	Fundamental concepts of environmental geology, its scope and necessity; natural hazards: earthquakes, volcanic activity, floods, landslides and coastal hazards. 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; River pollution and Characteristics and problems.
13 – 24	Water pollution: types of water pollution, groundwater pollution sources, pathways and mechanism, attenuation processes, case histories of natural and man-made water pollution; water logging, causes, effects and remedial measures; declining groundwater tables, subsidence and compaction of aquifers; Soil pollution- sources, causes, effects, and 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.
25 – 35	Introduction to medical geology and terminology; Minerals in medical geology; Geogenic distribution and abundance of elements; Anthropogenic sources of elements; Essential and Non-essential elements with reference to human health; Major, minor and trace elements of human body; Micronutrient Deficiencies in Soils, Crops and Health of Humans.
36-45	Trace element deficiency and toxicity health effects: Arsenic, Cadmium, Lead, Mercury, Radon, Fluoride and Selenium; Health hazards associated with volcanic eruptions; Carcinogenic associations with coal and fibrous minerals; geological effects on animal health; geophagy; Geospatial technology in Human Health Studies.
T = 15 Hours	Tutorial

Course Title: Statistics and Computer Application in Geology

Course Code	GEL82MJ03204	**Credits**	4
L + T + P	1+ 1+ 2	**Course Duration**	One Semester
Semester	Eight/Even	**Contact Hours**	15 (L) + 15 (T) + 60 (P) Hours
Course Type	Major Course		
Nature of the Course	Theory/Practical		
Special Nature/ Category of the Course	Value Based and Skill 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:

- To equip students with the ability to analyse geological data using statistical methods and relevant computer applications, allowing them to interpret complex geological patterns, test hypotheses, and effectively visualize their findings, ultimately providing insights into geological processes and resource exploration by applying statistical techniques to real-world geological datasets through various software tools.

Course Learning Outcomes:

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

- Utilise various statistical methods and computer applications very effectively to know complex geological phenomena and this will help to apply this application in various geological fields like resource exploration, environmental assessment, and hazard mitigation etc.

Course Contents (Statistics and Computer Application in Geology)	Weightage (%)
Unit –I Statistical parameters and their importance	**15** **05 Lectures**
Define statistics, the importance of statistics in geoscience, histograms, pie diagram, frequency distribution, mean, median and mode, variance, standard deviation, correlation coefficient, coefficient of determination, Regression, Least squares method, straight line equation.	
Unit- II Probability, hypothesis and test	
Descriptive statistics, random variables, probability distribution: Discrete and continuous distribution, Normal distribution curve, parametric and non-parametric test, Null and alternate hypothesis, chi-square test, t-test, z-test.	**15** **05 Lectures**
Unit- III Introduction to various Software used in Geological Sciences	**10** **03 Lectures**
Use of MATLAB software for various modelling; AutoCAD and their applications for 2 D and 3 D modeling; use Surfer for 3 D analysis; use of Origin software for strain analysis, rose diagram; ERDAS software and their applications; GIS application in Geology; Application of CORELDRAW Software; Use of GRADISTAT for grain size analysis.	
Unit – IV Different Tools used in Geology to carry out Research work	**06** **02 Lectures**
Brief Introduction of different software used in geological sciences to carry out the research work MATLAB, AUTOCAD, SURFER, ORIGIN, ERDAS, GIS, CORELDRAW, GRADISTAT, Q GIS, and GEOMATICA.	
Unit – V Lab Experiments	**54** **60 Hours Lab Sessions**
• Exercise on MATLAB software • Exercise on AutoCAD (2D – 3D) software • Exercise on Surfer, ORIGIN, ERDAS, QGIS CORELDRAW, GRADISTAT software • Exercise on Q GIS, and other GIS software	

Content Interaction Plan

Contact Hours	Topic

1-5	Define statistics, the importance of statistics in geoscience, histograms, pie diagram, frequency distribution, mean, median and mode, variance, standard deviation, correlation coefficient, coefficient of determination, Regression, Least squares method, straight line equation
6-10	Descriptive statistics, random variables, probability distribution: Discrete and continuous distribution, Normal distribution curve, parametric and non-parametric test, Null and alternate hypothesis, chi-square test, t-test, z-test.
11-13	Use of MATLAB software for various modelling; AutoCAD and their applications for 2 D and 3 D modelling; use Surfer for 3 D analysis; use of Origin software for strain analysis, rose diagram; ERDAS software and their applications; GIS application in Geology; Application of CORELDRAW Software; Use of GRADISTAT for grain size analysis.
14-15	Brief Introduction of different software used in geological sciences to carry out the research work MATLAB, AUTOCAD, SURFER, ORIGIN, ERDAS, GIS, CORELDRAW, and GRADISTAT software, Q GIS, GEOMATICA software.
P = 60 Hours	**List of Practical** • Exercise on MATLAB software • Exercise on AutoCAD (2D – 3D) software • Exercise on Surfer, ORIGIN, ERDAS, GIS, CORELDRAW, GRADISTAT software • Exercise on Q GIS, and other GIS software

Course Title: Mining Geology and Energy

Course Code	GEL82MJ03304	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	Eight/Even	**Contact Hours**	45 (L) + 15 (T) Hours
Course Type	Major Course		
Nature of the Course	Theory		
Special Nature/ Category of the Course	Skill 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 is aimed:

- ❖ To provide an in-depth understanding of petroleum geology, including the composition, origin, and migration of oil and gas.
- ❖ To explore the geology of coal and atomic fuels, their classifications, and industrial applications.
- ❖ To impart knowledge on mining terminology, planning, development, and the role of geologists in mining operations.
- ❖ To introduce advanced mining methods and safety measures for efficient resource extraction.

- ❖ To investigate the potential of gas hydrates and geothermal energy in India's energy sector.

Course Learning Outcomes:

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

- ❖ Analyze the composition and fractions of petroleum, and understand the transformation process from organic matter to kerogen.
- ❖ Classify coal types based on rank and grade, and perform proximate and ultimate analyses.
- ❖ Apply mining terminology in practical scenarios, plan fieldwork, and evaluate mine sites.
- ❖ Design and implement mining operations, considering different features such as ventilation, transport, and drainage.
- ❖ Assess the advancements in mining technology and the extraction of remote mineral resources.
- ❖ Identify and mitigate various mine hazards, ensuring safety in mining environments.
- ❖ Understand the duties of geologists in mining organizations and the operation of mine machineries.
- ❖ Evaluate the potential of gas hydrates and geothermal energy as future energy resources in India.

Course Contents (Mining Geology and Energy)	Weightage (%)
Unit - I Petroleum and Gas, their genesis and Reserves	**24** **11 Lectures**
Understanding petroleum: its composition and different fractions. Discussion on the origin, nature, and migration (primary and secondary) of oil and gas. Detailed study on the transformation of organic matter into kerogen. Understanding the surface and subsurface occurrence of petroleum and gas. Introduction to source and reservoir rocks; Characteristics of reservoir rocks. Study of traps (structural, stratigraphic, and correlation); Overview of oil-bearing basins of India. Detailed study on the geology of the productive oil fields of India. Gas hydrates and its future potential in India.	
Unit- II Coal Anatomy and their Reserves	**28** **12 Lectures**
Definition and Origin of Coal; Coal-bearing Strata; Types of Coal. Rank and Grade of Coal; Indian and International Classifications of Coal; Proximate and Ultimate Analysis of Coal. Macroscopic Ingredients and Microscopic Constituents of Coal. Concept of Maceral and Micro-lithotypes; Preparation of Coal for Industrial Purposes. Coal Carbonization (Coke Manufacture); Coal Gasification and Coal Hydrogenation; Coal Bed Methane as a New Energy Resource Atomic Fuel and Energy Resources: Mode of Occurrence and Prospecting Methods; Productive Geological Horizons in India; Nuclear Power Stations and Future Prospects. Geothermal Energy: Fundamentals of Geothermal Energy; Exploration Techniques; Case Studies and Potential in India.	
Unit- III Mining Prospecting, Techniques, and Recent Advances	**24** **11 Lectures**
Mining Terminology: Understanding Surface and Subsurface Concepts. Field Work Planning: Strategies and Tools. Mine Planning: Processes and Techniques. Mine Examination and Evaluation: Methods and Best Practices. Mapping: Surface and Underground Techniques.	

Developing & Mining: introduction to development a prospect; prospecting different features (shaft drift and tunnels, ventilation, illumination, transports, drainage etc.). Advanced Mining Techniques/ Remote Mineral Resource Extraction: Current Technologies. Sea Bed Mining: Mineral Resources and Techniques.	
Unit- IV Sampling Techniques, Estimation and Safety in Mining	**24** **11 Lectures**
Sampling Techniques: Learn various sampling methods, including channel sampling and borehole sampling. Understand the grades, uses, and precautions associated with explosives in mining. Elementary Principles and Methods: Explore open-pit and underground mining techniques. Gain insights into the duties of geologists within mining organizations and their role in mine development and operation of mine machinery. Mining Methods: Study surface, subsurface, and underground methods applicable to diverse minerals, building stones, ores, and fuels. Mine Safety: Investigate critical safety aspects, including roof supports in underground mining. Understand challenges related to mine ventilation, rock bursts, mine fires, and flooding.	

Text / Reference Books:

1. Barker, C. (1996) Thermal Modeling of Petroleum Generation, Elsevier Science, Netherlands.
2. Chandra, D., Singh, R.M. Singh, M.P. (2000). Textbook of Coal (Indian context), Tara Book Agency, Varanasi.
3. Holson, G.D. and Tiratso, E.N. (1985). Introduction of Petroleum Geology. Fulf Publishing, Houston, Texas
4. Hunt, J.M. (1996) Petroleum Geochemistry and Geology, 2nd Edition Freeman, San Francisco.
5. Jahn, F. Cook, M. and Graham, M. (1998) Hydrocarbon exploration and production. Elsevier.
6. North, F.K. (1985). Petroleum Geology. Allen Unwin.
7. Scott, A.C. (1987). Coal and Coal-bearing strata: Recent Advances. Blackwell Scientific Publications.
8. Selley, R.C. (1998) Elements of Petroleum Geology. Academic Press.
9. Singh, M.P. (1998). Coal and organic Petrology, Hindustan Publishing Corporation, New Delhi.
10. Stach;, E., Mackowsky, M-Th., Taylor, G.H., Chandra, D., Teichumullelr, M. and Teichmuller R. (1982). Texbook of Coal petrology, GebruderBorntraeger, Stuttgart.
11. Taylor,G.H., Teichmuller, M., Davis, A., Diessel, C.F.K., Littke, R. and Robert P. (1998). Organic Petrology. GebruderBorntraeger, Stuttgart.
12. Thomas, Larry (2002). Coal Geology, John Wiley and Sons Ltd., England.
13. Tissot, B.P. and Welte, D.H. (1984). Petroleum Formation and Occurrence. Springer – Verlag
14. Van Krevelen, D. W. (1993). Coal: Typology-Physics-Chemistry-Constitution). Elsevier Science, Netherlands.
15. Arogyaswami, R. N. P. (1988). A course in Mining Geology, 2nd Ed., MohamPrimlani (Oxford & IBH Pub. Co.), New Delhi
16. Peters, W. C. (1987). Exploration and Mining Geology. 2nd Ed., John Wiely& Sons, New York.
17. Haldar, S. K. (2018). Mineral Exploration: Principles and Applications, 2ed Edition. Elsevier Publication.
18. McKinstry, H. E. (1960). Mining Geology, 1st Ind. Ed., Asia Pub. House, Kolkata
19. Clark, G.B. (1967). Elements of Mining, III ed. John Wiley

Content Interaction Plan

Contact Hours	Topic
1 - 2	Understanding petroleum: its composition and different fractions.
3 - 5	Discussion on the origin, nature, and migration (primary and secondary) of oil and gas; Detailed study on the transformation of organic matter into kerogen.
6 - 8	Understanding the surface and subsurface occurrence of petroleum and gas; Introduction to source and reservoir rocks; Characteristics of reservoir rocks; Study of traps (structural, stratigraphic, and correlation).
9 - 12	Overview of oil-bearing basins of India; Detailed study on the geology of the productive oil fields of India; Gas hydrates and its future potential in India; Definition and Origin of Coal; Coal-bearing Strata; Types of Coal.
13 - 16	Rank and Grade of Coal; Indian and International Classifications of Coal; Proximate and Ultimate Analysis of Coal; Macroscopic Ingredients and Microscopic Constituents of Coal; Concept of Maceral and Micro-lithotypes; Preparation of Coal for Industrial Purposes
17 - 20	Coal Carbonization (Coke Manufacture); Coal Gasification and Coal Hydrogenation; Coal Bed Methane as a New Energy Resource; Atomic Fuel and Energy Resources: Mode of Occurrence and Prospecting Methods; Productive Geological Horizons in India; Nuclear Power Stations and Future Prospects.
21 - 27	Geothermal Energy: Fundamentals of Geothermal Energy; Exploration Techniques; Case Studies and Potential in India; Mining Terminology: Understanding Surface and Subsurface Concepts; Field Work Planning: Strategies and Tools; Mine Planning: Processes and Techniques; Mine Examination and Evaluation: Methods and Best Practices.
28 - 31	Mapping: Surface and Underground Techniques; Developing& Mining: introduction to development a prospect; Prospecting different features (shaft drift and tunnels, ventilation, illumination, transports, drainage etc.).
32 - 33	Advanced Mining Techniques/ Remote Mineral Resource Extraction: Current Technologies.
34 - 35	Sea Bed Mining: Mineral Resources and Techniques.
36 - 37	Sampling Techniques: Learn various sampling methods, including channel sampling and borehole sampling.
38	Understand the grades, uses, and precautions associated with explosives in mining; Elementary Principles and Methods: Explore open-pit and underground mining techniques; Gain insights into the duties of geologists within mining organizations and their role in mine development and operation of mine machinery.
41 - 42	Mining Methods: Study surface, subsurface, and underground methods applicable to diverse minerals, building stones, ores, and fuels.
43 - 45	Mine Safety: Investigate critical safety aspects, including roof supports in underground mining; Understand challenges related to mine ventilation, rock bursts, mine fires, and flooding.
T = 15 Hours	Tutorial

Course Title: Climatology

Course Code	GEL82MJ03404	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	Eight/Even	**Contact Hours**	45 (L) + 15 (T) Hours
Course Type	Major Course		
Nature of the Course	Theory		
Special Nature/ Category of the Course	Skill 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 is aimed:

- To provide students with a comprehensive understanding of Earth's climate system, including its components, driving forces, variations, and impacts, enabling them to analyse climate data, interpret climate patterns, and discuss the causes and consequences of climate change.

Course Learning Outcomes:

- After the successful completion of this course the students will definitely able to differentiate between weather and climate, explain the factors influencing climate distribution, analyse climatic classifications, and discuss the role of human activities on climate change

Course Contents (Climatology)	Weightage (%)
Unit - I Introduction to Climate and its Components	**24** **11 Lectures**
Introduction to Climate and Weather; Structure of earth's atmosphere and its layers: troposphere, stratosphere, mesosphere, ionosphere and exosphere; Composition of the atmosphere; Atmospheric boundary layers, lapse rate, Classification of climates – Koppen‟s and Thornthwaite‟s scheme of classification.	

Unit- II Factors Affecting the Climate	**28** **12 Lectures**
Insolation; Solar radiation; Factors affecting distribution of insolation, latitudinal and seasonal variation of insolation latitudinal and seasonal variation of insolation, Temperature of the atmosphere, distribution of temperature, inversion of temperature, humidity, cloud formation and their types; precipitation and their types.	
Unit- III Wind Circulation and Distribution	**24** **11 Lectures**
Atmospheric pressure: Vertical and horizontal distribution - Winds and their causes of circulation - Types of planetary, Periodic and local winds. Air masses and Fronts- Atmospheric disturbances: Tropical and Temperate cyclones- Anti-cyclones - ElNino-Southern Oscillation (ENSO).	
Unit- IV Indian Monsoon System and Controlling Factors	**24** **11 Lectures**
Concept of Monsoon; Indian Monsoon system: Southwest Monsoon (SW), Factors Influencing South-West Monsoon; Northeast Monsoon (NE); Western disturbances their Effects on monsoon; Recent climate change and its effect on Monsoon; Various Indian missions/programmes for weather and monsoon predication. An overview of Intergovernmental Panel on Climate Change (IPCC), their aims and objectives regarding climate change.	

Text / Reference Books:

1. Willett, S. D., 2006. Tectonics, Climate, and Landscape Evolution, Geological Society of America Publication.
2. Bradley, R.S., Paleoclimatology: Reconstructing Climates of the Quaternary, Academic. Press.
3. Lal, D.S., 2003. Climatology. Sharda Pustak Bhawan.
4. C. Donald Ahrens, 2001. Essentials of Meteorology: An Invitation to the Atmosphere. Publisher: Brooks/Cole/Thomson Learning.
5. K. Siddhartha., 2018. Climatology: Atmosphere Weather Climate. Kitab Mahal Publication

Content Interaction Plan

Contact Hours	Topic
1-7	Introduction to Climate and Weather; Structure of earth's atmosphere and its layers: troposphere, stratosphere, mesosphere, ionosphere and exosphere;
8-11	Composition of the atmosphere; Atmospheric boundary layers, lapse rate, Classification of climates – Koppen"s and Thornthwaite"s scheme of classification.
12-17	Insolation; Solar radiation; Factors affecting distribution of insolation, latitudinal and seasonal variation of insolation latitudinal and seasonal variation of insolation
18-23	Temperature of the atmosphere, distribution of temperature, inversion of temperature, humidity, cloud formation and their types; precipitation and their types.
24-28	Atmospheric pressure: Vertical and horizontal distribution - Winds and their causes of circulation - Types of planetary, Periodic and local winds.
29-34	Air masses and Fronts- Atmospheric disturbances: Tropical and Temperate cyclones- Anti- cyclones - ElNino-Southern Oscillation (ENSO).
35-39	Concept of Monsoon; Indian Monsoon system: Southwest Monsoon (SW), Factors Influencing South-West Monsoon; Northeast Monsoon (NE); Western disturbances

	their Effects on monsoon; Recent climate change and its effect on Monsoon.
40-45	Various Indian missions/programmes for weather and monsoon predication. An overview of Intergovernmental Panel on Climate Change (IPCC), their aims and objectives regarding climate change.
T = 15 Hours	Tutorial

Course Title: Geospatial Technology Applications in Water Resources Management

Course Code	GEL82MJ03504	**Credits**	4
L + T + P	2 + 1 + 1	**Course Duration**	One Semester
Semester	Eight/Even	**Contact Hours**	30(L) +15(T)+ 30(P) Hours
Course Type	Major Course		
Nature of the Course	Theory/Practical		
Special Nature/ Category of the Course	Application/Skill based		
Methods of Content Interaction	*(Lecture, Group discussion, primary data collection & analysis, seminar, 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:

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

- ❖ The course aims to give an idea on recent advances in technology and their applications to solve the issues related to water resources management.
- ❖ To learn the various software's used for water management and data collection.

Course Learning Outcomes:

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

- ❖ An ability to independently carry out research/investigation and solve the practical problems in the field of water resources.

Course Contents (Geospatial Technology Applications in Water Resources Management)	**Weightage (%)**
Unit - I Concept of Water Resources, Issues and Challenges	**30** **14 Lectures**
Basic concept of water resources, issue and Challenges: hydrological cycle and water balance, Issues in water resources development, management and utilization. Hydrologic elements. Hydrological cycle and general principles of remote sensing for evaluation of hydrologic elements. Application of geology	

and geomorphology in hydrology, Drainage characterization and Morphometric Analysis and calculation. Water harvesting structures and Ground water modelling. Recent research case studies. Water logging and salinity. Environment Impact Assessment of multipurpose water resources projects. Sustainable development Goal (SDGs) linkage with water resources issues and its management. AI and Machine learning application in water resources assessment and management.	
Unit- II Landscape changes and their impact on Water Resources	**20** **08 Lectures**
Landuse/landcover features and their relation with water resources. Hydrologic soil grouping. Rainfall-runoff modeling and water quality mapping and GWQI. Digital Elevation Model and its application water resources. Recent research case studies. Use of Google Earth Engine and Applications drone technology in Water resource mapping and Monitoring. Recent research case studies.	
Unit- III Flood and Drought Management	**20** **08 Lectures**
Types of Floods, Different methods of Flood control, Floods in major Indian river basins. Flood risk zone mapping and damage assessment, Drought monitoring and management. Concept of flood early warning system. Irrigation water management. Flood plain zoning and management. Flood estimation, forecasting, warning and damage assessment.	
Unit - IV Lab Experiments	**30** **30 Hours Lab Sessions**
• Development of various thematic maps using GIS software. • Flood modeling using Field and satellite data. • Development Groundwater recharge on GEE platform. • Development of Satellite derived indices. • Spatial-temporal mapping of groundwater quality parameters.	

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. Nandipati Subba Rao, 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 - 6	Basic concept of water resources, issue and Challenges: hydrological cycle and water balance, Issues in water resources development, management and utilization. Hydrologic elements. Application of geology and geomorphology in hydrology, Drainage characterization and Morphometric Analysis and calculation.

7 –14	Water harvesting structures and Ground water modelling. Recent research case studies. Water logging and salinity. Environment Impact Assessment of multipurpose water resources projects. Sustainable development Goal (SDGs) linkage with water resources issues and its management. AI and Machine learning application in water resources assessment and management.
15– 18	Landuse/landcover features and their relation with water resources. Hydrologic soil grouping. Rainfall-runoff modeling and water quality mapping and GWQI.
19– 20	Digital Elevation Model and its application water resources. Recent research case studies.
21– 22	Use of Google Earth Engine and Applications drones technology in Water resource mapping and Monitoring. Recent research case studies.
23 -26	Types of Floods, Different methods of Flood control, Floods in major Indian river basins. Flood risk zone mapping and damage assessment, Drought monitoring and management
27– 30	Concept of flood early warning system. Irrigation water management. Flood plain zoning and management. Flood estimation, forecasting, warning and damage assessment.
T = 15 Hours	Tutorial, field data collection, visit of river site and presentation.
P = 30 Hours	**List of Practical**
	• Development of various thematic maps using GIS software. • Flood modeling using Field and satellite data. • Development Groundwater recharge on GEE platform. • Development of Satellite derived indices. • Spatial-temporal mapping of groundwater quality parameters

BACHELOR OF SCIENCE HONOURS WITH RESEARCH IN GEOLOGY (FOURTH YEAR)

SEMESTER VIII				
Course Types	**Course Code**	**Name of Course**	**(L+T+P)**	**Credits**
Major Course	GEL82MJ03612	Research Project	0+0+12	12
Major Course	GEL82MJ03004	Engineering Geology	3+1+0	4
Minor Course		From Chemistry/Environmental Science/Physics/Maths/Statistics / Computer Sciences/ Biological Sciences/ SWAYAM courses		4
Minimum Credits required for Semester VIII				**20**

Course Title: Research Project

Course Code	GEL82MJ03612	**Credits**	12
L + T + P	0 + 0 + 12	**Course Duration**	One Semester
Semester	Eight/Even	**Contact Hours**	
Course Type	Major Course		
Nature of the Course	Field work cum Research work		
Special Nature/ Category of the Course	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 time line 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 examiners Internal and external. CUSB will not provide any financial support for dissertation work conducted outside the department.

MASTER OF SCIENCE (INTEGRATED) IN GEOLOGY (FIFTH YEAR)

SEMESTER IX				
Course Types	**Course Code**	**Name of Course**	**(L+T+P)**	**Credits**
Major Course	GEL91MJ03704	Applied Palaeontology	3+0+1	4*
Major Course	GEL91MJ03804	Oceanography	3+1+0	4*
Major Course	GEL91MJ03904	Quaternary Geology and Glaciology	3+1+0	4*
Major Course	GEL91MJ04004	Geo-Exploration	3+1+0	4*
Major Course	GEL91MJ04104	Urban Geology and Watershed Modelling	2+1+1	4*
Major Course	GEL91MJ04204	Geochronology and Isotope Geology	4+0+0	4*
Minimum Credits required for Semester IX				**20**

*All the major courses offered in IX semester are Discipline Based Core Elective (DE) in nature and student can choose any 5 courses as per your interest from the provided major course basket.

Courses offered for students of other Departments

Course Types	Course Code	Name of Course	(L+T+P)	Credits
Minor Course	GEL91MJ03804	Oceanography	3+1+0	4

Course Title: Applied Palaeontology

Course Code	GEL91MJ03704	**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	Nine /Odd	**Contact Hours**	45(L) + 30(P) Hours
Course Type	Major Course		
Nature of the Course	Theory/Practical		
Special Nature/ Category of the Course (*if applicable*)	Concept and Skill Based		
Methods of Content Interaction	Lecture, Group discussion; Self-study, Seminar		
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

- ❖ Understand the micro-fossils found in geological formations in India and the role of microfossils and micro-organisms in interpretation of depositional environment.
- ❖ Identify various types of microfossils, their role in depositional systems and application of microfossils in the field of oil-exploration, biostratigraphy, paleobiology and paleoclimatology.
- ❖ Understand interaction the present-day physical, chemical & biological characteristics of the ocean water.

Course Learning Outcomes:

The students will develop capability to

- ❖ Achieve methods and techniques dating ofrocks and 'high resolution biostratigraphy' based on microfossils
- ❖ Transform the 'taxonomic aspects' of microfossils in 'oil-exploration', and 'paleo-monsoonal studies' etc. through 'reconstructing the environment of sedimentation' based on 'their paleo-ecological aspects.
- ❖ Understand the main systematic groups of microfossils, its distribution and (paleo) environmental and (paleo) climatic connotation.
- ❖ Use the application of knowledge and understanding in collect, organize and analyze descriptive data of microfossils and associated sedimentary materials using adequate concepts, methodologies and techniques.

- ❖ Define role of micro fossils as geologic agents and their utility for describing and modeling the biologic evolution.

Course Contents (Applied Palaeontology)	Weightage (%)
Unit - I Application of Microfossils and Foraminifera	**21** **12 Lectures**
Micropaleontology and its significance; Modern field and laboratory techniques in the study of microfossils: methods of sampling, treatment and separation of microfossils from fossiliferous rocks, application of scanning electron microscopy and mass spectrometry; Types of environments and biotic distribution. Use of microfossils in dating, biozonation, biostratigraphic correlation; biozones and their types. Microfossils as low thermal metamorphic indicators. Micropaleontology in petroleum exploration. Foraminifera: Living animal, habit, life cycle; dimorphism; test shape, wall composition, wall structure, lamellar character of wall in Foraminifera; Formation and arrangement of chambers and ornamentation in Foraminifera; Test apertures, perforations, pore plates and taxonomic importance in Foraminifera. Classification of Foraminifera. Applications of foraminifera. Introduction to molecular study in foraminifera.	
Unit- II Other Mineral Walled Microfossils and Applications	**18** **11 Lectures**
Ostracoda: Living animal, life habit, and morphology. Classification, ecology and stratigraphic distribution of Ostracoda. Use of Ostracoda in petroleum exploration. Nannofossils: Introduction, history of study and significance of various groups of nannofossils. Sampling and methods of separation of nannofossils; Calcareous Nannoplanktons: Living organism, habitat, life history; Formation, utility and mineralogy of Nannoliths in Nannoplanktons; Types of Nanoliths: Nannoplanktons, Discoasters, Nannoconids; Classification of Nannoplanktons. Classification, ecology and paleoecology; Utility of nannofossils in high resolution biostratigraphy. Conodonts: morphology, classification and its applications. Radiolaria and Diatoms: morphology, classification and significance. Pteropoda: morphology, classification and scope. Application of micropaleontology in hydrocarbon exploration; and their use in bathymetric measurement and paleoclimate interpretation	
Unit- III Introduction to functional morphology and Principle of paleobiogeography	**18** **11 Lectures**
Functional morphology of major invertebrates and vertebrates; Brief on Taphonomy and ichnology; major evolutionary and extinction events in the past, Principle of paleobiogeography. Distribution, migration and dispersal of organisms applied to paleobiogeography and plate-tectonics with Indian examples.	
Unit - IV Fossil applications for Palaeoecology, Palaeoenvironment and Paleoclimate	

Use of paleontological data in stratigraphy, biostratigraphy, paleoecology, evolution, and sea level changes; Principle of palaeoenvironment, palaeoecology and paleoclimate: Principles of isotopic (oxygen, carbon, calcium, magnesium, strontium) studies of fossils and their application in paleoclimate, Eustacy, palaeo-oceanography and paleoenvironment. Use of microfossils in interpretation of sea floor tectonism. Management and conservation of palaeontological heritage.	**18** **11 Lectures**
Unit -V Lab Experiments (Micropaleontology)	**25** **30 Hours Lab Sessions**
• Techniques of samples preparation; • Techniques of separation of microfossils from matrix; • Preparation of micro-faunal species slides of microfossils: Foraminifera, Ostracoda etc. and their species level identification from the samples of Indian basins. • Techniques of samples collection and preparation for foraminifera molecular study. • 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.	

Text / Reference Books:

1. Aldrige, R. J. (1985): Paleobiology of Conodonts, (Ed.), British Micropaleontological Society
2. Babin Claude, 1980: Elements of Palaeontology. John Wiley & Sons.
3. Clarkson, E. N. K. (1979 & 2002), Invertebrate Paleontology & Evolution, London Gorge Allen & Unwin.
4. Howard A. Armstrong and Martin D. Brasier (2005) MICROFOSSILS (IInd Ed.) Blackwell Publishing Ltd.
5. Kathal P. K. (2012): Applied Geological Micropaleontology, Scientific Publishers (India)
6. Saraswati Pratul Kumar, Srinivasan M. S. (2016): Micropaleontology – Principles and Applications, Springer.

Additional/Further Readings:

1. Alfred Traverse (1988): Paleopalynology, Unwin Hyman, USA.
2. Arnold (2002): Quaternary Environmental Micropaleontology (Ed. Simon K. Haslett), Oxford University Press, New York.
3. Bignot, G., Grahm and Trottman (1985): Elements of Micropaleontology, London.
4. Boardman, R.S., Cheetham, A.H. and Rowell, A.J. 1987: Fossil Invertebrates. Blackwell Science
5. Haq, B. U. & Boersma, A. (Eds.), (1978): Introduction to Marine Micropaleontology, Elsevier, New York, 250 p.
6. Jones R.W. (1996): Micropaleontology in Petroleum exploration by Clarendon Press Oxford
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. Loelich, A. R. (Jr.) & Tappan, J. (1988): Foraminifera Genera & Their Classification (v. 1 & 2), Van Nostrand Renhold.
11. Murray, John, (2006): Ecology & Application of Benthic Foraminifera, Cambridge University Press.
12. Sen Gupta, B. K. (1998): Modern Foraminifera, Kluwer Academic Publishers.
13. Simon K. Haslett (Ed.) (2002): Quaternary Environmental Micropaleontology Arnold; Oxford University Press, New York Year.

Content Interaction Plan

Contact Hours	Topic
1 - 2	Sub disciplines, its relation with other branches of science and scope. Micropaleontology and its significance
3 - 6	Modern field and laboratory techniques in the study of microfossils, Methods of sampling, treatment and separation of microfossils from fossiliferous rocks, application of scanning electron microscopy and mass spectrometry; Types of environments and biotic distribution
7 - 9	Use of microfossils in dating, biozonation, biostratigraphic correlation; biozones and their types. Microfossils as low thermal metamorphic indicators. Micropaleontology in petroleum exploration
10 - 11	Foraminifera: Living animal, habit, life cycle; dimorphism; test shape, wall composition, wall structure, lamellar character of wall in Foraminifera, Formation and arrangement of chambers and ornamentation in Foraminifera; Test apertures, perforations, pore plates and taxonomic importance in Foraminifera. Classification of Foraminifera.
12	Applications of foraminifera. Introduction to molecular study in foraminifera.
13 - 15	Ostracoda: Living animal, life habit, and morphology. Classification, ecology and stratigraphic distribution of Ostracoda. Use of Ostracoda in petroleum exploration.
16 - 18	Nannofossils: Introduction, history of study and significance of various groups of nannofossils. Sampling and methods of separation of nannofossils.
19 - 21	Calcareous Nannoplanktons: Living organism, habitat, life history; Formation, utility and mineralogy of Nannoliths in Nannoplanktons; Types of Nanoliths: Nannoplanktons, Discoasters, Nannoconids; Classification of Nannoplanktons. Classification, ecology and paleoecology; Utility of nannofossils in high resolution biostratigraphy
22 - 23	Conodonts: morphology, classification and its applications. Radiolaria and Diatoms: morphology, classification and significance. Pteropoda: morphology, classification and scope. Application of micropaleontology in hydrocarbon exploration; and their use in bathymetric measurement and paleoclimate interpretation.
24 - 28	Functional morphology of major invertebrates and vertebrates. Brief on Taphonomy and ichnology; major evolutionary and extinction events in the past, Principle of paleobiogeography.
29 - 34	Distribution, migration and dispersal of organisms applied to palaeobiogeography and plate-tectonics with Indian examples.

35-40	Use of paleontological data in stratigraphy, biostratigraphy, paleoecology, evolution, and sea level changes; Principle of palaeoenvironment, palaeoecology and paleoclimate:
41 - 45	Principles of isotopic (oxygen, carbon, calcium, magnesium, strontium) studies of fossils and their application in paleoclimate, Eustacy, palaeo-oceanography and paleoenvironment. Use of microfossils in interpretation of sea floor tectonism. Management and conservation of palaeontological heritage.
P = 30 Hours	**List of Practical** • Techniques of samples preparation; • Techniques of separation of microfossils from matrix; • Preparation of micro-faunal species slides of microfossils: Foraminifera, Ostracoda etc. and their species level identification from the samples of Indian basins. • Techniques of samples collection and preparation for foraminifera molecular study. • 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 Title: Oceanography

Course Code	GEL91MJ03804	**Credits**	04
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	Nine/Odd	**Contact Hours**	45(L) + 15(T) Hours
Course Type	Major 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 provide a comprehensive introduction to oceanography, including its definition, scope, and the importance of studying oceans.
- ❖ To understand the geological aspects of oceans, such as plate tectonics, ocean basin formation, and the distribution of landmasses and oceans.
- ❖ To learn about scientific ocean drilling, its purpose, and the major accomplishments from drilling expeditions.

- To acquire knowledge of sampling techniques and their application in oceanography research.
- To explore the chemical and physical properties of ocean waters and their influence on marine life.
- To examine the dynamics of ocean waters, including waves, tides, currents, and deep ocean circulation.
- To study marine ecosystems, the zonation of the sea, and the impact of climate change on marine life.
- To assess the types and distribution of oceanic resources, and understand the importance of their management and conservation.

Course Learning Outcomes:

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

- Articulate the significance of oceanography and describe the structure of water and oceans.
- Explain the processes of plate tectonics, ocean formation, and the evolution of ocean basins.
- Summarize the goals and findings of scientific ocean drilling and apply modern sampling methods.
- Identify ocean floor features and use the hypsometric curve for topography analysis.
- Analyze the chemical composition of seawater and understand the factors affecting gas concentration.
- Interpret the physical properties of sea waters, such as temperature, salinity, and density.
- Predict the behaviour of sea waves, tides, and currents, and understand the Coriolis effect and Ekman spiral.
- Evaluate the role of thermohaline circulation in deep ocean currents and the formation of water masses.
- Classify marine organisms and understand their roles in marine ecosystems and food webs.
- Assess the impact of marine pollution and climate change on marine ecosystems.
- Distinguish between different types of ocean deposits and resources, and propose conservation strategies.

Course Contents (Oceanography)	Weightage (%)
Unit - I Introduction and Concepts of Oceanography	**28** **08 Lectures**
Introduction to Oceanography: Definition and scope of oceanography; Importance and relevance of studying oceans; Water and Ocean Structure. Geological Aspects of Oceans: Plate tectonics and the formation of oceans; Origin and evolution of ocean basins; Distributional patterns of landmasses and oceans. Scientific Ocean Drilling: Purpose and significance of scientific ocean drilling; Major accomplishments and discoveries from scientific ocean drilling expeditions. Sampling Techniques: Methods for sampling modern ocean biogenic flux; Sediment trap sampling and its application in oceanography research. Ocean Floor Features: Depth zones and their characteristics; Hypsometric curve and its use in analysing ocean topography; Submarine canyons: formation and significance.	
Unit- II Chemical and Physical Oceanography	**30** **09 Lectures**
Chemical Oceanography: Chemical composition of ocean waters; Gases Dissolved in Seawater; Factors affecting the concentration of gases in sea water; Ocean Acidification; Oxygen minimum layer in the ocean. Physical Oceanography: Temperature and Salinity of Sea Waters; Temperature and Salinity distribution (horizontal and vertical – Thermocline & Pycnocline etc.) in	

ocean waters. Sea-Water Density; Concept of mixed layer 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. Deep ocean circulation, concept of thermohaline circulation, formation of bottom waters.	
Unit- III Biological Oceanography	**20** **6 Lectures**
Biological oceanography: Marine Ecosystems; Plankton, Nekton, and Benthos; Marine Biota and 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.	
Unit - IV Oceanic Resources and Distribution	**22** **7 Lectures**
Ocean Deposits: Types, distribution, and characteristics of ocean deposits; Factors influencing the formation of ocean deposits. Significance of ocean deposits in understanding Earth's history and processes. 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.	

Reference / Text 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: Definition and scope of oceanography;
3-4	Importance and relevance of studying oceans; Water and Ocean Structure.
5-7	Geological Aspects of Oceans: Plate tectonics and the formation of oceans; Origin and

	evolution of ocean basins;
8-10	Distributional patterns of landmasses and oceans. Scientific Ocean Drilling: Purpose and significance of scientific ocean drilling; Major accomplishments and discoveries from scientific ocean drilling expeditions.
11-15	Sampling Techniques: Methods for sampling modern ocean biogenic flux; Sediment trap sampling and its application in oceanography research. Ocean Floor Features: Depth zones and their characteristics; Hypsometric curve and its use in analysing ocean topography; Submarine canyons: formation and significance.
16 - 19	Chemical Oceanography: Chemical composition of ocean waters; Gases Dissolved in Seawater; Factors affecting the concentration of gases in sea water; Ocean Acidification; Oxygen minimum layer in the ocean.
20 - 25	Physical Oceanography: Temperature and Salinity of Sea Waters; Temperature and Salinity distribution (horizontal and vertical - Thermocline & Pycnocline etc.) in ocean waters. Sea-Water Density; Concept of mixed layer and water masses. Dynamics of Ocean Waters: Sea Waves; Tides – Origin, Types, Prediction.
26-30	Oceanic Currents; Causes and Controlling factors; General Patterns of Circulation. Coriolis force and Ekman spiral; Upwelling, El Nino and La Nina. Deep ocean circulation, concept of thermohaline circulation, formation of bottom waters. Biological oceanography: Marine Ecosystems; Plankton, Nekton, and Benthos; Marine Biota and Zonation of the sea.
31 - 37	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. Ocean Deposits: Types, distribution, and characteristics of ocean deposits; Factors influencing the formation of ocean deposits.
38 - 45	Significance of ocean deposits in understanding Earth's history and processes. 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.
T = 15 Hours	Tutorials

Course Title: Quaternary Geology and Glaciology

Course Code	GEL91MJ03904	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	Nine/Odd	**Contact Hours**	45(L) + 15 (T) Hours
Course Type	Major Course		
Nature of the Course	Theory		
Special Nature/ Category of the Course (*if applicable***)**	Concept/Knowledge based		

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 (Quaternary Geology and Glaciology)	Weightage (%)
Unit – I Introduction to Quaternary time period	**28** **12 Lectures**
Definition, characteristics and duration of Quaternary Period; Chronostratigraphic status of Quaternary Period, its divisions and their climatic significance; Neogene- Quaternary boundary problem; Quaternary Stratigraphy of India; Different dating techniques (speleothem, dendrochronology and palynology dating) for the reconstruction of Quaternary time period.	
Unit- II Sedimentation during Quaternary	**24** **11 Lectures**
Sedimentation pattern/records during Pleistocene and Holocene (Fluvial, Glacial, Slope and cave sediments, Coastal sediments – storm, tsunami/paleo tsunami). Eustatic changes during Quaternary (long/short term), Marine records, continental - marine correlation of Quaternary record in India.	
Unit- III Introduction to Glaciology and Quaternary Glaciation	**24** **11 Lectures**
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; snout monitoring techniques, remote sensing and GIS application in the study of glaciers; Glacial terminology sediment transport and deposition by glaciers; sample collections and techniques used for the dating of glacial deposits. Mass balance study of glaciers, various methods of mass balance study.	
Unit- IV Glaciogenic hazards and Management	**24** **11 Lectures**
Glaciogenic hazards: Concept of Glacial Lake Outburst Flood (GLOF) and Landslide Lake Outburst Flood (LLOF) case studies, their monitoring and mapping for mitigation; Snow avalanches their types; Mitigation of avalanches; Case study of Himalayan glaciers regarding their health and future challenges.	

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
1-4	Definition, characteristics and duration of Quaternary Period; Chronostratigraphic status of Quaternary Period, its divisions and their climatic significance.
5– 9	Neogene- Quaternary boundary problem; Quaternary Stratigraphy of India
10– 15	Different dating techniques (speleothem, dendrochronology and palynology dating) for the reconstruction of Quaternary time period.
16-20	Sedimentation pattern/records during Pleistocene and Holocene (Fluvial, Glacial, Slope and cave sediments, Coastal sediments – storm, tsunami/paleo tsunami).
21-27	Eustatic changes during Quaternary (long/short term), Marine records, continental - marine correlation of Quaternary record in India.
28-32	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
33-37	Snout monitoring techniques, remote sensing and GIS application in the study of glaciers; Glacial terminology sediment transport and deposition by glaciers; sample collections and techniques used for the dating of glacial deposits. Mass balance study of glaciers, various methods of mass balance study.
38-41	Glaciogenic hazards: Concept of Glacial Lake Outburst Flood (GLOF) and Landslide Lake Outburst Flood (LLOF) case studies, their monitoring and mapping for mitigation
42-45	Snow avalanches their types; Mitigation of avalanches; Case study of Himalayan glaciers regarding their health and future challenges.
T = 15 Hours	Tutorial

Course Title: Geo- Exploration

Course Code	GEL91MJ04004	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	Nine/Odd	**Contact Hours**	45 (L) + 15 (T)
Course Type	Major Course		
Nature of the Course	Theory		
Special Nature/ Category of the Course (*if applicable*)	Concept and Skill Based		
Methods of Content Interaction	Lecture, Group discussion; Self-study, Seminar		
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 principle of different geophysical exploration methods and their application in Earth Sciences.
- Furthermore, in this course students will learn geochemical, geobotanical method, types of sampling, logging and drilling methods; Ore reserve calculation.

Course Learning Outcomes:

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

Course Contents (Geo-exploration)	Weightage (%)
Unit –I Mineral Exploration and Sampling	**25** **15 Lectures**
Concept of prospecting and mineral exploration, Selection of minerals for explorations; Criteria and field guides for mineral search; Stages of mineral exploration; (G-4 to G-1 stages), Field observations and field equipment; Sample and Types of sampling (e.g., pitting, trenching, channel, chip, grab, and bulk sampling)	
Unit- II Geophysical methods	**25** **15 Lectures**
Various geophysical exploration methods (Gravity, Magnetic, Seismic, Electrical, Radiometric, and Ground Penetration Radar (GPR)) and their application in mineral exploration. Gravity anomaly, factors affecting gravity reading, Gravity reduction, Gravity Instruments; reflection and refraction survey of the seismic method with different examples, Wenner and Schlumberger resistivity configuration, self-potential methods, Induced polarization method, application of GPR method.	

Unit- III Geochemical and Geobotanical surveys	**25** **15 Lectures**
Geochemical exploration: mobility of elements, Geochemical approaches, mapping and sample material; classification of various geochemical surveys, geochemical anomaly, pathfinder elements, Geochemical dispersion: primary & secondary dispersion halos; Fick's law of diffusion; Introduction to geobotanical exploration method and their application in mineral search, Geobotanical indicators, Biogeochemical survey, Biogeochemical anomalies, Hydrogeochemical survey	
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. 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	Concept of prospecting and mineral exploration, Selection of minerals for explorations; Criteria and field guides for mineral search; Stages of mineral exploration;
5-9	Field observations and field equipment; Sample and Types of sampling (e.g., pitting, trenching, channel, grab, and bulk sampling)
10-15	Geophysical exploration methods (Gravity, Magnetic, Seismic, Electrical, Radiometric, and Ground Penetration Radar (GPR)) and their application in mineral exploration. Gravity anomaly, factors affecting gravity reading, Gravity reduction, Gravity Instruments
16-20	Reflection and refraction survey of the seismic method with different examples, Wenner and Schlumberger resistivity configuration, self-potential methods, Induced polarization method, application of GPR method.
21-27	Geochemical exploration: mobility of elements and their primary & secondary dispersion; Geochemical approaches, mapping and sample material; classification of geochemical surveys, geochemical anomaly, pathfinder elements, Fick's law
28-35	Introduction to geobotanical exploration method and their application in mineral search, Geobotanical indicators, Biogeochemical survey, Biogeochemical anomalies, Hydrogeochemical survey
36-41	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.

42-45	Elementary knowledge of Logging: Electric, Radioactive and Sonic logs, Application of logs in petrophysical analysis and facies analysis.
T=15 Hours	Tutorial

Course Title: Urban Geology and Watershed Modelling

Course Code	GEL91MJ04104	**Credits**	4
L + T + P	2 + 1 + 1	**Course Duration**	One Semester
Semester	Nine/Odd	**Contact Hours**	30 (L) + 15 (T) + 30 (P) Hours
Course Type	Major Course		
Nature of the Course	Theory/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 with urban geology and its necessity and characteristics of watershed and its delineation for sustainable groundwater resources management.
- To familiarized the students for understanding the urbanization and role of geology.

Course Learning Outcomes:

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

- To develop and understand the concept of urban geology and its importance in sustainable urban development.
- Linking geology to the infrastructure developments and urbanization
- To develop concepts of watershed, morphometry and their implications in earth sciences.
- To understand role geospatial technology for watershed characterization and management and urban study.

Course Contents (Urban Geology and Watershed Modelling)	Weightage (%)
Unit – I Geology and Society	**25** **09 Lectures**
Geology and Society, need of Geological studies in Urban area. Geotechnical feature of the urban area and mapping of Building materials, Excavation and cutting in urban areas. Geotechnical site characterization, and land use mapping, Decision making in urban land use, Geological problems in construction of underground structures in urban areas. Urban environmental consideration and human health risk. Concept of UHI and its impact on human health. Concept of Urban flooding and water logging, Impact of urbanization on Agriculture, water level, natural recharge and land subsidence.	
Unit- II Urban Geological Issues and Role of Geology	

Urban water: Water lagging in built-up areas, Source of water, Standards for various uses of Water; Sources of contamination. Geospatial technology in Urban Geology, Application of GIS in Urban development and land use planning, Groundwater exploration and management. Concept and selection of suitable solid waste disposal site in urban area. Urban seismic hazard in urban planning and Micro-zonations of hazard based on engineering geological features.	**15** **07 Lectures**
Unit- III Concept of Watershed Management	**15** **07 Lectures**
Introduction and Concept of watershed management and their importance. Objectives of watershed management and people's participation. Watershed Characterization, Components of watershed, Watershed delineation and codification. Watershed Conservation, Planning and Management. Strategies for watershed management and characterization. Social and Community aspect of watershed management.	
Unit – IV Modern techniques in Watershed Modelling	**15** **07 Lectures**
Use of modern techniques in watershed delineation and management, Applications of Geographical Information System and Remote Sensing in Watershed Management. Concept of Integrated watershed management program. Geological considerations of watershed conservation. Watershed morphometric analysis and conservation of watershed and mitigation measures. Techniques of water harvesting and indigenous methods of water conservations.	
Unit – V Lab Exercises	**30** **30 Hours Lab Sessions**
• Watershed and Stream Network Delineation from DEMs • Watershed Morphometric analysis. • Urban Landscape change analysis on GEE • Development of satellite derived Indices. • Case studies of Urban flood	

Text / Reference Books:

1. Allam, Gamal Ibrahim Y. (1994) Decision Support System for Integrated Watershed Management, Colorado State University.
2. Black Peter E., Watershed Hydrology, Prentice Hall, London.
3. Michael A.M., Irrigation Engineering, Vikas Publishing House.
4. Murthy, J.V.S., Watershed Management in India, Wiley Eastern, New Delhi.
5. Purandare, A.P., Jaiswal A.K., Watershed Development in India, NIRD, Hyderabad.
6. Vir Singh, Raj, Watershed Planning and Management, Yash Publishing House, Bikaner.
7. Tideman, E.M., 1996. Watershed Management: Guidelines for Indian Conditions, Omega, New Delhi
8. Huggenberger, P. & Eptin, J. (2011). Urban Geology: Process-Oriented Concepts for Adaptive and Integrated Resource Management, Springer.
9. Lollino, G. et al. (Ed.), Engineering Geology for Society and Territory. Springer

Content Interaction Plan

Contact Hours	Topic

1-7	Geology, Society, and need of Geology studies in Urban area. Geotechnical feature of the urban area and mapping of Building materials, Excavation and cutting in urban areas.
8-14	Geotechnical site characterization, Geotechnical and land use mapping, Decision making in urban land use, Geological problems in construction of underground structures in urban areas. Urban water: Water lagging in built-up areas, Source of water, Standards for various uses of Water; Sources of contamination. Geospatial technology in Urban Geology.
15-20	Application of GIS in Urban development and land use planning, Groundwater exploration and management. Selection of Suitable Solid waste disposal site in urban area. Urban seismic hazard in urban planning and Micro-zonations of hazard based on engineering geological features.
21-25	Introduction and Concept of watershed management and their importance, watershed management policies and decision-making. Watershed characteristics- climatic and physiographic. Watershed Characterization, Components of watershed, Watershed delineation and codification. Watershed Conservation Planning and Management. Strategies for watershed management.
26-28	Integrated water resources management, conjunctive use of water resources. Sustainable integrated watershed management, natural resources management, agricultural practices, Soil erosion and conservation; Watershed Management Practices in Arid and Semiarid Regions.
29-30	Use of modern techniques in watershed morphometric analysis. Techniques of water harvesting- indigenous and engineering methods. Location and planning of water harvesting structures using Remote Sensing and GIS. Community participation, private sector participation, Institutional issues, Socio-economy, Integrated development.
T = 15 Hours	Tutorial based on case studies, field study to nearby river bodies and presentation.
P = 30 Hours	**List of Practical** • Watershed and Stream Network Delineation from DEMs • Watershed Morphometric analysis. • Urban Landscape change analysis on GEE • Development of satellite derived Indices. • Case studies of Urban flood

Course Title: Isotope Geology and Its applications

Course Code	GEL91MJ04204	**Credits**	4
L + T + P	4 + 0 + 0	**Course Duration**	One Semester
Semester	Nine/Odd	**Contact Hours**	60 (L) Hours
Course Type	Major Course		
Nature of the Course	Theory		
Special Nature/ Category of the Course	Knowledge and skill based		

Methods of Content Interaction	*(Lecture, Group discussion, primary data collection & analysis, seminar, 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:

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 (Isotope Geology and Its applications)	Weightage (%)
Unit - I Introduction to Isotope composition of the Earth	**30** **20 Lectures**
Introduction to Isotope Geology. Isotope geochemistry of the earth's mantle and whole earth composition. Fundamentals of nucleosynthesis and radioactive decay. Understanding of Cosmochemistry, solar system geochemistry and cosmochronology, meteorite, isotope content and cosmochronology. Atomic structure, elements and abundance of elements on the earth. Relationship of minerals present in the rock and the radioactive compositions in the minerals. Models of earth evolution through composition of the universe.	
Unit- II Types of Isotope studies of rocks	**40** **15 Lectures**
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. 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. Applications of isotope geochemistry to petrology – isotopic variations in MORB, mantle sources of basalts; closed- and open-system magma differentiation processes, AFC processes; OIB, oceanic and continental subduction zone magmas, CFB and LIP; effects of marine and hydrothermal waters alteration; genesis of granites; isotopic chemostratigraphy.	
Unit- III Isotope cycle of the earth processes	**20** **15 Lectures**
Isotope fractionation, O, H, S and C isotopes; carbon cycle processes. Stable isotope studies in igneous, sedimentary and metamorphicrock forming environments. Introduction to oxygen reservoirs (water, sedimentary rocks, the mantle and derivative rock types), mineral ordering, fractional crystallization, the oxygen-isotope geochemistry of granitoid rocks and the role of sediments. The delta notation, equilibrium and kinetic fractionations, mass-dependent and	

mass-independent fractionations; isotopic geothermometry in igneous rocks, meteorites, mass independent fractionation. Mixing and dilution: definitions, mixing equations, two- and three-components mixtures, isotopic mixtures.	
Unit – IV Instrumental analysis technique	**10** **10 Lectures**
Understanding of mass spectrometry and the main analytical methods for geochemical analysis of rock samples. Wet solution methods of analysis, spectral methods of analysis. Sampling and preservation techniques. Principles of chromatography, liquid chromatography and gas chromatography. Introduction to XRF, ICPMS, TIMS, Electron microprobe and ion probes. Laser ablation analysis for geochronology and mineral analysis. Discussion of detection limits, analytical precision and accuracy of analyses.	

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. Henderson, P. (1984). REE geochemistry. Elsevier.
8. Hoefs, J. (1980). Stable Isotope Geochemistry, Springer and Verlag.
9. Krauskopf, K.B. (1967). Introduction to Geochemistry. McGraw Hill.
10. Mason, B. and Moore, C.B. (1991). Introduction to Geochemistry, Wiley Eastern.
11. Rankama, K. and Sahama Th. G. (1950). Geochemistry. Univ. Chicago Press.
12. Rollinson, H.R. (1993). Using geochemical data: Evaluation, presentation, interpretation. Longman U.K.

Content Interaction Plan

Contact Hours	Topic
1 - 6	Introduction to Isotope Geology. Isotope geochemistry of the earth's mantle and whole earth composition. Fundamentals of nucleosynthesis and radioactive decay. Understanding of Cosmochemistry, solar system geochemistry and cosmochronology, meteorite, isotope content and cosmochronology.
7 –12	Atomic structure, elements and abundance of elements on the earth. Relationship of minerals present in the rock and the radioactive compositions in the minerals. Models of earth evolution through composition of the universe. Explanation of isotopes with focus on radiogenic isotope systems. Basics of radioactive decay, half-lives and decay constants. Concepts of geochemical cycle.
13– 15	Review of basic assumptions in radiometric dating. Rb-Sr, Sm-Nd, U-Pb, K-Ar and Ar-Ar. 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.
16 – 20	Applications of isotope geochemistry to petrology – isotopic variations in MORB, mantle sources of basalts; closed- and open-system magma differentiation processes,

	AFC processes; OIB, oceanic and continental subduction zone magmas, CFB and LIP; effects of marine and hydrothermal waters alteration; genesis of granites; isotopic chemo-stratigraphy.
21– 22	Isotope fractionation, O, H, S and C isotopes; carbon cycle processes. Stable isotope studies in igneous, sedimentary and metamorphic rock forming environments. Introduction to oxygen reservoirs (water, sedimentary rocks, the mantle and derivative rock types).
23 -26	mineral ordering, fractional crystallization, the oxygen-isotope geochemistry of granitoid rocks and the role of sediments. The delta notation, equilibrium and kinetic fractionations, mass-dependent and mass-independent fractionations; isotopic geothermometry in igneous rocks, meteorites, mass independent fractionation.
27– 29	Mixing and dilution: definitions, mixing equations, two- and three-components mixtures, isotopic mixtures.
30– 32	Understanding of mass spectrometry and the main analytical methods for geochemical analysis of rock samples.
33- 35	Wet solution methods of analysis, spectral methods of analysis. Sampling and preservation techniques. Principles of chromatography, liquid chromatography and gas chromatography.
36 - 40	Introduction to XRF, ICPMS, TIMS, Electron microprobe and ion probes.
41 -45	Laser ablation analysis for geochronology and mineral analysis. Discussion of detection limits, analytical precision and accuracy of analyses.
T=15 Hours	Tutorial

SEMESTER X				
Course Types	**Course Code**	**Name of Course**	**(L+T+P)**	**Credits**
Major Course	GEL92MJ04320	Dissertation	0+0+20	20
Minimum Credits required for Semester X				**20**

Course Title: Dissertation Course Details

Course Code	GEL92MJ04320	**Credits**	20
L + T + P	0 + 0 + 20	**Course Duration**	One Semester
Semester	Ten/Even	**Contact Hours**	Six Month
Course Type	Major 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.

List of Major Courses

S.N.	Course Code	Course Name	Semester	L+T+P	Credits
1.	GEL51MJ00104	Mineralogy	I	3+0+1	4
2.	GEL52MJ00504	Introduction to Geological Sciences	II	3+1+0	4
3.	GEL61MJ00904	Petrology	III	3+0+1	4
4.	GEL61MJ01004	Elements of Geochemistry	III	3+1+0	4
5.	GEL62MJ01304	Palaeontology	IV	3+0+1	4
6.	GEL62MJ01404	Structural Geology	IV	3+0+1	4
7.	GEL62MJ01504	Introduction of Geospatial Technology	IV	2+0+2	4
8.	GEL62MJ01602	Geohazards and Disaster Risk Reduction	IV	2+0+0	2
9.	GEL71MJ01704	Marine Geology and Micropaleontology	V	3+0+1	4
10.	GEL71MJ01804	Indian Stratigraphy	V	3+0+1	4
11.	GEL71MJ01904	Economic Geology	V	3+0+1	4
12.	GEL71MJ02002	Applied Geomorphology	V	2+0+0	2
13.	GEL71MJ02102	Internship/Seminar	V	0+0+2	2
14.	GEL72MJ02204	Research Methodology	VI	3+1+0	4
15.	GEL72MJ02304	Geophysical Techniques	VI	3+1+0	4
16.	GEL72MJ02404	Hydrogeology	VI	3+0+1	4
17.	GEL72MJ02504	Field Geology and Field Training	VI	2+0+2	4
18.	GEL81MJ02604	Igneous & Metamorphic Petrology	VII	3+0+1	4
19.	GEL81MJ02704	Advanced Remote Sensing & Its Applications in Geosciences	VII	2+1+1	4
20.	GEL81MJ02804	Advanced Mineralogy	VII	3+0+1	4
21.	GEL81MJ02904	Sedimentology and Sequence Stratigraphy	VII	3+0+1	4
22.	GEL82MJ03004	Engineering Geology	VIII	3+1+0	4
23.	GEL82MJ03104	Environmental and Medical Geology	VIII	3+1+0	4
24.	GEL82MJ03204	Statistics and Computer Applications in Geology	VIII	1+1+2	4
25.	GEL82MJ03304	Mining Geology and Energy	VIII	3+1+0	4
26.	GEL82MJ03404	Climatology	VIII	3+1+0	4
27.	GEL82MJ03504	Application of Geospatial	VIII	2+1+1	4

		Technology in Water Resources Management			
28.	GEL82MJ03612	Research Project	VIII	0+0+12	12
29.	GEL91MJ03704	Applied Palaeontology	IX	3+0+1	4
30.	GEL91MJ03804	Oceanography	IX	3+1+0	4
31.	GEL91MJ03904	Quaternary Geology and Glaciology	IX	3+1+0	4
32.	GEL91MJ04004	Geo-Exploration	IX	3+1+0	4
33.	GEL91MJ04104	Urban Geology and Watershed Modelling	IX	2+1+1	4
34.	GEL91MJ04204	Geochronology and Isotope Geology	IX	3+1+0	4
35.	GEL92MJ04320	Dissertation	IX	0+0+20	20

List of Minor Courses

S.N.	Course Code	Course Name	Semester	L+T+P	Credits
1.	GEL51MJ00104	Mineralogy	I	3+0+1	4
2.	GEL52MJ00504	Introduction to Geological Sciences	II	3+1+0	4
3.	GEL61MJ01004	Elements of Geochemistry	III	3+1+0	4
4.	GEL62MJ01304	Palaeontology	IV	3+0+1	4
5.	GEL71MJ01704	Marine Geology and Micropaleontology	V	3+0+1	4
6.	GEL72MJ02304	Geophysical Techniques	VI	3+1+0	4
7.	GEL81MJ02804	Advanced Mineralogy	VII	3+0+1	4
8.	GEL82MJ03004	Engineering Geology	VIII	3+1+0	4
9.	GEL91MJ03804	Oceanography	IX	3+1+0	4

List of Multidisciplinary Courses

S.N.	Course Code	Course Name	Semester	L+T+P	Credits
1.	GEL51MD00403	Earth System Science	I	2+1+0	3
2.	GEL52MD00803	Natural Resource Management	II	2+1+0	3
3.	GEL61MD01203	Geodiversity-Geoheritage-Geopark	III	2+1+0	3

List of Value-Added Courses

S.N.	Course Code	Course Name	Semester	L+T+P	Credits
1.	GEL51VA00302	Indian Contributors in Earth Sciences	I	2+0+0	2
2.	GEL52VA00702	Sustainable Development Goals (SDGs)	II	2+0+0	2

List of Skill Enhancement Courses

S. N.	Course Code	Course Name	Semester	L+T+P	Credits
1.	GEL51SE00203	Tools and Techniques used in Geological Sciences	I	1+1+1	3

2.	GEL52SE00603	Surveying and Mapping Techniques	II	1+0+2	3
3.	GEL61SE01103	Gemology	III	2+1+0	3