PERIYAR UNIVERSITY

SALEM - 636 011

DEGREE OF BACHELOR OF SCIENCE

CHOICE BASED CREDIT SYSTEM (CBCS)

Syllabus for

B.Sc., GEOLOGY

SEMESTER PATTERN

(For Candidates admitted in the Colleges affiliated to Periyar University from 2026-2027 onwards)

B.Sc., GEOLOGY

CHOICE BASED CREDIT SYSTEM (CBCS)

REGULATIONS

1. About the Programme

Periyar University offers B.Sc. Geology programme for the affiliated colleges, under Choice Based Credit System (CBCS). The CBCS enables the students to select choice of subjects as per her/his interest and requirement. Acquiring knowledge in the related discipline is advantageous to the students. The CBCS programme is framed in such a way that to impart more knowledge in the field of Geological Sciences.

2. Admission Eligibility Norms

A candidate who has passed Higher Secondary Examination (Academic Stream – Science) conducted by the Department of School Education, Tamil Nadu or an examination equivalent to 10+2 course including CBSE, that is recognized and accepted by Periyar University, Salem is eligible for admission to the B.Sc. Geology program. The candidates requesting admission shall have passed the qualifying examination with Physics and Chemistry as mandatory subjects, along with the aforesaid conditions for admission of students, the latest guidelines issued by the Department of Higher Education, Government of Tamil Nadu through the Directorate of Collegiate Education, Chennai shall be followed.

3. Duration of the Programme

The B.Sc. Geology programme shall be imparted to students for three academic years consisting of six semesters. Each academic year consists of two semesters and every semester includes 90 working days. The course is designed to provide students with both theoretical knowledge and practical training in various branches of geology. The programme includes different courses of theory, practical, geological field training and summer internship / industrial training. The semester system ensures continuous learning and regular assessment through internal and semester examinations.

4. Attendance Requirement

Attendance for theory and practical classes shall be calculated separately. The attendance for theory classes shall be calculated based on 90 working days for each semester. For practical examinations, the attendance for practical classes shall be calculated by combining the consecutive odd and even semesters of the respective academic year, amounting to 180 working days. Students are required to maintain the prescribed minimum attendance percentage in both theory and practical classes to become eligible for appearing in the examinations.

5. Examination

The maximum marks prescribed for each course shall be 100. The theory examinations shall be conducted at the end of each semester, and the duration of each examination shall be three hours. A candidate who fails to secure the minimum marks required for passing in any theory course shall be permitted to reappear for the failed theory subject(s) in the subsequent

semesters. The practical examinations shall be conducted at the end of the even semesters, and the duration of each practical examination shall also be three hours. Candidates who fail to obtain the minimum passing marks in any practical course shall be allowed to reappear for the failed practical examination only during the subsequent even semesters.

6. Distribution of Marks

The distribution of marks for each course shall consist of Internal Assessment marks and End Semester Examination marks. The maximum mark for each course shall be 100. In theory courses, marks shall be awarded based on continuous internal assessment and semester-end examinations. Internal assessment may include class tests, assignments, seminars, attendance, and other academic activities. Practical courses shall also carry internal and external marks based on laboratory performance, record work, viva voce, and practical examinations conducted at the end of even semesters. The final result shall be prepared based on the total marks obtained in both internal and external assessments as follows:

Course	Internal Marks	External Marks	Total
Theory	25	75	100
Practical	40	60	100
Internship / Health and wellness	Commended / Highly commended		

Classification of Internal Assessment for Theory:

Test	-	15
Assignment	-	5
Attendance	-	5
Total		25

Classification of Internal Assessment for Practical:

Test	-	15
Attendance	-	5
Field Training, Collections and Report	-	10
Practical Record(s)	-	10
		40

Assignment Component

Three assignments (with maximum 5 marks for each) have to be submitted for each theory course. The marks of the best assignments shall be normalized to 5 marks for the assignment component in Continuous Internal Assessment (CIA).

Test Component

Maximum marks for theory courses in test component are 15. The average marks of CIA Test 1, CIA Test 2, and Model Test will be normalized to 15 for each theory course.

Main Practical Component

The attendance marks for the main practical examination shall be a maximum of 5 (combining the total attendance recorded in the consecutive odd and even semesters). A maximum of 15 marks will be awarded for the practical tests and model practical tests.

7. Equivalence of Programme

The B.Sc. Geology degree awarded by recognized Universities and Colleges, having substantially similar curriculum content, credit requirements, practical training and fieldwork components, shall be treated as equivalent for the purpose of admission to higher studies, employment and academic progression in Geology and allied disciplines.
Equivalence: Applied Geology.

8. Pattern of Question Paper

Time: Three hours Maximum marks: 75

Part – A (15 x 1 = 15)

Answer all questions.

(a), (b), (c), (d) MCQ for 3 questions from each unit

Part – B (2 x 5 = 10)

Answer any TWO questions out of five. one question from each unit

Part – C (5 x 10 = 50)

Answer all questions (either or type) FIVE questions

one question from each unit

9. Field Training / Summer Internship / Industrial Training

Geological field training / Summer Internship / Industrial Training is included in the first year, second year and third year. The participation is a mandatory requirement. The training is to be scheduled for duration of maximum 15 days. It may be guided by faculty members in any place which is geologically significant within Tamil Nadu and India.

10. Programme Educational Objectives (PEOs)

The Bachelor of Science (B.Sc.) in Geology programme is designed to provide students with a comprehensive understanding of the Earth, its materials, processes, resources, and environmental systems. The programme integrates theoretical knowledge, practical laboratory training, field-based learning, and modern geospatial technologies to develop competent geoscience professionals. It aims to equip graduates with scientific knowledge, analytical abilities, technical skills, ethical values, and environmental awareness necessary for addressing geological and societal challenges. The Programme Educational Objectives (PEOs) define the broad career and professional accomplishments that graduates are expected to achieve within a few years of completing the programme. These objectives serve as a framework for curriculum development and ensure that graduates are prepared for higher education, research, professional employment, entrepreneurship, and lifelong learning in the field of Earth Sciences.

PEO1	To provide students with a strong foundation in geological sciences, including mineralogy, petrology, structural geology, geomorphology, paleontology, stratigraphy, hydrogeology, and environmental geology.
PEO2	To develop analytical, field investigation, and problem-solving skills for understanding Earth processes, natural resources, and environmental challenges.
PEO3	To equip students with practical skills in geological mapping, surveying, GIS, Remote Sensing, GPS, laboratory techniques, and data interpretation relevant to geoscience applications.

PEO4	To prepare graduates for higher education, research, and professional careers in geology, mining, hydrogeology, environmental management, disaster management, and related fields.
PEO5	To promote environmental awareness, sustainable resource management, ethical values, and social responsibility in addressing geological and environmental issues.
PEO6	To encourage lifelong learning, professional development, leadership qualities, and adaptability to advancements in Earth and Environmental Sciences.

11. Programme Specific Outcomes (PSOs)

Programme Specific Outcomes (PSOs) describe the discipline-specific knowledge, practical skills, technical competencies, and professional abilities that students are expected to acquire upon successful completion of the Bachelor of Science (B.Sc.) Geology programme. The PSOs reflect the core strengths of the geology curriculum and emphasize the application of geological principles, field investigations, laboratory techniques, and modern geospatial technologies in understanding Earth systems and addressing environmental and resource-related challenges. These outcomes are designed to prepare graduates for higher education, research, professional careers, and lifelong learning in the field of Earth and Environmental Sciences. The attainment of these outcomes ensures that students develop the necessary competencies to contribute effectively to geological exploration, natural resource management, environmental conservation, and sustainable development.

PSO1	Demonstrate comprehensive knowledge of geological principles, Earth materials, Earth processes, and the evolution of the Earth through the study of mineralogy, petrology, stratigraphy, paleontology, structural geology, and geomorphology.
PSO2	Identify, describe, and classify minerals, rocks, fossils, and geological structures using standard geological techniques and laboratory methods.
PSO3	Apply geological mapping, field surveying, and interpretation skills to investigate geological formations, structures, and landforms.
PSO4	Utilize modern geospatial technologies such as GIS, Remote Sensing, GPS, and digital mapping tools for geological and environmental studies.
PSO5	Assess groundwater resources, environmental issues, natural hazards, and sustainable management of Earth resources using geological knowledge and analytical techniques.
PSO6	Conduct basic geological research, collect and analyze field and laboratory data, prepare technical reports, and communicate scientific findings effectively.

12. Programme Outcomes (POs)

Programme Outcomes (POs) are broad statements that describe the knowledge, skills, attitudes, and competencies that students are expected to attain upon successful completion of the Bachelor of Science (B.Sc.) Geology programme. These outcomes reflect the graduate attributes envisioned under the Outcome-Based Education (OBE) and Learning Outcomes-based Curriculum Framework (LOCF) adopted by the University Grants Commission (UGC). The Programme Outcomes encompass disciplinary knowledge, critical thinking, problem-solving ability, field and laboratory skills, research aptitude, communication skills, ethical values, environmental awareness, teamwork, leadership, employability, and lifelong learning. The attainment of these outcomes ensures that graduates are well-equipped to address scientific, environmental, and societal challenges related to Earth systems, natural resources,

and sustainable development, while also preparing them for higher education, research, and professional careers in geosciences and allied fields.

PO1	Demonstrate comprehensive knowledge of geological concepts, Earth materials, Earth processes, and the evolution of the Earth system.
PO2	Apply geological principles, scientific methods, and analytical techniques to investigate and solve geoscientific problems.
PO3	Identify, classify, and interpret minerals, rocks, fossils, geological structures, and landforms using field and laboratory methods.
PO4	Conduct geological field investigations, prepare geological maps, cross-sections, and technical reports, and interpret geological data effectively.
PO5	Utilize modern geospatial technologies such as GIS, Remote Sensing, GPS, and digital mapping tools for geological and environmental applications.
PO6	Analyze groundwater resources, mineral resources, environmental issues, and geological hazards using appropriate scientific approaches.
PO7	Apply quantitative, statistical, and computational skills for geological data analysis, interpretation, and decision-making.
PO8	Communicate geological and scientific information effectively through written reports, presentations, and digital media.
PO9	Demonstrate professional ethics, environmental responsibility, and commitment to sustainable development in geoscience practices.
PO10	Work effectively as an individual and as a member of multidisciplinary teams, exhibiting leadership and collaborative skills.
PO11	Develop employability, entrepreneurship, and professional competencies required for careers in geology, environmental management, mining, hydrogeology, and related fields.
PO12	Engage in lifelong learning, higher education, research, and professional development to adapt to advances in Earth and Environmental Sciences.

13. Bloom's Taxonomy Levels

Bloom's Taxonomy is a framework used to classify learning objectives according to increasing levels of cognitive complexity:

- **K1 – Remember:** Recall facts, terms, concepts and basic information.
- **K2 – Understand:** Explain ideas, concepts and principles in one's own words.
- **K3 – Apply:** Use knowledge, methods and techniques to solve problems and perform tasks.
- **K4 – Analyze:** Examine information, identify relationships and interpret data critically.
- **K5 – Evaluate:** Assess, justify and make informed judgments based on evidence.
- **K6 – Create:** Develop new ideas, designs, plans or solutions using acquired knowledge and skills.

14. Correlation Levels Used in CO–PO Mapping Matrix

The Course Outcomes (COs) are mapped with the Programme Outcomes (POs) to assess the extent to which each course contributes to the attainment of the programme objectives. The degree of correlation between the Course Outcomes and Programme Outcomes is represented using the following scale:

Symbol	Correlation Level	Numerical Value	Description
S	Strong	3	The Course Outcome contributes significantly to the attainment of the Programme Outcome.
M	Medium	2	The Course Outcome contributes moderately to the attainment of the Programme Outcome.
L	Low	1	The Course Outcome contributes marginally to the attainment of the Programme Outcome.
–	No Correlation	0	The Course Outcome does not contribute directly to the attainment of the Programme Outcome.

The CO–PO mapping matrix serves as an important tool in Outcome-Based Education (OBE) for evaluating curriculum effectiveness and ensuring alignment between course-specific learning outcomes and the broader educational goals of the programme.

15. Course Structure/Curriculum Abstract for Bachelor of Science in Geology

Part	Category	No. of Courses	Total Credits	Marks
I	Language I - Tamil	4	12	400
II	English	4	12	400
III	Core Course (CC)	11	55	1100
III	Core Practical (CP)	4	20	400
III	Allied Theory (AT)	4	16	400
III	Allied Practical (AP)	2	8	200
III	Elective Course (EC)	3	9	300
IV	Skill Enhancement Course (SEC)	3	6	300
IV	Non-Major Elective (NME)	2	4	200
IV	Disaster Management	1	1	100
IV	Value Education	1	1	100
IV	Health and Wellness	1	1	100
IV	Extension Activity	1	1	100
IV	Environmental Studies (EVS)	1	2	100
IV	Internship	1	2	100
IV	Naan Mudhalvan Skill Development Course (NMSDC)	5	10	500
	Total	**48**	**160**	**4800**

16. Course of study and Scheme of Examinations

The course of study shall comprise instruction in the following subjects according to the syllabus and books prescribed from time to time.

CURRICULLUM FRAMEWORK

UNDER CHOICE BASED CREDIT SYSTEM (CBCS)

S. No.	Semester	Paper Code	Part	Course Group	Paper Type	Subject Title	Hours Week	Exam Hours	Internal Marks	External Marks	Total Marks	Credit
1	I		I	Language	Theory	Tamil I	6	3	25	75	100	3
2	I		II	Language	Theory	English I	6	3	25	75	100	3
3	I		III	Core-I	Theory	General Geology & Geomorphology	4	3	25	75	100	5
4	I		III	Core-II	Theory	Field Geology and Surveying Techniques	4	3	25	75	100	5
5	I		III	Allied-I	Theory	Chemistry-I / Mathematics-I	4	3	25	75	100	4
6	I		III	Allied-I Practical	Practical	Allied Chemistry / Allied Mathematics	3	--	--	--	--	--
7	I		IV	NME-I offered to other departments	Theory	Earth and Environment	2	3	25	75	100	2
8	I		IV	Value Education	Theory		1	3	25	75	100	1
							30	**21**	**175**	**525**	**700**	**23**
9	II		I	Language	Theory	Tamil II	6	3	25	75	100	3
10	II		II	Language	Theory	English II	6	3	25	75	100	3
11	II		III	Core-III	Theory	Structural Geology& Geotectonics	4	3	25	75	100	5
12	II		III	Core Practical-I	Practical	Structural Geology & Surveying Practical	3	3	40	60	100	5
13	II		III	Allied-I	Theory	Chemistry-II / Mathematics-II	3	3	25	75	100	4
14	II		III	Allied-I Practical	Practical	Allied Chemistry / Allied Maths	2	3	40	60	100	4
15	II		IV	NME-II offered to other departments	Theory	Geohazards	2	3	25	75	100	2
16	II		IV	--	Theory	Disaster Management	2	3	25	75	100	1
17	II		--	NMSDC	Theory	--	2	3	25	75	100	2
							30	**27**	**255**	**645**	**900**	**29**
18	III		I	Language	Theory	Tamil III	6	3	25	75	100	3
19	III		II	Language	Theory	English III	6	3	25	75	100	3
	III		III	Core-IV	Theory	Palaeontology	4	3	25	75	100	5
20	III		III	Allied-II	Theory	Physics-I	4	3	25	75	100	4
21	III		III	Allied-II Practical	Practical	Physics	2	--	--	--	--	--
22	III		III	Elective-I	Theory	Dynamic Earth: Oceans & Atmosphere	3	3	25	75	100	3
23	III		IV	SEC-I	Theory	Artificial Intelligence & Machine Learning Tools in Geology	2	3	25	75	100	2
24	III		IV	Health &Wellness.	Report	Health &Wellness	1	3	25	75	100	1
25	III		--	NMSDC	Theory	--	2	3	25	75	100	2

							30	**24**	**200**	**600**	**800**	**23**
26	IV		I	Language	Theory	Tamil IV	6	3	25	75	100	3
27	IV		II	Language	Theory	English IV	6	3	25	75	100	3
	IV		III	Core-V	Theory	Crystallography and Optical Mineralogy	4	3	25	75	100	5
28	IV		III	Core Practical-II	Practical	Palaeontology and Crystallography Practical	3	3	40	60	100	5
29	IV		III	Allied-II	Theory	Physics-II	3	3	25	75	100	4
30	IV		III	Allied-II Practical	Practical	Physics	2	3	40	60	100	4
31	IV		III	Elective-II	Theory	Remote Sensing & GIS	2	3	25	75	100	3
32	IV		IV	SEC-II	Theory	Geological Instruments & Software	2	3	25	75	100	2
33	IV		--	NMSDC	Theory	--	2	3	25	75	100	2
							30	**27**	**255**	**645**	**900**	**31**
34	V		III	Core-VI	Theory	Mineralogy	6	3	25	75	100	5
35	V		III	Core-VII	Theory	Igneous Petrology & Metamorphic Geology	6	3	25	75	100	5
36	V		III	Core-VIII	Theory	Sedimentary Petrology & Energy Geology	6	3	25	75	100	5
37	V		III	Elective-III	Theory	Hydrogeology & Engineering Geology	6	3	25	75	100	3
38	V		IV	SEC-III	Theory	Exploration Geology	2	3	25	75	100	2
39	V		IV	Skill Based	Training	Summer Internship / Industrial Training	--	3	25	75	100	2
40	V		IV	E.V.S.	Theory	--	2	3	25	75	100	2
41	V		--	NMSDC	Theory	--	2	3	25	75	100	2
							30	**24**	**200**	**600**	**800**	**26**
42	VI		III	Core-IX	Theory	Stratigraphy & Indian Geology	6	3	25	75	100	5
43	VI		III	Core-X	Theory	Economic Geology & Regional Geology	6	3	25	75	100	5
44	VI		III	Core-XI	Theory	Mining Geology & Environmental Geology	6	3	25	75	100	5
45	VI		III	Core Practical-III	Practical	Mineralogy & Petrology Practical	5	3	40	60	100	5
46	VI		III	Core Practical-IV	Practical	Economic Geology and Ore analysis Practical	5	3	40	60	100	5
47	VI		IV	Extension Activity	Training	--	--	3	25	75	100	1
48	VI		--	NMSDC	Theory	--	2	3	25	75	100	2
							30	**21**	**205**	**495**	**700**	**28**
							180	**144**	**1290**	**3510**	**4800**	**160**

Compulsory Courses

1. Value Education
2. Environmental Studies (EVS)
3. Extension Activities (NSS, NCC, YRC, RRC, Green Club etc.,)

SEMESTER-I

GENERAL GEOLOGY AND GEOMORPHOLOGY			
Learning Objectives			
CO1	The main objective of this course is to enumerate the origin of Earth.		
CO2	To describe the concepts of Dating and internal structure of the Earth		
CO3	To explain the dynamic of Earth		
CO4	To Identify the landforms and explore earth surface processes		
CO5	To explain the impact of river landforms and discuss the large expansion of rivers during the present day of earth history.		
UNIT	**Details**	**No. of Hours**	**Course Objectives**
I	**Geology:** Scope and Importance, Branches of Geology. Steller System- Solar System: Planets, Satellites, Asteroids, Meteorites and Comets. Origin of the Earth: Theories of Origin - Nebular, Planetesimal, and Tidal Hypotheses – Earth in the Solar System: Size, Shape, Mass, Density, Rotational and Revolution parameters. Parts of the Earth - Lithosphere, Hydrosphere, Atmosphere, Biosphere and their Composition.	12	CO1
II	Age of the Earth: Age determination Methods: - Indirect method: Salinity method, Sedimentation Method, Tree-Ring or Growth rings, Direct Method: Ur-Pb Method, K-Ar Method, Rb-Sr Method, C14 Method, Interior of the Earth: Structure and Composition of Crust, Mantle and Core.	12	CO2
III	Earthquake: Definition, Focus, Epicenter. Measurement of Earthquake: Seismograph, Seismogram- Richter's scale, Magnitude, Intensity. Earthquake belts of the world with a special reference to India. Volcanoes: Definition, Types, Causes and Effects, Volcanic Products, Volcanic Landforms, Distribution of Volcanoes, Volcanoes in India.	12	CO3
IV	**Geomorphology:** A brief account of first order, second order, and third order landforms. Land forms created by Wind: detailed outline of erosion, deflation, abrasion, and attrition with descriptive notes on the geomorphic features generated by them. Descriptive study of different transportation processes. Short notes on loess and sand deposits. Sand dunes: definition, parts and morphological features of sand dunes, types of sand dunes with a note on their origin. Outline on the concepts and ideas of geomorphic cycles. Outline of the major geomorphic features of Tamil Nadu.	12	CO4
V	Land forms created by rivers: detailed outline of different erosion processes and their erosional features. Description of transportation and depositional processes. Detailed outline of different depositional features. Outline of the cycle of erosion and different drainage patterns with a note on their origin. Outline of rivers of India with special reference to Tamil Nadu. Land forms derived from underground water: definition and sources of groundwater. Land forms created by glaciers: definition, formation, and movement of glaciers. Detailed outline	12	CO5

	on the different types of glaciers. Land forms created by ocean: detailed outline of features related to shore profile and shoreline development.		

UNIT	Learning Outcomes
I	Understand the origin of Galaxy, Our Solar System and Crystal Science
II	Knowledge on Dating of Earth Age
III	Correlate various Hypothesis on Origin of Earth
IV	Explain the major geomorphic processes acting on Earth's surface, especially wind erosion processes such as deflation, abrasion, and attrition.
V	Describe the cycle of erosion and various drainage patterns and explain their origin based on geological and structural conditions.

	Text Books / References Books
1.	A.K. Mukherjee (1990). Principles of Geology. Kolkata: EW Press.
2.	V. Radhakrishnan (1996). General Geology. Tuticorin: V.V.P. Publishers.
3.	A.M. Patwardhan (1999). Dynamic Earth System. New Delhi: Prentice Hall.
4.	William D. Thornbury (2004). Principles of Geomorphology. New Delhi: CBS Publishers and Distributors.
5.	J.S. Reed & T.H. Wicander (2005). Essentials of Geology. New York: McGraw Hill.
6.	G.P. Mahapatra (1994). Physical Geology. New Delhi: CBS Publishers.
7.	A.B. Dasgupta (1978). Physical Geography. Delhi: CBS Publishers.
8.	P.G. Worcester (1960). A Text Book of Geomorphology. Delhi: East West Press.
9.	Arthur Bloom (1985). Principles of Geomorphology. Delhi: Prentice Hall of India.
10.	Parbin Singh (2008). Engineering and General Geology. New Delhi: S.K. Kataria & Sons.

	Web Resources
1.	www.geology.com
2.	www.usgs.gov
3.	www.indiageomorph.org
4.	www.sepmstrata.org
5.	www.earthscienceworld.org

Summary of Course Outcomes (COs):

CO	Course Outcome Statement	Bloom's Level	Mapped POs
CO1	Explain the scope, importance and branches of geology and the composition of the lithosphere, hydrosphere, atmosphere and biosphere.	Understand (K2)	PO1, PO2, PO7
CO2	Describe the methods used for determination of the age of the Earth and composition of the Earth's interior including crust, mantle and core.	Understand (K2)	PO1, PO2
CO3	Analyze the causes, measurements, distribution and effects of earthquakes and volcanoes with special reference to India.	Analyze (K4)	PO1, PO2, PO3, PO7
CO4	Discuss geomorphological processes and landforms created by wind, including erosion, transportation, deposition and sand dune formation.	Understand/ Analyze (K2/K4)	PO1, PO2, PO3
CO5	Explain the geomorphic processes and landforms created by rivers, groundwater, glaciers and oceans.	Understand / Analyze (K2/K4)	PO1, PO2, PO3, PO7

CO–PO Mapping Matrix

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	-	-	-	-	1	-	-	-	-
CO2	3	2	2	-	-	-	1	1	-	-	-	-
CO3	3	3	3	1	-	3	2	1	1	-	2	-
CO4	2	3	3	2	-	1	2	1	-	-	1	-
CO5	2	3	3	2	1	3	2	1	2	-	2	1

FIELD GEOLOGY & SURVEYING TECHNIQUES			
Learning Objectives			
CO1	To understand principles of field geology and topographic map reading.		
CO2	To identify geological structures, landforms, and outcrop features in the field.		
CO3	To use surveying instruments and GPS for geological mapping.		
CO4	To apply remote sensing and aerial photo interpretation in mapping.		
CO5	To prepare geological field reports with proper data presentation.		
UNIT	Details	No. of Hours	Course Objectives
I	**Field Geology:** Definition and scope of Field Geology - Prior planning - Basic equipment required for field work - Field suggestions and precaution - Field work objectives and types of data collection - Introduction to topographic maps: parts, symbols and other information. Basic concepts: relief, contours, slope, gradients, profiles and sections - Interpretation of topographic maps. Base map preparation and map scale. Rock outcrops and their surficial expressions.	12	CO1
II	Basic concepts: strike, dip, apparent dip and rock trends - Introduction to the outcrop features used in mapping: foliations, lineations, bedding, and lithological contacts. Geological mapping: Traverse methods: Compass and Contact traverse. Field Equipment - Clinometer compass: different parts and their functions. Handling of the compass - determination of bearings - advantages and limitations- Brunton Compass: different parts and their functions - determination of bearings - advantages and limitations.	12	CO2
III	Use of Aerial Photographs in geological mapping - Structural mapping - Stratigraphic mapping methods - outline of mapping methodology for igneous terrain, sedimentary terrain and metamorphic terrain - Methods of mapping in areas with sparse outcrops. Field geological report preparation.	12	CO3
IV	**Surveying Techniques:** Introduction to Surveying: Definition, Principles, Scope and Applications of Surveying. Types of Surveying – Plane Surveying and Geodetic Surveying. Chain Surveying – Instruments, Field Procedures, Ranging, Chaining and Chain Survey Errors. Compass Surveying – Prismatic Compass, Bearings, Traverse Survey and Local Attraction. Plane Table Surveying – Equipment, Methods and Applications.	12	CO4
V	Theodolite Surveying – Measurement of Horizontal and Vertical Angles, Traversing and Triangulation. Electronic Distance	12	CO5

	Measurement (EDM) Techniques. Total Station Surveying – Components, Operation and Applications. Global Positioning System (GPS) and Global Navigation Satellite System (GNSS) – Principles, Data Collection and Mapping Applications. Remote Sensing and Geographic Information System (GIS) in Surveying. Preparation and Interpretation of Topographic Maps, Profiles, Cross-Sections and Contour Maps.		

UNIT	**Learning Outcomes**
I	Define and explain the scope, objectives, and importance of field geology.
II	Explain basic structural concepts such as strike, dip, apparent dip, and rock trends.
III	Demonstrate methods of measuring bearings and field directions.
IV	Apply GPS technology in field geology and mapping activities.
V	Measure horizontal and vertical angles and understand collimation errors.

Text Books / References Books

1.	Billings, M.P. (1972). Structural Geology (3rd Edition). Prentice Hall of India, New Delhi.
2.	Compton, R.R. (1985). Geology in the Field. John Wiley & Sons, New York.
3.	Lahee, F.H. (1961). Field Geology (6th Edition). McGraw-Hill Book Company, New York.
4.	Bennison, G.M. and Moseley, K.A. (2011). An Introduction to Geological Structures and Maps (8th Edition). Hodder Education, London.
5.	Badgley, P.C. (1965). Structural and Tectonic Principles. Harper & Row Publishers.
6.	Gokhale, K.V.G.K. (2011). A Textbook of Geological Maps and Structural Geology. CBS Publishers & Distributors, New Delhi.
7.	Chandra, A.M. (2007). Higher Surveying (3rd Edition). New Age International Publishers, New Delhi.
8.	Punmia, B.C., Jain, A.K. and Jain, A.K. (2016). Surveying, Volume I and II. Laxmi Publications, New Delhi.
9.	Duggal, S.K. (2017). Surveying, Volume I and II (5th Edition). McGraw Hill Education, New Delhi.
10.	Kanetkar, T.P. and Kulkarni, S.V. (2018). Surveying and Levelling, Part I and II. Pune Vidyarthi Griha Prakashan, Pune.

Web Resources

1.	www.gsi.gov.in
2.	www.surveyofindia.gov.in
3.	bhuvan.nrsc.gov.in
4.	www.nrsc.gov.in
5.	www.isro.gov.in

Summary of Course Outcomes (COs):

CO No.	Course Outcome Statement	Bloom's Level	Mapped POs
CO1	Explain the scope of Field Geology, fieldwork planning, safety precautions, geological data collection, and interpret topographic maps, contours, profiles and base maps.	Understand (K2)	PO1, PO2
CO2	Identify and measure geological structures such as strike, dip, apparent dip, bedding, foliations, lineations and lithological contacts, and apply geological mapping techniques using traverse methods.	Apply (K3)	PO1, PO3, PO4
CO3	Operate field instruments such as Clinometer Compass and Brunton Compass, determine bearings, and utilize aerial photographs and remote sensing data in geological mapping.	Apply (K3)	PO3, PO4, PO5
CO4	Analyze geological relationships through structural and stratigraphic mapping, prepare geological maps in different terrains, and develop comprehensive field geological reports.	Analyze (K4)	PO2, PO4, PO5
CO5	Apply surveying techniques including chain surveying, compass surveying, levelling, theodolite surveying, Total Station, GPS/GNSS, GIS and Remote Sensing for geological, engineering and environmental investigations.	Apply (K3)	PO3, PO4, PO5, PO6

CO–PO Mapping Matrix:

COs / Pos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	1	2	1	-	1	1	-	-	-	-
CO2	2	3	3	3	2	1	2	-	-	1	2	-
CO3	2	3	3	2	2	2	3	1	-	-	2	-
CO4	2	2	2	3	3	2	2	1	-	-	3	1
CO5	2	3	3	3	2	3	2	2	1	1	3	2

SEMESTER-II

	STRUCTURAL GEOLOGY & GEOTECTONICS		
	Learning Objectives		
CO1	Examine earth structures and learn to identify the rock		
CO2	Experiment on rock joints and tilt, dip and plunge.		
CO3	Understanding the surficial features		
CO4	Provide comprehensive understanding of the Earth's Interior		
CO5	The outline of plate tectonics, faults, mountain building activity		
UNIT	Details	No. of Hours	Course Objectives
I	**Structural Geology:** Introduction and scope of Structural Geology. Detailed outline of different components of topographic	12	CO1

	maps and their significance. Rock outcrops: definition, types: sedimentary, igneous and metamorphic. Foliation and Lineation: definition and detailed description of common types of foliations and lineation in metamorphic and igneous rocks. Cardinal directions of a compass: whole circle, quadrant, magnetic and true North. Detailed study of orientation, tilt, and attitude of rock outcrops and their measurement using Brunton and Clinometer compasses. Sedimentary beds: definition and types. Detailed outline of different surficial structures on sedimentary rocks.		
II	Unconformity: definition, types, genesis, geological significance, and criteria for their recognition in the field and prepared geological maps. Detailed outline of concordant and discordant igneous rocks with a note on their identification and recognition in geological maps. Rock Joints: definition, types, classification, and outline of genesis. Faults: definition and nomenclature of the parts of a fault. Descriptive outline of different fault plane features. Classification of faults: geometric, genetic, and tectonic classification of faults. Outline of fault related geomorphic features. Descriptive criteria for recognition of faults in the field and in a geological map.	12	CO2
III	Folds: definition and different parts of a fold. Outline of geometry and nomenclature of folds. Classification of folds based on closing and facing directions, inter limb angle, attitude of axial plane, fold profiles, and dip isogons. Short notes on outliers and inliers. Detailed criteria of recognition of folds in the field and in a geological map. Stereographic projection in structural geology: definition and description of dip and strike for planes, plunge and trend for linear structures. Theory behind the stereographic projections, representation of planes and lines on the stereograms.	12	CO3
IV	**Geotectonics:** Important concepts about Earth dynamics: Contraction, Expansion, Plate tectonics - basic concepts and definitions Types of plate margins, important characters of plate margins and Mechanism of plate movement. Theory of plate tectonics, types of plate boundaries -convergent, divergent, transform, and relative plate motions. Mantle plumes vis-à-vis island chains. Plate tectonics in relation to the distribution of seismic, volcanic and island arc belts. Plate tectonic models for the origin of mountain belts: Types of convergent boundaries Ocean-ocean, ocean-continent, Continent- Continent.	12	CO4
V	**Tectonics of the Indian subcontinent**: Tectonic divisions -Extra-peninsula; Indo- Gangetic Plain and Peninsular Shield, their tectonic characters and major structural trends. Northward movement of the Indian Plate and the origin and evolution of the Himalayas and its thrust belts. Tectonic models for the origin and evolution of the Indo-Gangetic plain. Seismicity of the Indian subcontinent. Structural Features: Diastrophism, folds, faults, joints, and unconformities. Mountain Building & Continental Evolution: Origin and evolution of mountains -Himalayas, geosynclines, and continental drift. Seismicity & Volcanism: Earthquake belts, seismic zones of India, and volcanic activity	12	CO5

UNIT	Leaning Outcomes
I	Define the scope and importance of structural geology in Earth sciences.
II	Explain discordant igneous bodies like dykes, batholiths, stocks, and volcanic vents.
III	Recognize structural landforms such as horst, graben, anticlines, and synclines.
IV	Analyze the relationship between plate movements and seismic-volcanic activity.
V	Identify major structural features such as folds, faults, and unconformities in India.
Text Books / References Books	
1.	Bhattacharya, A.R. (2022). Structural Geology.
2.	Davis, G.H., Reynolds, S.J. & Kluth, C.F. (2011). Structural Geology of Rocks and Regions.
3.	Fossen, H. (2016). Structural Geology.
4.	Ghosh, S.K. (2012). Structural Geology: Fundamentals and Modern Developments.
5.	Hobbs, B.E., Means, W.D. & Williams, P.F. (1976). An Outline of Structural Geology.
6.	Marshak, S. & Mitra, G. (2005). Basic Methods of Structural Geology.
7.	Mukherjee, S. (Ed.) (2026). Structural Geology and Tectonics.
8.	Billings, M.P. (1972). Structural Geology (3rd ed.). Prentice Hall.
9.	Twiss, R.J. & Moores, E.M. (2007). Structural Geology (2nd ed.). W.H. Freeman.
10.	Condie, K.C. (2016). Plate Tectonics and Crustal Evolution (4th ed.). Butterworth-Heinemann.
Web Resources	
1.	www.geologyin.com
2.	www.earthobservatory.nasa.gov
3.	www.noaa.gov
4.	www.iaea.org/topics/geology
5.	www.onegeology.org

Summary of Course Outcomes (COs):

CO	Course Outcome Statement	Bloom's Level	Mapped POs
CO1	Describe the fundamental concepts of structural geology, topographic maps, rock outcrops, foliations, lineations, and measurement of geological structures using field instruments.	Understand (K2)	PO1, PO2, PO6
CO2	Examine sedimentary structures, unconformities, igneous intrusions, joints, and faults, and interpret their occurrence and significance in geological maps and field studies.	Apply (K3)	PO1, PO2, PO3, PO7
CO3	Analyze the geometry, classification, and recognition of folds, faults, joints, and stereographic projections for structural interpretation and geological mapping.	Analyze (K4)	PO2, PO3, PO4, PO8
CO4	Evaluate the concepts of plate tectonics, plate boundaries, mantle plumes, mountain-building processes, seismicity, and volcanism in understanding Earth dynamics.	Evaluate (K5)	PO1, PO4, PO5, PO9
CO5	Assess the tectonic evolution, structural framework, seismicity, and geodynamic history of the Indian subcontinent and synthesize geological information for regional tectonic interpretations.	Create (K6)	PO2, PO4, PO5, PO10, PO11, PO12

CO–PO Mapping Matrix

COs \ Pos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	–	–	–	3	–	–	–	–	–	–
CO2	3	2	3	–	–	–	2	–	–	–	–	–
CO3	–	3	2	3	–	–	–	2	–	–	–	–
CO4	3	–	–	2	3	–	–	–	2	–	–	–
CO5	–	3	–	3	2	–	–	–	–	2	2	1

	STRUCTURAL GEOLOGY & SURVEYING PRACTICAL		
Leaning Objectives			
CO1	Understand the basics components of Structural Geology		
CO2	Know the formations of geological formations		
CO3	Basics of Aerial Photographs		
CO4	Understand the Application of Satellite science		
CO5	Analyze various physiographical features through GIS		
UNIT	Details	No. of Hours	Course Objectives
I	Contour Maps and their interpretation – Exercises to find out trend of the outcrop of horizontal, vertical, inclined beds with respect to topography – Reading of solid, conformable maps – Deciphering dip and strike of outcrops - Completion of map when three points over a bedding plane are given – Determination of vertical thickness of formations.	12	CO1
II	Reading of solid fold and fault maps – Determination of throw of faults – Construction of vertical sections – Reading of unconformable solid maps – Construction of sections – Reading of solid maps of areas with more than one structure and intrusion – Writing of geological history.	12	CO2
III	Solving of dip and strike problems by trignometrical method – Determination of true thickness of beds by calculations	12	CO3
IV	Interpretation of geomorphology, lithology and geological structures on aerial photographs. Visit to nearby geological organizations	12	CO4
V	Definition – Primary divisions – classification – Chain survey – description of instruments employed – chain traverse – Compass survey – description of prismatic compass – whole circle bearings – reduced bearings – quadrantal bearings – open traverse – closed traverse – finding distance between inaccessible stations – locating the instrument station - GPS - Clinometer compass – finding dip and strike of beds – Modern Surveying	12	CO5
UNIT	**Leaning Outcomes**		
I	Understand the basics components of Structural Geology		
II	Know the formations of geological formations		
III	Basics of Aerial Photographs		
IV	Understand the Application of Satellite science		
V	Analyse various physiographical features through GIS		

Text Books / References Books	
1.	Davis, G.H., Reynolds, S.J. & Kluth, C.F. (2011). Structural Geology of Rocks and Regions. 3rd Edition. Wiley.
2.	Fossen, H. (2016). Structural Geology. 2nd Edition. Cambridge University Press.
3.	Marshak, S. & Mitra, G. (2005). Basic Methods of Structural Geology. Prentice Hall.
4.	Hobbs, B.E., Means, W.D. & Williams, P.F. (1976). An Outline of Structural Geology. Wiley.
5.	Ghosh, S.K. (2012). Structural Geology: Fundamentals and Modern Developments. Elsevier.
6.	Bhattacharya, A.R. (2022). Structural Geology. Springer.
7.	Mukherjee, S. (Ed.) (2026). Structural Geology and Tectonics. Springer Nature.
8.	Ramsay, J.G. & Huber, M.I. (1987). The Techniques of Modern Structural Geology, Volume 2: Folds and Fractures. Academic Press.
9.	Ramsay, J.G. & Huber, M.I. (1983). The Techniques of Modern Structural Geology, Volume 1: Strain Analysis. Academic Press.
10.	Twiss, R.J. & Moores, E.M. (2007). Structural Geology. 2nd Edition. W.H. Freeman and Company.
Web Resources	
1.	www.wiley.com
2.	www.cambridge.org
3.	www.springer.com
4.	www.sciencedirect.com
5.	www.geosociety.org

Summary of Course Outcomes (COs):

CO	Course Outcome Statement	Bloom's Level (K1–K7)	Mapped POs
CO1	Interpret contour maps, geological maps, outcrop patterns, and determine dip, strike, trend, and thickness of rock formations using topographic and geological data.	Understand (K2)	PO1, PO2, PO6
CO2	Apply geological mapping techniques to analyze folds, faults, unconformities, intrusions, and construct geological cross-sections and geological histories from geological maps.	Apply (K3)	PO1, PO2, PO3, PO7
CO3	Analyze structural geological problems involving dip, strike, true thickness, fault throw, and bed orientation using trigonometric and graphical methods.	Analyze (K4)	PO2, PO3, PO4, PO8
CO4	Evaluate geomorphological features, lithological units, and geological structures using aerial photographs, field observations, and geological interpretation techniques.	Evaluate (K5)	PO3, PO4, PO5, PO9
CO5	Design and conduct geological and surveying investigations using chain survey, compass survey, GPS, clinometer compass, and modern surveying techniques for geological applications.	Create (K6)	PO4, PO5, PO10, PO11, PO12

CO–PO Mapping Matrix

COs \ Pos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	–	–	–	3	–	–	–	–	–	–
CO2	3	2	3	–	–	–	2	–	–	–	–	–
CO3	–	3	2	3	–	–	–	2	–	–	–	–
CO4	–	–	3	2	2	–	–	–	3	–	–	–
CO5	–	–	3	3	3	–	–	–	–	2	2	2

DISASTER MANAGEMENT			
Learning Objectives			
CO1	To introduce the basic concepts of disaster, hazard, vulnerability, and risk.		
CO2	To understand the types and causes of various natural and anthropogenic disasters.		
CO3	To provide knowledge of disaster management strategies, phases, and mitigation techniques.		
CO4	To understand the types, causes, effects and mitigation of Man- made and industrial hazards.		
CO5	To familiarize students with institutional frameworks like NDMA, NDRF and SDMA		
UNIT	Details	No. of Hours	Course Objectives
I	Fundamentals of Disaster Management: Concept of disaster and hazard: definition and distinctions. Types of disasters: Natural - geological, hydrological, climatological; Biological and Man-made. Disaster Management Cycle: preparedness, response, recovery and mitigation. Risk and Vulnerability analysis: Types of vulnerability, Risk and Resilience.	12	CO1
II	Geological Disasters: Earthquakes: causes, effects, and mitigation strategies. Tsunami: generation, impact zones, and early warning systems. Volcanoes: types, causes, effects, and risk zones. Landslides: mechanisms, triggers, and mitigation.	12	CO2
III	Hydrological, Climatological and Biological Disasters: Hydrological Disasters: Avalanches - definition, causes and facts. Floods - causes, types, impacts, and flood control measures. Climatological Disasters: global warming, climate change, droughts, cyclones - types, effects and warning systems. Biological Disasters: epidemics and pandemics - causes, spread and control measures (e.g., COVID-19, Dengue, Cholera etc.,).	12	CO3
IV	Man-Made and Industrial Disasters Man-Made Disasters: Famine, Transport - road, rail and air accidents, Conflicts, Terrorism and their impact on society. Industrial Disasters - chemical, nuclear, mine explosion, pollution, acid rain and oil spills. Urban Disasters - stampede, building collapse and effluence. Fire accidents - causes, effects, and safety regulations.	12	CO4
V	Disaster Management Framework and Institutions in India: Disaster prone regions of India. National Disaster Management	12	CO5

	Act and Policy. Role of NDMA, NDRF and SDMA. Disaster preparedness plan - awareness, mitigation and management.		

UNIT	Learning Outcomes
I	Know about the Nature of Disasters and Hazards.
II	Know about the Earthquakes, Volcanic Eruption and Landslides etc..,
III	Understand the Causes and effects of Cyclones, Floods, and Droughts.
IV	Acquired the knowledge of Fire Accidents, Explosions, Road Accidents and Stampede.
V	Know about the Role Agencies in Disaster Management.

Text Books / References Books	
1.	Kapur, A. (2010). Vulnerable India: A Geographical Study of Disasters. SAGE India Pvt. Ltd., New Delhi.
2.	Vulnerability Atlas of India (1997). Building Materials & Technology Promotion Council, Ministry of Urban Development, Government of India, New Delhi.
3.	Singh, R.B. (2006). Natural Hazards and Disaster Management: Vulnerability and
4.	Mitigation (Edited Volume). Rawat Publications, New Delhi.
5.	Modh, S. (2010). Managing Natural Disaster: Hydrological, Marine and Geological Disasters. Macmillan, New Delhi.
6.	Srivastava, H.N. & Gupta, G.D. (2006). Management of natural disasters in developing countries. Delhi: Daya Publishers.
7.	Coppola, D. P, (2007). Introduction to international disaster management. London:
8.	Elsevier Science (B/H).
9.	David Alexander. (1999). Natural disasters. London: Kluwer Academic
10.	Murthy, D.B.N. (2012) Disaster management. New Delhi: Deep and Deep Publication
Web Resources	
1.	NDMA Guidelines (available at: www.ndma.gov.in)
2.	NIDM (available at: www.nidm.gov.in)
3.	NDRF (available at: www.ndrf.gov.in)
4.	SDMA (available at: www.cra.tn.gov.in)
5.	NDMA Guidelines (available at: www.ndma.gov.in)

Summary of Course Outcomes (COs):

CO	Course Outcome Statement	Bloom's Level	Mapped POs
CO1	Understand disaster types and the disaster management cycle	Understand (K1, K2)	PO1, PO6, PO7
CO2	Analyze geological disasters and their management strategies	Analyze (K4)	PO1, PO2, PO6, PO7
CO3	Evaluate hydro-meteorological disaster impacts and responses	Evaluate (K5)	PO1, PO2, PO6, PO7
CO4	Identify and assess causes and responses to man-made disasters	Analyze (K4)	PO1, PO5, PO6, PO8
CO5	Apply institutional framework knowledge for disaster risk reduction in India	Apply (L3)	PO3, PO4, PO7, PO8

CO–PO Mapping Matrix

COs \ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	–	–	2	–	–	–	3	–	–	–
CO2	3	2	–	–	3	–	–	–	3	–	–	1
CO3	3	2	2	2	3	–	–	–	3	–	–	1
CO4	3	2	3	2	3	2	2	–	3	–	–	1
CO5	3	3	–	2	3	–	–	2	3	2	2	3

SEMESTER-III

PALAEONTOLOGY			
Learning Objectives			
CO1	Understand the basics of Fossils		
CO2	Understand the importance of fossils in Geological studies		
CO3	Know different phylum and their species with morphological changes		
CO4	Understand and correlate fossil with various rock formations		
CO5	Understand the importance of Palaeontology in dating and evolution studies		
UNIT	Details	No. of Hours	Course Objectives
I	Definition and types of fossils. Conditions and processes of fossilization. Different modes of preservation of animal organisms as fossils. Uses of fossils. Short notes on the exceptional preservation of fossils. Outline of Geological time scale. Morphological characters, classification, geological and stratigraphical importance of the following Phyla: Brachiopoda; Porifera; Mollusca: Class – Pelecypoda.	12	CO1
II	**Invertebrate Paleontology I:** Morphological characters, classification, geological and stratigraphical importance of the following Phyla: Phylum Mollusca: Class: Gastropoda; Class: Cephalopoda. Morphological characters, classification, geological and stratigraphical importance of the Phylum Hemichordata: Class – Graptoloidea. Morphological characters, classification, geological and stratigraphical importance of the Phylum Arthropoda;	12	CO2
III	**Invertebrate Paleontology II**: Morphological characters, classification, geological and stratigraphical importance of the Phylum Coelenterata: Class Anthozoa – Corals: Morphological characters, classification, geological and stratigraphical importance of the following: Phylum Echinodermata: Classes – Echinoidea, Blastoidea, and Crinoidea. Morphology and geological history of Foraminifera and Ostracoda.	12	CO3
IV	**Vertebrate Paleontology**: A short account on the classification of vertebrates. Outline of evolution of vertebrates through geological time. Brief account of Ostracoderms and Icthyostegids and their stratigraphic significance. Dinosaurs: definition, characteristics, classification, stratigraphic significance, and outline of their extinction. Short account of Indian dinosaurs: Kotasaurus, Rajasaurus, Stegosaurus, and Ankylosaurus. A brief account of Archaeopteryx and Pterosaurs.	12	CO4

V	**Paleobotany**: Detailed description and classification of land plant fossils. Detailed study of modes of preservation of plant fossils. Outline of important steps in plant evolution with geological time. Outline of adaptations relevant to land colonization of plants. Brief account of stromatolites and their geological significance. Short account of Gondwana flora; Glossopteris, Gangamopteris, Calamites, Lepidodendron, Sigillaria and Ptilophyllum.	12	CO5

UNIT	Learning Outcomes
I	Understand the basics of Fossils
II	Understand the importance of fossils in Geological studies
III	Know different phylum and their species with morphological changes
IV	Understand and correlate fossil with various rock formations
V	Understand the importance of Palaeontology in dating and evolution studies

Text Books / References Books	
1.	Jain, C. & Anantharaman, M.S. (1996) – Palaeontology: Evolution and Animal Distribution
2.	Woods, H. (1985) – Invertebrate Palaeontology
3.	Agashe, S.N. (1995) – Palaeobotany
4.	Stewart, W.N. & Rothwell, G.W. (2005) – Palaeobotany
5.	Moore, R.C. et al. (1952) – Invertebrate Fossils
6.	Shrock, R.R. & Twenhofel, W.H. (2005) – Principles of Invertebrate Palaeontology
7.	Moore, R.C., Lalicker, C.G. & Fisher, A.G. (1952) – Invertebrate Fossils
8.	Romer, A.S. (1959) – The Vertebrate Story
9.	Nield, E.W. & Tucker, V.C.T. (1985) – Palaeontology: An Introduction
10.	Colbert, E.H. et al. (2002) – Evolution of the Vertebrates

Web Resources	
1.	www.fossilworks.org
2.	www.paleobiodb.org
3.	www.sciencedirect.com
4.	www.geoscienceworld.org
5.	www.paleos.com

Summary of Course Outcomes (COs):

CO	Course Outcome Statement	Bloom's Level	Mapped POs
CO1	Define fossils, fossilization processes, modes of preservation, geological time scale, and explain their significance in palaeontology.	Understand (K2)	PO1, PO2, PO4, PO12
CO2	Classify and describe major invertebrate fossil groups such as Brachiopoda, Porifera, Mollusca, Arthropoda, and Hemichordata and explain their stratigraphic importance.	Apply (K3)	PO1, PO2, PO3, PO4, PO5
CO3	Analyze morphological features, classification, and geological importance of echinoderms, corals, foraminifera, and ostracods.	Analyze (K4)	PO1, PO2, PO3, PO4, PO5, PO6
CO4	Evaluate vertebrate evolution, including dinosaurs and transitional fossils, and interpret their stratigraphic and evolutionary significance.	Evaluate (K5)	PO1, PO2, PO3, PO4, PO5, PO6, PO7

CO5	Analyze paleobotanical records including plant fossils, Gondwana flora, stromatolites, and evolutionary adaptations of land plants.	Analyze–Evaluate (K4–K5)	PO1, PO2, PO3, PO4, PO5, PO6, PO12

CO–PO Mapping Matrix

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	3	1	1	1	1	-	1	-	2
CO2	3	3	3	3	2	1	1	1	1	1	-	1
CO3	3	3	2	3	2	3	2	1	1	1	-	1
CO4	3	3	2	3	2	3	3	1	1	2	1	2
CO5	3	3	2	3	2	3	3	1	1	1	-	2

DYNAMIC EARTH: OCEANS & ATMOSPHERE			
Learning Objectives			
CO1	Understand ocean floor topography and physical properties of seawater.		
CO2	Explain ocean currents, waves, tides, and tsunamis.		
CO3	Describe atmospheric structure, pressure, winds, and circulation.		
CO4	Understand weather systems, precipitation, and climate.		
CO5	Relate ocean-atmosphere interactions to climate change and resources.		
UNIT	Details	No. of Hours	Course Objectives
I	**Oceanography:** Definition, Scope, Content and Significance. Distribution of Land and Sea on the Earth. Hypsometric Curve and its significance. Origin and evolution of oceans. Surface configuration of the ocean floor – Continental Shelf, Continental Slope, Continental Rise, Abyssal Plains (Deep Sea Plains), Oceanic Deeps, Ocean Trenches, Mid-Oceanic Ridges and Submarine Canyons. Marine sediments – sources, types and distribution. Importance of oceans in climate regulation and resource management.	6	CO1
II	Major Oceans, Temperature and Salinity: Relief features of the major oceans – Atlantic Ocean, Pacific Ocean and Indian Ocean. Ocean basins and submarine topography. Physical and chemical properties of seawater. Horizontal and vertical distribution of seawater temperature. Factors affecting ocean temperature. Thermocline and ocean stratification. Salinity – definition, measurement and significance. Factors affecting salinity. Horizontal and vertical distribution of salinity in oceans.	6	CO2
III	Ocean Water Circulation, Waves, Tides and Tsunamis: Ocean water circulation and its significance. Factors influencing ocean circulation. General circulation of ocean currents. Warm and cold currents. Major currents of the Atlantic, Pacific and Indian Oceans. Upwelling and downwelling processes. Waves – definition, origin, characteristics and types. Tides – definition, causes and types - spring	6	CO3

	tide, neap tide, diurnal and semidiurnal tides. Coastal processes and shoreline changes.		
IV	**Atmosphere:** definition, composition, structure and importance. Atmospheric layers – Troposphere, Stratosphere, Mesosphere, Thermosphere and Exosphere. Atmospheric temperature and heat budget. Atmospheric pressure – definition, measurement and units. Diurnal and seasonal variations in pressure. Vertical and horizontal distribution of atmospheric pressure. Factors affecting atmospheric pressure. Pressure gradient force. Coriolis force and planetary circulation. Winds – causes, characteristics and classification. Planetary winds, Trade Winds, Westerlies and Polar Easterlies. Monsoon winds and mechanism of Indian Monsoon.	6	CO4
V	Atmospheric Moisture, Clouds and Precipitation: Atmospheric moisture – sources and significance. Humidity – definition and types: Absolute Humidity, Relative Humidity, Specific Humidity, Mixing Ratio and Saturation Humidity. Measurement of humidity and its applications. Evaporation and evapotranspiration. Precipitation – definition, formation and mechanisms. Types of precipitation – Convectional, Orographic and Cyclonic rainfall. Rainfall measurement – rain gauges and methods of measurement. Distribution of rainfall in India and Tamil Nadu.	6	CO5

UNIT	**Learning Outcomes**
I	Understand the basic concepts of oceanography and atmosphere, including their definition, scope, distribution of land and sea, and structure of Earth's oceans and atmosphere.
II	Describe and explain ocean floor features, marine sediments, ocean basins, and physical and chemical properties of seawater including temperature, salinity, and density variations.
III	Analyze ocean circulation systems including currents, waves, tides, tsunamis, and their role in coastal processes and climate regulation.
IV	Explain atmospheric structure, pressure systems, wind systems, monsoon circulation, and global atmospheric dynamics including jet streams and local winds.
V	Interpret atmospheric moisture processes, clouds, precipitation, rainfall distribution, and evaluate the impacts of climate change, global warming, and ocean-atmosphere interactions.

Text Books / References Books

1.	Marshall, J. & Plumb, R.A. (2008) – Atmosphere, Ocean and Climate Dynamics: An Introductory Text
2.	Wells, N.C. (2011) – The Atmosphere and Ocean: A Physical Introduction
3.	Sverdrup, H.U., Johnson, M.W. & Fleming, R.H. (1970) – The Oceans: Their Physics, Chemistry and General Biology
4.	Ahrens, C.D. & Henson, R. (2021) – Meteorology Today
5.	Catling, D.C. & Kasting, J.F. (2017) – Atmospheric Evolution on Inhabited and Lifeless Worlds
6.	Anikouchine, W.A. & Sternberg, R.W. (1973) – The World Oceans: An Introduction to Oceanography
7.	Pinet, P.R. (2019) – Invitation to Oceanography
8.	Garrison, T. (1998) – Oceanography
9.	Gerald, S. (1980) – General Oceanography: An Introduction
10.	Trujillo, A.P. & Thurman, H.V. (2017) – Essentials of Oceanography

Web Resources

1.	www.nationalgeographic.com
2.	www.britannica.com
3.	www.sciencedirect.com
4.	www.springer.com
5.	www.cambridge.org

Summary of Course Outcomes (COs):

CO No.	Course Outcome Statement	Bloom's Level	Mapped POs
CO1	Explain the fundamental concepts of oceanography and atmosphere including scope, land–sea distribution, ocean basins, and atmospheric structure.	Understand (K2)	PO1, PO2, PO4, PO12
CO2	Apply knowledge of ocean floor topography, marine sediments, and physical and chemical properties of seawater such as temperature, salinity, and density distribution.	Apply (K3)	PO1, PO2, PO3, PO4, PO5
CO3	Analyze ocean circulation systems including currents, waves, tides, tsunamis, and their impact on coastal processes and climate regulation.	Analyze (K4)	PO1, PO2, PO3, PO4, PO5, PO6
CO4	Evaluate atmospheric systems including pressure, winds, monsoon mechanisms, jet streams, and global atmospheric circulation patterns.	Evaluate (K5)	PO1, PO2, PO3, PO4, PO5, PO6, PO7
CO5	Analyze and evaluate atmospheric moisture, clouds, precipitation systems, rainfall distribution, and assess climate change and ocean-atmosphere interactions.	Analyze–Evaluate (K4–K5)	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO12

CO–PO Mapping Matrix

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	3	1	1	1	1	-	1	-	2
CO2	3	3	3	3	2	1	1	1	1	1	-	1
CO3	3	3	2	3	2	3	3	1	1	1	-	1
CO4	3	3	2	3	2	3	3	1	1	2	1	2
CO5	3	3	2	3	2	3	3	1	1	1	-	2

ARTIFICIAL INTELLIGENCE & MACHINE LEARNING TOOLS IN GEOLOGY			
Learning Objectives			
CO1	To introduce the basic concepts of Artificial Intelligence and Machine Learning and their relevance in geological studies		
CO2	To enable students to understand the application of AI/ML techniques in mineral exploration, resource prediction, and geological mapping.		
CO3	To develop skills in using GIS, remote sensing, and Python-based tools for geoscientific data analysis.		
CO4	To familiarize students with AI applications in seismic interpretation, groundwater modeling, and environmental geology.		
CO5	To prepare students for modern geoscience careers by integrating computational techniques with traditional geological methods.		
UNIT	Details	No. of Hours	Course Objectives
I	**Introduction to Artificial Intelligence**: Definition of Artificial Intelligence- history and evolution of AI- types of AI (narrow, general, strong AI). Applications of AI in Earth sciences and geology. Basic concepts of machine learning- data types and data preprocessing. Introduction to Python for AI; overview of AI tools used in geosciences.	12	CO1
II	**Machine Learning Fundamentals**: Supervised, Unsupervised, and Reinforcement Learning- regression and classification techniques, clustering methods, decision trees and random forests and support vector machines, model training and testing, evaluation metrics (accuracy, precision, recall). Applications in mineral exploration and geological data analysis.	12	CO2
III	**Data Science & Geospatial Analysis**: Introduction to data science in geology- role of GIS and remote sensing in AI. spatial data formats and analysis- image classification techniques. use of Python libraries such as NumPy, Pandas, and GeoPandas. satellite image processing; geological mapping using AI techniques.	12	CO3
IV	**AI Applications in Geology**: AI in mineral and petroleum exploration; seismic data interpretation using machine learning; groundwater potential zoning; landslide and hazard prediction; environmental monitoring; structural geology and lithological classification using AI; case studies in geoscience applications.	12	CO4
V	**Advanced Topics & Tools in AI for Geosciences:** Deep learning concepts -neural networks, CNN, RNN basics. AI tools such as TensorFlow and PyTorch; cloud-based AI platforms - Google Earth Engine, ArcGIS AI tools. Automation in geological mapping. integration of AI with GIS and remote sensing-future trends of AI in Earth sciences.	12	CO5
UNIT	**Learning Outcomes**		
I	Understand: Students will be able to explain the fundamental concepts of Artificial Intelligence, Machine Learning, and their relevance to Earth and geological sciences.		

II	Apply: Students will apply basic machine learning algorithms such as classification, regression, and clustering to geological datasets.
III	Analyze: Students will analyze geospatial, remote sensing, and geological data using AI-based tools and Python libraries.
IV	Evaluate: Students will evaluate the effectiveness of AI techniques in solving geological problems such as mineral exploration, seismic interpretation, and hazard prediction.
V	Create: Students will develop simple AI/ML models and integrate them with GIS and remote sensing data for geological applications.
Text Books / References Books	
1.	Petrelli, M. (2023). Machine Learning for Earth Sciences: Using Python to Solve Geological Problems. Springer.
2.	Moseley, B., & Krischer, L. (Eds.). (2020). Machine Learning and Artificial Intelligence in Geosciences. Elsevier.
3.	Cranganu, C. (Ed.). (2024). Artificial Intelligent Approaches in Petroleum Geosciences (2nd ed.). Springer.
4.	Mallick, S. (2025). Computation, Optimization, and Machine Learning in Seismology. Wiley.
5.	Chen, W., et al. (2024). Remote Sensing Intelligent Interpretation for Geology. Springer.
6.	Zhang, H., et al. (2024). Geoscience Artificial Intelligence Systems and Foundation Models.
7.	Bishop, C. M. (2006). Pattern Recognition and Machine Learning. Springer.
8.	Géron, A. (2022). Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow (3rd ed.). O'Reilly Media.
9.	Goodfellow, I., Bengio, Y., & Courville, A. (2016). Deep Learning. MIT Press.
10.	Hastie, T., Tibshirani, R., & Friedman, J. (2021). The Elements of Statistical Learning: Data Mining, Inference, and Prediction (2nd ed.). Springer.
Web Resources	
1.	www.sciencedirect.com
2.	www.springer.com
3.	www.geoscienceworld.org
4.	www.kaggle.com
5.	www.github.com

Summary of Course Outcomes (COs)

CO No.	Course Outcome Statement	Bloom's Level	Mapped POs
CO1	Explain the fundamental concepts of Artificial Intelligence, Machine Learning, data preprocessing, Python programming, and their applications in Earth Sciences and Geology.	Understand (K2)	PO1, PO2
CO2	Apply supervised and unsupervised machine learning techniques for geological data analysis, classification, clustering, and predictive modeling.	Apply (K3)	PO1, PO2, PO3
CO3	Analyze geospatial and geological datasets using GIS, Remote Sensing, Python libraries, and AI-based image processing techniques.	Analyze (K4)	PO2, PO4, PO5
CO4	Evaluate the effectiveness of AI models and tools in solving geological problems such as mineral	Evaluate (K5)	PO4, PO5, PO7

	exploration, hazard prediction, groundwater assessment, and environmental monitoring.		
CO5	Develop AI-driven solutions integrating deep learning, GIS, remote sensing, and cloud-based platforms for advanced geoscience applications and future research.	Create (K6)	PO3, PO5, PO11, PO12

CO–PO Mapping Matrix

COs \ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	-	-	-	-	-	-	-	-
CO2	3	3	2	-	-	-	-	-	-	-	-	-
CO3	-	3	-	3	3	-	-	-	-	-	-	-
CO4	-	2	-	3	3	-	2	-	-	-	-	-
CO5	-	-	3	-	3	-	-	-	-	-	2	3

SEMSTER-IV

CRYSTALLOGRAPHY AND OPTICAL MINERALOGY			
Learning Objectives			
CO1	Correlate the crystals with their internal forms		
CO2	Infer the cubic and tetragonal type minerals in field		
CO3	Distinguish the types of hexagonal, orthorhombic, monoclinic and triclinic types of minerals		
CO4	Assess optical mineralogy and know about the microscope and its working		
CO5	Identify minerals and their applications.		
UNIT	Details	No. of Hours	Course Objectives
I	CRYSTALLOGRAPHY: Definition of crystal and amorphous form- Morphological characters of crystals: Faces-Forms-Edges-Solid angles-Interface angles- Contact Goniometer and its uses- Symmetry elements in crystals-Crystallographic axes and axial ratio– Parameters-Indices and symbols: Weiss and Miller system of notation- Laws of Crystallography: Law of constancy of interfacial angles-Law of Rational Indices. Classification of crystal systems- Study of holohedral, hemihedral, hemimorphic and enantiomorphous forms of crystals. Cubic System: Symmetry elements- forms and representative mineral of the normal, pyritohedral, tetrahedral and plagiohedral classes.	12	CO1
II	**Tetragonal system**: Symmetry element and forms of normal, hemimorphic, tripyramidal, pyramidal hemimorphic, sphenoidal and trapezohedral classes- A brief outline of imperfection and irregularity in crystals. **Hexagonal system**: Symmetry elements and forms-A Hexagonal division: normal, hemimorphic, tripyramidal, and trapezohedral classes with type minerals B. Rhombohedral division: rhombohedral, rhombohedral- hemimorphic, trirhombohedral, and trapezohedral classes.	12	CO2
III	**Orthorhombic system:** study of the symmetry element and forms of the normal, hemimorphic, and sphenoidal classes with type	12	CO3

	minerals.**Monoclinic system:** study of the symmetry elements and forms of the normal class. **Triclinic system:** Study of the symmetry elements and forms of the normal class-Twin crystals: Definition– evidence of twinning-laws of twinning compositional plane, twinning plane and twin axis-twins: simple, repeated (polysynthetic twin), contact, and penetration twin and cyclic twin.		
IV	**Optical mineralogy:** Light: Corpuscular, electromagnetic and quantum theories. ordinary light and plane polarized light-Refractive index and its determination: Relief method, Becke line, central illumination and oblique illumination methods- Isotropism, isotropic minerals and isotropic ray velocity surface-behavior of light in isotropic minerals.	12	CO4
V	Petrological microscope and its parts-optical accessories and their uses: Quartz wedge, Gypsum plate and Mica plate-study of Isotropic minerals using the petrological microscope: properties of isotropic minerals under parallel Nicol conditions. Anisotropism and anisotropic minerals- behavior of ordinary light in uniaxial minerals: Double refraction- Indicatrix- Optic axes- Optic sign. - Nicol prism and its construction. behaviour of polarized light. Pleochroism, retardation, birefringence, extinction and interference colours.	12	CO5

UNIT	**Learning Outcomes**
I	Understand: Students will be able to explain the basic concepts of crystallography, crystal systems, symmetry elements, and mineral classification.
II	Identify: Students will identify and classify common rock-forming minerals based on their physical and optical properties.
III	Apply: Students will apply principles of crystal morphology and optical properties in the identification of minerals in hand specimens and thin sections.
IV	Analyze: Students will analyze mineral properties using polarizing microscope techniques and interpret optical behavior under plane and crossed Nicols.
V	Evaluate: Students will evaluate and distinguish minerals using optical mineralogy methods for accurate geological interpretation and rock identification.

Text Books / References Books

1.	Ford, W.E. (1988). Dana's Textbook of Mineralogy.
2.	Sengupta, S. (1980). Crystallography and Optical Mineralogy.
3.	Marcos, C. (2022). Crystallography: Introduction to the Study of Minerals.
4.	Dyar, M.D., & Gunter, M.E. (2020). Mineralogy and Optical Mineralogy.
5.	Verma, P.K. (2023). Optical Mineralogy.
6.	Phillips, F.C. (1965). Crystallography.
7.	Bishop, A.C. (1967). An Outline of Crystal Morphology.
8.	Kerr, P.F. (1977). Optical Mineralogy.
9.	Correns, C.W. (1967). Introduction to Mineralogy, Crystallography and Petrology.
10.	Gribble, C.D., & Hall, A.J. (1985). A Practical Introduction to Optical Mineralogy.

Web Resources

1.	https://www.labotka.net
2.	https://ocw.mit.edu
3.	https://www.geologyin.com
4.	https://www.tulane.edu
5.	www.webmineral.com

Summary of Course Outcomes (COs)

CO No.	Course Outcome Statement	Bloom's Level	Mapped POs
CO1	Explain the fundamental concepts of crystallography, crystal morphology, symmetry elements, crystallographic notation, laws of crystallography, and crystal classification systems.	Understand (K2)	PO1, PO2
CO2	Apply crystallographic principles to identify crystal systems, crystal forms, twinning phenomena, and symmetry relationships in minerals.	Apply (K3)	PO1, PO2, PO3
CO3	Analyze crystal structures and morphological characteristics of minerals belonging to cubic, tetragonal, hexagonal, orthorhombic, monoclinic, and triclinic systems.	Analyze (K4)	PO2, PO4, PO5
CO4	Evaluate optical properties of minerals using refractive index determination methods, petrological microscope techniques, and optical accessories under plane and crossed nicols.	Evaluate (K5)	PO4, PO5, PO6
CO5	Interpret and classify isotropic, uniaxial, and biaxial minerals through optical mineralogical investigations, interference figures, indicatrices, and optical sign determination.	Create (K6)	PO3, PO4, PO5, PO12

CO–PO Mapping Matrix

COs \ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	-	-	-	-	-	-	-	-
CO2	3	3	2	-	-	-	-	-	-	-	-	-
CO3	2	3	-	3	2	-	-	-	-	-	-	-
CO4	-	2	-	3	3	2	-	-	-	-	-	-
CO5	-	2	3	3	3	-	-	-	-	-	-	2

PALAEONTOLOGY & CRYSTALLOGRAPHY PRACTICAL	
Learning Objectives	
CO1	To provide practical knowledge on the identification and study of fossils and their morphological features.
CO2	To train students in recognizing different fossil groups and understanding their geological significance.
CO3	To develop skills in identifying crystal systems, symmetry elements, and crystal habits using models and specimens.
CO4	To enable students to analyze and interpret crystallographic and palaeontological data for geological applications.
CO5	To enhance laboratory skills in drawing, labeling, and documenting fossils and crystal structures systematically.

UNIT	Details	No. of Hours	Course Objectives
I	Identification and description of the following fossils: Lamellibranchs: Arca, Meretrix, Pecten, Cardita, Lima, Allectronia, Inoceramus, Gryphaea, Exogyra, Radiolites, Ostrea, Unio, Trigonia. Gastropods: Turritella, Turbo, Cerithium, Trochus, Physa, Murex, Voluta, Helix, Euomphalus, Cyprea.	12	CO1
II	Cephalopods: Nautilus, Orthoceras, Ceratite, Goniatite, Belemnites, Baculites, and Perisphinctes. Echinodermata: Cidaris, Holaster, Hemiaster, Stigmatophygus, Apiocrinus. Trilobites: Paradoxides, Olenus, Olenellus, Phacops, Calymene.	12	CO2
III	Corals: Calceola, Zaphrentis, Lithostrotion, Omphyma, Thecosmelia. Brachiopoda: Terebratula, Spirifer, Productus, Monograptus, Tetragraptus, Diplograptus.	12	CO3
IV	Isometric System: Normal Class – Galena, Fluorite, Magnetite, Garnet, and Leucite, Copper- Pyritohedral class – Pyrite, Tetrahedral Class – Tetrahedrite. Tetragonal System: Normal Class – Zircon, Vesuvianite, Cassiterite, and Rutile. Tripyramidal – Scheelite, MeioniteSphenidal Class – Chalcopyrite. Hexagonal System: Normal Class – Beryl, Tripyramidal – Apatite, Hemimorphic – Zincite, Rhombohedral Normal – Calcite, Trapezohedral Class – Quartz.	12	CO4
V	Orthorhombic System: Normal – Barite, Sulphur, Stibnite, Topaz, Staurolite, and Aragonite. Hemimorphic – Calymene, Sphenoidal Class – Epsomite. Monoclinic System: Normal – Gypsum, Pyroxenes and Amphiboles. Triclinic System: Normal – Axinite, Albite, and Rhodonite. Twin Crystals: Contact and Penetration twins of Fluorite, Iron Cross Twin of Pyrite, Knee type twin of Cassiterite, Polysynthetic twin of Aragonite, Cyclic twin of Cerussite, Swallow Tail of Gypsum, Twins of Carlsbad, Baveno, Manebach, Albite law of Albite.	12	CO5

UNIT	**Learning Outcomes**
I	Understand: Students will be able to understand and describe the morphological features of common fossils and their geological significance.
II	Identify: Students will identify major fossil groups and classify minerals based on crystal systems and symmetry elements.
III	Apply: Students will apply laboratory techniques to study fossils and crystallographic models for geological interpretation.
IV	Analyze: Students will analyze fossil assemblages and crystal structures to interpret past environments and mineral properties.
V	Demonstrate: Students will demonstrate skills in drawing, labeling, and recording fossil and crystal specimens accurately in practical records.

Text Books / References Books	
1.	Perkins, D. (2014). Mineralogy.
2.	Thornbury, W.D. (2004). Principles of Geomorphology.
3.	Agashe, S.N. (1995). Paleobotany.
4.	Nesse, W.D. (2000). Introduction to Mineralogy.
5.	Dana, E.S. (2000). Textbook of Mineralogy.

6.	Tilley, R.J.D. (2006). Crystals and Crystal Structures.
7.	Correns, C.W. (1967). Introduction to Mineralogy, Crystallography and Petrology.
8.	Colbert, E.H., Morales, M., & Minkoff, E.C. (2002). Evolution of the Vertebrates.
9.	Klein, C., & Dutrow, B. (2007). Manual of Mineral Science.
10.	Deer, W.A., Howie, R.A., & Zussman, J. (2013). An Introduction to the Rock-Forming Minerals.
Web Resources	
1.	www.fossilworks.org
2.	www.paleobiodb.org
3.	www.ucmp.berkeley.edu
4.	www.fossilmuseum.net
5.	www.nhm.ac.uk

Summary of Course Outcomes (COs)

CO No.	Course Outcome Statement	Bloom's Level	Mapped POs
CO1	Identify and describe the morphological characteristics, classification, and geological significance of major fossil groups including Lamellibranchs, Gastropods, Cephalopods, Echinoderms, Trilobites, Corals, and Brachiopods.	Understand (K2)	PO1, PO2
CO2	Apply principles of paleontology to recognize, classify, and interpret fossils for stratigraphic correlation and paleoenvironmental reconstruction.	Apply (K3)	PO1, PO2, PO3
CO3	Analyze the crystallographic characteristics, symmetry elements, and crystal systems of common minerals belonging to isometric, tetragonal, hexagonal, orthorhombic, monoclinic, and triclinic systems.	Analyze (K4)	PO2, PO4, PO5
CO4	Evaluate mineral specimens based on crystal forms, symmetry classes, and diagnostic properties for accurate mineral identification.	Evaluate (K5)	PO4, PO5, PO6
CO5	Interpret crystal twinning, mineral associations, and fossil assemblages to solve geological problems and reconstruct geological history.	Create (K6)	PO3, PO4, PO5, PO12

CO–PO Mapping Matrix

COs \ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	-	-	-	-	-	-	-	-
CO2	3	3	2	-	-	-	-	-	-	-	-	-
CO3	2	3	-	3	3	-	-	-	-	-	-	-
CO4	-	2	-	3	3	2	-	-	-	-	-	-
CO5	-	2	3	3	3	-	-	-	-	-	-	2

REMOTE SENSING & GIS			
Learning Objectives			
CO1	Explain remote sensing		
CO2	Demonstrate the aerial photographs and how to utilize it constructively		
CO3	Examine satellites, their working and applications		
CO4	Discuss the satellites in India and the space missions.		
CO5	Explore the minerals and groundwater		
UNIT	Details	No. of Hours	Course Objectives
I	**Remote Sensing:** Definition, scope and importance of Remote Sensing in Geology- Electromagnetic spectrum – definition and components- Outline of interaction of electromagnetic spectrum with atmosphere and earth surface features- Spectral signatures and their geological significance- Atmospheric windows	12	CO1
II	**Types based on Energy sources:** Active and Passive- Types based on Platforms: Aerial and Satellite- Types based on Sensors: Optical, Thermal, and Microwaves- RADAR and LiDAR – principles and geological applications- Aerial Remote Sensing: Types of Aerial Photographs – Vertical and Oblique- Scale of aerial photographs- Flight procedures- Stereoscopes: Pocket and Mirror stereoscopes.	12	CO2
III	Photo interpretation elements Mosaics: Controlled and Uncontrolled – advantages and disadvantages. Application of mosaics in Geology studies. Image processing system: enhancement, classification and filtering techniques. Satellite remote sensing: Principles of optical remote sensing- Satellite orbiting mechanisms. Types of resolution: spatial, spectral, temporal and radiometric- Data acquisition and interpretation	12	CO3
IV	**Thermal Remote Sensing:** Thermal radiation principles – atmospheric windows- Advantages and disadvantages of thermal remote sensing- SLAR – principle and applications- A short account of LANDSAT, SPOT and Sentinel satellite series- Indian Remote Sensing satellites: IRS series and Cartosat missions- Indian Space Mission and ISRO contributions to Earth observation	12	CO4
V	A short account of the Remote sensing techniques in the study of drainage patterns, major landforms and geological structures- Groundwater exploration, mineral exploration and disaster monitoring- Basic principles of GIS: Components of GIS- Hardware and software module- Raster and vector data structures- Introduction of GPS and GNSS systems- Application of GPS in geological studies.	12	CO5
UNIT	**Learning Outcomes**		
I	Understand: Students will be able to explain the fundamental concepts of Remote Sensing, GIS, and their importance in Earth and geological sciences.		
II	Identify: Students will identify different types of satellite data, sensors, and GIS components used in spatial data analysis.		
III	Apply: Students will apply Remote Sensing and GIS techniques for mapping geological features, land use/land cover, and natural resources.		

IV	Analyze: Students will analyze spatial and temporal data using GIS tools to interpret geological structures, terrain, and environmental changes.
V	Evaluate & Create: Students will evaluate GIS-based models and develop simple spatial analysis projects for geological and environmental applications.
Text Books / References Books	
1.	Curran, P.J. (1985). Principles of Remote Sensing.
2.	Sabins, F.F. (1974). Remote Sensing: Principles and Interpretation.
3.	Reddy, A. (2010). Principles of Remote Sensing and GIS.
4.	Pandey, S.N. (1989). Principles and Applications of Photogeology.
5.	Gupta, R.P. (2003). Remote Sensing Geology.
6.	Lillesand, T.M., & Kiefer, R.W. (2000). Remote Sensing and Image Interpretation.
7.	Campbell, J.B., & Wynne, R.H. (2023). Introduction to Remote Sensing.
8.	Bhatta, B. (2020). Remote Sensing and GIS.
9.	Jensen, J.R. (2007). Remote Sensing of the Environment: An Earth Resource Perspective.
10.	Burrough, P.A., & McDonnell, R.A. (2006). Principles of Geographical Information Systems.
Web Resources	
1.	www.usgs.gov.faqs
2.	imagine.gsfc.nasa.gov
3.	www.wamis.org
4.	Crisp.nus.edu.sg
5.	www.intechopen.com

Summary of Course Outcomes (COs)

CO No.	Course Outcome Statement	Bloom's Level	Mapped POs
CO1	Explain the principles of Remote Sensing, electromagnetic radiation, spectral signatures, atmospheric interactions, and their significance in geological investigations.	Understand (K2)	PO1, PO2
CO2	Apply knowledge of remote sensing platforms, sensors, aerial photography, stereoscopic interpretation, and image acquisition techniques in geological studies.	Apply (K3)	PO1, PO2, PO3
CO3	Analyze remotely sensed data using image processing, photo interpretation, satellite data interpretation, and resolution concepts for geological mapping and resource assessment.	Analyze (K4)	PO2, PO4, PO5
CO4	Evaluate the effectiveness of thermal remote sensing, radar, LiDAR, satellite missions, and Earth observation systems in solving geological and environmental problems.	Evaluate (K5)	PO4, PO5, PO7
CO5	Develop geospatial solutions by integrating Remote Sensing, GIS, GPS, and GNSS technologies for groundwater exploration, mineral exploration, geological mapping, and disaster monitoring.	Create (K6)	PO3, PO5, PO11, PO12

CO–PO Mapping Matrix

COs \ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	-	-	-	-	-	-	-	-
CO2	3	3	2	-	-	-	-	-	-	-	-	-
CO3	-	3	-	3	3	-	-	-	-	-	-	-
CO4	-	2	-	3	3	-	2	-	-	-	-	-
CO5	-	-	3	-	3	-	-	-	-	-	2	3

	GEOLOGICAL INSTRUMENTS & SOFTWARE		
	Learning Objectives		
CO1	Proficiency in Geological Instrumentation		
CO2	Knowledge of resistivity meters, magnetic survey equipment for surface and subsurface investigations		
CO3	Application of technical knowledge to identify ore minerals in hand specimens/thin sections, assess groundwater potential, and evaluate fuel resources		
CO4	Students will be able to prepare technical geological reports and analyze data using software		
CO5	Learn to use software such as Arc GIS and Surfer for map-making, spatial data analysis, and creating geological models		
UNIT	Details	No. of Hours	Course Objectives
I	**Geological Laboratory Instruments and Analytical Techniques**: Introduction to geological laboratory techniques. Sample collection, preparation and preservation of rock, soil and water samples. Principles and applications of X-Ray Fluorescence (XRF) for elemental analysis. X-Ray Diffraction (XRD) for mineral identification and crystal structure determination. Scanning Electron Microscope (SEM) for microstructural and mineralogical studies. Atomic Absorption Spectroscopy (AAS), UV-Visible Spectrophotometry, pH Meter, Conductivity Meter and their geological applications.	12	CO1
II	**Geological Field Instruments and Data Collection Techniques**: Principles and methods of geological field investigations. Field instruments and their applications. Global Positioning System (GPS) for navigation and location tracking. Geological and Brunton Compass for measuring strike and dip. Rock hammer, hand lens, measuring tape, clinometer and field notebook. Field mapping techniques, sample collection procedures and field documentation. Geological traverses, outcrop studies and preparation of field reports. Use of digital cameras and mobile devices in geological investigations.	12	CO2
III	**Geophysical Sensors and Survey Equipment:** Introduction to geophysical survey methods. Smartphone-based geological sensors and mobile applications. Magnetometers for magnetic surveys and anomaly detection. Electrical resistivity surveys and groundwater investigations. Ground Penetrating Radar (GPR) for subsurface studies. Voltmeter, Ammeter and Galvanometer in electrical	12	CO3

	measurements. Outlines of Seismic, magnetic and electrical methods in geological exploration.		
IV	**Geological Modelling and Data Analysis Software**: Introduction to geological data processing and visualization. Concepts of digital geology and geospatial databases. Geological modelling using Leapfrog Geo, Rock Works, Surfer, Petrel and GeoStudio. Three-dimensional geological and hydrogeological modelling. Borehole data management and subsurface interpretation. Digital terrain modelling (DTM) and digital elevation models (DEM). Applications in mineral exploration, engineering geology, groundwater assessment and environmental studies.	12	CO4
V	**Geographic Information Systems (GIS) and Geological Mapping Applications**: Fundamentals of Geographic Information Systems (GIS). Spatial and attribute data management. QGIS – open-source GIS software for geological mapping and spatial analysis. ArcGIS – GIS tools for geospatial analysis, map preparation and database management. Georeferencing, digitization, spatial interpolation and thematic map preparation. Integration of GPS, Remote Sensing and GIS in geological investigations. Applications of GIS in geomorphology, hydrogeology, mineral exploration, environmental management and disaster studies.	12	CO5
UNIT	**Learning Outcomes**		
I	Understand: Students will be able to explain the principles, functions, and applications of common geological instruments and software used in field and laboratory studies.		
II	Identify: Students will identify various geological instruments such as compass, GPS, clinometer, theodolite, and levelling equipment along with their uses.		
III	Apply: Students will apply geological instruments and software tools for field data collection, mapping, and geological analysis.		
IV	Analyze: Students will analyze geological data using software applications such as GIS, remote sensing tools, and basic geospatial modelling programs.		
V	Evaluate & Create: Students will evaluate the accuracy of instrument-based and software-based results and develop simple digital geological maps and reports.		
Text Books / References Books			
1.	Joe Carry (2016): Geoscience: Instrumentation and Analytical Techniques: Describes instruments used for evaluation in fields like geology, hydrology, and remote sensing		
2.	Kliti Grice (2014): Principles and Practice of Analytical Techniques in Geosciences Offers a comprehensive outlook on modern chemical detection science, including mass spectrometry and stable isotope analysis.		
3.	R.S. Khandpur (3rd Ed, 2015): Handbook of Analytical Instruments A standard reference for the principles and building blocks of high-tech instruments, including scanning electron microscopes and particle size analyzers		
4.	Robin Gill (2014): Modern Analytical Geochemistry. An introduction to quantitative chemical analysis techniques for earth and environmental scientists.		
5.	Chang, K., Introduction to Geographic Information Systems, McGraw-Hill Education, 9th Edition, 2020		
6.	Hugh Rollinson and Victoria Pease (2nd Ed, 2021): Using Geochemical Data: To Understand Geological Processes. An updated guide on modern geochemical techniques and data analysis.		

7.	R. Saran (2022): Analytical Techniques for Trace Elements in Geochemical Exploration Covers destructive and non-destructive techniques for quantifying trace elements, including ICP-OES and ICP-MS. The Royal Society of Chemistry
8.	(USGS Bulletin 1770): Methods for Geochemical Analysis A detailed guide to inorganic chemical analysis of rock and mineral samples used in U.S. Geological Survey laboratories.
9.	Ghilani, C.D. & Wolf, P.R., Elementary Surveying: An Introduction to Geomatics, Pearson, 16th Edition, 2023.
10.	Kavanagh, B.F. & Glenn Bird, S.J., Surveying: Principles and Applications, Pearson Education, 9th Edition, 2020
Web Resources	
1.	www.g6tools.com
2.	www.igslis.com
3.	www.lefa.geologov.net
4.	www.geoma.in
5.	www.jmars.asu.edu

Summary of Course Outcomes (COs)

CO No.	Course Outcome Statement	Bloom's Level	Mapped POs
CO1	Explain the principles, operation, and applications of geological laboratory instruments and analytical techniques used in mineralogical, geochemical, and environmental investigations.	Understand (K2)	PO1, PO2
CO2	Apply geological field instruments, mapping techniques, GPS technologies, and field data collection methods for geological investigations and documentation.	Apply (K3)	PO1, PO2, PO3
CO3	Analyze geophysical survey data obtained from magnetometers, resistivity instruments, GPR, and other sensors for subsurface characterization and resource exploration.	Analyze (K4)	PO2, PO4, PO5
CO4	Evaluate geological, hydrogeological, and environmental datasets using geological modelling software and geospatial analysis tools for interpretation and decision-making.	Evaluate (K5)	PO4, PO5, PO11
CO5	Develop integrated geological solutions using GIS, Remote Sensing, GPS, geophysical techniques, and digital modelling platforms for mineral exploration, groundwater assessment, environmental management, and disaster studies.	Create (K6)	PO3, PO5, PO7, PO11, PO12

CO–PO Mapping Matrix

COs \ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	2	-	-	-	-	-	-	-
CO2	3	3	2	-	2	-	-	-	-	1	-	-
CO3	-	3	-	3	3	-	-	-	-	-	-	-
CO4	-	2	-	3	3	-	-	-	-	-	3	-
CO5	-	-	3	2	3	-	3	-	-	-	2	3

SEMESTER-V

MINERALOGY			
Learning Objectives			
CO1	Understand the basics of Minerals		
CO2	Understand the importance of Minerals in Geological studies		
CO3	Know different group of minerals systems		
CO4	Understand the descriptive mineralogy of different groups		
CO5	Understand the importance of Minerals and mineralogical studies		
UNIT	Details	No. of Hours	Course Objectives
I	Mineral: Definition and basic differences between minerals, mineraloids, and crystals. Megascopic properties of minerals based on external appearance: different forms, habits, and states of aggregation; colour: idiochromatic and allochromatic colours; lustre and their types; diaphaneity and their types; Mineral properties based on crystal structure: hardness based on Moh's and Vicker's scale; tenacity and its types; cleavage and its types; fracture and its types; short note on mineral partings.	12	CO1
II	Mineral properties based on sense of taste; odour; and tactile feeling. Specific gravity and density of minerals. Thermal, magnetic, and electrical properties of minerals.Megascopic, chemical, optical properties, mode of occurrences, petrological association, and uses of the following mineral groups and their members: quartz group; feldspar group; feldspathoids group. Short note on twinning in feldspars.	12	CO2
III	Megascopic, chemical, optical properties, mode of occurrences, petrological association, and uses of the following mineral groups and their members: pyroxene group, amphibole group, Olivine group,	12	CO3
IV	Megascopic, chemical, optical properties, mode of occurrences, petrological association, and uses of the following mineral groups and their members: mica group, garnet group, zeolite group.	12	CO4
V	Megascopic, chemical, optical properties, mode of occurrences, petrological association, and uses of the following mineral groups and their members: epidote group; spinel group; kyanite group; descriptive study of the following minerals: tourmaline, scapolite, sphene, cordierite; beryl, calcite, apatite, fluorite, and monazite.	12	CO5
UNIT	**Learning Outcomes**		
I	Understand the basics of Minerals		
II	Understand the importance of Minerals in Geological studies		

III	Know different group of minerals systems
IV	Understand the descriptive mineralogy of different groups
V	Understand the importance of Minerals and mineralogical studies
Text Books / References Books	
1.	Dana, E. S. (2000). A Textbook of Mineralogy. CBS Publishers & Distributors.
2.	Gribble, C. D. (1991). Rutley's Elements of Mineralogy. CBS Publishers & Distributors.
3.	Wenk, H. R., & Bulakh, A. (2006). Minerals: Their Constitution and Origin. Cambridge University Press.
4.	Perkins, D. (2010). Mineralogy (3rd ed.). Prentice Hall India.
5.	Haldar, S. K., & Tišljar, J. (2014). Introduction to Mineralogy and Petrology. Elsevier.
6.	Hurlbut, C. S. Jr. Dana's Manual of Mineralogy. John Wiley & Sons.
7.	Kerr, P. F. (1959). Optical Mineralogy. McGraw-Hill.
8.	Deer, W. A., Howie, R. A., & Zussman, J. (1982). An Introduction to the Rock-Forming Minerals (2nd ed.). Orient Longman.
9.	Deer, W. A., Howie, R. A., & Zussman, J. (1992). An Introduction to the Rock-Forming Minerals. ELBS.
10.	Berry, L. G., Mason, B., & Dietrich, R. V. (1985). Mineralogy. CBS Publishers.
Web Resources	
1.	https://en.m.wikipedia.org/wiki/mineral
2.	https://britannica.com/science/chlorite-mineral
3.	https://mineralseducationcoalition.org/minerals-database/zeolite
4.	https://www.britannica.com/science/epidote
5.	https://www.abracom.es

Summary of Course Outcomes (COs)

CO No.	Course Outcome Statement	Bloom's Level	Mapped POs
CO1	Explain the fundamental concepts of minerals, mineraloids, crystals, crystal morphology, physical properties, and mineral identification techniques based on megascopic characteristics.	Understand (K2)	PO1, PO2, PO4
CO2	Classify and identify major rock-forming minerals such as quartz, feldspars, feldspathoids, pyroxenes, amphiboles, and olivines using their physical, chemical, optical, and structural properties.	Apply (K3)	PO1, PO2, PO3, PO4
CO3	Interpret crystal chemistry concepts including chemical bonding, Pauling's rules, ionic substitution, polymorphism, isomorphism, exsolution, mixed crystals, and intergrowths in minerals.	Analyze (K4)	PO1, PO2, PO4, PO5
CO4	Examine the occurrence, petrological association, economic significance, and diagnostic characteristics of mineral groups such as micas, garnets, zeolites, chlorites, epidotes, spinels, and kyanite.	Analyze (K4)	PO2, PO3, PO5, PO7
CO5	Evaluate and interpret the mineralogical characteristics, industrial applications, and geological significance of selected accessory and economic minerals including tourmaline, scapolite, sphene, cordierite, beryl, calcite, apatite, fluorite, and monazite.	Evaluate (K5)	PO3, PO5, PO7, PO12

COs \ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	3	-	-	-	-	-	-	1	-
CO2	3	2	3	2	-	-	-	-	-	-	1	-
CO3	3	3	-	2	2	-	-	-	-	1	1	-
CO4	2	3	2	-	3	-	2	-	-	-	1	-
CO5	2	-	3	-	2	-	2	-	-	-	1	3

IGNEOUS & METAMORPHIC PETROLOGY			
Learning Objectives			
CO1	To provide fundamental knowledge on the origin, classification, and characteristics of igneous and metamorphic rocks.		
CO2	To enable students to understand the processes involved in magma formation, crystallization, and metamorphism.		
CO3	To develop skills in identifying igneous and metamorphic rocks based on mineralogy, texture, and field relationships.		
CO4	To help students interpret the physicochemical conditions of rock formation such as temperature, pressure, and tectonic environment.		
CO5	To build a strong foundation for advanced studies and research in petrology, economic geology, and tectonic evolution.		
UNIT	Details	No. of Hours	Course Objectives
I	**Igneous Petrology:** definition and scope. Magma: definition, composition and constituents. Field configurations of igneous rocks: intrusive forms and extrusive forms. Assimilation of host rocks by magmas. Bowen's Reaction Series. Mechanism and processes of magmatic differentiation. Classification of igneous rocks based on: mode of occurrence, silica and alumina saturation.	12	CO1
II	Outline of experimental petrology and phase rule. Binary systems: definition, components, application of lever rule. Melting relations and course of crystallization of the Diopside-Anorthosite system – simple eutectic. Albite – Anorthite system – solid solution series. Forsterite – Silica system – incongruent melting. Ternary system: definition, components, and method of plotting. Melting relations and course of crystallization in the Diopside – Anorthite – Albite system.	12	CO2
III	Textures, Structure and microstructures of igneous rocks. Outline of petrography of acid rocks, intermediate rocks, and basic rocks. Descriptive study of lamprophyre, carbonatite, anorthosites, dunite, pyroxenite and kimberlite. A short notes on: consanguinity, kindred, petrographic provinces and periods. Outline of variation diagrams and a short account of Harker's variation diagram.	12	CO3
IV	**Metamorphic Petrology:** Metamorphism- definition and scope. Agents and kinds of metamorphism. Metamorphic zones and grades. Concept of metamorphic facies and its applications. Textures and structures of metamorphic rocks. Outline of	12	CO4

	crystalloblastic series and its applications. Metasomatism and metasomatic processes. Contact or Thermal metamorphism of pelitic sediments and calcareous rocks.		
V	Pneumatolytic and injection metamorphism. Cataclastic metamorphism and its products. Regional metamorphism of argillaceous, calcareous, and impure calcareous rocks and their products. Short notes: retrograde metamorphism, anatexis and palingenesis. Descriptive petrography of the following metamorphic rocks; slate, phyllite, quartzite, schist, gneiss, migmatite, granulite, charnockite, amphibolite, eclogites, hornfels, and marble.	12	CO5

UNIT	Learning Outcomes
I	Understand: Students will be able to explain the origin, composition, and classification of igneous and metamorphic rocks and their petrogenetic processes.
II	Identify: Students will identify different types of igneous and metamorphic rocks based on texture, mineral composition, and field occurrence.
III	Apply: Students will apply petrological concepts to interpret rock formation processes and geological environments.
IV	Analyze: Students will analyze mineral assemblages and textures to understand the conditions of formation such as temperature, pressure, and tectonic setting.
V	Evaluate: Students will evaluate the relationship between igneous and metamorphic processes and their significance in crustal evolution and tectonic history.

Text Books / References Books

1.	Winter, J.D. (2010). Principles of Igneous and Metamorphic Petrology. PHI.New Delhi.
2.	McBirney, A.R. (1993). Igneous Petrology. CBS. New Delhi.
3.	Best,M.G. (2003). Igneous and Metamorphic Petrology. Wiley.New Delhi.
4.	Hyndman,D.W. (1985). Petrology of the Igneous and Metamorphic Rocks. McGraw Hill.
5.	Middlemost,E.A.K. (1985). Magmas and Magmatic Rocks.Longman. UK.
6.	Mason, R. (1988). Petrology of the Metamorphic Rocks. CBS. New Delhi.
7.	Tyrell,G.W. (1958). Principles of Petrology. B.I. Publications. New Delhi.
8.	Haung,W.T. (1962). Petrology. McGraw Hill. New York.
9.	Williams,H. et al. (1982). Petrography. CBS. New Delhi.
10.	Philpotts, A.R. & Ague, J.J., (2022) Principles of Igneous and Metamorphic Petrology, Cambridge University Press, 3rd Edition.

Web Resources

1.	www.webmineral.com
2.	www.mindat.org
3.	www.iucr.org
4.	www.minsocam.org
5.	www.mints.uwc.ac.za

Summary of Course Outcomes (COs):

CO No.	Course Outcome Statement	Bloom's Level	Mapped POs
CO1	Explain the origin, composition, evolution, classification, and field occurrence of igneous rocks, including magma generation, differentiation, and Bowen's reaction series.	Understand (K2)	PO1, PO2, PO4
CO2	Apply principles of experimental petrology, phase equilibria, binary and ternary systems, and phase diagrams to interpret crystallization and melting processes in igneous systems.	Apply (K3)	PO1, PO2, PO3, PO4, PO5
CO3	Analyze textures, microstructures, petrography, and geochemical variations of igneous rocks and evaluate their petrogenetic significance.	Analyze (K4)	PO2, PO3, PO4, PO5
CO4	Examine metamorphic processes, facies, grades, textures, structures, metasomatism, and the role of metamorphic agents in rock transformation.	Analyze (K4)	PO1, PO2, PO4, PO5, PO7
CO5	Evaluate the origin, mineral assemblages, petrography, and geological significance of major metamorphic rocks and metamorphic processes in diverse tectonic environments.	Evaluate (K5)	PO3, PO5, PO7, PO11, PO12

CO–PO Mapping Matrix:

COs \ Pos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	3	-	-	-	-	-	-	1	-
CO2	3	2	3	2	2	-	-	-	-	1	1	-
CO3	2	3	3	2	3	-	-	-	-	1	1	-
CO4	3	3	-	2	2	-	2	-	-	-	1	-
CO5	2	-	3	-	3	-	2	-	-	-	2	3

SEDIMENTARY PETROLOGY & ENERGY GEOLOGY			
Learning Objectives			
CO1	To classify and interpret sedimentary rocks and textures.		
CO2	To understand sedimentary processes and depositional environments.		
CO3	To reconstruct paleogeography using sedimentary structures and facies.		
CO4	To understand origin, occurrence, and exploration of coal, petroleum, natural gas.		
CO5	To evaluate sedimentary basins for hydrocarbon potential.		
UNIT	Details	No. of Hours	Course Objectives
I	**SEDIMENTARY PETROLOGY:** Definition and scope of Sedimentary Petrology. Sedimentary rocks: definition, origin, disintegration and decomposition of rocks. Transportation and deposition of sediments. Outline of compaction, lithification and diagenesis of sediments. Classification of sedimentary rocks:	12	CO1

	Megascopic classification. Textures of sedimentary rocks. Outline of size of sediments, phi scale and grain size parameters.		
II	Structures of sedimentary rocks. Outline of methods to determine the top and base of sedimentary beds. Sedimentary residual deposits: soils, regolith, laterite, and terra rosa. Sedimentary mechanical deposits. Outline of different depositional sedimentary environments and their common sedimentary rocks.	12	CO2
III	Sedimentary deposits of chemical origin: evaporite, siliceous, carbonate, ferruginous, and clay rich deposits. Sedimentary deposits of organic origin: calcareous, phosphatic, iron rich, and silica rich deposits. Petrographic description, classification, and types of: conglomerate, breccia, sandstone, shale and limestones.	12	CO3
IV	**ENERGY GEOLOGY:** Introduction to Energy Geology: Scope, Importance and Applications. Energy Resources – Classification of Renewable and Non-Renewable Resources. Origin, Occurrence, Exploration and Utilization of Fossil Fuels. Coal – Types, Properties, Classification and Distribution in India. Petroleum and Natural Gas – Formation, Migration, Accumulation, Reservoir Rocks, Traps and Exploration Methods. Coal Bed Methane (CBM), Shale Gas and Oil Shale Resources. Energy Resources of India and Tamil Nadu. Environmental Impacts of Fossil Fuel Extraction and Utilization.	12	CO4
V	Renewable Energy Resources – Concepts and Significance. Solar Energy, Wind Energy, Hydroelectric Energy, Geothermal Energy, Biomass Energy and Ocean Energy – Principles, Potential and Applications. Geological Controls on Renewable Energy Development. Geothermal Systems and Exploration Techniques. Energy Resource Assessment and Management. Carbon Capture and Storage (CCS). Sustainable Energy Development and Climate Change. Environmental Issues Related to Energy Production. Future Energy Resources and Energy Security in India.	12	CO5

UNIT	**Learning Outcomes**
I	Students will be able to identify, classify, and describe different types of sedimentary rocks based on their composition, texture, and origin.
II	Students will understand sedimentary processes and interpret depositional environments using sedimentary structures and facies analysis.
III	Students will gain the ability to reconstruct paleogeographic and paleoclimatic conditions from sedimentary records.
IV	Students will acquire knowledge of major energy resources such as coal, petroleum, and natural gas, including their genesis and occurrence.
V	Students will develop skills to evaluate sedimentary basins for energy resource exploration using petrological and geological principles.

Text Books / References Books

1.	Tucker, M. E. & Jones, S. J. (2023) – Sedimentary Petrology (4th Edition) Wiley
2.	Boggs, S. (2011) – Principles of Sedimentology and Stratigraphy Pearson
3.	Nichols, G. (2009) – Sedimentology and Stratigraphy Wiley-Blackwell
4.	Selley, R. C. (1998) – Elements of Petroleum Geology Academic Press
5.	Levorsen, A. I. (1967) – Geology of Petroleum CBS Publishers / W.H. Freeman
6.	Tucker, M.E. Sedimentary Petrology, 4th Ed, Wiley, 2023.

7.	Boggs, S. Principles of Sedimentology and Stratigraphy, 6th Ed, Pearson, 2020.
8.	Bjorlykke, K. Petroleum Geoscience, 3rd Ed, Springer, 2023.
9.	Selley, R.C. Elements of Petroleum Geology, 3rd Ed, Academic Press, 2015.
10.	Tissot, B. P. & Welte, D. H. (1984) – Petroleum Formation and Occurrence Springer-Verlag
Web Resources	
1.	www.onegeology.org
2.	www.geolsoc.org.uk
3.	www.sepm.org
4.	www.sedimentology.org
5.	www.earthobservatory.nasa.gov

Summary of Course Outcomes (COs):

CO No.	Course Outcome Statement	Bloom's Level	Mapped POs
CO1	Explain the origin, classification, textures, structures, transportation, deposition, and diagenetic processes of sedimentary rocks and sediments.	Understand (K2)	PO1, PO2, PO4
CO2	Apply sedimentological principles to interpret depositional environments, sedimentary structures, grain-size parameters, and residual and mechanical sedimentary deposits.	Apply (K3)	PO1, PO2, PO3, PO4, PO5
CO3	Analyze the petrography, classification, origin, and economic significance of major sedimentary rocks and chemical and organic sedimentary deposits.	Analyze (K4)	PO2, PO3, PO4, PO5, PO12
CO4	Examine the origin, occurrence, exploration, utilization, and environmental impacts of fossil fuel resources including coal, petroleum, natural gas, CBM, shale gas, and oil shale.	Analyze (K4)	PO1, PO3, PO5, PO7, PO12
CO5	Evaluate renewable energy resources, geothermal systems, energy management strategies, carbon capture technologies, and sustainable energy development in the context of climate change and energy security.	Evaluate (K5)	PO3, PO5, PO7, PO10, PO11, PO12

CO–PO Mapping Matrix:

COs \ Pos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	--	3	--	--	--	--	--	--	1	--
CO2	3	2	3	2	2	--	--	--	--	--	1	--
CO3	2	3	3	2	3	--	--	--	--	--	1	2
CO4	3	--	3	--	2	--	3	--	--	--	1	3
CO5	--	2	3	--	3	--	3	--	--	2	2	3

HYDROGEOLOGY & ENGINEERING GEOLOGY			
Learning Objectives			
CO1	To understand the occurrence, movement, distribution, and properties of groundwater in different geological formations.		
CO2	To develop knowledge of aquifers, groundwater recharge, groundwater exploration, and water resource management techniques.		
CO3	To study the geological factors influencing engineering structures such as dams, tunnels, roads, and foundations.		
CO4	To provide an understanding of rock mechanics, soil properties, geological hazards, and site investigation methods relevant to engineering projects.		
CO5	To integrate hydrogeological and engineering geological principles for solving problems related to groundwater development, construction, and environmental management.		
UNIT	Details	No. of Hours	Course Objectives
I	Definition and scope of Hydrogeology. Concise account of the hydrologic and hydrogeological cycle. Origin and sources of groundwater: meteoric water, connate water and juvenile water. Vertical distribution of groundwater and subsurface movement of groundwater. Rock properties affecting groundwater occurrence: porosity – primary and secondary, factors controlling porosity. Groundwater occurrence in igneous, sedimentary and metamorphic rocks.	12	CO1
II	Specific yield and specific retention. Darcy's Law and its limitations. Laminar and turbulent flow. Permeability and permeameters. Coefficient of permeability. Water springs and their types. Hydraulic conductivity vs. intrinsic permeability; Reynolds number and its relevance to groundwater flow regimes.	12	CO2
III	Aquifers: definition and types – unconfined, confined, leaky and perched aquifers. Confining layers: aquitard, aquifuge and aquiclude. Isotropic, anisotropic and layered aquifers. Aquifer properties: transmissivity, storativity and compressibility. Artesian wells. Types of wells and drilling methods. Theis equation and Cooper-Jacob method for pumping test analysis; concept of safe yield and sustainable groundwater development.	12	CO3
IV	Engineering Geology: Definition, scope and importance of Engineering Geology. Role of geology in civil engineering projects. Dams and Reservoirs – classification, geological requirements and site selection. Types of dams – gravity, arch, buttress and earth dams. Reservoirs – capacity, storage and geological considerations. Tunnels – classification, alignment, excavation methods and geological problems in tunneling. Engineering properties of rocks – porosity, permeability, elasticity, compressive strength, durability and weathering characteristics.	12	CO4
V	Foundations – definition, classification and functions. Types of foundations – shallow and deep foundations. Site investigation methods – geological mapping, borehole logging, geophysical surveys and subsurface exploration. Slope stability and landslides in engineering projects. Groundwater conditions in foundation	12	CO5

	engineering. Rainwater harvesting structures – principles, types, design considerations and groundwater recharge.		

UNIT	Learning Outcomes
I	Students will be able to understand the occurrence, movement, and storage of groundwater in various geological formations.
II	Students will acquire skills in identifying aquifers, groundwater exploration methods, and groundwater resource evaluation.
III	Students will be able to apply hydrogeological principles for groundwater management and sustainable utilization of water resources.
IV	Students will gain knowledge of engineering geological investigations for the construction of dams, tunnels, roads, and other civil engineering structures.
V	Students will develop the ability to assess geological hazards, rock and soil conditions, and their impact on engineering and environmental projects.

Text Books / References Books	
1.	Todd, D. K. & Mays, L. W. (2005) – Groundwater Hydrology Wiley India
2.	Karanth, K. R. (2012) – Groundwater Assessment, Development and Management Tata McGraw Hill
3.	Raghunath, H. M. (2011) – Ground Water New Age International Publishers
4.	Parbin Singh (2018) – Engineering and General Geology S. K. Kataria & Sons
5.	Bell, F. G. (2007) – Engineering Geology Butterworth-Heinemann
6.	Davis, S. N. & De Wiest, R. J. M. (1966) – Hydrogeology Wiley
7.	Freeze, R. A. & Cherry, J. A. (1979) – Groundwater Prentice Hall
8.	Fetter, C. W. (2001) – Applied Hydrogeology Prentice Hall
9.	Todd, D. K. (1980) – Groundwater Hydrology John Wiley & Sons
10.	Krynine, D. P. & Judd, W. R. (2005) – Principles of Engineering Geology and Geotechnics CBS Publishers
Web Resources	
1.	www.asce.org
2.	www.isrm.net
3.	www.issmge.org
4.	www.icevirtuallibrary.com
5.	www.earthdata.nasa.gov

Summary of Course Outcomes (COs):

CO No.	Course Outcome Statement	Bloom's Level	Mapped POs
CO1	Explain the principles of hydrogeology, hydrologic cycle, groundwater occurrence, groundwater movement, aquifer systems, and factors controlling groundwater storage and flow.	Understand (K2)	PO1, PO2, PO4
CO2	Apply hydrogeological concepts such as Darcy's law, permeability, hydraulic conductivity, aquifer parameters, pumping test analysis, and groundwater resource assessment.	Apply (K3)	PO1, PO2, PO3, PO4, PO5
CO3	Analyze groundwater occurrence, aquifer behavior, well hydraulics, sustainable groundwater development, and groundwater recharge mechanisms.	Analyze (K4)	PO2, PO3, PO5, PO7
CO4	Examine geological factors influencing engineering structures such as dams, reservoirs, tunnels, bridges, highways, canals, and foundations.	Analyze (K4)	PO1, PO3, PO4, PO5, PO12

CO5	Evaluate engineering geological conditions, slope stability, site investigation techniques, groundwater-related engineering problems, and rainwater harvesting for sustainable resource management.	Evaluate (K5)	PO3, PO5, PO7, PO10, PO11, PO12

CO–PO Mapping Matrix:

COs \ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	--	3	--	--	--	--	--	--	1	--
CO2	3	2	3	2	2	--	--	--	--	--	1	--
CO3	2	3	3	--	3	--	3	--	--	--	1	--
CO4	3	0	3	2	2	--	--	--	--	--	1	3
CO5	--	2	3	--	3	--	3	--	--	2	2	3

EXPLORATION GEOLOGY			
Learning Objectives			
CO1	To understand the basic principles and methods of mineral exploration.		
CO2	To study the application of geology, geophysics, and geochemistry in locating mineral deposits		
CO3	To gain knowledge about different types of economic mineral deposits.		
CO4	To develop skills in geological mapping, sampling, and field data collection.		
CO5	To learn the use of exploration instruments and interpretation of exploration data.		
UNIT	Details	No. of Hours	Course Objectives
I	Geological methods: Guides to ore deposits: Mineralogic, lithologic, structural, stratigraphic, and physiographic. Controls of ore localization. Sampling of ores and minerals: definition and types of samples. Outline of sampling methodology. Geochemical classification of elements. Short account on geochemical cycles and elemental mobility. Outline of composition of the crust, mantle, and core.	12	CO1
II	Exploration Geochemistry: Outline of elemental abundance in different earth materials. Geochemical classification of elements. Fundamental Concepts: background values, threshold values, geochemical anomaly and geochemical province. Geochemical cycle. Dispersion of elements: Primary and Secondary. Controls of dispersion: Utility of path finder elements and minerals in ore and mineral exploration. Short account on geo-botanical prospecting.	12	CO2
III	Gravity Method: Definition of gravity. Newton's Law of Gravitation. Gravity field of the earth – surface gravity variation – size and shape of earth – geoidal and spheroidal surface. Gravity measurements: Absolute and relative. Gravity units. Gravimeters: Gravity Surveys. Applications and limitations of gravity methods. Magnetic Methods: Earth's magnetic field and its components – origin and units of measurement. Types of magnetism observed in rocks and minerals. Outline of normal and reversed magnetic	12	CO3

	fields. Magnetometers: Types. Magnetic surveys. Applications and limitations of magnetic methods.		
IV	Electrical Methods: Definition – Ohm's Law – true resistivity – apparent resistivity and conductivity – types of electrical conduction – Electrical properties of rocks and minerals - Units of measurement. Resistivity surveying equipment. Current paths in the subsurface: two and three layers. Electrode configurations: Wenner – Schlumberger. Applications and limitations of resistivity methods. Outline of Induced polarization and Self Potential methods.	12	CO4
V	Seismic Methods: General principles. Methods of generating artificial seismic waves. Geophones – types and their limitations. Recording equipment. Refraction Methods: Principle – Instruments and equipment – Field Methods: Fan, Arc, and Profile shooting. Reflection Methods: Principle – Instruments and equipment – Field Operations: Shot point and Detector spreads. Applications and limitations.	12	CO5

UNIT	**Learning Outcomes**
I	Explain the geological, geochemical, and sampling principles used in mineral and ore deposit exploration.
II	Apply exploration geochemical techniques to identify and evaluate mineralized zones and geochemical anomalies.
III	Analyze gravity and magnetic geophysical data for subsurface investigation and mineral exploration.
IV	Interpret electrical geophysical survey results for groundwater, engineering, and mineral exploration studies.
V	Evaluate seismic exploration methods and their applications in subsurface geological investigations.

Text Books / References Books

1.	Banerjee, P.K, (1997). Elements of Prospecting for Non-Fuel Mineral Deposits.
2.	Hawkes, H.E. (1959). Principles of Geochemical Prospecting. Bulletin 1000F.USGS.
3.	Moon, C.J et al.(2006). Introduction to Mineral Exploration. Wiley Blackwell. New Delhi.
4.	Kearey, P, et al.(2002). An Introduction to Geophysical Exploration. Wiley. Delhi.
5.	Mussett,A.E.& Khan,M.A.(2000). Looking into the Earth. CUP. Delhi.
6.	Arogyaswamy, R.N.P. (1980). Courses in Mining Geology. Oxford & IBH, New Delhi.
7.	Sharma, P.V. (2005). Environmental and Engineering Geophysics. CUP. Delhi.
8.	Ramachandra Rao,M.B.(1993).Outlines of Geophysical Prospecting. EBD. Dhanbad.
9.	Alan M. Bateman, 3rd Edition, 1981 Economic Mineral Deposits
10.	Moon, C.J., Whateley, M.K.G. & Evans, A.M., 2006. Introduction to Mineral Exploration

Web Resources

1.	www.spgindia.org
2.	www.aseg.org.au
3.	www.geolsoc.org.uk
4.	www.geochemistry.org
5.	www.smenet.org

Summary of Course Outcomes (COs):

CO No.	Course Outcome Statement	Bloom's Level	Mapped POs
CO1	Explain the principles of ore deposit exploration, geological guides, sampling methods, geochemical cycles, and elemental distribution within the Earth.	Understand (K2)	PO1, PO2, PO4
CO2	Apply geochemical exploration techniques, geochemical surveys, dispersion studies, and analytical methods for mineral prospecting.	Apply (K3)	PO1, PO2, PO3, PO4, PO5
CO3	Analyze gravity and magnetic methods, instrumentation, survey procedures, and interpretation techniques used in geophysical exploration.	Analyze (K4)	PO2, PO3, PO4, PO5
CO4	Examine electrical geophysical methods including resistivity, induced polarization, and self-potential techniques for subsurface investigations.	Analyze (K4)	PO3, PO4, PO5, PO10
CO5	Evaluate seismic exploration methods and integrate geological, geochemical, and geophysical data for resource exploration and subsurface characterization.	Evaluate (K5)	PO3, PO5, PO10, PO11, PO12

CO–PO Mapping Matrix:

COs \ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	--	3	--	--	--	--	--	--	1	--
CO2	3	2	3	2	3	--	--	--	--	1	1	--
CO3	2	3	3	3	2	--	--	--	--	1	1	--
CO4	--	2	3	3	2	--	--	--	--	3	1	--
CO5	--	--	3	--	3	--	--	--	--	3	2	3

SEMESTER-VI

STRATIGRAPHY & INDIAN GEOLOGY			
Learning Objectives			
CO1	Understand the basic of Historical Geology		
CO2	Know the Important group of Stratigraphic systems		
CO3	Know various economic importance of various periods		
CO4	Understand the various rocks of different periods from the formation of Earth		
CO5	Present is the Key to the Past – Critical Analyse		
UNIT	Details	No. of Hours	Course Objectives
I	General Stratigraphy: Principles of Stratigraphy - Time units - Time rock units - Standard Geological Time scale. Indian Stratigraphy: Archaean: Dharwar Supergroup - Champian Gneiss - Peninsular Gneiss - closepet Granite - Sakoli Series - Saucer Series - Banded gneissic complex - Aravalli Supergroup - Raiolo Series - Singhbhum Iron ore Series - Singhbhum copper belt shear zone - Newer Dolerite - Mineral riches of Archaean.	12	CO1
II	Proterozoic: Cuddapah Supergroup - Kaladgi series - Delhi Supergroup - Erinpura Granite - Malani Igneous suite - Hazara slates - Mineral riches of Cuddapah - Vindyan Supergroup - Kurnool Supergroup - Bhima Series - Mineral riches of Vindhyan.	12	CO2
III	Palaeozoic: Cambrian of Salt range - Age of Saline series - Haimanta System - Muth Quartzites - Kanawar System - Fenestella Shales - Kuling System - Panjal Volcanic Series. Gondwana Supergroup - Climate and Sedimentation – Classification – Lithology - Fossil contents - Distribution of Coal Deposits.	12	CO3
IV	Mesozoic: Triassic of Spiti - Succession and fossil contents Jurassic of Kutch - Succession and fossil content - Cretaceous of Tiruchirapalli and Bagh beds. Cenozoic: Deccan traps – Age – Distribution – Petrology - Lameta beds - Infratrappean and Intertrappean beds.	12	CO4
V	Tertiary of Assam and Tamil Nadu Siwalik Supergroup - Varkala and Quilon beds of Kerala - Tertiary of Cambay a Karewa formation - Rise of Himalayas - Pleistocene Glaciation - Indo-Gangetic alluvium - Laterite.	12	CO5
UNIT	**Learning Outcomes**		
I	Understand the basic of Historical Geology		
II	Know the Important group of Stratigraphic systems		
III	Know various economic importance of various periods		
IV	Understand the various rocks of different periods from the formation of Earth		
V	Present is the Key to the Past – Critical Analyse		
Text Books / References Books			
1.	Wadia, D.N. (1975), Geology of India, Tata McGraw-Hill Publishing Company, New Delhi.		
2.	Krishnan, M.S. (1982), Geology of India and Burma, CBS Publishers & Distributors, New Delhi.		

3.	Ravindra Kumar (2014), Fundamentals of Historical Geology and Stratigraphy of India, New Age International Publishers, New Delhi.
4.	Valdiya, K.S. (2016), The Making of India: Geodynamic Evolution, Springer India, New Delhi.
5.	Pascoe, E.H. (1964), A Manual of the Geology of India and Burma (Vols. I–III), Geological Survey of India, Kolkata.
6.	Jain, P.C. & Anantharaman, M.S. (2009), Geology of India, Scientific Publishers, Jodhpur.
7.	Mathur, S.M. (2010), Elements of Geology of India, Scientific Publishers, Jodhpur.
8.	Mukherjee, P.K. (2011), A Textbook of Geology, World Press Pvt. Ltd., Kolkata.
9.	Levin, H.L. (2013), The Earth Through Time (10th Edition), Wiley.
10.	Stanley, S.M. (2014), Earth System History (4th Edition), W.H. Freeman and Company.
Web Resources	
1.	https://stratigraphy.org/
2.	https://www.sepm.org/
3.	https://www.geosocindia.org/
4.	https://www.moes.gov.in/
5.	https://isegindia.org/

Summary of Course Outcomes (COs):

CO No.	Course Outcome Statement	Bloom's Level	Mapped POs
CO1	Explain the fundamental principles of stratigraphy, geological time scale, stratigraphic units, and the evolution of the Archaean formations of India.	Understand (K2)	PO1, PO2, PO4
CO2	Describe the lithology, stratigraphic succession, mineral resources, and geological significance of the Proterozoic formations of India.	Understand (K2)	PO1, PO2, PO4, PO7
CO3	Analyze the stratigraphy, fossil assemblages, depositional environments, and economic importance of Palaeozoic and Gondwana sequences.	Analyze (K4)	PO2, PO3, PO4, PO5
CO4	Examine the stratigraphic succession, palaeontology, volcanism, and sedimentary records of Mesozoic and early Cenozoic formations of India.	Analyze (K4)	PO1, PO3, PO4, PO5
CO5	Evaluate the geological evolution of Tertiary and Quaternary formations, Himalayan uplift, glaciation, alluvial deposits, and lateritization processes in India.	Evaluate (K5)	PO3, PO5, PO7, PO11, PO12

CO–PO Mapping Matrix:

COs \ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	-	3	-	-	-	-	-	-	1	-
CO2	3	2	-	2	-	-	2	-	-	-	1	-
CO3	2	3	3	2	3	-	-	-	-	-	1	-
CO4	3	2	3	2	2	-	-	-	-	-	1	-
CO5	-	2	3	-	3	-	2	-	-	-	2	3

ECONOMIC GEOLOGY & REGIONAL GEOLOGY			
Learning Objectives			
CO1	Understand basics of Economic minerals		
CO2	Know the various process of mineral formation		
CO3	Know the various mode of mineral deposits		
CO4	Know the physical and chemical characters of minerals		
CO5	To understand various uses of minerals		
UNIT	Details	No. of Hours	Course Objectives
I	**Economic Geology:** Definition of ore, tenor, grade and metallic and non-metallic minerals. Geologic thermometry - Classification of ore deposits, Lindgren and Bateman. Process of mineral formations - magmatic concentration - sublimation, contact metasomatism - Hydrothermal process – sedimentation - evaporation.	12	CO1
II	Processes of mineral formation: Residual and mechanical concentration - Oxidation and supergene sulphide enrichment - metamorphism. Coal deposits: Use, origin, Mode of Occurrence, distribution in India. Petroleum deposits: Origin and distribution in India.	12	CO2
III	Mineralogy, origin, mode of occurrence, uses and distribution in India of the following: Gold Deposits, Iron deposits, and copper deposits. Mineralogy, origin, mode of occurrence, uses and distribution in India of the following: - manganese deposits, lead and zinc deposits, bauxite deposits and chromite deposits.	12	CO3
IV	**Regional Geology:** Mode of occurrence, uses, origin, and distribution in Tamil Nadu of the followings deposit- Cuddalore Sandstone, Neyveli Lignite Deposits - Mode of occurrence & distribution of precious and Semi - precious stones in Tamil Nadu. Distribution of commercial granites, Heavy mineral sands and Thorium deposits of Manavalakurichi in Tamil Nadu.	12	CO4
V	Mode of occurrence, uses, origin, and distribution in Tamil Nadu of the followings mineral deposit: Iron ores of Kanjamalai, Gauthimalai; Magnesite deposits of Chalk hills; Bauxite deposits of Shaveroy hill; Sittampundi Anorthosite Complex (SAC), Graphite beds of Sivaganga- Silica Sands of coastal areas in Kanchipuram, Thiruvallur, Cuddalore and Nagapattinam districts- River sand deposits of Tamil Nadu.	12	CO5
UNIT	**Learning Outcomes**		
I	Understand the basics of Minerals		
II	Understand the importance of Minerals in Geological studies		
III	Know different group of minerals systems		
IV	Understand the descriptive mineralogy of different groups		
V	Understand the importance of Minerals and mineralogical studies		
Text Books / References Books			
1.	Bateman, A.M. (1950), Economic Mineral Deposits, John Wiley & Sons, New York.		
2.	Lindgren, W. (1933), Mineral Deposits, McGraw-Hill Book Company, New York.		

3.	Edwards, R. and Atkinson, K. (1986), Ore Deposit Geology and Its Influence on Mineral Exploration, Chapman and Hall, London.
4.	Evans, A.M. (2013), Ore Geology and Industrial Minerals: An Introduction (4th Edition), Wiley-Blackwell.
5.	Jensen, M.L. and Bateman, A.M. (1981), Economic Mineral Deposits (3rd Edition), John Wiley & Sons, New York.
6.	Krishnaswamy, S. (2009), India's Mineral Resources, Oxford & IBH Publishing Co., New Delhi.
7.	Arogyaswamy, R.N.P. (1996), Courses in Mining Geology, Oxford & IBH Publishing Co., New Delhi.
8.	Mukherjee, P.K. (2011), A Textbook of Geology, World Press Pvt. Ltd., Kolkata.
9.	Guilbert, J.M. and Park, C.F. Jr. (2007), The Geology of Ore Deposits, Waveland Press Inc., Illinois.
10.	Robb, L. (2020), Introduction to Ore-Forming Processes (2nd Edition), Wiley-Blackwell.
Web Resources	
1.	https://www.britannica.com/topic/economic-geology
2.	https://en.m.wikipedia.org/wiki/
3.	https://energymining.sa.gov.au/minerals/
4.	https://www.slideshare.net/
5.	https://link.spring.com/

Summary of Course Outcomes (COs):

CO No.	Course Outcome Statement	Bloom's Level	Mapped POs
CO1	Explain the fundamental concepts of economic geology, ore-forming processes, classification of ore deposits, and mechanisms of mineral formation.	Understand (K2)	PO1, PO2, PO4
CO2	Describe the origin, occurrence, distribution, and economic significance of coal, petroleum, and major ore-forming processes.	Understand (K2)	PO1, PO2, PO3, PO7
CO3	Analyze the mineralogy, genesis, occurrence, utilization, and distribution of major metallic mineral deposits in India.	Analyze (K4)	PO2, PO3, PO4, PO5, PO12
CO4	Examine the geological occurrence, economic importance, and regional distribution of industrial minerals, gemstones, heavy mineral sands, and lignite deposits of Tamil Nadu.	Analyze (K4)	PO1, PO3, PO5, PO7, PO12
CO5	Evaluate the geological and economic significance of important mineral deposits of Tamil Nadu and their role in sustainable mineral resource development.	Evaluate (K5)	PO3, PO5, PO7, PO11, PO12

CO–PO Mapping Matrix:

COs \ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	-	3	-	-	-	-	-	-	1	-
CO2	3	2	2	-	-	-	2	-	-	-	1	-
CO3	2	3	3	2	3	-	-	-	-	-	1	3

CO4	3	-	3	-	2	-	3	-	-	-	1	3
CO5	-	2	3	-	3	-	3	-	-	-	2	3

MINING GEOLOGY & ENVIRONMENTAL GEOLOGY			
Learning Objectives			
CO1	To understand the basic principles of mining geology and its role in mineral extraction and resource development.		
CO2	To study different mining methods, ore reserve estimation, and geological controls of mineral deposits.		
CO3	To gain knowledge about the impact of mining activities on land, water, air, and ecosystems.		
CO4	To learn environmental management practices, including mine reclamation and sustainable mining techniques.		
CO5	To develop skills in assessing environmental hazards and applying mitigation measures in mining areas.		
UNIT	Details	No. of Hours	Course Objectives
I	**Mining Geology:** Definition and scope of mining geology. Methods of breaking overburden and rocks: manual methods, mechanical methods and utility of explosives in mining. Sampling of mined materials: channel, grab, chip and bulk sampling. Sizing, pulverization and coning and quartering of samples. Drilling: definition and purpose. Drilling methods: rotary, percussion and diamond Auger drilling. Borehole geophysical logging: gamma-ray, resistivity and SP logs for subsurface lithology correlation. Geological logging of borehole samples. Core samples and their preservation.	12	CO1
II	Opencast mining methods: Parts of an opencast mine: overburden, surface adit, bench, slope, drop-cut, over-break. Opencast mining equipment: bulldozer, frontend loader, poclain, dragline with bucket and wheel excavators. Strip mining and surface augering of coal bed sands and seams. Quarrying method for hard rocks. Glory hole mining. A short note on explosive methods of breaking rocks. Environmental impact of opencast mining: land degradation, acid mine drainage and reclamation strategies.	12	CO2
III	Alluvial mining of unconsolidated sediments and soft rocks. Hydraulic method - panning and sluicing of sediments. Dredging of offshore unconsolidated sediments. Placer mineral concentration: hydrodynamic controls on heavy mineral enrichment; economic placer deposits of India including beach sand minerals of Tamil Nadu coast. Subsurface and underground mining methods: Components of an underground mine: adit, shaft, level, cross cut, drift, tunnel, winze, raise, stope, foot-wall and hanging wall. Mine stoping methods: open stope, level stoping, supported stopes, square set stopes, pillar supported stopes and shrinkage stopes.	12	CO3
IV	**Environmental Geology:** Definition and scope of environmental geology. Classification and types of natural resources. Renewable and nonrenewable resources. Impact of man on the environment.	12	CO4

	Groundwater pollution: definition, types and remedial measures. Geological factors in environmental health. Trace elements and human health. Chronic disease and geological environment.		
V	Energy resources: definition, types, renewable and non-renewable energy resources. Environmental impact due to mining and mineral processing and its remediation. Coastal environments: definition, pollution in coastal areas, prevention of erosion along coasts. Types of human generated waste and outline of methods of disposal. Outline of Environmental law in India.	12	CO5

UNIT	**Learning Outcomes**
I	Understand the fundamental concepts of mining geology and the geological factors controlling ore formation and extraction.
II	Apply different mining methods and techniques for efficient mineral resource exploitation.
III	Evaluate ore reserves and interpret geological data for mining planning and development.
IV	Assess environmental impacts of mining activities on land, water, air, and ecosystems.
V	Propose suitable mitigation measures and sustainable practices for environmental protection and mine rehabilitation.

Text Books / References Books	
1.	McKinstry, H.E. (1980), Mining Geology.
2.	Arogyaswamy, R.P.N. (1999), Courses in Mining Geology (3rd Edition).
3.	Hartman, H.L. (1987), Introductory Mining Engineering (2nd Edition).
4.	Keller, E.A. (2011), Environmental Geology (10th Edition).
5.	Keller, E.A. (2007), Introduction to Environmental Geology (5th Edition).
6.	Howard, A.D. (1999), Geology and the Environment.
7.	Dhar, B.B. (2005), Mining and Environment.
8.	Montgomery, C.W. (2016), Environmental Geology (8th Edition).
9.	Murthy, P.S.N. (2024), Methods of Mining Geology and Estimation of Ore Reserves.
10.	Saxena, N.C., Singh, G. & Ghosh, R. (2021), Environmental Management in Mining Areas.

Web Resources	
1.	www.nmdc.co.in
2.	www.hindustancopper.com
3.	www.coalindia.in
4.	www.sail.co.in
5.	www.moefcc.gov.in

Summary of Course Outcomes (COs):

CO No.	Course Outcome Statement	Bloom's Level	Mapped POs
CO1	Explain the principles of mining geology, drilling methods, sampling techniques, borehole logging, and geological investigation of mineral deposits.	Understand (K2)	PO1, PO2, PO4
CO2	Apply knowledge of opencast and underground mining methods, mining equipment, quarrying techniques, and mineral extraction practices.	Apply (K3)	PO1, PO2, PO3, PO4, PO12

CO3	Analyze placer, alluvial, offshore, and subsurface mining operations and evaluate their geological and economic significance.	Analyze (K4)	PO2, PO3, PO4, PO5, PO12
CO4	Examine environmental geological processes, natural resources, groundwater pollution, environmental health issues, and geological factors affecting human well-being.	Analyze (K4)	PO1, PO3, PO5, PO7, PO8
CO5	Evaluate environmental impacts of mining, energy resource utilization, waste management, coastal protection measures, and environmental legislation for sustainable development.	Evaluate (K5)	PO3, PO5, PO7, PO8, PO11, PO12

CO–PO Mapping Matrix:

COs \ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	--	3	--	--	--	--	--	--	1	--
CO2	3	2	3	2	--	--	--	--	--	--	1	3
CO3	2	3	3	2	3	--	--	--	--	--	1	2
CO4	3	--	3	--	2	--	3	2	--	--	1	--
CO5	--	2	3	--	3	--	3	3	--	--	2	3

MINERALOGY AND PETROLOGY PRACTICAL			
Learning Objectives			
CO1	Understand the basic Petrology		
CO2	Know the macro and micro-structures		
CO3	Know various agents of sedimentary and metamorphic petrology		
CO4	Understand the Petrographically characters of rocks		
CO5	Analyse Origin of various rock types		
UNIT	Details	No. of Hours	Course Objectives
I	Megascopic identification and description of the following: quartz, chalcedony, opal, agate, flint, jasper, amethyst, rose quartz, orthoclase, microcline, albite, oligoclase, labradorite, adularia, sanidine, nepheline, sodalite, lapislazuli, hornblende, Actinolite, tremolite, enstatite, bronzite, hypersthene, augite, olivine, serpentine, muscovite, biotite, phlogopite, lepidolite, vermiculite, chlorite, epidote, garnet, apophyllite, talc, steatite, beryl, kaolin, cordierite, apatite, andalusite, sillimanite, kyanite, tourmaline, topaz, calcite, dolomite and fluorspar.	12	CO1
II	Microscopic identification and description of the following: quartz, orthoclase, albite, oligoclase, andesine, labradorite, anorthite, nepheline, leucite, sodalite, hypersthene, augite, diopside,hornblende, tremolite, actinolite, glaucophane, riebeckite, muscovite, biotite, phlogopite, olivine, serpentine, chlorite, epidote, garnet, apatite, zircon, sphene, magnetite, tourmaline, calcite, dolomite, andalusite, staurolite, sillimanite and cordierite.	12	CO2
III	Megascopic identification and description of the following rocks: granite, graphic granite, pegmatite, aplite, orbicular granite, schorl	12	CO3

	rock, tourmaline rock, granite porphyry, Syenite, dolerite, gabbro, anorthosite, olivine, gabbro, dunite, pyroxenite, norite, dolerite porphyry, basalt, trachyte, rhyolite, obsidian, pumice, scoria, pitchstone, volcanic tuff and volcanic breccia.		
IV	Megascopic identification and description of the following: conglomerate, breccia, laterite, sandstone, arkose, greywacke, grit, shales, limestones, chert, flint, peat, bituminous coal, anthracite, lignite, chalk, gneisses, schist, phyllite, slates, quartzite, marble, ophicalcite, quartz-magnetite rock, amphibolite, eclogite, leptynite, khondalite, kodurite, gondite, charnockite, calc granulite and basic granulite.	12	CO4
V	Microscopic identification and description of the following: mica granite, hornblende granite, tourmaline granite, schorl rock, aplite, graphic granite, quartz syenite, mica syenite, hornblende syenite, nepheline syenite, diorite, olivine, gabbro, hypersthene gabbro, dunite, peridotite granite porphyry; syenite porphyry, diorite porphyry, quartz porphyry, dolerite, anorthosite, rhyolite, trachyte, andesite, basalt, leucite and phonolite.	12	CO5
UNIT	**Learning Outcomes**		
I	Understand the basic Petrology		
II	Know the macro and micro-structures		
III	Know various agents of sedimentary and metamorphic petrology		
IV	Understand the Petrographically characters of rocks		
V	Analyse Origin of various rock types		
	Text Books / References Books		
1.	Kerr, P.F. (1977). Optical Mineralogy (4th Edition). McGraw-Hill Book Company, New York.		
2.	Perkins, D. (2011). Mineralogy (3rd Edition). Pearson Education, New Delhi.		
3.	Nesse, W.D. (2012). Introduction to Mineralogy (2nd Edition). Oxford University Press.		
4.	Mackenzie, W.S., Donaldson, C.H. & Guilford, C. (1982). Atlas of Igneous Rocks and Their Textures. Longman Group Ltd., London.		
5.	Mackenzie, W.S. & Adams, A.E. (1994). A Colour Atlas of Rocks and Minerals in Thin Section. Manson Publishing Ltd., London.		
6.	Dana, E.S. & Ford, W.E. (2002). Dana's Textbook of Mineralogy (4th Edition). CBS Publishers & Distributors, New Delhi.		
7.	Deer, W.A., Howie, R.A. & Zussman, J. (2013). An Introduction to the Rock-Forming Minerals (3rd Edition). Mineralogical Society, London.		
8.	Phillips, F.C. & Griffen, D.T. (1981). Optical Mineralogy: The Non-Opaque Minerals. W.H. Freeman & Company.		
9.	Shelley, D. (1993). Igneous and Metamorphic Rocks under the Microscope: Classification, Textures and Microstructures. Chapman & Hall.		
10.	Yardley, B.W.D. (1989). An Introduction to Metamorphic Petrology. Longman Scientific & Technical.		
	Web Resources		
1.	www.minsocam.org (Mineralogical Society of America)		
2.	www.mindat.org (Mindat Mineral Database)		
3.	www.usgs.gov (United States Geological Survey)		
4.	www.bgs.ac.uk (British Geological Survey)		

5.	www.geosocindia.org (Geological Society of India)

Summary of Course Outcomes (COs):

CO No.	Course Outcome Statement	Bloom's Level	Mapped POs
CO1	Identify and describe common rock-forming, accessory, ore, and industrial minerals in hand specimens using their physical properties and diagnostic characteristics.	Apply (K3)	PO1, PO2, PO4, PO5
CO2	Examine and distinguish minerals under the polarizing microscope using optical properties and mineral associations.	Analyze (K4)	PO1, PO2, PO4, PO5
CO3	Classify and characterize igneous, sedimentary, and metamorphic rocks in hand specimens based on texture, structure, and mineral composition.	Analyze (K4)	PO1, PO2, PO4, PO5
CO4	Interpret petrographic features of rocks in thin sections and evaluate mineralogical and textural relationships for rock classification.	Evaluate (K5)	PO1, PO2, PO3, PO4, PO5
CO5	Integrate megascopic and microscopic observations to prepare systematic mineralogical and petrographic descriptions of rocks and minerals.	Create (K6)	PO1, PO2, PO3, PO4, PO5, PO10

CO–PO Mapping Matrix:

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1 (K3)	3	2	-	3	2	-	-	-	-	-	-	1
CO2 (K4)	3	3	-	3	2	-	-	-	-	-	-	1
CO3 (K4)	3	3	2	3	2	-	-	-	-	-	-	1
CO4 (K5)	3	3	3	3	2	-	-	-	-	1	-	1
CO5 (K6)	3	3	3	3	2	-	-	-	-	3	-	2

ECONOMIC GEOLOGY AND ORE ANALYSIS PRACTICAL			
Learning Objectives			
CO1	Understand the basics of Minerals		
CO2	Understand the importance of Minerals in Geological studies		
CO3	Know different group of minerals systems		
CO4	Understand the descriptive mineralogy of different groups		
CO5	Understand the importance of Minerals and mineralogical studies		
UNIT	Details	No. of Hours	Course Objectives
I	Megascopic identification, description of visible characteristics, mode of occurrence and uses of the following ores: galena, anglesite, cerrusite, sphalerite, zincite, willemite, bornite, azurite, chalcopyrite, cuprite, malachite.	12	CO1
II	Megascopic identification, description of visible characteristics, mode of occurrence and uses of the following ores: haematite, magnetite, siderite, goethite, pyrolusite, psilomelane,	12	CO2

	rhodochrosite, rhodonite, chromite, cinnabar, bauxite, realgar, orpiment, stibnite, molybdenite, pyrite, coal and its varieties.		
III	Megascopic identification and description of: monazite, samarskite, columbite, tantalite, beryl, zircon, Megascopic identification and description of the following minerals used for industrial purposes – magnesite, calcite, dolomite, gypsum, strontianite, celestite, fluorite, apatite.	12	CO3
IV	Megascopic identification and description of the following minerals used for industrial purposes: barite, witherite, limonite, asbestos, quartz, feldspar, kaolin, garnet, rutile and ilmenite.	12	CO4
V	Identification of the following mineral powders by blowpipe methods: galena, chalcopyrite, haematite, magnetite, celestite, strontianite, witherite, gypsum, bauxite, apatite, pyrite, siderite, orpiment, realgar, calcite, psilomelane, rhodochrosite, smithsonite and ilmenite.	12	CO5

UNIT	**Learning Outcomes**
I	Understand the basics of Minerals
II	Understand the importance of Minerals in Geological studies
III	Know different group of minerals systems
IV	Understand the descriptive mineralogy of different groups
V	Understand the importance of Minerals and mineralogical studies

Text Books / References Books

1.	Bateman, A.M. & Jensen, M.L. (1981). Economic Mineral Deposits (3rd Edition). John Wiley & Sons, New York.
2.	Evans, A.M. (2013). Ore Geology and Industrial Minerals: An Introduction (4th Edition). Wiley-Blackwell, Oxford.
3.	Jensen, M.L. & Bateman, A.M. (1981). Economic Mineral Deposits. John Wiley & Sons, New York.
4.	Krishnaswamy, S. (2009). India's Mineral Resources. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
5.	Arogyaswamy, R.N.P. (1996). Courses in Mining Geology (4th Edition). Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
6.	Lindgren, W. (2009 Reprint). Mineral Deposits. CBS Publishers & Distributors, New Delhi.
7.	Mukherjee, A. (2011). Elements of Economic Geology. World Press Pvt. Ltd., Kolkata.
8.	Edwards, A.B. (1954). Textures of Ore Minerals and Their Significance. Australasian Institute of Mining and Metallurgy.
9.	Park, C.F. & MacDiarmid, R.A. (1975). Ore Deposits (2nd Edition). W.H. Freeman & Company.
10.	Guilbert, J.M. & Park, C.F. (2007). The Geology of Ore Deposits. Waveland Press.

Web Resources

1.	www.usgs.gov
2.	www.mindat.org
3.	www.minsocam.org
4.	www.onegeology.org
5.	www.bgs.ac.uk

Summary of Course Outcomes (COs):

CO No.	Course Outcome Statement	Bloom's Level	Mapped POs
CO1	Identify and describe metallic ore minerals based on their physical properties, visible characteristics, mode of occurrence, and economic significance.	Apply (K3)	PO1, PO2, PO4, PO5
CO2	Examine and classify ore minerals associated with ferrous, non-ferrous, precious, strategic, and industrial mineral deposits.	Analyze (K4)	PO1, PO2, PO3, PO4
CO3	Recognize and evaluate industrial and strategic minerals with respect to their geological occurrence, industrial applications, and economic importance.	Analyze (K4)	PO1, PO2, PO3, PO5, PO6
CO4	Apply megascopic and diagnostic methods to differentiate economically important minerals and interpret their utilization in mineral industries.	Evaluate (K5)	PO1, PO2, PO3, PO4, PO5
CO5	Perform blowpipe analysis and integrate mineralogical observations for accurate identification and characterization of ore and industrial minerals.	Create (K6)	PO1, PO2, PO3, PO4, PO5, PO10

CO–PO Mapping Matrix:

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	3	2	-	-	-	-	-	-	1
CO2	3	3	2	3	-	-	-	-	-	-	-	1
CO3	3	3	2	-	2	2	-	-	-	-	-	1
CO4	3	3	3	3	2	-	-	-	-	-	-	1
CO5	3	3	3	3	2	-	-	-	-	3	-	2

NON-MAJOR ELECTIVE COURSE (NME-I)

EARTH AND ENVIRONMENT			
Learning Objectives			
CO1	To understand the basic concepts of environment, ecology, ecosystem, and natural resources, including renewable and non-renewable resources.		
CO2	To study various types of environmental pollution, waste disposal methods, and their effects on surface water, groundwater, and ecosystems.		
CO3	To explain environmental problems caused by geological processes such as soil erosion, landslides, floods, earthquakes, tsunamis, and volcanic activities along with their mitigation measures.		
CO4	To develop knowledge on coastal and marine environmental issues including coastal degradation, marine pollution, coral reef destruction, and mangrove conservation.		
CO5	To analyses human-induced environmental degradation caused by mining, mineral processing, urbanization, desertification, and other anthropogenic activities, and to understand sustainable environmental management practices.		
UNIT	Details	No. of Hours	Course Objectives
I	Definition of environment, ecosystem and ecology – Different ecosystems – Classification of natural resources – A short account of renewable and non-renewable resources – Environmental pollution: causes and consequences with special reference to	12	CO1

	surface and groundwater – Solid waste and radioactive waste disposal.		
II	Environment problems due to surface geological processes: Soil erosion: causes, hazards and remedial measures – Landslides: causes, hazards and remedial measures – Floods: causes, hazards and remedial measures	12	CO2
III	Influence of deep seated geological processes: Earthquake – origin, distribution, hazards and their mitigation measures – Outline of Tsunamis – Volcanoes: types, products, distribution, hazards, and their mitigation measures of volcanic eruption.	12	CO3
IV	Degradation of coastal environment and measures for coastal protection – Marine pollution: causes, hazards and remedial measures – Environmental problems relating to coral reefs and mangroves and their conservation measures.	12	CO4
V	Environmental impacts associated with mining and mineral processing – Urbanisation: causes and impacts – Desertification: causes and impacts – Man as an agent for environmental degradation	12	CO5

UNIT	**Learning Outcomes**
I	Explain the concepts of environment, ecology, ecosystem, and classification of natural resources including renewable and non-renewable resources.
II	Identify and examine different types of environmental pollution, waste disposal methods, and their impacts on surface water, groundwater, and ecosystems.
III	Describe and assess geological hazards such as earthquakes, landslides, floods, tsunamis, and volcanic eruptions along with their mitigation measures.
IV	Evaluate coastal and marine environmental problems and recommend suitable conservation measures for coral reefs, mangroves, and coastal environments.
V	Analyze the environmental impacts of mining, urbanisation, desertification, and human activities, and propose sustainable environmental management practices.

Text Books / References Books

1.	Keller, E.A. (2017). Environmental Geology (13th Edition). Pearson Education.
2.	Keller, E.A. & DeVecchio, D.E. (2019). Natural Hazards: Earth's Processes as Hazards, Disasters, and Catastrophes (5th Edition). Routledge.
3.	Valdiya, K.S. (2018). Environmental Geology: Indian Context. Springer India.
4.	Gautam, A. (2012). Environmental Geology. Shree Publishers & Distributors, New Delhi.
5.	B.K. Sharma (2021). Environmental Chemistry (16th Edition). Krishna Prakashan Media Pvt. Ltd.
6.	Raghunandan, D. (2012). Environmental Studies. PHI Learning Pvt. Ltd., New Delhi.
7.	Anji Reddy, M. (2017). Textbook of Environmental Science and Technology (3rd Edition). BS Publications, Hyderabad.
8.	Bharucha, E. (2019). Textbook of Environmental Studies for Undergraduate Courses (2nd Edition). Universities Press, Hyderabad.
9.	Holmes, A. & Holmes, D. (2001). Principles of Physical Geology (4th Edition). Stanley Thornes Publishers.
10.	Bell, F.G. (1998). Environmental Geology: Principles and Practice. Blackwell Science Ltd.

Web Resources

1.	www.usgs.gov

2.	www.earthdata.nasa.gov
3.	www.nationalgeographic.org
4.	www.britannica.com
5.	www.iucn.org

Summary of Course Outcomes (COs):

CO No.	Course Outcome Statement	Bloom's Level	Mapped POs
CO1	Explain the fundamental concepts of environment, ecology, ecosystems, natural resources, and environmental pollution and their interactions with geological processes.	Understand (K2)	PO1, PO2, PO6, PO7
CO2	Analyze environmental problems caused by surface geological processes such as soil erosion, landslides, and floods, and evaluate suitable mitigation measures.	Analyze (K4)	PO1, PO2, PO3, PO6
CO3	Assess the origin, distribution, hazards, and mitigation strategies related to earthquakes, tsunamis, and volcanic activities.	Evaluate (K5)	PO1, PO2, PO3, PO6, PO9
CO4	Examine coastal and marine environmental degradation, including impacts on coral reefs and mangroves, and recommend conservation measures.	Analyze (K4)	PO1, PO2, PO6, PO7, PO9
CO5	Evaluate environmental impacts of mining, mineral processing, urbanization, and desertification and propose sustainable environmental management strategies.	Create (K6)	PO1, PO2, PO3, PO6, PO7, PO10, PO12

CO–PO Mapping Matrix:

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	-	3	2	-	-	-	-	1
CO2	3	3	2	-	-	3	-	-	-	-	-	1
CO3	3	3	3	-	-	3	-	-	2	-	-	1
CO4	3	3	-	-	-	3	2	-	2	-	-	1
CO5	3	3	3	-	-	3	2	-	-	2	-	2

NON-MAJOR ELECTIVE COURSE (NME-II)

GEOHAZARDS	
Learning Objectives	
CO1	To understand the nature, causes, and classification of various geological hazards such as earthquakes, landslides, floods, tsunamis, and volcanic eruptions.
CO2	To study the geological and environmental factors responsible for the occurrence of natural hazards and disasters.
CO3	To develop knowledge on hazard assessment, risk analysis, and disaster management techniques related to geo-hazards.
CO4	To understand the impacts of geo-hazards on human life, infrastructure, environment, and economic activities.
CO5	To create awareness about hazard mitigation measures, preparedness strategies, and sustainable management practices for reducing disaster risks.

UNIT	Details	No. of Hours	Course Objectives
I	Natural Hazard–Definition-Earth's processes: catastrophic geological hazards: study of floods, tsunamis, Landslides, Earthquakes, Volcanism and avalanches–with a view to assess the magnitude of the problem, prediction and perception of the hazards. Laws and regulations towards hazard management.	12	CO1
II	Earthquakes-Definition–focus-epicenter-seismic waves intensity and magnitude-Richter scales–Tsunami- Seismograph-seismogram-seismicity in Indian region- Seismic gaps-mitigation measures and management. Preparation of seismic hazard map.	12	CO2
III	Volcanoes-Definition-structure-types–Global distribution-mitigation measures and management. Avalanche Definition–types–mitigation-Definition- causes vulnerable zones in India-Mitigation measures and management. Coastal erosion– its causes- mitigation measures and management.	12	CO3
IV	Landslides-types-slow flowage, rapid flowage, sliding and subsidence–causes and mechanism-Vulnerable zones in India-mitigation measures and management. Deforestation and land degradation-Cyclone-Definition-causes vulnerable zones in India-mitigation measures and management.	12	CO4
V	Mass movement–factor influencing slope stability–types of mass movement–hazards of mass movement– strategies for their reduction and the role of geology. Soil erosion– Soil formation–soil classification– factor influencing soil erosion–hazards of soil erosion–Drought–types, mitigation measures.	12	CO5

UNIT	**Learning Outcomes**
I	Explain the concepts, causes, and classification of major geo-hazards such as earthquakes, landslides, floods, tsunamis, and volcanic eruptions.
II	Identify and interpret the geological and environmental factors responsible for the occurrence of natural hazards and disasters.
III	Examine the impacts of geo-hazards on human life, infrastructure, environment, and socio-economic conditions.
IV	Evaluate hazard assessment methods, disaster management strategies, and mitigation measures for reducing disaster risks.
V	Develop suitable preparedness and sustainable management plans for minimizing the effects of geo-hazards in vulnerable regions

Text Books / References Books

1.	Keller, E.A. & DeVecchio, D.E. (2016). Natural Hazards. Pearson Education.
2.	Hyndman, D. & Hyndman, D. (2016). Natural Hazards and Disasters. Cengage Learning.
3.	Singh, S. (2010). Introduction to Geomorphology and Hazards. Prentice Hall of India.
4.	Singh, P. (2012). Engineering Geology. S.K. Kataria & Sons.
5.	Singh, R.B. (2010). Disaster Management. Rawat Publications.
6.	Castedo, R.C., Llorente, M. & Moncoulon, D. (Eds.) (2023). Geohazards: Risk Assessment, Mitigation and Prevention. MDPI Books.
7.	Chen, J.C. & Xu, C. (Eds.) (2024). Geological Hazards and Risk Management. MDPI Books.
8.	Sandeep et al. (2023). Geohazards: Analysis, Modelling and Forecasting. Springer Nature.

9.	Martino, S., Della Seta, M. & Esposito, C. (2025). Geohazards and Disasters: Modelling Scenarios as a Challenge for the Future. Elsevier.
10.	Murali Krishna, A. & Katsumi, T. (Eds.) (2020). Geotechnics for Natural Disaster Mitigation and Management. Springer.
Web Resources	
1.	www.ndma.gov.in
2.	www.nidm.gov.in
3.	www.gsi.gov.in
4.	www.imd.gov.in
5.	www.incois.gov.in

Summary of Course Outcomes (COs):

CO No.	Course Outcome Statement	Bloom's Level	Mapped POs
CO1	Explain the concepts, causes, characteristics, and impacts of major natural hazards and geological disasters affecting human society and the environment.	Understand (K2)	PO1, PO2, PO6, PO9
CO2	Analyze the occurrence, distribution, monitoring techniques, and mitigation strategies of earthquakes and tsunamis, including seismic hazard assessment.	Analyze (K4)	PO1, PO2, PO3, PO5, PO9
CO3	Evaluate the causes, distribution, impacts, and management practices related to volcanoes, avalanches, coastal erosion, and cyclones.	Evaluate (K5)	PO1, PO2, PO3, PO6, PO9
CO4	Assess landslides, deforestation, land degradation, and related environmental hazards and recommend suitable mitigation measures.	Evaluate (K5)	PO1, PO2, PO3, PO6, PO7, PO9
CO5	Develop hazard mitigation and disaster management strategies using geological knowledge for reducing risks associated with mass movement, soil erosion, and drought.	K6 (Create)	PO1, PO2, PO3, PO5, PO6, PO9, PO10, PO12

CO–PO Mapping Matrix:

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	-	2	-	-	3	-	-	1
CO2	3	3	2	-	2	-	-	-	3	-	-	1
CO3	3	3	3	-	-	2	-	-	3	-	-	1
CO4	3	3	3	-	-	3	2	-	3	-	-	1
CO5	3	3	3	-	2	3	-	-	3	2	-	2

NAAN MUDHALVAN SKILL DEVELOPMENT COURSES (NMSDC)

(For Naan Mudhalvan Arrear Students only)

Semester-II

UNDERSTANDING THE EARTH			
Learning Objectives			
CO1	The main objective of this course is to understand various properties of Earth.		
CO2	To describe the concepts of internal structure of the Earth		
CO3	To explain various components related to external processes of Earth		
CO4	To study concepts of various currents and atmospheric circulation.		
CO5	To understand the availability of elements in the Earth.		
UNIT	Details	No. of Hours	Course Objectives
I	Understanding of planet Earth: Astronomy, Geology, Meteorology and Oceanography. 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 and its age.	12	CO1
II	Internal structure: core, mantle, crust; External Structure: hydrosphere, atmosphere and biosphere. Earth's magnetic field.	12	CO2
III	Plate tectonics, sea-floor spreading and continental drift; Mid Oceanic Ridges, trenches, transform faults and island arcs Origin of oceans, continents, mountains and rift valleys Earthquake and Volcanoes.	12	CO3
IV	Concepts of eustasy; Land-air-sea interaction Oceanic current system and effect of Coriolis force; Wave erosion and beach processes Atmospheric circulation; Weather and climatic changes.	12	CO4
V	Distribution of elements in solar system and in Earth; Chemical differentiation and composition of the Earth; General concepts about geochemical cycles and mass balance Properties of elements; Geochemical behavior of major elements; Mass conservation of elements and isotopic fractionation.	12	CO5
UNIT	**Learning Outcomes**		
I	Understand the properties of Earth		
II	Knowledge on Dating of Earth Age		
III	Correlate various Hypothesis on Origin of Earth		
IV	Analyze the importance of Crystallography Studies		
V	Various Type minerals and their respective crystal system		
Text Books / References Books			
1.	Duff, P.M.D. & Duff, D. (Eds.) (1993). Holmes' Principles of Physical Geology. Taylor & Francis.		
2.	Emiliani, C. (1992). Planet Earth: Cosmology, Geology, and the Evolution of Life and Environment. Cambridge University Press.		
3.	Patwardhan, A.M. (1999). Dynamic Earth System. Prentice Hall, New Delhi.		
4.	Mukherjee, A.K. (1990). Principles of Geology. EW Press, Kolkata.		
5.	Reed, J.S. & Wicander, T.H. (2005). Essentials of Geology. McGraw-Hill, New York.		
6.	Gross, M.G. (1977). Oceanography: A View of the Earth.		

7.	Thornbury, W.D. (2004). Principles of Geomorphology. CBS Publishers & Distributors, New Delhi.
8.	Tilley, R.J.D. (2006). Crystals and Crystal Structures. John Wiley & Sons, England.
9.	Correns, C.W. (1967). Introduction to Mineralogy, Crystallography and Petrology (2nd Edition). Springer.
10.	Radhakrishnan, V. (1996). General Geology. V.V.P. Publishers, Tuticorin.
Web Resources	
1.	www.iau.org
2.	www.esa.int
3.	www.unesco.org
4.	www.onegeology.org
5.	www.geology.com

Summary of Course Outcomes (COs):

CO No.	Course Outcome Statement	Bloom's Level (K-Level)	Mapped POs
CO1	Explain the origin, evolution, structure, and characteristics of the Universe, Solar System, Earth, and other planetary bodies.	Understand (K2)	PO1, PO2, PO12
CO2	Describe the internal and external structure of the Earth and interpret the interactions among the lithosphere, atmosphere, hydrosphere, biosphere, and geomagnetic field.	Apply (K3)	PO1, PO2, PO3
CO3	Analyze plate tectonic processes and evaluate their role in the formation of oceans, continents, mountains, earthquakes, and volcanoes.	Analyze (K4)	PO1, PO2, PO3, PO6
CO4	Examine oceanic and atmospheric processes, including ocean circulation, coastal dynamics, weather systems, and climate change.	Analyze (K4)	PO1, PO2, PO3, PO6
CO5	Evaluate the distribution and geochemical behavior of elements, geochemical cycles, isotopic fractionation, and mass balance processes within the Earth system.	K5 (Evaluate)	PO1, PO2, PO3, PO5, PO12

CO–PO Mapping Matrix:

Os / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1 (K2)	3	2	-	-	-	-	-	-	-	-	-	2
CO2 (K3)	3	2	2	-	-	-	-	-	-	-	-	1
CO3 (K4)	3	3	3	-	-	2	-	-	-	-	-	1
CO4 (K4)	3	3	2	-	-	3	-	-	-	-	-	1
CO5 (K5)	3	3	3	-	2	-	-	-	-	-	-	2

NAAN MUDHALVAN SKILL DEVELOPMENT COURSES (NMSDC)

(For Naan Mudhalvan Arrear Students only)

Semester-III

BASIC OF EARTH SCIENCE			
Learning Objectives			
CO1	The main objective of this course is to understand various properties of Earth.		
CO2	To describe the concepts of internal structure of the Earth		
CO3	To explain various components related to external processes of Earth		
CO4	To study concepts of various currents and atmospheric circulation.		
CO5	To understand the availability of elements in the Earth.		
UNIT	Details	No. of Hours	Course Objectives
I	Universe – Evolution of the Universe. Solar System –Inner and outer planets – characteristics of solar system. Satellites – Asteroids – Meteors – comets. Earth – movements – revolution – rotation – solstice – equinox. Atmosphere - El Nino – hydrosphere – lithosphere- Origin of the Earth.	12	CO1
II	Age of the Earth - old methods – new methods – Radioactivity – Half-life period – Radiometric methods. Interior of the Earth – Density – Shape – Seismic waves – Composition and thickness of the crust, mantle and core. Discontinuities: Conrad Discontinuity – Mohorovicic Discontinuity.	12	CO2
III	Introduction to Geomorphology: Geological action of wind, water, glaciers and ground water. Volcanoes and earthquakes. Rock deformation: Folds, Faults, Joints, Cleavage, Unconformities, Concepts of plate tectonics, sea floor spreading and geosynclines.	12	CO3
IV	Study of Fossils- Introduction, Geological Record and its nature. Geological Time Scale. Introduction, Definition of Paleontology, Classification of Plants, Invertebrate and Vertebrate fossils. Fossils - Tophonomy (Burial Law), Types of Fossilization, Mode of preservation- Applications of Fossils– National fossil parks across India.	12	CO4
V	Applications of Geology: Environmental impacts due to mining and mineral process, Engineering Geology: Dams, Reservoirs and Tunnels, strategic, critical and essential mineral –Mineral resources of India. Fossil Fuels and Groundwater.	12	CO5
UNIT	**Learning Outcomes**		
I	Gather basic information on Earth Sciences		
II	Understand the importance of various components of Earth		
III	Process of Geomorphological features		
IV	Understand, predict and analyze the fossil and dating		
V	Apply the geological knowledge in various civil structures		
Text Books / References Books			
1.	Perkins, D. (2014). Mineralogy (3rd Edition).		
2.	Thornbury, W.D. (2004). Principles of Geomorphology.		

3.	Patwardhan, A.M. (1999). Dynamic Earth System.
4.	Mukherjee, A.K. (1990). Principles of Geology.
5.	Reed, J.S. & Wicander, T.H. (2005). Essentials of Geology.
6.	Nesse, W.D. (2000). Introduction to Mineralogy.
7.	Dana, E.S. (2000). Textbook of Mineralogy (3rd Edition).
8.	Tilley, R.J.D. (2006). Crystals and Crystal Structures.
9.	Correns, C.W. (1967). Introduction to Mineralogy, Crystallography and Petrology (2nd Edition).
10.	Radhakrishnan, V. (1996). General Geology.
Web Resources	
1.	www.nasa.gov
2.	www.isro.gov.in
3.	www.incois.gov.in
4.	www.geosocindia.org
5.	www.meteo.gov.i

Summary of Course Outcomes (COs):

CO No.	Course Outcome Statement	Bloom's Level	Mapped POs
CO1	Explain the origin, evolution, and characteristics of the Universe, Solar System, Earth, and its major spheres.	Understand (K2)	PO1, PO2, PO12
CO2	Describe the age, internal structure, composition, and geophysical characteristics of the Earth using geological and geochronological principles.	Apply (K3)	PO1, PO2, PO3
CO3	Analyze geomorphic processes, tectonic activities, rock deformation structures, and their role in shaping the Earth's surface.	Analyze (K4)	PO1, PO2, PO3, PO6
CO4	Examine fossils, geological time scale, fossilization processes, and their applications in understanding Earth history and evolution of life.	Analyze (K4)	PO1, PO2, PO3, PO12
CO5	Evaluate the applications of geology in mining, engineering projects, groundwater exploration, fossil fuels, and sustainable utilization of mineral resources.	Evaluate (K5)	PO1, PO2, PO3, PO5, PO6, PO12

CO–PO Mapping Matrix:

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1 (K2)	3	2	-	-	-	-	-	-	-	-	-	2
CO2 (K3)	3	2	2	-	-	-	-	-	-	-	-	1
CO3 (K4)	3	3	3	-	-	2	-	-	-	-	-	1
CO4 (K4)	3	3	2	-	-	-	-	-	-	-	-	2
CO5 (K5)	3	3	3	-	2	2	-	-	-	-	-	2

NAAN MUDHALVAN SKILL DEVELOPMENT COURSES (NMSDC)

(For Naan Mudhalvan Arrear Students only)

Semester-IV

GEO-HERITAGE AND GEO-TOURISM			
Learning Objectives			
CO1	To understand the importance of Geological Heritage.		
CO2	To know about the locations of geological sites		
CO3	To know the geo-tourisms in India.		
CO4	To understand the importance of field visits to geological sites.		
CO5	To know the both geological and geomorphological heritage in India.		
UNIT	Details	No. of Hours	Course Objectives
I	Introduction to Heritage-Geodiversity-Geo-heritage. Definition and introduction to Geo-tourism. Geo-conservation. Importance of studying Geological heritage. Geo-heritage site -meaning, distribution in Tamil Nadu.	3	CO1
II	Geo-heritage sites in Tamil Nadu- detailed study on their location, Geology, conservation and important features- Fossil wood near Tiruvakkarai, National fossil wood park Sattanur, Charnockite St.Thomas Mount, Badlands of Karai-Kulakkalnatham.	3	CO2
III	Geo-heritage sites in South India- detailed study on their location, Geology conservation and their important features-Peninsular gneiss, Lalbagh Botanical Garden; Columnar Basalt, Coconut Island; Pillowlavas, Chitradurga District; Pyroclastic rocks Kolardistrict. Varkalacliffsection, Thiruvananthapuram; Volcanogenic bedded barytes, Cuddapah; Eparchaean Unconformity, Chittor;	3	CO3
IV	Geo-heritage sites in other than South India- detailed study on their location, Geology, conservation and their important features-Stromatolite Fossilpark, Jamarkotra; Wood Park, Jaisalmer; Plant fossil-bearing inter-trappean beds of Rajmahal Formation; Lonar Lake, Buldana Dist. Maharashtra.	3	CO4
V	Recognition of Geological and Geomorphological heritage in India. Importance of Geology and geography in tourism, natural and climatic regions of India. Important places of attraction for geological sites.	3	CO5
UNIT	**Learning Outcomes**		
I	Students gain knowledge of the geological importance of the various places.		
II	Students understand geoheritage and geotourism concepts.		
III	Students understand the importance of field visits to geological monuments.		
IV	They can know ideas about fossil wood and rock types.		
V	Students understand the importance of geology and geography in tourism.		
Text Books / References Books			

1.	Dingwall, P., Weighell, T. & Badman, T. (2005). Geological World Heritage: A Global Framework. IUCN.
2.	INTACH, Natural Heritage Division (2016). A Monograph on National Geoheritage Monuments of India. New Delhi.
3.	Singh, R.B., Wei, D. & Anand, S. (Eds.) (2021). Global Geographical Heritage, Geoparks and Geotourism: Geoconservation and Development. Springer Nature.
4.	Hose, T.A. (Ed.) (2016). Geoheritage and Geotourism: A European Perspective. Boydell & Brewer.
5.	Tripathi, S.C., Pant, N.C. & Rajora, S. (Eds.) (2025). Geoconservation and Geotourism Potential of India. Springer.
6.	Philip, G. (1998). Tourism Geography. National Publishers.
7.	Drinia, H., Voudouris, P. & Antonarakou, A. (Eds.) (2024). Geoheritage and Geotourism Resources II: Education, Recreation, Sustainability. MDPI Books.
8.	Braga, V., Duarte, A. & Marques, C.S. (Eds.) (2022). Economics and Management of Geotourism. Springer.
9.	Dowling, R. & Newsome, D. (2006). Geotourism. Elsevier.
10.	Gray, M. (2013). Geodiversity: Valuing and Conserving Abiotic Nature. Wiley-Blackwell.
Web Resources	
1.	www.intach.org
2.	www.geosocindia.org
3.	www.gsi.gov.in
4.	www.nationalgeographic.com
5.	www.onegeology.org

Summary of Course Outcomes (COs):

CO No.	Course Outcome Statement	Bloom's Level	Mapped POs
CO1	Explain the concepts of geoheritage, geodiversity, geoconservation, and geotourism, and describe the significance of geological heritage in Earth sciences.	Understand (K2)	PO1, PO2, PO6, PO7, PO12
CO2	Identify and describe major geoheritage sites in Tamil Nadu with respect to their geological setting, significance, and conservation aspects.	Apply (K3)	PO1, PO2, PO4, PO6, PO10
CO3	Analyze geoheritage sites of South India based on geological formation, rock types, geomorphology, and conservation importance.	Analyze (K4)	PO1, PO2, PO3, PO6, PO9
CO4	Evaluate geoheritage sites in India outside South India with respect to their geological significance, uniqueness, and conservation value.	Evaluate (K5)	PO1, PO2, PO3, PO6, PO7, PO9
CO5	Develop awareness and strategies for geoheritage conservation and geotourism promotion by integrating geological and geographical knowledge of India.	Create (K6)	PO1, PO2, PO3, PO6, PO7, PO10, PO12

CO–PO Mapping Matrix:

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1 (K2)	3	2	-	-	-	3	2	-	-	-	-	2
CO2 (K3)	3	3	-	3	-	3	-	-	-	2	-	1
CO3 (K4)	3	3	3	-	-	3	-	-	2	-	-	1
CO4 (K5)	3	3	3	-	-	3	2	-	2	-	-	1
CO5 (K6)	3	3	3	-	2	3	2	-	2	3	2	2

NAAN MUDHALVAN SKILL DEVELOPMENT COURSES (NMSDC)

(For Naan Mudhalvan Arrear Students only)

Semester-V

PRINCIPLES OF SURVEYING			
Learning Objectives			
CO1	To learn about the principles of surveying, sources and errors.		
CO2	To know about the components and procedures of Prismatic Compass and Traverse survey.		
CO3	Know about the levelling procedures, instruments and its applications.		
CO4	Understand the principles, adjustments, methods of Plane Table Survey.		
CO5	To acquire the knowledge about the Total Station Survey and its merits and demerits.		
UNIT	Details	No. of Hours	Course Objectives
I	Surveying: Introduction – objectives – Uses - Classification – Principle of Surveying - Units of measurements – Errors – Sources, Types of errors and their corrections – accuracy and precision, Stages of survey operations – Methods of Linear Measurement – Distance measurement devices: Ranging rod, Chain, tape.	12	CO1
II	Measurement of Angles and Directions – Definitions - Meridians – Bearings – Magnetic and True bearings – Azimuth. Prismatic Compass: Components -Adjustment of the compass: Centering, Levelling, and focusing the prism. Traverse: Types of the traverse –procedures – Control establishments –Adjustment of closing error.	12	CO2
III	Levelling and its application: Introduction to Levelling – Methods - Types of instruments –Description of Dumpy level: Temporary adjustment of level. Auto levelling: Types – Parts – Operation – Merits and demerits.	12	CO3
IV	Table Surveying: Definition - Principles – Accessories – Temporary adjustments – Setting up the Plane Table - Methods of Plane table surveying: Radiation, Intersection, Traversing &	12	CO4

	Resection methods. Advantages, disadvantages and Errors in Plane Tabling.		
V	Total Station Survey: Introduction – Features: Linear, Angle and Height measurements – Accessories – Setting-up and orientation - Types of error and error correction – Advantages and disadvantages of TSS. Introduction to Drone Survey.	12	CO5

UNIT	Learning Outcomes
I	Gain the knowledge over principles, various errors and types of surveying.
II	Ability to know the measurement of angles and direction using Prismatic Compass survey.
III	Gaining knowledge about levelling instruments and its applications.
IV	Complete understating the Plane Table survey.
V	Understand the concept of recent techniques of Total Station

Text Books / References Books	
1.	Venkatramaiah, C. (2011). A Textbook of Surveying.
2.	Duggal, S.K. (2009). Surveying and Levelling.
3.	Whyte, W.S. (1981). Basic Surveying.
4.	Bhavikatti, S.S. (2008). Engineering Surveying.
5.	Venkatramaiah, C. (1996). A Textbook of Surveying (Earlier Edition).
6.	Anderson, J.M. & Mikhail, E.M. (1985). Surveying: Theory and Practice.
7.	Basak, N.N. (1994). Surveying and Levelling.
8.	Kanetkar, T.P. & Kulkarni, S.V. (2008). Surveying Vol. I & II.
9.	Uren, J. & Price, B. (2000). Surveying for Engineers.
10.	Garg, P.K. (2025). Surveying and Geomatics.
Web Resources	
1.	www.surveyofindia.gov.in
2.	www.nrsc.gov.in
3.	www.isro.gov.in
4.	www.nptel.ac.in
5.	www.usgs.gov

Summary of Course Outcomes (COs):

CO No.	Course Outcome Statement	Bloom's Level	Mapped POs
CO1	Understand the fundamentals of surveying including classification, principles, units of measurement, errors, accuracy & precision, and linear measurement methods using chain, tape, and ranging rods.	Understand (K2)	PO1, PO2, PO5, PO12
CO2	Apply concepts of angular measurement and direction such as meridians, bearings, azimuth, and execute compass traversing with error adjustment and field procedures.	Apply (K3)	PO1, PO2, PO4, PO5, PO11
CO3	Apply levelling principles and operate surveying instruments (dumpy level and auto level) for determination of elevations with proper temporary adjustments and field operations.	Apply (K3)	PO1, PO2, PO4, PO5, PO11

CO4	Apply plane table surveying techniques such as radiation, intersection, traversing, and resection for mapping and field data plotting with error considerations.	Apply (K3)	PO1, PO2, PO4, PO5, PO10
CO5	Analyze modern surveying systems including total station and drone surveying for precise spatial data acquisition, including error correction, setup, and interpretation.	Analyze (K4)	PO2, PO4, PO5, PO11, PO12

CO–PO Mapping Matrix:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	–	–	2	–	–	–	–	–	–	2
CO2	3	3	–	2	3	–	–	–	–	–	1	–
CO3	3	3	–	2	3	–	–	–	–	–	1	–
CO4	3	3	–	2	3	–	–	–	–	2	–	–
CO5	–	3	–	3	3	–	–	–	–	–	2	2

NAAN MUDHALVAN SKILL DEVELOPMENT COURSES (NMSDC)

(For Naan Mudhalvan Arrear Students only)

Semester-VI

FIELD HYDROGEOLOGY AND TECHNIQUES			
Learning Objectives			
CO1	To impart knowledge of basic field hydrogeology including groundwater origin, occurrence and distribution.		
CO2	To train students on basics of Calculation of Porosity and Permeability, Pump Testdata, Calculation of Groundwater Fluctuations.		
CO3	To train students on basics of well hydraulics, method of exploration, water budgetand management.		
CO4	To impart theoretical, practical and field knowledge pertaining to Hydrogeological domain.		
CO5	To understand the relationship in between water and rock interaction and salt water intrusion and its remedial measures in the coastal aquifers.		
UNIT	Details	No. of Hours	Course Objectives
I	Importance of Hydrology – Difference between Hydrogeology and Hydrology, Water Bearing Geologic formations. Ground water Provinces of Tamil Nadu. Collection of Rainfall data. Short account on Thiessen Polygon Isohyetal maps.	12	CO1
II	Hydrogeologic Parameters: Calculation of Porosity and Permeability, PumpTest data, Calculation of Groundwater Fluctuations.	12	CO2

III	Wells – Well Inventory Survey: Water level, Water level Fluctuation, Subsurface Layers(Soil thickness, Weathered zone, Fractured zone, Bed rock) – Well construction - Well logging - Sedimentary aquifers: Sandstone, limestone.	12	CO3
IV	Hardrock Aquifers: Charnockites, Gneiss, Granite formation - Field observation andMeasurement of Soil moisture zone, Zone of Aeration, Zone of saturation.	12	CO4
V	Pumping Test: Yield, Drawdown, Recuperation, Transmissivity, Permeability. Case studies: Rainfall in Salem district, Groundwater condition in Salem district. Rain WaterHarvesting.	12	CO5

UNITS	**Learning Outcomes**
I	Explain the fundamental concepts of hydrogeology, groundwater occurrence, aquifer systems, and field investigation techniques.
II	Identify and interpret different groundwater conditions using field methods such as water level measurement, pumping tests, and geological mapping.
III	Apply hydrogeological tools and techniques for data collection, aquifer characterization, and groundwater resource evaluation in field studies.
IV	Evaluate groundwater quality, quantity, and sustainability based on field data and hydrogeological parameters.
V	Design and develop suitable groundwater exploration and management strategies for sustainable utilization of water resources.

Text Books / References Books	
1.	Brassington, R. (2017). Field Hydrogeology.
2.	Moore, J.E. (2011). Field Hydrogeology: A Guide for Site Investigations and Report Preparation.
3.	Assaad, F.A. & LaMoreaux, P.E. (2003). Field Methods for Geologists and Hydrogeologists.
4.	Singhal, B.B.S. & Gupta, R.P. (2010). Applied Hydrogeology of Fractured Rocks.
5.	Patra, H.P., Adhikari, S.K. & Kumar, S. (2016). Groundwater Prospecting and Management.
6.	Hiscock, K.M. & Bense, V.F. (2014). Hydrogeology.
7.	Freeze, R.A. & Cherry, J.A. (1979). Groundwater.
8.	Domenico, P.A. & Schwartz, F.W. (1998). Physical and Chemical Hydrogeology.
9.	Anderson, M.P., Woessner, W.W. & Hunt, R.J. (2015). Applied Groundwater Modeling: Simulation of Flow and Advective Transport.
10.	Driscoll, F.G. (1986). Groundwater and Wells.

Web Resources	
1.	www.cgwb.gov.in
2.	www.gsi.gov.in
3.	www.nrsc.gov.in
4.	www.isro.gov.in
5.	www.moes.gov.in

Summary of Course Outcomes (COs):

CO No.	Course Outcome Statement	Bloom's Level	Mapped POs

CO1	Explain the fundamental concepts of hydrology and hydrogeology, water-bearing geological formations, groundwater provinces of Tamil Nadu, and methods of rainfall data collection and analysis.	Underst and (K2)	PO1, PO2, PO7, PO12
CO2	Apply hydrogeological parameters such as porosity, permeability, groundwater fluctuations, and pumping test data for groundwater assessment.	Apply (K3)	PO1, PO2, PO4, PO5
CO3	Conduct well inventory surveys and interpret well construction, well logging data, and characteristics of sedimentary aquifers.	Apply (K3)	PO1, PO2, PO4, PO5, PO10
CO4	Analyze the hydrogeological characteristics of hard rock aquifers and evaluate subsurface water zones through field observations and measurements.	Analyze (K4)	PO1, PO2, PO4, PO5, PO7
CO5	Evaluate groundwater resources using pumping test parameters and assess groundwater conditions, rainfall patterns, and rainwater harvesting practices through case studies.	Evaluate (K5)	PO2, PO4, PO5, PO7, PO11, PO12

CO–PO Mapping Matrix:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	–	–	–	–	2	–	–	–	–	2
CO2	3	3	–	2	3	–	–	–	–	–	–	–
CO3	3	3	–	2	3	–	–	–	–	2	–	–
CO4	3	3	–	3	2	–	3	–	–	–	–	–
CO5	–	3	–	3	2	–	3	–	–	–	2	2

ALLIED GEOLOGY – I

ALLIED GEOLOGY – I			
Learning Objectives			
CO1	To introduce the fundamental concepts of Geology, including the origin of the Earth and solar system, internal structure of the Earth, and major geological processes such as earthquakes and volcanism.		
CO2	To develop an understanding of Structural Geology, including the identification and interpretation of rock structures such as dip, strike, folds, faults, joints, and unconformities.		
CO3	To provide basic knowledge of Crystallography, including crystal morphology, symmetry elements, Miller indices, and classification of crystal systems.		
CO4	To impart systematic knowledge of Mineralogy, including the physical properties of minerals and classification of important rock-forming and economic minerals.		
CO5	To enable students to recognize and describe common minerals and geological structures through theoretical understanding, forming a foundation for advanced geological studies and field applications.		
UNIT	Details	No. of Hours	Course Objectives
I	General Geology: Definition and scope of Geology. Origin of solar system: Nebular and Planetesimals hypotheses. Introduction and outline of constitution and composition of earth's interior.	12	CO1

	Brief account of the important methods of determining the age of the earth. Earthquakes and their effects. Short note on seismograph and seismogram. Richter's scale of earthquake intensity. Brief account of volcanoes.		
II	Structural Geology: Definition and scope of Structural Geology. Concept of rock outcrop - definition of dip and strike of rock formations. Folds: definition and parts of a fold. Brief description of the following fold types: anticline, syncline, symmetrical, asymmetrical, isoclinal and recumbent folds. Brief description of the following fold systems: anticlinorium and synclinorium. Faults: definition and parts of a fault. Brief description of the following types of faults: normal, reverse, strike, dip, oblique, parallel and step faults. Brief outline of joints and unconformities.	12	CO2
III	Crystallography: Definition of crystallography and crystals. Morphological characters of crystals: faces – forms – edges. Symmetry elements of crystals: Axis, plane and center of symmetry. Miller's Indices. Study of the following crystal systems: normal classes of the cubic, tetragonal, hexagonal, orthorhombic, monoclinic and triclinic systems.	12	CO3
IV	Mineralogy I: Definition of mineralogy and mineral. Outline of physical properties of minerals: color, form, luster, hardness, cleavage, fracture, and specific gravity. Description of the following minerals: Quartz. Orthoclase – Microcline – Albite – Labradorite - Anorthite. Nepheline – Leucite – Sodalite. Enstatite -Hypersthene – Augite – Diopside.	12	CO4
V	Mineralogy II: Description of the following minerals: Hornblende – Actinolite – Tremolite. Muscovite – Biotite – Chlorite. Topaz - Olivine – Serpentine – Talc. Tourmaline – Beryl – Apatite – Corundum. Garnet – Diamond – Apatite – Staurolite – Sillimanite – Epidote.	12	CO5
Learning Outcomes			
CO1	Explain fundamental geological concepts such as origin of the Earth and solar system, internal structure of the Earth, earthquakes, volcanoes, and methods used to determine Earth's age.		
CO2	Identify and interpret structural features of rocks including dip, strike, folds, faults, joints, and unconformities in geological formations.		
CO3	Analyze crystal morphology and symmetry, and apply Miller indices to classify and understand different crystal systems.		
CO4	Recognize and describe important rock-forming and economic minerals based on their physical properties such as color, hardness, cleavage, luster, and specific gravity.		
CO5	Apply basic geological and mineralogical knowledge to interpret Earth processes and support further studies in geology, field mapping, and resource identification.		
Text Books / References Books			
1.	Mahapatra, G.B. (2016). A Textbook of Geology.		
2.	Mukherjee, P.K. (2012). A Textbook of Geology.		
3.	Singh, P. (2005). Engineering and General Geology.		
4.	Fossen, H. (2016). Structural Geology.		
5.	Tyrrell, G.W. (1958). Principles of Petrology.		
6.	Read, H.H. (1996). Rutley's Elements of Mineralogy.		

7.	Nesse, W.D. (2000). Introduction to Mineralogy.
8.	Hurlbut, C.S. & Klein, C. (1998). Manual of Mineralogy.
9.	Ford, W.E. (1958). Dana's Textbook of Mineralogy.
10.	Billings, M.P. (1972). Structural Geology.
Web Resources	
1.	www.geolsoc.org.uk
2.	www.usgs.gov
3.	www.bgs.ac.uk
4.	www.geology.com
5.	www.mindat.org

Summary of Course Outcomes (COs):

CO No.	Course Outcome Statement	Bloom's Level	Mapped POs
CO1	Explain the fundamental concepts of General Geology, including the origin of the solar system, structure and composition of the Earth, geological time scale, earthquakes, volcanoes, and methods of determining the age of the Earth.	Understand (K2)	PO1, PO2, PO4
CO2	Describe and interpret geological structures such as dip, strike, folds, faults, joints, and unconformities, and explain their significance in geological investigations.	Understand (K2)	PO1, PO2, PO3, PO4
CO3	Classify crystals based on symmetry elements, crystal morphology, Miller indices, and crystal systems, and apply crystallographic principles in mineral identification.	Apply (K3)	PO1, PO2, PO3, PO4, PO5
CO4	Identify and distinguish major rock-forming minerals using their physical properties and diagnostic characteristics.	Apply (K3)	PO1, PO2, PO3, PO5
CO5	Analyze the mineralogical characteristics, occurrence, and significance of silicate and non-silicate minerals for geological interpretation and resource evaluation.	Analyze (K4)	PO1, PO2, PO3, PO4, PO5, PO12

CO–PO Mapping Matrix:

COs \ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	2	-	-	-	-	-	-	1	-
CO2	3	2	2	3	-	-	-	-	-	-	1	-
CO3	3	2	2	2	3	-	-	-	-	-	1	-
CO4	3	2	2	-	3	-	-	-	-	-	1	-
CO5	3	3	2	2	3	-	-	-	-	-	1	2

ALLIED GEOLOGY – II

ALLIED GEOLOGY – II			
Learning Objectives			
CO1	To introduce the fundamental concepts of paleontology and fossils, including modes of preservation, fossil groups, and their significance in geological studies and interpretation of Earth's history.		
CO2	To develop an understanding of stratigraphy and geological time scale, along with the study of major Indian stratigraphic formations and their geological significance.		
CO3	To provide knowledge of igneous petrology, including classification, forms of igneous bodies, and identification of important igneous rocks based on their mineral composition and texture.		
CO4	To impart understanding of sedimentary and metamorphic petrology, including sedimentary structures, rock types, metamorphic processes, agents of metamorphism, and rock identification.		
CO5	To enable students to understand economic geology, including major ore minerals, industrial minerals, coal types, and basic concepts of petroleum origin and occurrence in India, for resource evaluation and applications.		
UNIT	Details	No. of Hours	Course Objectives
I	Paleontology: Definition of Paleontology and fossils. Outlines of modes of preservation in sedimentary rocks. Brief account of the uses of fossils. Study of the morphological characters and geological age of the following fossil groups: pelecypods, gastropods, cephalopods, brachiopods, corals, and trilobites.	12	CO1
II	Stratigraphy: Definition and scope of Stratigraphy. Outline of the Geological Time Scale. Brief account of the following geological formations in India: Dharwar Group, Cuddapah Group, Vindhyan Group, Gondwana Group, Cretaceous formations of Tiruchirapalli, and Karewa Formation.	12	CO2
III	Igneous Petrology: Definition of igneous petrology and igneous rocks. Forms of igneous rocks: sill, lopolith, laccolith, phacolith, dyke, and batholith. Brief description of the following igneous rocks: dunite, pyroxenite, gabbro, dolerite, syenite, granite, pegmatite, aplite, andesite, and basalt.	12	CO3
IV	Sedimentary Petrology: Definition of sedimentary rocks and sedimentary petrology. Primary structures of sedimentary rocks: common bedding, cross-bedding, current-bedding, graded-bedding. Surface structures: ripple marks, mud-cracks, and rain prints. Brief description of the following sedimentary rocks: sandstone, arkose, grit, shale, and limestone. Metamorphic Petrology: Definition of metamorphic rocks. Metamorphism and metamorphic process. Agents of metamorphism. Brief description of the following metamorphic rocks: slate, phyllite, schist, gneiss, marble, quartzite, granulite, and amphibolite.	12	CO4
V	Economic Geology: Brief description of the physical properties and Indian occurrences of the following ore and industrial minerals: graphite, bauxite, magnesite, hematite, magnetite, chromite, gold, pyrolusite, pyrite, galena, asbestos, gypsum, chalk, calcite, dolomite, barite, and kaolin. Brief description of the	12	CO5

	following coal types: peat, lignite, bituminous, and anthracite. Brief introduction to petroleum, its origin and occurrence in India.		
UNIT	**Learning Outcomes**		
I	Explain the fundamentals of paleontology, including fossils, their modes of preservation, and the geological significance of major fossil groups such as mollusks, brachiopods, corals, and trilobites.		
II	Interpret geological time and stratigraphic units, with an understanding of the Geological Time Scale and major Indian stratigraphic formations.		
III	Identify and classify igneous rocks and structures, including forms of igneous bodies and common rock types based on mineral composition and texture.		
IV	Analyze sedimentary and metamorphic rocks, including primary and surface sedimentary structures, metamorphic processes, agents, and identification of key rock types.		
V	Recognize economic minerals and energy resources, including major ore minerals, coal types, and basic concepts of petroleum origin and occurrence in India for resource evaluation.		
Text Books / References Books			
1.	Benton, M.J. & Harper, D.A.T. (1997). Basic Palaeontology.		
2.	Kumar, R. (1985). Fundamentals of Historical Geology and Stratigraphy of India.		
3.	Boggs, S. Jr. (2006). Principles of Sedimentology and Stratigraphy.		
4.	Prothero, D.R. & Schwab, F. (2013). Sedimentary Geology.		
5.	Evans, A.M. (1993). Ore Geology and Industrial Minerals.		
6.	Clarkson, E.N.K. (2013). Invertebrate Palaeontology and Evolution.		
7.	Best, M.G. (2003). Igneous and Metamorphic Petrology.		
8.	Tucker, M.E. (2011). Sedimentary Rocks in the Field.		
9.	Winter, J.D. (2010). Principles of Igneous and Metamorphic Petrology.		
10.	Evans, A.M. (1993). Ore Geology and Industrial Minerals. (Duplicate entry in the original list).		
Web Resources			
1.	www.palaeosoc.org		
2.	www.ucmp.berkeley.edu		
3.	www.fossilmuseum.net		
4.	www.stratigraphy.org		
5.	www.geosociety.org		

Summary of Course Outcomes (COs):

CO No.	Course Outcome Statement	Bloom's Level	Mapped POs
CO1	Explain the fundamentals of Paleontology, fossil preservation, fossil groups, and their applications in interpreting geological history and evolution.	Understand (K2)	PO1, PO2, PO4
CO2	Describe the principles of Stratigraphy, Geological Time Scale, and major stratigraphic formations of India and their geological significance.	Understand (K2)	PO1, PO2, PO4, PO10
CO3	Identify and classify igneous, sedimentary, and metamorphic rocks based on their origin, structures, textures, and mineralogical composition.	Apply (K3)	PO1, PO2, PO3, PO5

CO4	Analyze petrological characteristics and geological processes responsible for the formation of igneous, sedimentary, and metamorphic rocks.	Analyze (K3)	PO1, PO2, PO3, PO4, PO5
CO5	Evaluate the occurrence, economic importance, and utilization of ore minerals, industrial minerals, coal, and petroleum resources in India.	Evaluate (K5)	PO1, PO2, PO3, PO5, PO10, PO12

CO–PO Mapping Matrix:

COs \ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	2	-	-	-	-	-	-	1	-
CO2	3	2	-	2	-	-	-	-	-	2	1	-
CO3	3	2	2	-	3	-	-	-	-	-	1	-
CO4	3	3	2	3	3	-	-	-	-	-	1	-
CO5	3	2	2	-	3	-	-	-	-	2	1	3

ALLIED GEOLOGY PRACTICAL-I

ALLIED GEOLOGY PRACTICAL-I			
Learning Objectives			
CO1	To develop knowledge on identification and physical properties of minerals, including silicates, non-silicates, ore minerals, industrial minerals, and coal varieties through systematic classification.		
CO2	To enable students to understand and identify common igneous, metamorphic, and sedimentary rocks based on their mineral composition, texture, and diagnostic characteristics.		
CO3	To impart skills in fossil identification and morphological study, including major invertebrate and plant fossils such as mollusks, brachiopods, trilobites, corals, and fossil plants.		
CO4	To train students in basic geological map interpretation and construction, including strike and dip representation, outcrop completion, and preparation of geological sections for conformable strata.		
CO5	To strengthen practical geological understanding by integrating mineral, rock, and fossil identification with field and map-based applications for academic and applied geological studies.		
UNIT	Details	No. of Hours	Course Objectives
I	Mineralogy: Identification and physical description of the following minerals: Quartz Group: rock crystal, chalcedony, agate, jasper, flint. Feldspar Group: orthoclase, microcline, albite, perthite. Pyroxene Group: augite, hypersthene. Amphibole Group: hornblende, tremolite, actinolite. Mica Group: muscovite, biotite, chlorite.	12	CO1
II	Other silicate minerals: olivine, garnet, beryl, tourmaline, staurolite. Non silicates: corundum, apatite. Ore minerals: magnetite, chromite, bauxite, pyrolusite, pyrite, galena, hematite. Industrial Minerals: talc, asbestos, magnesite, barite, gypsum. Coal varieties: peat, lignite, bituminous, and anthracite.	12	CO2

III	Petrology: Identification and physical description of the following rocks: Igneous rocks: granite, pegmatite, syenite, diorite, gabbro, dolerite, dunite, pyroxenite. Metamorphic rocks: slate, mica schist, chlorite schist, hornblende gneiss, garnet-mica gneiss, granulite, marble. Sedimentary rocks: sandstone, conglomerate, arkose, grit, shale, limestone.	12	CO3
IV	Fossils: Identification and morphological description of the following fossils: Pelecypods: Meretrix, Arca, Pecten, Ostrea. Gastropods: Turritella, Natica, Turbo, Conus. Cephalopods: Nautilus, Acanthoceras. Brachiopods: Terebratula, Spirifer. Trilobites: Calymene, Paradoxides. Corals: Calceola, Lithostrotion. Plant Fossils: Glossopteris, Ptilophyllum.	12	CO4
V	Geological Maps Geological map drawing exercises: drawing strike lines and determining dip amounts. Outcrop completion geological maps with conformable series of beds. Preparation of geological sections for conformable series of beds.	12	CO5

UNIT	Learning Outcomes
I	Describe and explain the physical properties and classification of important minerals, rocks, and fossils, including silicates, non-silicates, igneous, sedimentary, metamorphic rocks, and fossil groups.
II	Identify and classify common rock-forming minerals, ore minerals, industrial minerals, coal varieties, rocks, and fossils based on their diagnostic physical and morphological characteristics.
III	Apply mineralogical and petrological principles to distinguish and interpret unknown mineral, rock, and fossil specimens using standard identification techniques.
IV	Analyze geological map features by interpreting strike, dip, outcrop patterns, and construct geological sections for conformable sedimentary sequences.
V	Evaluate geological relationships and reconstruct subsurface structures by integrating data from mineral, rock, fossil identification, and geological map exercises.

Text Books / References Books	
1.	Klein, C. & Hurlbut, C.S. (2001). Manual of Mineral Science.
2.	Winter, J.D. (2010). Principles of Igneous and Metamorphic Petrology.
3.	Benton, M.J. (2014). Vertebrate Palaeontology.
4.	Boggs, S. Jr. (2006). Principles of Sedimentology and Stratigraphy.
5.	Evans, A.M. (1993). Ore Geology and Industrial Minerals.
6.	Berry, L.G., Mason, B. & Dietrich, R.V. (1983). Mineralogy: Concepts, Descriptions, Determinations.
7.	Yardley, B.W.D. (1989). An Introduction to Metamorphic Petrology.
8.	Clarkson, E.N.K. (2013). Invertebrate Palaeontology and Evolution.
9.	Kumar, R. (1985). Fundamentals of Historical Geology and Stratigraphy of India.
10.	Park, C.F. Jr. & MacDiarmid, R.A. (1964). Ore Deposits.

Web Resources	
1.	www.geosociety.org
2.	www.geolsoc.org.uk
3.	www.sepm.org
4.	www.stratigraphy.org
5.	www.ucmp.berkeley.edu

Summary of Course Outcomes (COs):

CO No.	Course Outcome Statement	Bloom's Level	Mapped POs
CO1	Identify and describe the physical properties, diagnostic characteristics, and classification of major rock-forming, ore, and industrial minerals.	Apply (K3)	PO1, PO2, PO3, PO5
CO2	Classify silicate, non-silicate, ore, industrial minerals, and coal varieties based on their composition, occurrence, and economic significance.	Apply (K3)	PO1, PO2, PO3, PO5, PO12
CO3	Identify and distinguish igneous, sedimentary, and metamorphic rocks using their textures, structures, mineral composition, and field characteristics.	Apply (K3)	PO1, PO2, PO3, PO5
CO4	Recognize and describe major fossil groups based on their morphology and geological significance for paleoenvironmental and stratigraphic interpretation.	Analyze (K4)	PO1, PO2, PO4, PO5
CO5	Interpret geological maps, determine strike and dip, construct geological sections, and analyze outcrop patterns in conformable rock sequences.	Analyze (K4)	PO1, PO2, PO3, PO4, PO5, PO8

CO–PO Mapping Matrix:

COs \ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	-	3	-	-	-	-	-	1	-
CO2	3	2	2	-	2	-	-	-	-	-	1	2
CO3	3	2	2	-	3	-	-	-	-	-	1	-
CO4	3	2	-	3	2	-	-	-	-	-	1	-
CO5	3	3	3	3	3	-	-	2	-	-	1	-