PERIYAR UNIVERSITY

NAAC 'A++' Grade – State University - NIRF Rank 59–
NIRF Innovation Band of 11-50

SALEM – 636 011, TAMIL NADU

DEPARTMENT OF GEOLOGY

UGC NON-SAP & DST-FIST Sponsored Department

M.Sc., Geology

Choice Based Credit System - CBCS

Effective from the Academic year 2024-2025 onwards and thereafter

July, 2024

LIST OF CONTENTS

DEPARTMENT OF GEOLOGY
Programme: M.Sc., GEOLOGY
CHOICE BASED CREDIT SYSTEM (CBCS)
Programme code: 514, Duration: 2 Years

TANSCHE –SYLLABUS
REGULATIONS

I. About the Programme

Periyar University offers M.Sc., Geology programme, 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.

Geology is an inter-disciplinary subject which enables to understand the earth processes and its treasures. It incorporates inputs from almost all science disciplines. Geologists are mainly involved in the exploration and extraction of natural resources viz., minerals, rocks, fossil fuel and water. As it is a fast growing area geologists will have to play a vital role in building the nation. They can also engage in geological research, which has immense potential in the current scenario.

II. Program Educational Objectives (PEOs)

PEO1: To demonstrate an understanding of the fundamental principles, concepts in theoretical and practical knowledge of the geological Science.

PEO2: Ability to recognize, evaluate, interpret, and understand issues and opportunities at the frontiers of geological domain.

PEO3: Ability to apply the basic knowledge of geology to real-life problems besides the use of computational and mathematical knowledge and tools.

PEO4: Work ethically and professionally alone and as part of a team, complying with applicable legislation and managing time and other resources efficiently and effectively and manage, execute their geological plans to meet desired goals realistic constraints.

PEO5: Communicate geological information concisely and accurately using written, visual, and verbal means appropriate to the situation.

III. Program Outcomes (POs)

PO1: Problem Solving Skill

Apply knowledge of Management theories and Human Resource practices to solve business problems through research in Global context.

PO2: Decision Making Skill

Foster analytical and critical thinking abilities for data-based decision-making.

PO3: Ethical Value

Ability to incorporate quality, ethical and legal value-based perspectives to all organizational activities

PO4: Communication Skill
Ability to develop communication, managerial and interpersonal skills.

PO5: Individual and Team Leadership Skill
Capability to lead themselves and the team to achieve organizational goals.

PO6: Employability Skill
Inculcate contemporary business practices to enhance employability skills in the competitive environment.

PO7: Entrepreneurial Skill
Equip with skills and competencies to become an entrepreneur.

PO8: Contribution to Society
Succeed in career endeavors and contribute significantly to society.

PO9: Multicultural competence
Possess knowledge of the values and beliefs of multiple cultures anda global perspective.

PO10: Moral and ethical awareness/reasoning
Ability to embrace moral/ethical values in conducting one’s life

IV. Program Specific Outcomes (PSOs)

PSO1: Placement
To prepare the students who will demonstrate respectful engagement with others’ ideas, behaviors, beliefs and apply diverse frames of reference to decisions and actions.

PSO2: Entrepreneur
To create effective entrepreneurs by enhancing their critical thinking, problem solving, decision making and leadership skill that will facilitate startups and high potential organizations.

PSO3: Research and Development
Design and implement HR systems and practices grounded in researches that comply with employment laws, leading the organization towards growth and development.

PSO4: Contribution to Business World
To produce employable, ethical and innovative professionals to sustain in the dynamic business world

PSO5: Contribution to the Society
To contribute to the development of the society by collaborating with stakeholders for mutual benefit

V. Eligibility for Admission

A candidate who has passed B.Sc. degree in Applied Geology/Geology of this university or an examination of any other university accepted by the Syndicate as equivalent thereto shall be permitted to appear and qualify for the M.Sc., Geology Degree examinations of this university after a course of two academic years, in the Department of Geology, Periyar University.

VI. Duration of the Programme

The course for the degree of Master of Science in Geology shall consist of two academic years divided into four semesters. Each Semester consists of 90 working days.

VII. List of Courses

Template for P.G., Programmes

Semester–I	*Credit*	*Hours*	*Semester-II*	*Credit*	*Hours*	*Semester-III*	*Credit*	*Hours*	*Semester–IV*	*Credit*	*Hours*
1.1. Core-I	5	7	2.1. Core-IV	5	6	3.1. Core-VII	5	6	4.1. Core-XI	5	6
1.2 Core-II	5	7	2.2 Core-V	5	6	3.2 Core-VIII	5	6	4.2 Core-XII	5	6
1.3 Core – III	4	6	2.3 Core – VI	4	6	3.3 Core – IX	5	6	4.3 Project with viva voce	7	10
1.4 Discipline Centric Elective -I	3	5	2.4 Discipline Centric Elective – III	3	4	3.4 Core – X	4	6	4.4Elective - VI (Industry / Entrepreneurship) 20% Theory 80% Practical	3	4
1.5 Generic Elective-II:	3	5	2.5 Generic Elective -IV:	3	4	3.5 Discipline Centric Elective - V	3	3	4.5 Skill Enhancement course / Professional Competency Skill	2	4
			2.6 NME I	2	4	3.6 NME II	2	3	4.6 Extension Activity	1	
						3.7 Internship/ Industrial Activity	2	-			
	20	**30**		**22**	**30**		**26**	**30**		**23**	**30**
Total Credit Points -91											

Choice Based Credit System (CBCS), Learning Outcomes Based Curriculum Framework (LOCF) Guideline Based Credits and Hours Distribution System for all Post – Graduate Courses including Lab Hours

First Year – Semester – I

Part	List of Courses	Credits	No. of Hours
	Core – I	5	7
	Core – II	5	7
	Core – III	4	6
	Elective – I	3	5
	Elective – II	3	5
		20	**30**

Semester-II

Part	List of Courses	Credits	No. of Hours
	Core – IV	5	6
	Core – V	5	6
	Core – VI	4	6
	Elective – III	3	4
	Elective – IV	3	4
	Skill Enhancement Course [SEC] - I	2	4
		22	**30**

Second Year – Semester – III

Part	List of Courses	Credits	No. of Hours
	Core – VII	5	6
	Core – VIII	5	6
	Core – IX	5	6
	Core (Industry Module) – X	4	6
	Elective – V	3	3
	Skill Enhancement Course - II	2	3
	Internship / Industrial Activity [Credits]	2	-
		26	**30**

Semester-IV

Part	List of Courses	Credits	No. of Hours
	Core – XI	5	6
	Core – XII	5	6
	Project with VIVA VOCE	7	10
	Elective – VI (Industry Entrepreneurship)	3	4
	Skill Enhancement Course – III / Professional Competency Skill	2	4
	Extension Activity	1	-
		23	**30**

M.Sc., Geology Programme Structure and Scheme for the Students Admitted in the Year 2024-2025 onwards

Sem-ester	Course Code	Title of the Courses	Credits	Hours	Int. Marks	Ext. Marks	Total Marks
I	24UPGEO1C01	Physical Geology and Geomorphology	4	5	25	75	100
	24UPGEO1C02	Mineralogy and Instrumentation Techniques	4	5	25	75	100
	24UPGEO1C03	Recent Trends in Paleontology	4	5	25	75	100
	24UPGEO1C04	Stratigraphy of India and Its Application	4	5	25	75	100
	24UPGEO1L01	Mineralogy and Paleontology– *Laboratory Practical-I*	3	6	40	60	100
	24UPGEO1E__	Elective Course (I Or II)	3	4	25	75	100
	24UPGEO1X01	Geological Field Training	1	*	25	75	100
		Total	***23***	***30***	***190***	***510***	***700***
II	24UPGEO1C05	Structural Geology and Geotectonics	4	6	25	75	100
	24UPGEO1C06	Applied Petrology	4	6	25	75	100
	24UPGEO1C07	Economic Geology	4	6	25	75	100
	24UPGEO1L02	Structural Geology, Petrology and Economic Geology- *Laboratory Practical-II*	3	6	40	60	100
	24UPGEO1E__	Elective Course (III Or IV)	3	4	25	75	100
	24UPPGC1H01	Fundamental of Human Rights	1	2	25	75	100
	———	NME-I, Online Course *(SWAYAM, MOOC, NPTEL etc.,)*	2	*	00	100	100
		Total	***21***	***30***	***165***	***535***	***700***
III	24UPGEO1C08	Applied Geophysics	4	5	25	75	100
	24UPGEO1C09	Applied Remote Sensing and GIS	4	5	25	75	100
	24UPGEO1C10	Hydrogeology	4	5	25	75	100
	24UPGEO1C11	Geological Field Mapping	4	4*	25	75	100
	24UPGEO1L03	Geophysics and Hydrogeology & Remote Sensing and GIS –*Laboratory Practical -III*	3	5	40	60	100
	24UPGEO1E__	Elective Course (V Or VI)	3	4	25	75	100
	24UPGEO1N__	NME-II Supportive Courses	2	2	25	75	100
	24UPGEO1I01	Internship / Industrial Activity (During Vacation at the end of First Year)	2	*	25	75	100
		Total	***26***	***30***	***215***	***585***	***800***
IV	24UPGEO1C12	Engineering and Mining Geology	4	5	25	75	100
	24UPGEO1C13	Applied Geochemistry	4	5	25	75	100
	24UPGEO1L04	Engineering and Mining Geology &Geochemistry – *Laboratory Practical-IV*	3	6	40	60	100
	24UPGEO1P01	Project with Viva-voce	7	10	50	150	200
	24UPGEO1E__	Elective Course(VII Or VIII)	3	4	25	75	100
	24UPGEO1S01	Skill Enhancement Course: *(NSDC-SSC)* SCMS-Mining Mate	2	*	25	75	100
		Total	***23***	***30***	***190***	***510***	***700***
		Grand Total	***93***	***120***	***760***	***2140***	***2900***

Note: UP-University Programme, GEO1- Geology Programme1, C- Core Course, E–Elective Course, S-Skill Enhancement, L- Laboratory Practical, P – Project, N/NME-Non Major Elective, H-Fundamental Human Rights, X- Extension Activities (Geological Field Training for 7-10 days/60 hours), I* – Internship (15 days), *Geological Field Mapping for 10-12 days/60 hours, SWAYAM - Study Webs of Active Learning for Young Aspiring Minds, MOOC-Massive Open Online Courses, NPTEL- National Programme on Technology Enhanced Learning, NSDC-National Skill Development Corporation, SSC-Sector Skill Council, SCMS-Skill Council for Mining Sector.*

Credits for M.Sc., Geology Program	
Core Courses	13 x 4 = 52
Core Laboratory Practical	4 x 3 = 12
Core Project	1 x 7 = 7
Elective Courses	4 x 3 = 12
Non-Major Elective (NME) Courses	2 x 2 = 4
Fundamental of Human Rights	1 x 1 = 1
Skill Enhancement	1 x 2 = 2
Internship	1 x 2 = 2
Geological Field Training	1 x 1 = 1
Total Credits	**93**

Furthermore, the TANSCHE, Govt. of Tamil Nadu, recommends the candidates to select Non Major Elective two credit courses (NME-I) to be adopted as online course from the platforms such as SWAYAM, MOOC, NPTEL etc., for Even Semester. The fee for these course works will be prescribed by the Controller of Examinations in concurrence with the authorities of Periyar University, Separate certificate will be issued and these exam credits will be included in the Academic Bank Credit (ABC) portal of the candidate. For NME-II (to be offered during odd semester) students should take any one of the courses offered by other Departments. It has to be taught in the last two hours on Tuesdays.

Elective Courses (Including Discipline Centric, Generic, Industry / Entrepreneurship)							
Sl. No.	***Course Code***	***Title of the Course work***	***Credits***	***Hours***	***Int. Marks***	***Ext. Marks***	***Total Marks***
I	24UPGEO1E01	Geo-statistics	3	4	25	75	100
II	24UPGEO1E02	Geo-heritage and Geo-tourism	3	4	25	75	100
III	24UPGEO1E03	Environmental Earth Science	3	4	25	75	100
IV	24UPGEO1E04	Applied Micropaleontology	3	4	25	75	100
V	24UPGEO1E05	Isotope Geology	3	4	25	75	100
VI	24UPGEO1E06	Disaster Management	3	4	25	75	100
VII	24UPGEO1E07	Oceanography and Climatology	3	4	25	75	100
VIII	24UPGEO1E08	Petroleum Exploration and Mud Logging	3	4	25	75	100
NME-I, SWAYAM Courses *(Study Webs of Active Learning for Young Aspiring Minds-SWAYAM)*							
Sl. No.	***Course Code***	***Title of the Course work***	***Credits***	***Hours***	***Int. Marks***	***Ext. Marks***	***Total Marks***
01	--	***Based on Courses offered by SWAYM Portal***	2	4	00	100	100
Non-Major Elective (NME-II) Courses (Offered to Other University Departments)							
Sl. No.	***Course Code***	***Title of the Course work***	***Credits***	***Hours***	***Int. Marks***	***Ext. Marks***	***Total Marks***
1	24UPGEO1N01	Earth and Environment	2	4	25	75	100
2	24UPGEO1N02	Water Resources Management	2	4	25	75	100
3	24UPGEO1N03	Gemmology	2	4	25	75	100
4	24UPGEO1N04	Rainwater Harvesting and Artificial Groundwater Recharge	2	4	25	75	100
5	24UPGEO1N05	Geohazards	2	4	25	75	100
Skill Enhancement Courses (offered by NSDC-SSC)							
Sl. No.	***Course Code***	***Title of the Course work***	***Credits***	***Hours***	***Int. Marks***	***Ext. Marks***	***Total Marks***
1	24UPGEO1S01	NSDC-SCMS-Mining Mate	2	4	25	75	100
Value Added (VA) Courses (Certificate will be issued separately – Through Online Mode)-*Semester-IV*							
Sl. No.	***Course Code***	***Title of the Course work***	***Credits***	***Hours***	***Int. Marks***	***Ext. Marks***	***Total Marks***
1	24UPGEO1VA1	Hydrology and Water Management (or)	2	30	25	75	100
2	24UPGEO1VA2	Environmental Studies and Earth Sciences	2	30	25	75	100
Add On (AO) Courses (Certificate will be issued separately – Through Online Mode) - *Semester-IV*							
Sl. No.	***Course Code***	***Title of the Course work***	***Credits***	***Hours***	***Int. Marks***	***Ext. Marks***	***Total Marks***
1	24UPGEO1AO1	Medical Geology	2	30	25	75	100
2	24UPGEO1AO2	Petroleum Geology	2	30	25	75	100
3	24UPGEO1AO3	Groundwater exploration	2	30	25	75	100

Extra Credits	
Credits for Value Added Courses	2 x 2 = 4
Credits for Add On Courses	3 x 2 = 6
Total Credits	**10**

VIII. Semester

An academic year consists of two semesters. The Normal semester periods are

- Odd Semester : July to November
- Even Semester: December to April

Each semester has 18 teaching weeks with working hours spread over 5 days a week.

IX. Teaching Methodologies

The classroom teaching would be through conventional lectures and use of power point presentation and field demonstration. The lecture would be such that the student should participate actively in the discussion. The Student seminars would be conducted and scientific discussions would be arranged to improve their communicative skill. In the laboratory, instruction would be given for the experiments/exercise followed by demonstration and finally the students have to do the experiments individually. Periodic tests are conducted for the students, In the case of slow learners; they will be given special attention.

X. Course Components

Core courses

Core courses are compulsory basic subjects in the programme offered by the department. Each core course carries 4 credits. Core courses offered by one department will not be treated as elective by other. Core courses include theory, practical, project work, geological mapping, internship, training, field training and industrial visits. Students can be permitted to carry out project works at reputed institutions and industries.

Elective courses

Elective courses (disciplinary) are offered by the parent department. Each elective course carries 4 credits.

Soft Skills

Soft Skillis aimed at bridging the gap in the curricula and to learn the advancements in other disciplines. The department, in consultation with other departments, will offer supportive courses during I, II III & IV semesters. Similarly, students from Geology Department will study the supportive course from other department.

Compulsory Course

A course on Human rights-Duties is compulsory in the II semester.

XI. SWAYAM Courses

Massive Open Online Course (MOOC) introduced to the students to help them compare their course content with that of the eminent faculty across the country. MOOC online course is available in the SWAYAM and SWAYAM PRABHA MHRD web portal.

All the master level students must enroll and complete two MOOC courses related to their discipline of study.

XII. Extension Activities (Field Work/Training)

Geological field mapping is included in the second semester and its participation is a mandatory requirement. The training is to be scheduled in a single batch for duration of maximum 15 days. It may be guided by faculty members in any place which is geologically significant region within India. Alternatively, the student may be attached to an organization engaged in geological field work (say Geological survey of India) for imparting training.

XIII. Credits

The quantum of syllabus for various programs in terms of hours of study. It indicates differential weightage given according to the contents and duration of the courses in the curriculum design. The minimum credit requirement for a two-year Master's programme shall be 90.

XIV. Course weightage

A course carrying one credit for lectures will have instruction of one period per week during the semester. If four hours of lecture are necessary in each week for that course, then 4 credits will be the weighted. Thus, normally in each of the courses, credits will be assigned on the basis of the lectures/ tutorials/ laboratory work and other forms of learning in a 18-week schedule.

XV. Evaluation

Evaluation will be done on a continuous basis during the course work through class test and midterm exams. Evaluation may be done by objective type questions, short answers, essays or a combination of these, but the end semester examination is a written examination.

XVI. Attendance

Every teaching faculty handling a course shall be responsible for the maintenance of the common attendance register being maintained in the department for the candidates who have registered for the course.

The student should earn 75% attendance in the courses of that particular semester failing which; he /she will not be permitted to sit for the End-Semester Examination. The student has to repeat the semester in the next year.

XVII. Examinations

There shall be four examinations, each at the end of the semester. Candidates failing in any subject/ subjects will be permitted to re-appear for subsequent semesters as per University norms.

The practical examinations will be conducted at the end of the first, second and third semester. Candidates failing in any of the practical examination / examinations will be permitted to appear for such failed practical examination/ examinations at corresponding subsequent practical examinations.

XVIII. Scheme of Examination

Scheme of examination will be followed as per TANSCHE direction.

XIX. Passing Minimum

A candidate has to secure a minimum of 50% mark in each course and earn a minimum of 90 credits for the award of a Master's degree.

XX. Distribution of Marks

Theory

University Examination (External)	:	75 marks
Internal Assessment	:	25 marks

Distribution of Internal Assessment mark

Test	:	10 marks
Attendance	:	5 marks
Assignment	:	5 marks
Seminar	:	5 marks
Total Marks	:	25 marks

Passing Minimum: Internal Assessment	: No Minimum for Internal assessment
Passing Minimum: External Assessment	: 50% - 38 marks (Mandatory)
Total Passing Minimum	: 50 marks

Practicals

Internal Assessment	:	No Minimum for Internal assessment
University Examination (External)	:	60 marks
Total Passing Minimum	:	50 marks

XXI. Calculation of Internal Assessment mark

Attendance	:	05 marks
Practical Record Notes	:	10 marks
Practical Test	:	10 marks
Geological Field work, Sample Display and Report	:	15 marks
Total Marks	:	40 marks

Passing Minimum: Internal Assessment: 50% - 20 marks

Passing Minimum: External Assessment: 50% - 30 marks

Total Passing Minimum : 50 marks

Everything should be supported by proper record separate passing minimum is necessary for Internal and External.

XXII. Project/Dissertation

The student should undertake an individual project work during fourth semester under the guidance and supervision of a faculty. A faculty member may supervise the work of more than one student in related fields of study in adjacent field areas, but should be separate on topics. He/ she should choose a topic within the purview of the course curriculum. The work can be done in collaboration with the scientific research institutes/establishment/academic institutions on cooperating co-guides from that organization.

The student should submit a thesis (certified as authentic and bonafide by both supervising teacher and Head of the Department) prior to attending via-voce. The work done should be presented before the examiners and part of viva-voce. Submission of thesis prior viva-voce and presentation during it are mandatory requirements, without which course will be incomplete. If the candidate failed to attend the viva-voce, they are permitted to appear at the subsequent viva-voce examination.

Project Evaluation

Internal Assessment	:	50
Report Evaluation	:	50
Viva –Voce Examination	:	100
		……………………..
Total Marks	:	200
		……………………..

XXIII. Question Paper Pattern

Time: 3 Hours　　　　Max. Marks – 75

PART- A Objective Type: 20x1=20

(Answer all questions)

(Four questions from each unit)

PART-B Analytical Type: 3 x 5=15

(Answer any three questions)

(One question from each unit)

PART- C Descriptive Type: 5x8=40

(Answer all questions)

(One question from each unit with either or type)

XXV. Syllabus

Semester – 1

Semester – 1: Physical Geology and Geomorphology (1st year)

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
24UPGEO1C01	**Physical Geology and Geomorphology**	Core	Y	-	-	-	4	5	25	75	100

Course Objectives			
CO1	To interpret natural processes which act on the Earth's surface and the landforms		
CO2	To recall the types of landforms and quaternary landscapes		
CO3	To employ geomorphological studies for structural and mineral exploration		
CO4	To understand the pedochemical process responsible for the dissolution rate.		
CO5	To identify different processes involved different geological landforms.		
UNIT	**Details**	**No. of Hours**	**Course Objectives**
I	Earth and its internal structure, composition, size and shape. An overview of plate tectonics including elementary concepts of plates, lithosphere, asthenosphere, types of plate boundaries and associated important geological features like oceanic trenches, volcanic arcs, accretionary wedges, topography of mid-ocean ridges and transform faults. Palaeomagnetism and its application for determining palaeoposition of continents. Isostasy, Orogeny and Epeirogeny.	12	CO1
II	Concepts of geomorphology. Landforms in relation to climate, lithology, and structure. Earthquakes and related landscape alterations, Seismic belts of the earth. Seismicity at plate boundaries.	12	CO2
III	Geomorphic Processes – Geomorphic Agents, weathering, pedogenesis, mass movement, erosion, transportation and deposition.	12	CO3
IV	Geomorphic landforms – fluvial, glacial, Aeolian ,coastal, volcanoes and karst.	12	CO4
V	Quaternary landscapes. Major geomorphic features of India: Fluvial landscapes, Aeolian landscapes, coastal landscapes.	12	CO5
	Total	**60**	

Text Books	
1.	Holmes, D.L. (1981) Principles of Physical Geology.ELBS Edition.
2.	Pethick, J. (1984) An Introduction to Coastal Geomorphology. Arnold, London.
3	Thornbury, W.D. (1969) Principles of Geomorphology.Wiley Eastern Ltd.
4	RicharHuggett, Fundamentals of Geomorphology
5	Strahler, A.N. (1952) Physical Geology. John Wiley & Sons Inc., New York.

References Books (Latest editions, and the style as given below must be strictly adhered to)	
1.	Holmes, D.L. (1981) Principles of Physical Geology.ELBS Edition.
2.	Pethick, J. (1984) An Introduction to Coastal Geomorphology. Arnold, London.
3.	Thornbury, W.D. (1969) Principles of Geomorphology.Wiley Eastern Ltd.
4.	RicharHuggett, Fundamentals of Geomorphology
5.	Strahler, A.N. (1952) Physical Geology. John Wiley & Sons Inc., New York.

Web Resources	
1.	https://journals.sagepub.com/home/jom

2.	https://www.americangeosciences.org/
3.	https://www.egu.eu/
4.	https://www.geosociety.org/

Course outcome:
CO1: Basic knowledge about the internal structure of earth,
CO2: Students studiedthe plate tectonics theory.
CO3: Get knowledge about the Landform: Exogenic and endogenic processes
CO4: Learn the Landform and tectonics Drainage pattern, sea level change and geomorphic cycle.
CO5: Students can introduce the basis of Quaternary landscapes

In order to avoid pull the score down of each PO, it is suggested that the usage L-Low (1) to the minimum.
The S, M, L is based on the course outcome. The mapping is based on the revised Bloom's Taxonomy Verbs used to describe your course outcome.

- Remember and Understanding – Lower level
- Apply and Analyze – Medium Level
- Evaluate and Create – Strong Level

Mapping with Programme Outcomes:

	PO 1	*PO 2*	*PO 3*	*PO 4*	*PO 5*	*PO 6*	*PO 7*	*PO 8*
CO 1	3	3	3	2	3	3	3	2
CO 2	3	3	3	3	3	3	3	3
CO 3	3	2	3	3	3	3	3	1
CO 4	2	3	3	3	2	3	3	3
CO 5	3	3	2	3	3	3	3	3

S-Strong-3 ; M-Medium -2 ; L-Low-1.
Program Specific Outcomes

CO/PO	*PO 1*	*PO 2*	*PO 3*	*PO 4*	*PO 5*
CO 1	3	3	3	3	3
CO 2	3	3	3	3	3
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course contribution to Pos	3.0	3.0	3.0	3.0	3.0

Semester- I: Mineralogy and Instrumentation Techniques (1st year)

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
24UPGEO1C02	Mineralogy and Instrumentation Techniques	Core	Y	-	-	-	4	5	25	75	100

Course Objectives

CO1	The students will be able to understand and explain the basic of mineral characteristics.
CO2	Will be able to employ their practical knowledge in further studies.
CO3	Can recall techniques for certain necessities.
CO4	Can evaluate the accuracy and summaries the methods adapted for certain practical activities.
CO5	Can explain and summarise problem.

UNIT	Details	No. of Hours	Course Objectives
I	Introduction to crystallography – Crystal systems – Symmetry elements – Isometric, Tetragonal, Orthorhombic, Hexagonal, Monoclinic and Triclinic systems – Normal classes.	12	CO1
II	Stereographic projections – Axial ratio – Zones and zonal symbols – Tautozonal faces – Equation of the normal – Napier's Theorem – Tangent relations – Sine ratio – Cosine ratio.	12	CO2
III	Description and composition of the following mineral groups: Quartz, Feldspars, Feldspathoids, Micas, Garnets, Olivine, Pyroxenes, Amphiboles, Zeolites and Carbonate minerals.	12	CO3
IV	Introduction to Optical Mineralogy Electrical, magnetic and optical properties of minerals – Properties of light – Transmissivity and Reflectivity – Polarization – Extinction – Dichroism – Pleochroism – Interference colors – Refringence and Birefringence – Order of interference – Conoscopy – Interference figures - Concepts of crystal field theory and mineralogical spectroscopy.	12	CO4
V	Spot tests – Paper chromatography – Nephelometry – Turbidimetry – Spectroscopy – Flame photometry – X-ray spectroscopy – UV spectroscopy – Mass spectroscopy – Accelerated mass spectroscopy.	12	CO5
	Total	**60**	

1.	Donald Bloss F. (1971) Crystallography and Crystal Chemistry – An Introduction published by Holt, Rinehart and Winston, Inc., New York.
2.	William M. Blackburn and William H. Dennen (1988) Principles of Mineralogy (Second Edition) published by WCB Publishers England.
3.	Kerr P.F, Optical Mineralogy, 4th ed McGraw Hill New York (1977)
4.	Gribble C.D. &A.J. Hall, A. Practical Introduction to Optical Mineralogy,Springer.London(1985)
5.	Tisljar, S.K. Haldar, Josip (2013). Introduction to mineralogy and petrology. Burlington: Elsevier Science. ISBN 9780124167100.

References Books
(Latest editions, and the style as given below must be strictly adhered to)

1.	Cornelis Klein and Cornelius S. Hurlbut, Jr. (1993) Manual of Mineralogy published by John Wiley & Sons, Inc. Singapore.
2.	Paul F. Kerr (1967) Optical Mineralogy, John Wiley & Sons, New York.
3.	Wenk, Hans-Rudolf; Bulakh, Andrey (2016). Minerals: Their Constitution and Origin. Cambridge University Press. ISBN 9781316425282.
4.	Whewell, William (2010). "Book XV. History of Mineralogy". History of the Inductive Sciences:

	From the Earliest to the Present Times. Cambridge University Press. pp. 187–252. ISBN 9781108019262.
5.	Laudan, Rachel (1993). From mineralogy to geology : the foundations of a science, 1650-1830 (Pbk. ed.). Chicago: University of Chicago Press. ISBN 9780226469478.
Web Resources	
1.	https://mineralogy-ima.org/
2.	https://www.socminpet.it/dwl.php?file=SIMP/GNM/SIMP_ELEM.pdf
3.	https://www.mineralogicalassociation.ca/
4.	https://www.cambridge.org/core/societies/mineralogical-society-of-great-britain-and-ireland
5.	http://www.minsocam.org/

Course outcome

CO1: Basic knowledge on crystal structures and bonding and laws

CO2: student can learn about the Silicate structures and their physical and chemical properties

CO3: students get knowledge about the description and composition the minerals

CO4: Student gain knowledge on Optical mineralogical studies

CO5: student apply the instrumentation techniques in mineralogical studies

Mapping with Programme Outcomes:

Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low

	PO 1	***PO 2***	***PO 3***	***PO 4***	***PO 5***	***PO 6***	***PO 7***	***PO 8***	***PO 9***	***PO 10***
CO 1	3	2	2	3	1	2	3	2	1	2
CO 2	3	2	2	3	1	2	3	2	1	2
CO 3	3	2	2	3	1	2	3	2	1	2
CO 4	3	2	2	3	1	2	3	2	1	2
CO 5	3	2	2	3	1	2	3	2	1	2

S-Strong-3 ; M-Medium -2 ; L-Low-1.

Program Specific Outcomes

CO/PO	***PSO 1***	***PSO 2***	***PSO 3***	***PSO 4***	***PSO 5***
CO 1	3	3	3	3	3
CO 2	3	3	3	3	3
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course contribution to Pos	3.0	3.0	3.0	3.0	3.0

Semester-I: Recent Trends in Paleontology (1st year)

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
24UPGEO1C03	**Recent Trends in Paleontology**	Core	Y	-	-	-	4	5	25	75	100

Course Objectives

CO1	Learn about the origin and evolution of life, understanding species concept and study of the major events in the history of Precambrian and Phanerozoic life. Detailed study about vertebrate paleontology.
CO2	Learn about the morphology, classification, evolutionary trend, composition and structure of shells of selected groups of organisms.
CO3	To explain about geological history, geographical distribution and description of more important genera
CO4	Demonstrating the sampling methods and sample processing techniques of micropaleontology.
CO5	To know about the application of micropaleontology in hydrocarbon exploration.

UNIT	Details	No. of Hours	Course Objectives
I	Fossil record and geological time-scale. Evolutionary changes in molluscs and mammals in geological time. Principles of evolution. Use of species and genera in biostratigraphic correlation. Functional morphology, evolution and significance of Plant Fossils, Fishes, Horse, Elephant and Man. Taphonomy and environmental factors, Oxygen and Carbon isotope studies of fossils and paleoclimates – Palaeobiogeographic Provinces.	12	CO1
II	Theories on origin and evolution of life – Phylogenetic and Ontogenic Analysis – Species Concept – Types of Fossils and Types of Species – Palingensis – Coenogensis – Proterogenesis - Thanatocoenosis – Biocoenosis – Sidocoenosis - Biomineralisation and Trace Fossils – Fossils and their uses – Biometrics – Major events in the history of Precambrian and Phanerozoic life.	12	CO2
III	Vertebrate paleontology: Succession of vertebrate life through geologic time. Broad classification and study of some characteristic Indian vertebrate genera. Indian pre-Tertiary vertebrate - their distribution and paleogeographic implication; extinction of dinosaurs. Indian Tertiary vertebrate - Siwalik mammals; phylogeny - Equidae and Proboscidae.Indian fossil Hominoides and modern theories regarding human evolution.	12	CO2
IV	Invertebrate paleontology: an overview. Morphology, classification, evolutionary trend, composition and structure of shells of selected groups of organisms - Porifera, Bryozoa, Mollusca, Brachiopoda. Geological history, geographical distribution and description of important genera of Trilobita, Echinoides, Coelenterata and Graptoloidea.	12	CO2
V	Micropaleontology: Sampling methods and sample processing techniques. Types of microfossils.Calcareous Microfossils - Foraminifera - major morphologic groups; Benthic Foraminifera; depth biotopes, value in paleobathymetric determination.Larger foraminifera – their utility in Indian stratigraphy.Planktonic foraminifera and calcareous nannofossils.Ostracoda - outline morphology, paleoecology	12	CO2

	& geological history. Brief knowledge about Pteropods, Calpionellids, Calcareous algae, Siliceous algae, Radiolaria and Conodonts.Application of micropaleontology in hydrocarbon exploration.Different microfossil groups and their distribution in India.		
	Text Books		
1.	Palaeontology Evolution and animal distribution. .C. Jain and M.S. Anantharaman, (1996), Vishal Publications, Jalandhar.		
2.	Invertebrate Palaeontology - H.Woods, (1985), CBS Publishers and Distributors, New Delhi.		
3.	Agashe, S.N, Paleo botany, Oxford & IBH. Delhi(1995)		
4.	Stewart W.N. & G.W. Rothwell, Palaeobotany, Cambridge University Press. D 2005)		
5.	Moore R.C. et al., Invertebrate Fossils. CBS. Delhi (1952).		
References Books (Latest editions, and the style as given below must be strictly adhered to)			
1.	Principles of Invertebrate Palaeontology, Shrock R.R and Twenohofel W.H, (2005), CBS Publishers and Distributors, New Delhi.		
2.	Invertebrate Fossils. Moore R.C, Lalicker C.G and Fisher A.G (1952) McGraw Hill.		
3.	The Vertebrate Story, Romer A.S, (1959) University of Chicago Press, 4th Edt. Chicago.		
4.	Palaeontology An Introduction, E.W.Nield and V.C.T.Tucker (1985) Pergamon Press, Oxford.		
5.	Colbert E.H. et al.,Evolution of the Vertebrates, Wiley. New Delhi 2002)		
Web Resources			
1.	https://en.wikipedia.org/wiki/Age_of_Earth		
2.	https://www.lyellcollection.org/doi/10.1144/GSL.SP.2001.190.01.14.		
3.	https://digitalatlas.cose.isu.edu/geo/basics/fossil.htm		
4.	https://www.sciencedirect.com/topics/immunology-and-microbiology/hemichordata		
5.	https://www.qm.qld.gov.au/Explore/Research/Biodiversity		

Course outcome:

CO1: Student can understand about the fossil record and geological time-scale

CO2: To get knowledge about the theory and Origin of life

CO3: Students get more knowledge about vertebrate paleontology

CO4: Students get more knowledge about Invertebrate paleontology

CO5: Student gain knowledge on micropaleontology: Sampling methods and sample processing techniques

Mapping with Programme Outcomes:

Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low

	PO 1	***PO 2***	***PO 3***	***PO 4***	***PO 5***	***PO 6***	***PO 7***	***PO 8***	***PO 9***	***PO 10***
CO 1	2	3	1	3	3	1	3	2	3	2
CO 2	2	3	1	3	3	1	3	2	3	2
CO 3	2	3	1	3	3	1	3	2	3	2
CO 4	3	3	3	3	3	3	2	3	3	3
CO 5	3	3	3	3	3	3	2	3	3	3

S-Strong-3 ; M-Medium -2 ; L-Low-1.

Program Specific Outcomes

CO/PSO	***PSO 1***	***PSO 2***	***PSO 3***	***PSO 4***	***PSO 5***
CO 1	3	3	3	3	3
CO 2	3	3	3	3	3
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course contribution to Pos	3.0	3.0	3.0	3.0	3.0

Semester-I: Stratigraphy of India and its Applications (1st year)

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
24UPGEO1C04	**Stratigraphy of India and its Applications**	Core	Y	-	-	-	4	5	25	75	100

Course Objectives

CO1	Can recall the Stratigraphy of India.
CO2	Can differentiate different deposits of geological time.
CO3	To understand and compare different applications related to Stratigraphy.
CO4	Can interpret the sequence of stratigraphic column.
CO5	Can identify different processes involved during different geological time.

UNIT	Details	No. of Hours	Course Objectives
I	**Stratigraphy of India –** Tectonic divisions, Cratons and Mobile belts of India. Dharwar Supergroup – Mineral riches of Archaean. Cuddapah System and its mineral riches. Vidhyan System and its mineral riches. Cambrian, Ordovician and Silurian Systems. Paleozoic Formations of India. Precambrian-Cambrian (pC/C) boundary.	12	CO1
II	**Stratigraphy of India (Contd.) -** Devonian and Carboniferous Systems. Gondwana Super group – Classification and Age, Stratigraphy and Structure, Life, Climate and Sedimentation– Economic importance of Gondwana Sequences. Carboniferous and Permian Systems – Triassic System – Lilang System – Permo-Triassic (P/T) Boundary- Jurassic System – Jurassic of Kutch - Cretaceous System – Cretaceous of Trichinopoly/ Tiruchirappalli, Mahadek Formation, Bagh beds. Cretaceous-Tertiary (K/T) Boundary.	12	CO2
III	**Stratigraphy of India (Contd**.) - Deccan Traps – Lameta Formation – Infra- and Inter-trappean beds – Age of Deccan Traps – Economic riches of Deccan Traps. Cenozoic History – Tectonics - Magmatic activity, Climate, Life, Rise of the Himalayas – Siwalik Group, Tertiary of Assam-Arakan region, Andaman-Nicobar Islands, Niniyur Formation, Cuddalore Formation, Quilon Formation. Neogene-Quaternary boundary. Quaternary tectonic activity, climate changes, sea level changes, fossil primates/ early man in India. Coastal sediments and its useful mineral deposits, Karewa Formation, Potwar Silts and Loess – Indo-Gangetic alluvium.	12	CO2
IV	**Applications of Stratigraphy** –Principles of Stratigraphy– Stratigraphic Classification and Correlation - Geological Time Scale - Geological time – Chronostratigraphic and time Units – Geochronology. Categories of Stratigraphic Classification – Incompleteness of the Rock record. Stratotypes and Type Localities - Golden spikes – Global Standard Section and Point (GSSP). Lithostratigraphy - Stratigraphic relationships - Lithostratigraphic Units – Lithodemic units – Application of Lithostratigraphy. Biostratigraphy – Nature of Biostratigraphic Units - Fossils and Stratigraphy –– Biozones – Types of Biostratigraphic Units – Biostratigraphic correlation – Relationship of biostratigraphic Units to	12	CO2

	other stratigraphic units. Chronostratigraphy- classification, Chronostratigraphic Units and equivalent Geochronologic Units.		
V	**Applications of Stratigraphy** (Contd.) - Dating and correlation techniques – Radiometric dating – Application of radiometric dating – Other isotopic and chemical techniques – Chemo stratigraphy. Magneto stratigraphy. Introduction to seismic and cyclo- and event startigraphy. Sequence stratigraphy - Causes and controls of sequence development - Sea-level changes - Sea level changes and sedimentation – Depositional sequences and systems tracts – Parasequences– Sequence stratigraphy of carbonates– Sequence stratigraphy of siliciclastics — Applications of sequence stratigraphy	12	CO2
	Text Books		
1.	Geology of India and Burma M.S. Krishnan, (2010), 6th Edi., C.B.S publishers and Distributors, Delhi		
2.	Geology of India, D.N. Wadia, (1984), Tata McGraw Hill,		
3.	Fundamentals of Historical Geology and Stratigraphy of India, Ravindrakumar (1988), Wiley Eastern ltd, New Delhi.		
4.	M.Ramakrishnan&Vaidyanadhan.R. Geology of India. Vol. I, Geological Society of India. Bangalore(2008).		
5.	Vaidyanadhan.R&M.Ramakrishnan, Geology of India. Vol. II, Geological Society of India. Bangalore(2010)		
6.	Mehdiratta. R.C,Geology of India, Pakistan, Bangladesh and Burma. Atma Ram &Sons.Delhi(1974)		
7.	Pascoe, E.H. (1968) A Manual of the Geology of India & Burma (Vols.I-IV) Govt. of India Press, Delhi		
References Books (Latest editions, and the style as given below must be strictly adhered to)			
1.	Doyle, P. & Bennett. M.R. (1996) Unlocking the Stratigraphic Record (John Willey).		
2.	Stratigraphy: A Modern Synthesis. Andrew D. Miall. 2016. Springer**.**		
3.	Principle of Stratigraphy, Dunbar and Roggers, (1964), John Wiley and co, New York		
4.	An Introduction in Stratigraphy, Stamp L.D, (1964), Thomas Murby, Museum St, WCI, London.		
5.	Stratigraphic Principles and Practices, Weller, J.M, (1962), Harper & Bros, New York		
6.	Ramkumar, M., (2015)Chemostratigraphy: Concepts, techniques and applications. Elsevier. The Netherlands.		
7.	Neil Craigie 92018). Principles of Elemental Chemostratigraphy - A Practical User Guide. Springer. ISBN-978-3-319-71215-4.		
8.	Robert, M. S. (1989) Stratigraphy: Principles and Methods, Van Nostrand Reinhold, New York.		
9.	International Stratigraphic Guide — An abridged version. Edited by Murphy and Salvador, Episodes, Vol. 22, no. 4, pp.255-271.		
10.	International Stratigraphic Guide. Hedberg. H.D. 1976. Jhon Wiley & Sons		
11.	Code of Stratigraphic Nomenclature of India. Geological Survey of India. Miscellaneous Publication No. 20. (1977)		
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/		

Course outcome:

CO1: Students studied and gain knowledge on Dharwar Super group – Mineral riches of Archaean.

CO2: Students able to understand about the Gondwana Group and its stratigraphy

CO3: Students get knowledge on Deccan traps

CO4: Students understand the Stratigraphy of India

CO5: Students used to study the Applications of Stratigraphy

Mapping with Programme Outcomes:

Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low

	PO 1	*PO 2*	*PO 3*	*PO 4*	*PO 5*	*PO 6*	*PO 7*	*PO 8*	*PO 9*	*PO 10*
CO 1	2	3	1	3	3	1	3	2	3	2
CO 2	2	3	1	3	3	1	3	2	3	2
CO 3	2	3	1	3	3	1	3	2	3	2
CO 4	3	3	3	3	3	3	2	3	3	3
CO 5	3	3	3	3	3	3	2	3	3	3

S-Strong-3 ; M-Medium -2 ; L-Low-1.

Program Specific Outcomes

CO/PSO	*PSO 1*	*PSO 2*	*PSO 3*	*PSO 4*	*PSO 5*
CO 1	3	3	3	3	3
CO 2	3	3	3	3	3
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course contribution to Pos	3.0	3.0	3.0	3.0	3.0

Semester- I: Mineralogy and Paleontology Laboratory Practical-I(1st year)

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
24UPGEO1L01	**Mineralogy and Paleontology Practical**	Core	Y	-	Y	-	3	6	40	60	100

Course Objectives			
CO1	To study of symmetry and forms in the crystal models		
CO2	To describe and explain the Crystal projections		
CO3	To determination and calculate through different procedures to find out solution		
CO4	To recognition of fossils.		
CO5	To Interpretation of palaeoclimate.		
UNIT	**Details**	**No. of Hours**	**Course Objectives**
I	Study of symmetry and forms in the crystal models. X-rays and X-ray refraction, Powder method, Determination of unit cell parameters	12	CO1
II	Crystal projections –Stereographic projection, Spherical Projection and Gnomonic projection. Study of common rock forming minerals under petrological microscope	12	CO2
III	Determination of: relative relief (RI) of minerals by Becke-line test, sign of elongation of minerals, pleochroic scheme of minerals, optic sign of uniaxial and biaxial minerals, extinction angle and its types. Identification of rock forming minerals in hand specimens. Chemical examination of Industrial and ore minerals / Blowpipe analysis.	12	CO2
IV	Recognition of fossils, taxonomic classification, and assignation of age based on morphological characteristics of fossils belonging to Trilobita, Gastropoda, Bivalvia, Cephalopoda, Brachiopoda, and Echinodermata.	12	CO2
V	Interpretation of palaeoclimate and palaeoenvironment based on fossil data. Biostratigraphic zonal assignment. Identification of source, reservoir and seal facies with fossil data.	12	CO2
1.	Battey, M.H., (1972), Mineralogy for students		
2.	Deer, W., Howie, R.A. &Zussman, J., (1996), The Rock forming minerals. Longman.		
3	Hutchison, C.S., (1974), laboratory handbook of Petrographic Techniques. John Wiley		
4.	Murray, J.W. (1985), Atlas of Invertebrate Macrofossils, Longman		
5.	Woods, H. (1966), Invertebrate Palaeontology, International Book Bureau		
References Books (Latest editions, and the style as given below must be strictly adhered to)			
1.	Hans-RudoltWenk and Andrei Bulakh.,(2004), Minerals – Their constitution and origin. Cambridge University Press		
2.	Berry Mason, (2004), Mineralogy, CBS Publishers, New Delhi		
3.	Putnis Andrew., (1992), Introduction to Mineral Science, Cambridge University Press.		
4.	Benton, M.J. and Harper, D.A.T., (2009) Introduction to Paleobiology and the fossil record. Wiley-Blackwell. London.		
5.	Jain, P.C &Anantharaman, M.S (1996), Palaeontology, Evolution and Animal Distribution, Vishal Publications		

Web Resources	
1.	https://handbookofmineralogy.org/
2.	https://www.mindat.org/
3.	https://www.webmineral.com/
4.	https://www.paleosoc.org/
5.	http://paleoportal.org/

Course outcome

CO1: Basic knowledge on crystal structures and bonding and laws

CO2: student can learn about the Silicate structures and their physical and chemical properties

CO3: students get knowledge about the description and composition the minerals

CO4: Student gain knowledge on Optical mineralogical studies

CO5: student apply the instrumentation techniques in mineralogical studies

Mapping with Programme Outcomes:

Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low

	PO 1	*PO 2*	*PO 3*	*PO 4*	*PO 5*	*PO 6*	*PO 7*	*PO 8*	*PO 9*	*PO 10*
CO 1	3	2	2	3	1	2	3	2	1	2
CO 2	3	2	2	3	1	2	3	2	1	2
CO 3	3	2	2	3	1	2	3	2	1	2
CO 4	3	2	2	3	1	2	3	2	1	2
CO 5	3	2	2	3	1	2	3	2	1	2

S-Strong-3 ; M-Medium -2 ; L-Low-1.

Program Specific Outcomes

CO/PO	*PSO 1*	*PSO 2*	*PSO 3*	*PSO 4*	*PSO 5*
CO 1	3	3	3	3	3
CO 2	3	3	3	3	3
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course contribution to Pos	3.0	3.0	3.0	3.0	3.0

Semester-I: Geo-Statistics (Elective-I) (1st year)

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
24UPGEO1E01	**Geo-Statistics**	Elective	Y	-	-	-	3	4	25	75	100

Course Objectives	
CO1	This course provides the learners to have an idea about the nature and variability of Earth Science Data sets
CO2	The course aims to introduce the different statistical operations done on such data enabling estimation, prediction, simulation and modeling
CO3	Knowledge of statistical procedures is inherent in data analysis and management.
CO4	This course will help the students in the skill of data handling and data management.
CO5	The students will be able to correlate between variables and use statistical procedures as estimators.

UNIT	Details	No. of Hours	Course Objectives
I	Basic Statistics – Classification and presentation of statistical data, Characteristics of Normal distribution, measures of central tendency and dispersion, correlation, Least square method and regression analysis, probability and probability distributions, concept of population and sample, Sampling and sample distributions	12	CO1
II	Central limit theorem; Concept and methodology of Hypotheses Testing and its application in geology - student's t test, F test, $\chi 2$ test, ANOVA (one way)	12	CO2
III	Concept of regionalized variable- semi variance &semivariogram, kriging, Basic spatial interpolation: nearest neighbors, inverse distance, trend surfaces, Introduction to simulation methods	12	CO2
IV	Analysis of sequences of data: Markov chains, auto correlation and cross correlation, Univariate statistics: Measures tools of Location and Spread, Mean, median, variance, Standard Deviation. Univariate Plots: Histogram, Probability Density Function (PDF), Cumulative Density Function (CDF). Bivariate Statistics: Bivariate Data Display: Scatterplot or Cross plot, Bivariate Measures (Covariance, Correlation Coefficient).	12	CO2
V	Analysis of multivariate data, Map analysis. Fractals in geology. Linear Regression, De-clustering.	12	CO2

1.	Cressie, N. (1993). Statistics for Spatial Data (Revised Ed.). John Wiley & Sons, Inc.
2.	Chiles, J. P. and Delfiner, P. (1999) Geostatistics: Modeling Spatial Uncertainty Wiley.

References Books
(Latest editions, and the style as given below must be strictly adhered to)

1.	Peter J. Diggle, Paulo J. Ribeiro, Jr (2007) Model-based geostatistics, Springer
2.	Schabenberger, O. and Gotway, C. (2005) Statistical Methods for Spatial Data Analysis Chapman & Hall/CRC.

Web Resources

1.	*https://www.nrc.gov/docs/ML0227/ML022770097.pdf*
2.	*https://www.science.gov/topicpages/g/geostatistics*

Course outcome:
CO1: Student can understand about the fossil record and geological time-scale
CO2: To get knowledge about the theory and Origin of life
CO3: Students get more knowledge about vertebrate paleontology
CO4: Students get more knowledge about Invertebrate paleontology
CO5: Student gain knowledge on micropaleontology: Sampling methods and sample processing techniques

Mapping with Programme Outcomes:
Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low

	PO 1	***PO 2***	***PO 3***	***PO 4***	***PO 5***	***PO 6***	***PO 7***	***PO 8***	***PO 9***	***PO 10***
CO 1	2	3	1	3	3	1	3	2	3	2
CO 2	2	3	1	3	3	1	3	2	3	2
CO 3	2	3	1	3	3	1	3	2	3	2
CO 4	3	3	3	3	3	3	2	3	3	3
CO 5	3	3	3	3	3	3	2	3	3	3

S-Strong-3 ; M-Medium -2 ; L-Low-1.
Program Specific Outcomes

CO/PSO	***PSO 1***	***PSO 2***	***PSO 3***	***PSO 4***	***PSO 5***
CO 1	3	3	3	3	3
CO 2	3	3	3	3	3
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course contribution to Pos	3.0	3.0	3.0	3.0	3.0

Semester-I: Geo-heritage and Geo-tourism (Elective-II) (1st year)

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
24UPGEO1E02	**Geo-heritage and Geo-tourism**	Elective	Y	-	-	-	3	4	25	75	100

Course Objectives	
CO1	The concept of developing geoparks and geotourism will be introduced and a need for making laws to preserve them would be emphasized
CO2	An attempt will be made to familiarize the above fact in the mind of common man.
CO3	The unique geological and geomorphologic features distributed throughout the country that constitutes its geoheritage.
CO4	The development process obliterates many of these features and this loss necessitates.
CO5	Due to the lack of awareness and stringent laws little efforts are being made to preserve these national treasures.

UNIT	Details	No. of Hours	Course Objectives
I	Introduction and importance of Geodiversity, Geoheritage, Geoconservation; Geoparks andGeotourism; History of the concept of Geoheritage.	12	CO1
II	Geological outcrops and society; Threats to geodiversity; Conservation, protection, maintenance of geological sites and related features of National importance; Conservation of geosites as a tool to protect geoheritage.	12	CO2
III	Potential geoparks and geosites in India; Rajasthan, Odisha, Karnataka, Andhra Pradesh, Madhya Pradesh, Telangana, Tamil Nadu, Kerala, Gujarat, Himachal Pradesh	12	CO2
IV	UNESCO geoparks, Geopark networks across the globe; Geotourism and National geological Monuments.	12	CO2
V	Guidelines for selection of Geosites; Geoheritage laws, Role of local, state and national governments; Current status of Geoheritage protection in the country; Global geoheritage and protection laws.	12	CO2

1.	A Monograph on National geoheritage monuments of India, Indian National Trust for Art and Cultural Heritage, Natural Heritage Division, New Delhi
References Books (Latest editions, and the style as given below must be strictly adhered to)	
1.	Ranawat, P. S., George, S., 2016 Potential Geoheritage&Geotourism Sites in India International Journal of Scientific and Research Publications, Volume 9, Issue 6, June 2019
2.	EzzouraErrami, Margaret Brocx (Ed.) 2009. Geoheritage, Geoparks and Geotourism Conservation and Management Series Springer. P 268.
Web Resources	
1.	https://www.springer.com/series/11639
2.	*https://www.gsi.gov.in/webcenter/portal/OCBIS/pages_pageGeoInfo/pageGEOTOURISM*

Course outcome:
CO1: Student can understand about the fossil record and geological time-scale
CO2: To get knowledge about the theory and Origin of life
CO3: Students get more knowledge about vertebrate paleontology
CO4: Students get more knowledge about Invertebrate paleontology
CO5: Student gain knowledge on micropaleontology: Sampling methods and sample processing techniques

Mapping with Programme Outcomes:
Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low

	PO 1	***PO 2***	***PO 3***	***PO 4***	***PO 5***	***PO 6***	***PO 7***	***PO 8***	***PO 9***	***PO 10***
CO 1	2	3	1	3	3	1	3	2	3	2
CO 2	2	3	1	3	3	1	3	2	3	2
CO 3	2	3	1	3	3	1	3	2	3	2
CO 4	3	3	3	3	3	3	2	3	3	3
CO 5	3	3	3	3	3	3	2	3	3	3

S-Strong-3 ; M-Medium -2 ; L-Low-1.
Program Specific Outcomes

CO/PSO	***PSO 1***	***PSO 2***	***PSO 3***	***PSO 4***	***PSO 5***
CO 1	3	3	3	3	3
CO 2	3	3	3	3	3
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course contribution to Pos	3.0	3.0	3.0	3.0	3.0

Semester-I Geological Field Training (I Year)

<table>
<tr><th rowspan="2">Subject Code</th><th rowspan="2">Subject Name</th><th rowspan="2">Category</th><th rowspan="2">L</th><th rowspan="2">T</th><th rowspan="2">P</th><th rowspan="2">O</th><th rowspan="2">Credits</th><th rowspan="2">Inst. Hours</th><th colspan="3">Marks</th></tr>
<tr><th>CIA</th><th>External</th><th>Total</th></tr>
<tr><td>24UPGEO1X01</td><td>Geological Field Training</td><td>Core</td><td>Y</td><td>-</td><td>-</td><td>-</td><td>1</td><td>--</td><td>25</td><td>75</td><td>100</td></tr>
</table>

Course Objectives	
CO1	Understand the occurrence of various mineral resources across the country.
CO2	Students will comprehend the importance of various mining methods that are being adopted in the country.
CO3	Interpret the occurrence of mineral resources and its relationship with various geological and geotechnical processes.
CO4	Acquiring practical knowledge through actual field visits and interaction with subject experts
CO5	Evaluate the importance of mineral exploration techniques.

UNIT	Details	No. of Hours	Course Objectives
I	Students will be taken to various mines and mineral exploration industries across the country to gain first hand field experience on various mining methods, R&D activities in mineral exploration, interaction with subject experts in various industries and organizations involved in mineral exploration activities.	*	CO1

**Geological Field Training: 7-10 days/60 hours*

	Text Books
1.	Lisle, R.J. (1988). Geological Structures and Maps. Pergamon Press, Oxford.
2.	Brian Simpson. (1968). Geological Maps. Pergamon Press Limited, Oxford

References Books
(Latest editions, and the style as given below must be strictly adhered to)

1.	Thomas, J.A.G. (1977). *An Introduction to Geological Maps*. George Allen and Unwin (Publishers) Limited, London. 2nd Edition.
2.	Bhattacharya, D.S. and Bagchi, T.C. (1973). *Elements of Geological Map Reading and Interpretation with Exercises*. Orient Longman Limited, Calcutta.

	Web Resources
1.	Journal of Geological Society

Course outcomes

CO1: students learn the practical knowledge in the field visit
CO2: students identify and collect the rock specimens in the field visit
CO3: students experienced in mining areas and learn about the mining techniques.
CO4: students get interaction with eminent scientist at various institutions during filed visit
CO5: Students prepare the field training reports and gain knowledge about the geological sites.

Mapping with Programme Outcomes:
Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low

	PO 1	***PO 2***	***PO 3***	***PO 4***	***PO 5***	***PO 6***	***PO 7***	***PO 8***	***PO 9***	***PO 10***
CO 1	2	2	3	2	1	3	2	3	2	2
CO 2	2	2	3	2	1	3	2	3	2	2
CO 3	2	2	3	2	1	3	2	3	2	2
CO 4	2	2	3	2	1	3	2	3	2	2
CO 5	2	2	3	2	1	3	2	3	2	2

S-Strong-3 ; M-Medium -2 ; L-Low-1.
Program Specific Outcomes

CO/PSO	***PSO 1***	***PSO 2***	***PSO 3***	***PSO 4***	***PSO 5***
CO 1	3	3	3	3	3
CO 2	3	3	3	3	3
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course contribution to Pos	3.0	3.0	3.0	3.0	3.0

.

Semester- II

Semester- II: Structural Geology and Geotectonics (Iyear)

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
24UPGEO1C05	**Structural Geology and Geotectonics**	Core	Y	-	-	-	4	6	25	75	100

Course Objectives

CO1	The student can interpret and evaluate different structures that exist in the earth.
CO2	Can critically assess and review the energy needed to cause different structures.
CO3	Can describe and explain major and minor structures.
CO4	Can understand to compare and contrast structures related to each other.
CO5	Can evaluate and explain the causes of different structures.

UNIT	Details	No. of Hours	Course Objectives
I	Theory of stress and strain – Behavior of rocks under stress – Mohr's circle – Various states of stress and their representation by Mohr's circles – Different types of failure and sliding criteria – Geometry and mechanics of fracturing and conditions for re-activation of pre-existing discontinuities – Paleostress analysis – Common types of finite strain – Ellipsoids – L-, L-S-, and S-tectonic fabrics.	12	CO1
II	Techniques of strain analysis – Particle paths and flow patterns – Progressive strain history and methods for its determination.Deformation mechanisms – Role of fluids in deformation processes – Geometry and analysis of brittle-ductile and ductile shear zones – Petrofabric analysis – Field and laboratory techniques – Point and percentage diagrams – Preparation of petrofabric diagrams of quartz, biotite and calcite – Symmetry of fabric – Symmetry of movement.	12	CO2
III	Rotated minerals – Syn-, pre- and post-kinematic – Differential movement in rocks using rotated minerals – Oscillatory movements – Characteristics – Neotectonics – Indian and global evidences – Methods of study of neotectonics. Sheath folds – Geometry and mechanics of development of folds – Boudins – Foliation and lineation – Interference patterns and structural analysis in areas of superposed folding – Fault-related folding – Geometry and mechanics of faults – Gravity-induced structures.	12	CO2
IV	Major tectonic features and associated structures in extensional-, compressional-, and strike-slip terrains – Joints and unconformities – Penecontemporaneous deformational structures of sedimentary rocks. Plate tectonics – Concept and principles – Continental drift – Geological and geophysical evidences – Mechanics, objections and present status of plate tectonics.	12	CO2
V	Gravity and magnetic anomalies at mid-oceanic ridges, deep sea trenches, continental shield areas and mountain chains –	12	CO2

	Geological and geophysical characteristics of plate boundaries – Geodynamic evolution of the Himalayas – Paleomagnetism – Sea floor spreading and plate tectonics – Island arcs, oceanic islands and volcanic arcs – Isostasy, orogeny and epeirogeny – Geodynamic of the Indian Plate.		
	Text Books (Latest Editions)		
1.	Billings, M.P. (2014) *Structural Geology*. Prentice-Hall, Inc., Learning Pvt. Ltd., Delhi. 3rd Edition. ISBN: 978-81-203-0059-03.		
2.	Beloussov, V.V. (1962).*Basic Problems in Geotectonics*. McGraw-Hill Book Co., New York.		
3	Badgeley, P.C. (1965) *Structural and Tectonic Principles*. Harper & Row Publishers, New York. ASIN: BOOBXTMTK6.		
4	Twiss, R.J. and Moores, E.M. (2007).*Structural Geology*. W.H.Freeman and Company, New York. 2nd Edition. ISBN: 10: 0-7167-4951-		
5	B.A. van der Pluijm and S. Marshak (2004). Earth Structure - An Introduction to Structural Geology and Tectonics (2nd ed.). New York: W. W. Norton. p. 656. ISBN 0-393-92467-X.		
References Books (Latest editions, and the style as given below must be strictly adhered to)			
1.	Suppe, J. (1985) *Principles of Structural Geology*. Prentice-Hall, Inc., Englewood Cliffs, New Jersey. ISBN: ISBN 0137105002.		
2.	Marshak, S. and Mitra, G. (1988) *Basic Methods of Structural Geology*. Prentice-Hall, Inc., Englewood Cliffs, New Jersey. ISBN: 0130651788.		
3.	M. King Hubbert (1972). Structural Geology. Hafner Publishing Company.		
4.	G.H. Davis and S.J. Reynolds (1996). The structural geology of rocks and regions (2nd ed.). Wiley. ISBN 0-471-52621-5.		
5.	C.W.Passchier and R.A.J. Trouw (1998). Microtectonics. Berlin: Springer. ISBN 3-540-58713-6.		
Web Resources			
1.	http://www.labotka.net		
2.	http://www.patnasciencecollege.org		
3.	https://geomorphology.org.uk		
4.	https://gradeup.co		
5.	https://www.nps.gov>subjects>gla		

Course outcome:
CO1:To gain knowledge about the geological structures like fold, fault, unconformity, foliation and lineation and its causes and mechanisms.
CO2: Gain knowledge on techniques of strain analysis
CO3: Student learn about the Methods of study of neotectonics
CO4: Student understand on Major tectonic features and associated structures in extensional-, compressional-, and strike-slip terrains – Joints and unconformities
CO5: Student gain knowledge on Gravity and magnetic anomalies at mid-oceanic ridges, deep sea trenches, continental shield areas and mountain chains.

Mapping with Programme Outcomes:
Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	3	3	3	2	3	3	2	3	3	2
CO 2	3	3	3	2	3	3	2	3	3	2
CO 3	3	3	3	2	3	3	2	3	3	2
CO 4	3	3	3	2	3	3	3	3	3	2
CO 5	3	3	3	2	3	3	3	3	3	2

S-Strong-3; M-Medium -2; L-Low-1
Program Specific Outcomes

CO/PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	3	3	3	3	3
CO 2	3	3	3	3	3
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course contribution to Pos	3.0	3.0	3.0	3.0	3.0

Semester II- Applied Petrology (I year)

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
24UPGEO1C06	**Applied Petrology**	Core	Y	-	-	-	4	6	25	75	100

Course Objectives

CO1	Understanding the basics of the Earth as a System.
CO2	To analyze various magmatic compositions to understand the formation of various igneous rocks.
CO3	To comprehend the genesis of metamorphic rocks.
CO4	To understand the formation of sedimentary rocks, their depositional environments and provenance
CO5	Understanding the complete system of the Earth

UNIT	Details	No. of Hours	Course Objectives
I	Forms, textures and structures of igneous rocks. Petrology and geotectonic evolution of granites, basalts, andesites and alkaline rocks. Petrology of gabbros, kimberlites, anorthosites and carbonatites.Origin of primary basic magmas. Classification of igneous rocks. Steady-state geotherms. Genesis, properties, emplacement and crystallization of magmas. Phase equilibrium studies of simple systems, effect of volatiles on melt equilibria. Magma -mixing, - mingling and -immiscibility. Generation of magmas. Factors affecting their evolution and their relation to plate tectonics– Magmatic differentiation and Assimilation. Variation diagrams.	12	CO1
II	Silicate melts equilibria, binary and ternary phase diagrams. Experimental Petrology - Phase equilibrium of binary and ternary silicate systems and its petrological implications – Effect of Pressure on silicate systems – Trace elements in magmatic crystallization – Trace element modelling. Petrogenetic aspects of important rock suites of India, such as the Deccan Traps, layered intrusive complexes, anorthosites, carbonatites, charnockites, alkaline rocks, Kimberlites, ophiolites and granitoids.	12	CO2
III	Basic Concepts of Metamorphic Petrology – Types of metamorphism – agents of metamorphism – Zones and grades. Facies concept of metamorphism. Graphical Representation of metamorphic paragenesisPetrogenesis of important metamorphic rocks – charnockite – eclogite – amphibolite – migmatites – Khondalites – metamorphic belts Textures and structures of metamorphic rocks. Regional and contact metamorphism of pelitic and impure calcareous rocks.Mineral assemblages and P/T conditions.Experimental and thermodynamic appraisal of metamorphic reactions.Characteristics of different grades and facies of metamorphism.Metasomatism and granitization, migmatites.Plate tectonics and metamorphic zones.Paired metamorphic belts.Mineral reactions with condensed phases,solid solutions, mixed volatile equilibria and	12	CO2

	thermobarometry.		
IV	Earth Surface System: Liberation and flux of sediments, Processes of transport and generation of sedimentary structures, Control on the sedimentary record, Cyclic Sediments, – Classification of sedimentary rocks – Definition, measurements and interpretation of grain size. Evolution of Sedimentary Basins: Classification and definition of Sedimentary basins, Tectonics and Sedimentation – Plate tectonic concepts – Sedimentary basins of India – Paleocurrent and Basin analysis – Provenance and Diagenesis of sediments.	12	CO2
V	Sedimentary environments and facies, Continental alluvial – fluvial, lacustrine, desert – Eolian and Glacial sedimentary systems; Shallow Coastal Facies, Marine and Continental Evaporates; Shallow water Carbonates; Deep sea basins; Volcanoclasts Petrography of rocks of Clastic, Chemical and Biochemical origin, ClasticPetrofacies, Paleoclimate and Paleoenvironment analyses; Application of trace elements, Rare-earth elements and Stable isotope geochemistry to sedimentological problems. Depositional environments and systems. Paleocurrent analysis.	12	CO2

	Text Books
1.	Philpotts, A., 1992, Igneous and Metamorphic Petrology, Prentice Hall.
2.	Turner,F.J., 1980, Metamorphic Petrology, McGraw Hill., New York.
3.	Best M.G,IgneousPetrology.Wiley.NewDelhi(2005)
4.	Hatch,F.H. et al,Petrology of the Igneous Rooks, CBSDelhi.
5.	Hyndman D.W, Petrology of the Igneous and Metamorphic Rocks McGrawHill.NewYork(1985)
	References Books (Latest editions, and the style as given below must be strictly adhered to)
1.	Bose, M.K., 1997, Igneous Petrology., World Press.
2.	Bucher, K and Frey, M., 1994, Petrogenesis of Metamorphic Rocks, Springer – Verlag.
3.	Winter,J.D,Principles of Igneous and Metamorphic Petrology, PHI.New
4.	Middlemost E.A.K,Magmas and Magmatic Rocks.Longman UK(1985)
5.	Winkler,H.G.F, Petrology of the Metamorphic Rocks. Springer,New Delhi(1970)
	Web Resources
1.	https://minerva.union.edu/hollochk/c-petrology/resources.html
2.	https://topex.ucsd.edu/es10/lecture/lecture10/lecture10.html
3.	https://geology.com/rocks/igneous-rocks.shtml
4.	https://course.lumenlearning.com/wmopen-geology/chapter/outcome-metamorphic-rocks/
5.	https://serc.carleton.edu/NAGTWorkshops/coursedesign/goalsdb/10875.html

Course outcome:

CO1: To gain knowledge about the study of rocks - igneous, metamorphic, and sedimentary - and the processes that form and transform them.

CO2: Students gain on Silicate melt equilibria, binary and ternary phase diagrams.

CO3: students learn about the Basic Concepts of Metamorphic Petrology

CO4: Students learn Definition, measurements and interpretation of grain size

CO5: Students get knowledge on Sedimentary environments and facies

Mapping with Programme Outcomes:
Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	3	3	3	3	3	3	3	3	3	3
CO 2	3	2	3	3	3	3	2	3	1	3
CO 3	3	3	3	3	3	3	2	3	3	3
CO 4	3	3	3	3	3	2	3	3	3	3
CO 5	1	1	2	3	3	3	2	1	2	2

S-Strong-3 ; M-Medium -2 ; L-Low-1.
Program Specific Outcomes

CO/PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	3	3	3	3	3
CO 2	3	3	3	3	3
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course contribution to Pos	3.0	3.0	3.0	3.0	3.0

Semester II- Economic Geology (I year)

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
24UPGEO1C07	Economic Geology	Core	Y	-	-	-	4	6	25	75	100

Course Objectives	
CO1	To study mineral deposits and processes of formation of deposits and the nature of different mineral deposits, its genesis and distribution of major ore minerals.
CO2	To familiarize with the common ore minerals and their identifying criteria at various scales of study.
CO3	To understand the genetic controls exerted by physical and chemical processes on ore formation in various geological settings.
CO4	To provide the knowledge on geological processes responsible for mineral and ore formation, weathering and other secondary mineralization processes.
CO5	To familiarize mode of occurrence of economic minerals, metallic and non-metallic minerals.

UNIT	Details	No. of Hours	Course Objectives
I	Scope of economic geology. Mode of occurrence and morphology of ore bodies and relationship with host rocks -Textures and Structures of ore and gangue minerals. Modern concepts of ore genesis. Fluid inclusions -Wall rock alteration. Geothermometry- geobarometry.	12	CO1
II	Paragenesis and zoning in mineral deposits-Metallogenetic Epochs and Provinces. Structural, physico-chemical and stratigraphic controls of ore localization. Study of ore forming processes- Orthomagmatic processes- Sedimentary processes- Metamorphic processes- Hydrothermal processes. Ore deposits in relation to plate tectonics.	12	CO2
III	Mineralogy, mode of occurrences, uses and distribution in India of the following metalliferous deposits – Iron, Manganese, Aluminium, Copper, Gold, lead, Zinc – Chromium, Molybdenum, Rare Earth Group of metals. Distribution of mineral deposits in Indian shield; geological characteristics of important industrial mineral and ore deposits in India- chromite, diamond, muscovite, Sn-W, Au, Fe-Mn, bauxite; minerals used in refractory, fertilizer, ceramic, cement, glass, paint industries; minerals used as abrasive, filler; building stones.	12	CO2
IV	The study of non- metallic mineral deposits with reference to geology, mode of occurrence, origin, uses and distribution in India of Mica, Asbestos, Barytes, Gypsum, Limestone, Garnet, Corundum, Calcite, Quartz, Feldspar, Clays, Kyanite, Sillimanite, Graphite, Talc, Fluorite, Beryl and Gem minerals.	12	CO2
V	Strategic, critical and essential minerals; India's status in mineral production; co-products and byproducts; consumption, substitution and conservation of minerals; National Mineral Policy; Mineral Concession Rules; marine mineral resources and its laws.	12	CO2

	Text Books
1.	Anthony Evans, (1993) Ore Geology and Industrial Mineral, John Wiley & sons, USA,

2.	Bateman Allan .M. (1962) Economic Mineral Deposits, Asian Publishing House, 2nd Edition.
3.	Coggin, B. and Dey, A.K. (1955) India's Mineral Wealth, OUP.,
4.	Craig, J.M. & Vaughan, D.J., (1981): ore Petrography and Mineralogy. John Wiley
5.	Cuilbert, J.M. and Park, Jr. C.F.(1986): The Geology of Ore Deposits, Freidman
References Books (Latest editions, and the style as given below must be strictly adhered to)	
1.	R.M. Umathay, (2006)Mineral Deposits of India, Dattsons, New Delhi, India
2.	Robb, L. (2005)Introduction to ore-forming processes, Blackwell publishing, U.K.
3.	Mookherjee, A. (2000): Ore Genesis-A Holistic Approach, Allied Publisher
4.	James R. Craig and David J.Vaughan (1994): Ore Microscopy and Petrography
Web Resources	
1.	https://www.ualberta.ca/science/economic-geology
2.	https://pubs.geoscienceworld.org/economicgeology
3.	https://www.britannica.com/topic/economic-geology

Course outcome:
CO1: This is the course which links directly to the industry and share the knowledge about a wide range of ore deposit the geometry of ore bodies, alteration patterns and assemblage of ore and gangue minerals.
CO2:It offers a detailed study of origin of economic mineral deposits, its identification, properties, and distribution in India. .
CO3: The students will be familiar with how, where, and when earth's most important ore deposits have formed,
CO4:This course also aims at providing a comprehensive knowledge in reflective light optic and ore textures.
CO5:The students get a basic concept of mineral deposit modeling

Mapping with Programme Outcomes:
Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	3	3	3	3	3	3	3	3	3	3
CO 2	3	2	3	3	3	3	2	3	1	3
CO 3	3	3	3	3	3	3	2	3	3	3
CO 4	3	3	3	3	3	2	3	3	3	3
CO 5	1	1	2	3	3	3	2	1	2	2

S-Strong-3 ; M-Medium -2 ; L-Low-1.
Program Specific Outcomes

CO/PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	3	3	3	3	3
CO 2	3	3	3	3	3
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course contribution to Pos	3.0	3.0	3.0	3.0	3.0

Semester- II: Structural and Economic Geology Practical (I year)

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
24UPGEO1L02	**Structural and Economic Geology Practical**	Core	Y	-	-	-	3	6	40	60	100

Course Objectives

CO1	To identify and list out the issues and problems.
CO2	To describe and explain the solution to follow
CO3	To select a particular solution for some specific problems. To interpret and calculate through different procedures to find out solution
CO4	To review an idea regarding solution for a problem.
CO5	To different between different structures.To conceive and conceptualize the solutions arrived at.

UNIT	Details	No. of Hours	Course Objectives
I	Determination of attitude of beds – Geometrical, graphical and trigonometric projections – Tabular and nomograph methods.	12	CO1
II	Reconstruction of parallel fold and fault – Preparation and analysis of structure contour map – Isopachs.	12	CO2
III	Construction of perpendicular and vertical sections of plunging fold. Geochronology – Pi and beta diagrams – Structural complex –	12	CO2
IV	Depth to strata – True thickness of beds - Interpretation of geological maps involving normally dipping beds, bore well data. Interpretation of geological maps involving symmetrical and asymmetrical fold, isoclinal fold, recumbent fold, plunging fold, strike fault and step fault.	12	CO2
V	Study of Industrial and ore minerals with special emphasis on physical, chemical characteristic mode of occurrences and uses.	12	CO2

Text books

1.	Brian Simpson. (1968).*Geological Maps*. Pergamon Press Limited, Oxford.
2.	Lisle, R.J. (1988).*Geological Structures and Maps*. Pergamon Press, Oxford.
3	Gass, J.G., Butcher, N.E., Clark, P., Francis, P.W., Jackson, D.E., McCurry, P., Skipsey, E., Smith, P.J., Stevenson, J., Thorpe, R.S., Turner, C., Wilson, R.C.L., Wright, J.B. (1972). *Field Relations – A Second Level Course in Science*. The Open University Press, London.
4.	Structural geology, Billing. M.P. (1974), Prentice Hall, New Delhi
5.	An outline of Structural Geology, Hobbs, B.E., Means, W.D. and Williams, P.F. (1976):, John Wiley, New York.

References Books
(Latest editions, and the style as given below must be strictly adhered to)

1.	Bhattacharya, D.S. and Bagchi, T.C. (1973).*Elements of Geological Map Reading and Interpretation with Exercises*. Orient Longman Limited, Calcutta.
2.	Gokhale, N.W. (2006).*A Manual of Problems in Structural Geology*. CBS Publishers and Distributors, New Delhi.

3.	Basic Problems of GeotectonicsBelousov.V.V. (1962):, McGraw Hill, New York
4.	Structural GeologyDe Sitter. L.U. (1956):, McGraw Hill, New York
5.	Elements of Structural GeologyHill. E.S. (1972):, John Wiley, New York
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/

Course outcome:
CO1: Students workout on the determination of attitude of beds
CO2:Student gain knowledge on preparation and analysis of structure contour map
CO3:Students learn about the Construction of perpendicular and vertical sections of plunging fold
CO4: Students gain knowledge on find out the true thickness and vertical thickness of beds
CO5:Interpretation of geological maps

Mapping with Programme Outcomes:

Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	3	3	2	3	1	3	2	3	1	1
CO 2	3	3	2	3	1	3	2	3	1	1
CO 3	3	3	2	3	1	3	2	3	1	1
CO 4	3	3	2	3	1	3	2	3	1	1
CO 5	3	3	2	3	1	3	2	3	1	1

S-Strong-3 ; M-Medium -2 ; L-Low-1.

Program Specific Outcomes

CO/PSO	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**
CO 1	3	3	3	3	3
CO 2	3	3	3	3	3
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course contribution to Pos	3.0	3.0	3.0	3.0	3.0

Semester-II- Petrology Practical (Ist year)

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
24UPGEO1L02	**Petrology Practical**	Core	Y	-	-	-	3	6	40	60	100

Course Objectives

CO1	To compare and contrast different rock types by means of megascopic and microscopic studies.
CO2	To enhance the knowledge about minerals in rocks using petrographic techniques
CO3	To carry out grain size analysis to distinguish genesis.
CO4	To carry out grain size analysis to distinguish depositional environments.
CO5	To carry out gravel analysis to establish of paleofluvial channels and provenance.

UNIT	Details	No. of Hours	Course Objectives
I	Megascopic and microscopic study (textural and mineralogical) of the following igneous rocks: Granite, Syenite, Gabbro, Basalt, Peridotite, Pyroxenite, Dunite. Lamprophyres, Dolerite, Phonolite, Rhyolite, Trachyte, Andesite, Pitchstone, Anorthosite, Aplite, Pegmatite. Introduction to modal analyses of Granite, Basalt and Gabbro.	12	CO1
II	Megascopic and microscopic study (textural and mineralogical) of the following metamorphic rocks: Low grade metamorphic rocks: serpentinites, albite-epidote-chlorite-quartz schist, slate, talc-tremolite-calcite-quartz schist. Medium to high grade metamorphic rocks: Gneisses, amphibolite, hornfels, garnetiferousschists, sillimanite-kyanite-bearing rocks, Granulites, eclogite, diopside-forsterite marble. Laboratory exercises in graphic plots for petrochemistry and interpretation of paragenetic diagrams.	12	CO2
III	Megascopic and microscopic study (textural and mineralogical) of the following Sedimentary rocks: Sand stone, Lime stone, Conglomerate, Arkose, mud rocks.	12	CO2
IV	Harker's, Larsen's variation diagrams – Peacock's Alkali-Lime Index – Niggli's variation diagram –	12	CO2
V	Preparation of Thin sections – Grain size analysis – Statistical parameters in Sedimentology – Frequency and cumulative frequency distribution curves – Moment and graphic measures – Gravel analysis.	12	CO2

Text Books

1.	Vernon R. H. and Clarke G. L. 2008. Principles of metamorphic Petrology. Cambridge publication.
2.	John D. Winter 2001. An Introduction to Igneous and Metamorphic Petrology.
3.	Wenk,H.R&A. Bulakh, Minerals, Cambridge University Press,New Delhi(2006)
4.	Perkins D, 3rd ed. Prentice Hall India, NewDelhi(2010)
5.	HaIdar,S.K.&J.Tisjlar, Introduction to Mineralogy and Petrology, Elsevier,(2014)

References Books
(Latest editions, and the style as given below must be strictly adhered to)

1.	Yardley, B W D. 1990. An introduction to metamorphic petrology. ELBS publication.
2.	Best, M.G. 2002. Igneous and metamorphic petrology. Wiley publication.
3.	An Introduction to Rock forming Minerals, Deer, Howie and Hussmann, (1982), 2nd Edit., Orient Longman, London.
4.	Deer,W.A.,R.A.Howie&J.Zussman. An Introduction to the Rock-Forming Minerals. ELBS.London(1992)
5.	Berry L.G.,B.Mason&R.V. Dietrich, Mineralogy, CBS New Delhi (1985).
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

Course outcome:
CO1 Study theMegascopic and microscopic study for igneous rocks
CO2 Study theMegascopic and microscopic study for sedimentary rocks
CO3 Megascopic and microscopic study for metamorphic rocks
CO4 Statistical parameters in Sedimentology
CO5 Preparation of Thin sections
(textural and mineralogical) of the following igneous rocks, metamorphic rocks and sedimentology rocks is also studied

Mapping with Programme Outcomes:
Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low

	PO 1	***PO 2***	***PO 3***	***PO 4***	***PO 5***	***PO 6***	***PO 7***	***PO 8***	***PO 9***	***PO 10***
CO 1	3	3	3	3	3	3	3	3	3	3
CO 2	2	3	3	3	3	3	1	2	1	2
CO 3	1	2	2	1	2	1	1	1	2	1
CO 4	3	3	3	3	3	3	3	3	3	3
CO 5	3	3	3	3	3	3	3	3	3	3

S-Strong-3 ; M-Medium -2 ; L-Low-1.
Program Specific Outcomes

CO/PSO	***PSO 1***	***PSO 2***	***PSO 3***	***PSO 4***	***PSO 5***
CO 1	3	3	3	3	3
CO 2	3	3	3	3	3
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course contribution to Pos	3.0	3.0	3.0	3.0	3.0

Semester-II: Environmental Earth Science (I year)

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
24UPGEO1E03	**Environmental Earth Science**	Elective	Y	-	-	-	3	4	25	75	100

Course Objectives

CO1	To identify knowledge on various types of environmental issues in relation to the Earth as a System
CO2	To explain the various causes of pollution
CO3	To explain the various types of pollution
CO4	To select the remedial measures to be taken as an individual and a group
CO5	Understanding the dynamics of the Earth

UNIT	Details	No. of Hours	Course Objectives
I	Concept of environment – Environmental monitoring – Water as a resource, Water pollution – Point and non-point pollution sources – Ground water pollution.	12	CO1
II	Air pollution – Natural and anthropogenic sources of air pollution – Primary and secondary air pollutants – Anthropogenic activities and air pollution – Indoor air quality – Biological sources of indoor pollution – Health effects – Air quality standards – Case histories – Air quality monitoring – Acid rain – Adverse effects of acid rain – Health effects – Mitigation measures – Roles and responsibilities.	12	CO2
III	Smog – Mechanism of smog formation – Health disorders – Photochemical smog – Ozone and PAN formation – Health effects – Catalytic converters – Greenhouse gases and effect – Processes of removal of greenhouse gases.	12	CO2
IV	Methods of waste disposal – Landfills – Trash compactors – Incineration – Recycling – Biological processing – Mulch and compost – Energy production – Waste reduction – Waste handling and transport – Waste management – Concept of waste hierarchy – Education and awareness.	12	CO2
V	Medical geology – Problems associated with fluoride, arsenic, asbestos, mercury, chromium, cadmium, zinc, copper and lead contamination – Alternate energy resources – Climate change.	12	CO2

Text Books

1.	Fairbridge, R.W. (1972) Encyclopedia of Geochemistry and Environmental Science. John Wiley.
2.	Keller, Edward A. (1996) Environmental Geology. New Jersey: Prentice-Hall
3.	Coppola D.P, Introduction to International Disaster Management, Butterworth Heinemann(2007)
4.	Pine,J.C, Natural Hazards Analysis: Reducing the Impact of Disasters, CRC Press, Taylor and Francis Group(2009)
5.	Smith K, Environmental Hazards: Assessing Risk and Reducing Disaster Rout ledge

	Press(2001)
References Books (Latest editions, and the style as given below must be strictly adhered to)	
1.	Strahler, A.N. and Strahler, A.H. (1973) Environmental Geoscience – Interaction between Natural Systems and Man. Hamilton Publishing Co., Santa Barbara, California.
2.	Kudesia, V.P. (1980) Water Pollution. PragathiPrakasam, Meerut.
3.	Groundwater Assessment Development and Management, Karanth.K.R. (1987) Tata McGraw Hill Publishing Company, Ltd.
4.	Miller T.G. Environmental Science. Wadsworth Publishing.US(2004).
5.	Coates,D.R. Environmental Geology. McGraw Hill.NewYork(1984)
Web Resources	
1.	https://www.britannica.com/science/geology/sedimentary-petrology
2.	https://limk.springer.com/chapter/10
3.	https://www.geo.mtu.edu/UPSeis/hazards.html
4.	https://www.omafra.gov.on.ca/english/engineer/facts/
5.	https://geology.com/rocks/rock-salt.shtml

Course Outcome:

CO1: To know the basic knowledge about theClimate: Classification, Global warming and climate change

CO2: Student gets knowledge on Pollution Monitoring studies

CO3: Students know about the EnvironmentalHealth hazard

CO4: Students learn the Waste management studies

CO5:Student get involved in Medical geology applications

Mapping with Programme Outcomes:

Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low

	PO 1	***PO 2***	***PO 3***	***PO 4***	***PO 5***	***PO 6***	***PO 7***	***PO 8***	***PO 9***	***PO 10***
CO 1	3	2	1	2	3	3	1	2	2	3
CO 2	3	2	1	2	3	3	1	2	2	3
CO 3	3	2	1	2	3	3	1	2	2	3
CO 4	3	2	1	2	3	3	1	2	2	3
CO 5	3	2	1	2	3	3	1	2	2	3

S-Strong-3 ; M-Medium -2 ; L-Low-1.

Program Specific Outcomes

CO/PSO	***PSO 1***	***PSO 2***	***PSO 3***	***PSO 4***	***PSO 5***
CO 1	3	3	3	3	3
CO 2	3	3	3	3	3
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course contribution to Pos	3.0	3.0	3.0	3.0	3.0

Semester-II: Applied Micropaleontology (I year)

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
24UPGEO1E04	**Applied Micropaleontology**	Elective	Y	-	-	-	3	4	25	75	100

Course Objectives

CO1	To make the students well-versed in the field work, laboratory techniques and applications of Micropaleontology
CO2	To develop skills, innovation, research temperament and contribution to the geological sciences through critical thinking
CO3	Develop capability to identify the microfossils, determination of age of the sediments
CO4	Find solution to the geological problems through the application of microfossils
CO5	Work ethically in an interdisciplinary and multidisciplinary environment and correlation of scientific data

UNIT	Details	No. of Hours	Course Objectives
I	Definition, scope, historical developmentsof micropaleontology. Microfossils - definition, types of microfossils. Sampling methods, processing techniques used in separation of microfossils and preparation of faunal slides. Field and Laboratory equipments used for micropaleontological studies.	12	CO1
II	Foraminifera: habit, life cycle, dimorphism; test morphology, wall composition, wall structure, chamber shape and arrangements, aperture openings and ornamentation of foraminifera. Ecology, paleoecology, geological distributionand classification of foraminifera.	12	CO2
III	Ostracoda: Morphology, hinge types, ornamentation, ecology and paleoecology, geological distribution and classification. Nannofossils: Sample preparation techniques, morphology, ecology, paleoecology and geological distribution.	12	CO2
IV	Conodonts: Extraction methods, morphology, composition and stratigraphic utility of conodonts. Sample preparation techniques, major morphological groups and application of radiolarians and diatoms. Maceration techniques, outline of morphology and application of fossil spores and pollen.	12	CO2
V	Application of Microfossils: Significance of microfossils in biostratigraphy and correlation. Major mass extinction events in earth's history - types of global bio-events: causes and effects. Use of micropaleontology in hydrocarbon exploration. Importance of microfossils in interpretation paleoenvironment, paleotemperature and sea-level changes.	12	CO2

	Text Book
1.	Bignot, G., (1985). Elements of Micropaleontology. Graham and Trotman
2.	Brasier, M.D., (1982). Principles of Microfossils. George Allen &Unwin.
3.	Glaessner, M.F., (1945). Principles of Micropaleontology. Hafner Publishing Company.
4.	Jones, D.J.,(1969). Introduction to Microfossils. Hafner Publishing Company, New York.
5.	Loelich, A. R. (Jr.) & Tappan, J. (1988): Foraminifera Genera & Their Classification (v. 1 & 2), Van NostrandRenhold.

References Books (Latest editions, and the style as given below must be strictly adhered to)	
1.	Armstrong, H. and Brasier, M.D., (2005). Microfossils. Blackwell Publishing.
2.	Kathal, P. K. (2012). Applied Geological Micropaleontology, Scientific Publishers, New Delhi-Jodhpur.
3.	Saraswati, P. K. &Srinivasan, M. S. (2016): Micropaelontology, Principles & Applications, Springer.
4.	Martin, R.E. (2000). Environmental Micropaleontology. Springer.
5.	Haq, B.U. and Boersma, A., (1998). Introduction to Marine Micropaleontology. Elsevier.
Web Resources	
1.	https://en.wikipedia.org/wiki/Micropaleontology
2.	*https://www.britannica.com/science/micropaleontology*
3.	https://www.ucl.ac.uk/earth-sciences/research/micropalaeontology
4.	https://www.sciencedirect.com/topics/earth-and-planetary-sciences/micropaleontology
5.	https://egyankosh.ac.in/bitstream/123456789/69612/1/Unit-10.pdf

Course Outcome:

CO1: To know the basic knowledge about theClimate: Classification, Global warming and climate change

CO2: Student get knowledge on Pollution Monitoring studies

CO3: Students know about the Environmental Health hazard

CO4: Students learn the Waste management studies

CO5:Student get involved in Medical geology applications

Mapping with Programme Outcomes:

Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low

	PO 1	***PO 2***	***PO 3***	***PO 4***	***PO 5***	***PO 6***	***PO 7***	***PO 8***	***PO 9***	***PO 10***
CO 1	3	2	1	2	3	3	1	2	2	3
CO 2	3	2	1	2	3	3	1	2	2	3
CO 3	3	2	1	2	3	3	1	2	2	3
CO 4	3	2	1	2	3	3	1	2	2	3
CO 5	3	2	1	2	3	3	1	2	2	3

S-Strong-3 ; M-Medium -2 ; L-Low-1.

Program Specific Outcomes

CO/PSO	***PSO 1***	***PSO 2***	***PSO 3***	***PSO 4***	***PSO 5***
CO 1	3	3	3	3	3
CO 2	3	3	3	3	3
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course contribution to Pos	3.0	3.0	3.0	3.0	3.0

Semester-III

Semester-III: Applied Geophysics (II year)

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
24UPGEO1C08	**Applied Geophysics**	Core	Y	-	-	-	4	5	25	75	100

Course Objectives

CO1	Student will able to apply geophysical methods for exploring hidden ore minerals, ground water, oil and natural gas resources.
CO2	Explain the principles behind different geophysical surveying techniques.
CO3	Process, analyze and interpret gravitational, magnetic and electromagnetic surveying data.
CO4	Understandthe earth subsurface using electrical resistivity.
CO5	Describes the subsurface of the Earth in physical terms – density, electrical resistivity, magnetism, conductivity, and heat flow.

UNIT	Details	No. of Hours	Course Objectives
I	Introduction – Physical basis of geophysical exploration, various surface and sub-surface methods and their classification. Physical properties of rocks and minerals exploited in exploration and factors that control them. Geophysical anomaly, Radioactivity of rocks and ores, radioactive minerals and ores. Radiation measuring devices – Ionization chambers, gas filled (Geiger Möller) counters, scintillation counters, radiometers and γ ray spectrometers. Field radiometric methods – Air-borne surveys, automobile surveys, foot surveys.Processing and interpretation of field data.Application of radiometric methods.	12	CO1
II	Gravity Prospecting: Gravity prospecting – Principles, the Earth's gravitational field and units, its variation, Newton's Law – Geoid, spheroid and normal gravity field, figure of earth. Order of anomalies produced by geological discontinuities, absolute and relative measurement of gravity, gravimeters and their operation in the field. Field procedure, reduction and correction of gravity field data, separation of regional and residuals, upward and downward continuation, interpretation of gravity data obtained over spherical and cylindrical objects, sheet, dike and faults – Applications of gravity methods.	12	CO2
III	Electrical methods – Electrical properties of earth materials – Conduction in rocks, conduction in water-bearing rocks, description of geoelectric sections, classification of electrical methods. Resistivity method – Ohm's Law, resistivity, factors affecting resistivity, effect of homogenous earth, various configurations for resistivity methods, configuration factor, response over a layered earth. AC and DC type resistivity meters, field procedure for electrical profiling and sounding, logarithmic curve matching, advantages of plotting the data on a logarithmic graph paper. Interpretation of profiling and sounding field data, use of modelling in electrical methods, introduction to self-potential,	12	CO2

	induced polarization methods.		
IV	Seismic methods – Fundamentals of elasticity – Young's modulus, Bulk modulus, Poisson's ratio, elastic waves, laws of reflection and refraction, Huygen's principle, Fermat's principle, Principle of superposition, Seismic wave theory – Helmhotz's theorem and seismic wave propagation – Body and surface waves – Primary, Secondary, Rayleigh and Love waves – Seismic energy sources – Detectors – Seismic noises and noise profile analysis – Reduction to a datum and weathering corrections - Short period, long period, broad band and strong motion – Seismic instruments – Seismic channel – Details of geophones – Filters, Amplifier and reproducible and non-reproducible recording – Seismic timer field layout – Arc shooting – Fan shooting – Profile shooting	12	CO2
V	Data processing – Corrections applied to seismic field data , Simple interpretation of field data – Seismic refraction and reflection data processing – Applications.	12	CO2
	Text Books		
1.	Keller, G.V. and Frischknecht, F.C. (1982) Electrical Methods inGeophysical Prospecting. Pergamon Press, New York.		
2.	Rama Rao, B.S. and Murthy, I.V.R. (1978) Gravity and Magnetic Methods of Prospecting. Arnold Heinemann Publishers, New Delhi		
3.	Davies, Geoffrey F. (2001). Dynamic Earth: Plates, Plumes and Mantle Convection. Cambridge University Press. ISBN 0-521-59067-1.		
4.	Bozorgnia, Yousef; Bertero, Vitelmo V. (2004). Earthquake Engineering: From Engineering Seismology to Performance-Based Engineering. CRC Press.		
5.	Pedlosky, Joseph (1987). Geophysical Fluid Dynamics (Second ed.). Springer-Verlag. ISBN 0-387-96387-1.		
References Books (Latest editions, and the style as given below must be strictly adhered to)			
1.	Dobrin, M.B. (1984) An Introduction to Geophysical Prospecting. McGraw-Hill, New Delhi.		
2.	Telford, W.M., Geldart, L.P., Sheriff, R.E. and Keys, D.A. (1976) Applied Geophysics. Oxford-IBH Publishing Co. Pvt. Ltd., New Delhi		
3.	Hardy, Shaun J.; Goodman, Roy E. (2005). "Web resources in the history of geophysics". American Geophysical Union. Archived from the original on 27 April 2013. Retrieved 30 September 2011.		
4.	Kivelson, Margaret G.; Russell, Christopher T. (1995). Introduction to Space Physics. Cambridge University Press. ISBN 978-0-521-45714-9.		
5.	Lowrie, William (2004). Fundamentals of Geophysics. Cambridge University Press. ISBN 0-521-46164-2		
Web Resources			
1.	https://iugg.org/associations-commissions/commissions/sedi/		
2.	https://iugg.org/		
3.	https://www.usgs.gov/programs/geomagnetism		
4.	https://www.udemy.com/course/learn-seismic-data-processing/		
5.	https://seg.org/Default.aspx?TabId=176&language=en-US		

Course Outcome:

CO1: Student can learn in detail about the Gravity and gravity anomalies, gravity survey, gravity map preparation

CO2: Magnetic fields, magnetic behavior of rocks, magnetic methods – anomalies, preparation of magtnetic anomaly maps

CO3: Thermal and electrical properties of rocks, resistivity method
CO4: Application of electrical method in groundwater exploration
CO5 Seismic method, wave propagation principles, seismic data interpretation.

Mapping with Programme Outcomes:

Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low

	PO 1	***PO 2***	***PO 3***	***PO 4***	***PO 5***	***PO 6***	***PO 7***	***PO 8***	***PO 9***	***PO 10***
CO 1	3	3	3	2	3	3	3	2	3	3
CO 2	3	3	3	3	3	3	3	3	3	3
CO 3	3	3	3	3	3	3	2	2	3	2
CO 4	3	3	3	3	2	3	3	3	3	3
CO 5	3	3	2	3	3	2	3	3	2	3

S-Strong-3 ; M-Medium -2 ; L-Low-1.

Program Specific Outcomes

CO/PSO	***PSO 1***	***PSO 2***	***PSO 3***	***PSO 4***	***PSO 5***
CO 1	3	3	3	3	3
CO 2	3	3	3	3	3
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course contribution to Pos	3.0	3.0	3.0	3.0	3.0

SEMESTER-III: Applied Remote Sensing and GIS (II Year)

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
24UPGEO1C09	**Applied Remote Sensing and GIS**	Core	Y	-	-	-	4	5	25	75	100

Course Objectives

CO1	Understand the basics of remote sensing, electromagnetic radiation (EMR) and its properties, aerial photography and to list the important merits of these technology tools.
CO2	Students will comprehend the core part of remote sensing i.e. spectral properties of earth objects, interaction of EMR with the atmosphere and the acquisition of data by different satellite sensors including the generate of False Color Composite (FCC) imagery.
CO3	Based on the understanding of the basics, the students are expected to do thorough interpretation of aerial photographs and FCC imagery for the preparation of various thematic maps.
CO4	Acquiring advanced skills on the aspects of digital image processing and the Spatial Information Technology tools, the students are expected to do quantitative analysis on change detection, monitoring of resources etc.
CO5	Evaluate the importance of these technology tools over conventional techniques and its way forward.

UNIT	Details	No. of Hours	Course Objectives
I	Fundamentals of remote sensing: History of remote sensing technology – Remote sensing system – Electromagnetic radiation – Spectral properties of terrestrial objects – Analysis of spectral reflectance curves – Types of satellites – Image acquisition – Multi-spectral scanners – Remote sensing resolution – Introduction to thermal remote sensing – Introduction to microwave remote sensing and new satellite sensors – Remote sensing in landform and land use mapping, structural mapping, coastal and ocean studies – Global and Indian space missions.	12	CO1
II	Aerial photography: Introduction – Vertical and oblique photographs – Photoscale – Image displacement due to relief – Parallax in aerial photographs – Aerial photographic procedures – Camera and flight requirement – Flight planning – Filters – Compensation – Stereoscopy – Photomosaics. Photographical studies – Photo recognition elements and keys – Interpretation of lithology, structures and landforms from aerial photographs.	12	CO2
III	Image processing in remote sensing: Digital data recording – Digital data format. Introduction to digital image processing – Pre-processing techniques – Image classification methods – Image enhancement techniques.	12	CO2
IV	Applications of remote sensing: Visual interpretation – Different sensors – Data and image interpretation key elements. Exercises on mapping of geology – Land use/land cover and geomorphology based on visual method – Preparation of base maps and transformation of thematic maps. Validation of remote	12	CO2

	sensing analysis output by ground truth – Accuracy, estimation and introduction to GPS technology.		
V	Fundamentals and application of GIS: Concept of GIS – GIS types – Data storage – Retrieval and analysis. GIS database organization and development – Combined use of remote sensing and GIS. Preparation of spatial decision support system (SDSS).Highlights on different applications using GIS tool with particular reference to Applied Geosciences and Ocean Science.	12	CO2

	Text Books
1.	Asrar, G. (1989) *Theory and Applications of Optical Remote Sensing*. John Wiley & Sons, New York.
2.	Curran, P.J. (1984) *Principles of Remote Sensing*. Longman Group Ltd.
3	Lillesand, T.M., Kiefer, R.W. and Chipman, J.W. (2007) *Remote Sensing and Image Interpretation.* Wiley India, 763.
4	Paul R. Wolf. (1986) *Elements of Photogrammetry*, McGraw-Hill Book company. 628.
5.	Lasaponara, R. and Masini N. 2012: Satellite Remote Sensing - A new tool for Archaeology. Remote Sensing and Digital Image Processing Series, Volume 16, 364 pp., ISBN 978-90-481-8801-7.
References Books (Latest editions, and the style as given below must be strictly adhered to)	
1.	Sabins, F.F. (1998) *Remote Sensing Principles and Interpretation*. W.H.Freeman& Co
2.	Agarwal, C.S. and P.K. Garg (2000) *Textbook on Remote Sensing In natural resources monitopring and management*, Wheeler Publishing, 196.
3.	Campbell, J. B. (2002). Introduction to remote sensing (3rd ed.). The Guilford Press. ISBN 978-1-57230-640-0.
4.	Jensen, J. R. (2007). Remote sensing of the environment: an Earth resource perspective (2nd ed.). Prentice Hall. ISBN 978-0-13-188950-7.
5.	Richards, J. A.; X. Jia (2006). Remote sensing digital image analysis: an introduction (4th ed.). Springer. ISBN 978-3-540-25128-6.
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/

Course outcome:

CO1:To gain the basic concept of remote sensing

CO2: Students study the Photogeology

CO3:Student gets knowledge on Image processing in remote sensing

CO4: Students learn about the Applications of remote sensing

CO5: Students gain knowledge on Fundamentals and application of GIS

Mapping with Programme Outcomes:
Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	S	3	3	2	3	3	3	2	3	3
CO 2	S	3	3	3	3	3	3	3	3	3
CO 3	S	3	3	3	3	3	2	2	3	2
CO 4	S	3	3	3	2	3	3	3	3	3
CO 5	S	3	2	3	3	2	3	3	2	3

S-Strong-3 ; M-Medium -2 ; L-Low-1.
Program Specific Outcomes

CO/PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	3	3	3	3	3
CO 2	3	3	3	3	3
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course contribution to Pos	3.0	3.0	3.0	3.0	3.0

Semester-III: Hydrogeology (II year)

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
24UPGEO1C10	**Hydrogeology**	Core	Y	-	-	-	4	5	25	75	100

Course Objectives

CO1	To define different terms and parameters involved in Hydrogeology
CO2	To enumerate the concept and to interpret the processes involved in groundwater
CO3	To describe the importance of groundwater and summaries the occurrence of groundwater
CO4	To interpret the conditions of water resources and to select some areas where the groundwater is being exploited against the natural laws
CO5	To critically assess different factors/aspects involve

UNIT	Details	No. of Hours	Course Objectives
I	**Introduction to Hydrogeology:** Water on Earth - Types of water - Distribution of water - Hydrological cycle and its components: precipitation, evaporation, evapotranspiration, infiltration, surface runoff and sub-surface distribution and movement of ground water and their estimation for the purpose of assessing water availability. Water-bearing properties of rock formations: aquifer- isotropic and anistropic, porosity, permeability, compressibility of rocks.	12	CO1
II	**Occurrence and movement of Groundwater:** Vertical distribution of groundwater: zone of aeration and zone of saturation – Geological formations as aquifers – Springs - Darcy's experiment and its limitations, fluid pressure, hydraulic conductivity, transmissitivity – Reynolds Number - Barometric and tidal efficiency of aquifers – Ground water flow- Groundwater flow direction –Unsaturated flow –Steady and unsteady state flow.	12	CO2
III	**Water wells:** Types of wells - Well hydraulics – Cone of depression, radius of influence, drawdown and specific capacity - Drilling of shallow wells and deep wells – Well Completion – Well development – Testing wells for yield- Protection and rehabilitation of well- Collector wells and Infiltration galleries - Tracer tests and slug tests - Ground water budgeting – Ground water levels and water level maps – Safe yield and Conjunctive uses – Artificial recharge and methods.	12	CO2
IV	**Groundwater Quality and Pollution:** Chemical constituents in groundwater: sources and effects - Quality criteria for different uses -Geochemical cycle of surface water and ground water- Graphical presentation of groundwater quality data- Dissolved gases in groundwater- Impact of solar energy on groundwater – Sources and causes for pollution of groundwater – Pollution attenuation – Treatment for contaminated groundwater.	12	CO2
V	**Exploration techniques and Saline water intrusion :** Methods for exploration of ground water – Geological methods, Remote	12	CO2

	Sensing techniques, geomorphological inputs, gravity, magnetic, seismic and electrical methods – Basics of ground water modeling – Physical, analog and mathematical models, finite difference modeling –Hydrogeology of arid zones of India – Hydrogeology of wetlands. Hydrodynamic equilibrium of fresh and saline water –Ghyben-Herzberg relation- Control of saline water intrusion.		
	Text Books		
1.	Freeze, R.A. and Cherry, J.A. (1979) *Groundwater*. Prentice-Hall. London.		
2.	Fetter, C. W. (2018). *Applied Hydrogeology*.Waveland Press. ISBN: 9781478637448. 4th Edition. E-Book.		
3.	De Marsily, G., 1986. Quantitative Hydrogeology: Groundwater Hydrology for Engineers, Academic Press, Inc., Orlando Florida. — Classic book intended for engineers with mathematical background but it can be read by hydrologists and geologists as well. ISBN 0-12-208916-2		
4.	LaMoreaux, Philip E.; Tanner, Judy T, eds. (2001), Springs and bottled water of the world: Ancient history, source, occurrence, quality and use, Berlin, Heidelberg, New York: Springer-Verlag, ISBN 3-540-61841-4 Good, accessible overview of hydrogeological processes.		
5.	Porges, Robert E. & Hammer, Matthew J., 2001. The Compendium of Hydrogeology, National Ground Water Association, ISBN 1-56034-100-9. Written by practicing hydrogeologists, this inclusive handbook provides a concise, easy-to-use reference for hydrologic terms, equations, pertinent physical parameters, and acronyms		
References Books (Latest editions, and the style as given below must be strictly adhered to)			
1.	Todd, D.K. and Mays, L.W. (2013)*GroundwaterHydrology*.John Wiley & Sons, New York. ISBN: 978-81-265-3003-8. 3rd Edition.		
2.	Davis and DeWeist. (1966).*Geohydrology*. John Wiley & Sons, New York.		
3.	Domenico, P.A. & Schwartz, W., 1998. Physical and Chemical Hydrogeology Second Edition, Wiley. — Good book for consultants, it has many real-world examples and covers additional topics (e.g. heat flow, multi-phase and unsaturated flow). ISBN 0-471-59762-7		
4.	Driscoll, Fletcher, 1986. Groundwater and Wells, US Filter / Johnson Screens. — Practical book illustrating the actual process of drilling, developing and utilizing water wells, but it is a trade book, so some of the material is slanted towards the products made by Johnson Well Screens. ISBN 0-9616456-0-1		
5.	Anderson, Mary P.&Woessner, William W., 1992 Applied Groundwater Modeling, Academic Press. — An introduction to groundwater modeling, a little bit old, but the methods are still very applicable. ISBN 0-12-059485-4		
Web Resources			
1.	https://iah.org/		
2.	http://www.groundwateruk.org/		
3.	https://gw-project.org/books/groundwater-resource-development.		
4.	https://www.epa.gov/dwreginfo/drinking-water-regulations.		
5.	https://www.guidelinegeo.com/groundwater-prospection		

Course Outcome:

CO1: This study helps to understand the Hydrological cycle, Aquifer; flow rates and flow directions, Groundwater fluctuation: types, controlling factors

CO2: Occurrence and movement of Groundwater

CO3: Groundwater wells, types and methods

CO4: Groundwater chemistry: Components of groundwaterGroundwater pollution: Arsenic, fluoride and Nitrate

CO5 Salinity in Groundwater, Seawater intrusion and Ghyben-Herzberg Relation

Mapping with Programme Outcomes:
Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low

	PO 1	***PO 2***	***PO 3***	***PO 4***	***PO 5***	***PO 6***	***PO 7***	***PO 8***	***PO 9***	***PO 10***
CO 1	3	3	3	2	1	2	3	3	3	2
CO 2	3	3	3	2	1	2	2	3	3	2
CO 3	3	3	3	2	2	3	2	3	3	3
CO 4	3	3	3	3	2	3	2	3	3	3
CO 5	3	3	3	3	2	3	2	3	3	3

S-Strong-3 ; M-Medium -2 ; L-Low-1.
Program Specific Outcomes

CO/PSO	***PSO 1***	***PSO 2***	***PSO 3***	***PSO 4***	***PSO 5***
CO 1	3	3	3	3	3
CO 2	3	3	3	3	3
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course contribution to Pos	3.0	3.0	3.0	3.0	3.0

Semester-III: Geological Field Mapping (II year)

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
24UPGEO1C11	**Geological Field Mapping**	Core	Y	-	-	-	4	4	25	75	100

Course Objectives	
CO1	To identify and list out the issues and problems
CO2	To describe and explain the solution to follow
CO3	To interpret and calculate through different procedures to find out solution
CO4	To select a particular solution for some specific problems
CO5	To review an idea regarding solution for a problem

UNIT	Details	No. of Hours*	Course Objectives
I	Use of clinometer compass for geographic directions, taking bearing and back bearing, strike and dip, reading of and locating oneself on toposheet – Use of GPS for co-ordinates and mapping of features (One day) – Geomorphological mapping (One day).	12	CO1
II	Visit to igneous rock outcrops for mapping, collection of rock samples and field set-up studies (Two days) – Mapping of dikes and veins – Thin section studies of rocks (One day).	12	CO2
III	Visit to sedimentary terrain for mapping of strata and collection of fossils (Two days).	12	CO2
IV	Visit to metamorphic terrain for mapping of rocks and metamorphic structures, collection of rock samples (Two days) – Thin section studies (One day).	12	CO2
V	Geophysical investigations – Field measurements using gravity, magnetic and electrical methods (Two days).	12	CO2

**Geological Field Mapping for 10-12 days/60 hours*

1.	Brian Simpson. (1968).*Geological Maps*. Pergamon Press Limited, Oxford.
2.	Lisle, R.J. (1988).*Geological Structures and Maps*. Pergamon Press, Oxford.
3	Gass, J.G., Butcher, N.E., Clark, P., Francis, P.W., Jackson, D.E., McCurry, P., Skipsey, E., Smith, P.J., Stevenson, J., Thorpe, R.S., Turner, C., Wilson, R.C.L., Wright, J.B. (1972). *Field Relations – A Second Level Course in Science*. The Open University Press, London

References Books
(Latest editions, and the style as given below must be strictly adhered to)

1.	Thomas, J.A.G. (1977).*An Introduction to Geological Maps*. George Allen and Unwin (Publishers) Limited, London. 2nd Edition.
2.	Bhattacharya, D.S. and Bagchi, T.C. (1973).*Elements of Geological Map Reading and Interpretation with Exercises*. Orient Longman Limited, Calcutta

Web Resources

1.	https://pubs.geoscienceworld.org/jgs
2.	https://www.geosocindia.org/index.php/gsi/pages/view/ed
3.	https://www.gsi.gov.in/webcenter/portal/OCBIS

Course outcome:
CO1:Student apply the knowledge on use of clinometer compass for geographic directions
CO2:Students studied practically on the collection of rock samples and field set-up studies
CO3:Students can get the field exposure and field knowledge for identification of rock types
CO4:Students studied the mapping of rocks and metamorphic structures
CO5: Student trained the Geophysical investigations using geophysical instruments

Mapping with Programme Outcomes:

Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low

	PO 1	***PO 2***	***PO 3***	***PO 4***	***PO 5***	***PO 6***	***PO 7***	***PO 8***	***PO 9***	***PO 10***
CO 1	3	3	2	3	1	3	2	3	1	1
CO 2	3	3	2	3	1	3	2	3	1	1
CO 3	3	3	2	3	1	3	2	3	1	1
CO 4	3	3	2	3	1	3	2	3	1	1
CO 5	3	3	2	3	1	3	2	3	1	1

S-Strong-3 ; M-Medium -2 ; L-Low-1.

Program Specific Outcomes

CO/PSO	***PSO 1***	***PSO 2***	***PSO 3***	***PSO 4***	***PSO 5***
CO 1	3	3	3	3	3
CO 2	3	3	3	3	3
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course contribution to Pos	3.0	3.0	3.0	3.0	3.0

Semester-III: Geophysics and Hydrogeology & Remote Sensing, GIS Practical (II year)

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
24UPGEO1L03	**Geophysics and Hydrogeology & Remote Sensing, GIS Practical**	Core	Y	-	-	-	3	5	40	60	100

Course Objectives	
CO1	To identify the groundwater potential zone
CO2	To describe the different geophysical methods
CO3	Understand how groundwater infiltrates and flows through Earth materials
CO4	To interpret groundwater flow direction from the topographic features
CO5	To critically assess the quality of groundwater

UNIT	Details	No. of Hours	Course Objectives
I	**Electrical Resistivity methods**: Interpretation of vertical electrical sounding data obtained over 2- and 3-layered earth using the S-line, curve matching and auxiliary point chart method – Field demonstration of resistivity, seismic SP and magnetic prospecting techniques.	12	CO1
II	**Gravity Methods:** Computation of gravity response over a sphere – Exercises on drift correction, separation of regional and residual of gravity data – Contouring of gravity data – Calibration of magnetometer – Interpretation of field magnetic data over a dike. Interpretation of seismic refraction data obtained over 2- and 3-layered earth – Computation of configuration constant.	12	CO2
III	**Aquifers and Aquitards:**Factors affecting infiltration and ground water flow: Porosity – Permeability - Grain size – Specific yield – Specific retention – Hazen method for Hydraulic conductivity – Storativity. **Groundwater flow:** Specific discharge – Average linear velocity – Flow net – Flow across water table –Steady unidirectional flow – Unsteady radial flow. **Water chemistry: S**olubility –Ionic strength of groundwater - Trilinear diagram – Oxidation potential *Eh.* **Laboratory –** Uses of Multiparameter – On field water parameter analysis techniques – Preparation of standards for analysis.	12	CO2
IV	**Aerial Photography:** Stereovision Test, Pocket & Mirror Stereoscope - 3D Observation, Demarcation of marginal information, Identification photo Recognition elements. Interpretation of drainage pattern, landforms, rock types and structures.**Satellite Remote sensing:**Decoding of Satellite data, Interpretation of satellite datafor geomorphology, structure and lithology. Exposure to Digital Image Processing techniques, spectral plot for different features.	12	CO2
V	**GIS:** Scanning, Digitization, Preparation of Vector and Raster Image, Geo-Referencing. Overlay analysis. Network analysis, Proximity analysis. Digital Elevation Model.	12	CO2
	Text Books		
1.	Freeze, R.A. and Cherry, J.A. (1979) *Groundwater*. Prentice-Hall. London.		

2.	Fetter, C. W. (2018). *Applied Hydrogeology*.Waveland Press. ISBN: 9781478637448. 4^{th} Edition. E-Book.
3.	De Marsily, G., 1986. Quantitative Hydrogeology: Groundwater Hydrology for Engineers, Academic Press, Inc., Orlando Florida. — Classic book intended for engineers with mathematical background but it can be read by hydrologists and geologists as well. ISBN 0-12-208916-2
4.	LaMoreaux, Philip E.; Tanner, Judy T, eds. (2001), Springs and bottled water of the world: Ancient history, source, occurrence, quality and use, Berlin, Heidelberg, New York: Springer-Verlag, ISBN 3-540-61841-4 Good, accessible overview of hydrogeological processes.
5.	Porges, Robert E. & Hammer, Matthew J., 2001. The Compendium of Hydrogeology, National Ground Water Association, ISBN 1-56034-100-9. Written by practicing hydrogeologists, this inclusive handbook provides a concise, easy-to-use reference for hydrologic terms, equations, pertinent physical parameters, and acronyms
References Books (Latest editions, and the style as given below must be strictly adhered to)	
1.	Todd, D.K. and Mays, L.W. (2013)*GroundwaterHydrology*.John Wiley & Sons, New York. ISBN: 978-81-265-3003-8. 3^{rd} Edition.
2.	Davis and DeWeist. (1966).*Geohydrology*. John Wiley & Sons, New York.
3.	Domenico, P.A. & Schwartz, W., 1998. Physical and Chemical Hydrogeology Second Edition, Wiley. — Good book for consultants, it has many real-world examples and covers additional topics (e.g. heat flow, multi-phase and unsaturated flow). ISBN 0-471-59762-7
4.	Driscoll, Fletcher, 1986. Groundwater and Wells, US Filter / Johnson Screens. — Practical book illustrating the actual process of drilling, developing and utilizing water wells, but it is a trade book, so some of the material is slanted towards the products made by Johnson Well Screens. ISBN 0-9616456-0-1
5.	Anderson, Mary P.&Woessner, William W., 1992 Applied Groundwater Modeling, Academic Press. — An introduction to groundwater modeling, a little bit old, but the methods are still very applicable. ISBN 0-12-059485-4
Web Resources	
1.	https://iah.org/
2.	https://gw-project.org/books/groundwater-resource-development/
3.	https://info.aquaclara.org/what-are-the-most-common-water-contaminants
4.	https://www.usgs.gov/mission-areas/water-resources

Course Outcome:

CO1:The student will be able tounderstand the **Electrical Resistivity methods**
CO2: Understand the application of near surface geophysical techniques for aquifer characterization.
CO3: Student gain knowledge on Groundwater flow
CO4: Student gets knowledge on Aquifers and Aquitards studies
CO5: Student learn about the Water chemistry

Mapping with Programme Outcomes:
Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low

	PO 1	***PO 2***	***PO 3***	***PO 4***	***PO 5***	***PO 6***	***PO 7***	***PO 8***	***PO 9***	***PO 10***
CO 1	3	3	3	3	3	2	2	3	3	3
CO 2	3	3	3	3	3	2	3	3	3	3
CO 3	2	3	3	3	3	1	2	3	3	3
CO 4	2	3	3	3	3	1	2	3	3	3
CO 5	2	3	3	3	3	1	2	3	3	3

S-Strong-3 ; M-Medium -2 ; L-Low-1.
Program Specific Outcomes

CO/PO	***PSO 1***	***PSO 2***	***PSO 3***	***PSO 4***	***PSO 5***
CO 1	3	3	3	3	3
CO 2	3	3	3	3	3
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course contribution to Pos	3.0	3.0	3.0	3.0	3.0

Semester-III: Isotope Geology (II year)

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
24UPGEO1E05	**Isotope Geology**	Elective	Y	-	-	-	3	4	25	75	100

Course Objectives

CO1	To provide knowledge on economically relevant radioactive minerals
CO2	To explain the abundances of unstable nuclides in earth
CO3	To provide practical knowledge on the minerals
CO4	Detail on the methods applied for mineral exploration
CO5	To summarise the radioactive mineral deposits

UNIT	Details	No. of Hours	Course Objectives
I	Discovery of radioactivity, stable and radiogenic isotopes. Literature on isotope geology. Nuclear structure, atomic weights, nuclear stability and abundance. Theory and mechanism of decay, particles emitted, positron, negatron and alpha decay, effect of mineral/crystal structures, growth and retaintion of daughter isotopes in earth systems.	12	CO1
II	Abundances of unstable nuclides in earth, core, mantle, crust, oceans and different rock types; their decay schemes, radioactive elements as major elements, minor elements and trace elements and their geochemical behaviour.Mass spectrometer: Instrumentation, chemical separation, isotope dilution and ratio analysis.	12	CO2
III	Methods of dating: Isochron method, model/mineral ages, Fission track, 40Ar-39Ar, U and Th disequilibrium, choncordia method, 14C, Be and Al. Interpretation and geological significance of ages.	12	CO2
IV	Isotope systematics of K-Ar, Rb-Sr, Sm-Nd, U-Th-Pb in igneous, metamorphic and sedimentary rocks and in evolution of ocean, crust and mantle.	12	CO2
V	Stable isotopes of oxygen and hydrogen, carbon, nitrogen and sulphur. Fractionation of stable isotopes in lithosphere, hydrosphere and atmosphere. Stable isotope geothrermometry and geobarometry.Isotopes in mineral exploration, petroleum exploration, paleo-climate evaluation, health and environmental aspects.	12	CO2

Text Books

1.	Doe, B.R. (1970) Lead isotopes. Springer Verlag, 137p.
2.	Faure, G. and Powell, J.L. (1972) Strontium Isotope Geology. Springer Verlag, 188p.

References Books
(Latest editions, and the style as given below must be strictly adhered to)

1.	Faure, G. (1986). Principles of Isotope Geology. John Wiley, 589p

Web Resources

1.	https://www.britannica.com/topic/economic-geology
2.	https://en.m.wikipedia.org/wiki/supergene-(geology)
3.	https://energymining.sa.gov.au/minerals/mineral-commodities
4.	https://www.slideshare.net/mobile/monokaonaBoruah/magmatic-deposits-economic-geology

Course outcome:
CO1: Students will have the knowledge and skills to recognise common ore minerals.
CO2: Demonstrate familiarity with a wide range of mineral deposits, including recognising the overall geometry, zonation and alteration patterns associated with specific classes
CO3: To get awareness on geochemistry of radioactive minerals
CO4: Fundamentals of coal petrology, Gain knowledge on the Origin, migration and entrapment of natural hydrocarbons
CO5: Student learns more knowledge on industrial aspects in geological studies.

Mapping with Programme Outcomes:
Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low

	PO 1	*PO 2*	*PO 3*	*PO 4*	*PO 5*	*PO 6*	*PO 7*	*PO 8*	*PO 9*	*PO 10*
CO 1	3	3	3	2	3	3	3	2	3	3
CO 2	3	3	3	3	3	3	3	3	3	3
CO 3	3	3	3	3	3	3	2	2	3	2
CO 4	3	3	3	3	2	3	3	3	3	3
CO 5	3	3	2	3	3	2	3	3	2	3

S-Strong-3 ; M-Medium -2 ; L-Low-1.
Program Specific Outcomes

CO/PSO	*PSO 1*	*PSO 2*	*PSO 3*	*PSO 4*	*PSO 5*
CO 1	3	3	3	3	3
CO 2	3	3	3	3	3
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course contribution to Pos	3.0	3.0	3.0	3.0	3.0

Semester-III: Disaster Management (II year)

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
24UPGEO1E06	**Disaster Management**	Elective	Y	-	-	-	3	4	25	75	100

Course Objectives

CO1	Understand the basics of natural hazards, distinguish hazards and disasters, global trends, vulnerable communities, importance of inter-disciplinary studies.
CO2	Students will comprehend the core part of disaster management i.e. geotechnical aspect, community aspect and environmental aspect and its inter-linkages
CO3	Comprehend the complexity of climate change induced disasters, mapping and monitoring techniques including risk zonation and appropriate technology tools for mitigation.
CO4	Acquiring knowledge on community-based disaster management, disaster risk reduction (DRR), community resilience and the importance of hazard mapping.
CO5	Evaluate the importance of this inter-disciplinary course through case study experiences and to use these skills in the real-world scenario

UNIT	Details	No. of Hours	Course Objectives
I	General introduction to natural hazards and disasters: Physical and geodynamic characteristics of earthquakes, tsunamis and storm surges, tropical cyclones, monsoonal floods, landslides. Droughts - different types – monitoring and management and wildfires – Worldwide trends in natural catastrophes and occurrence.	12	CO1
II	Global Climate Change: Global warming and environmental change – Threat of sea level changes on global coasts - Impact on natural resources, environment – Social impact of disasters – Gender, food security, poverty and Climate Change Adaptation.	12	CO2
III	Assessment: Hazard-prone areas identification – Application of remote sensing and GIS tools – Hazard mapping – Risk modeling – Risk zonation and case studies.	12	CO2
IV	Preparedness: Risk reduction concepts – Pre- and post-disaster comparison and analysis – Understanding the disaster cycle – Stakeholders' participation and preparation of comprehensive management plans – Community-based disaster risk management – Participatory risk assessment – Coastal regulations – Coastal management in tsunami reconstruction – National and international scenarios.	12	CO2
V	Mitigation and recovery: Inter-relationship between mitigation and recovery – Process for developing hazards mitigation plan, implementation of comprehensive mitigation strategies – Disaster recovery planning – Disaster emergency preparedness and on recovery and reconstruction – Disaster Risk Reduction (DRR) approaches - Early warning systems.	12	CO2

	Text Books
1.	Handbook of Disaster Research Eds. H. Rodriguez et al., (2006).
2.	Rajib Shaw and Krishnamurthy, R.R. (2008) Disaster Management – The Global

	Challenges and Local Solutions, Universities Press, Hyderabad, pp. 560.
3.	Groundwater Assessment Development and Management, Karanth.K.R. (1987) Tata McGraw Hill Publishing Company, Ltd.
4.	Miller T.G. Environmental Science. Wadsworth Publishing.US(2004).
5.	Coates,D.R. Environmental Geology. McGraw Hill.NewYork(1984)
References Books (Latest editions, and the style as given below must be strictly adhered to)	
1.	Shaw, R. and Rouhban, B. (2005) Disaster Reduction and Human Security. UNESCO & Kyoto University.
2.	Babar, Md. (Ed.) (2007) Environmental Changes and Natural Disasters. New Delhi Publishing Agency.
3.	Coppola D.P, Introduction to International Disaster Management, Butterworth Heinemann(2007)
4.	Pine,J.C, Natural Hazards Analysis: Reducing the Impact of Disasters, CRC Press, Taylor and Francis Group(2009)
5.	Smith K, Environmental Hazards: Assessing Risk and Reducing Disaster Rout ledge Press(2001)
Web Resources	
1.	https://www.britannica.com/science/geology/sedimentary-petrology
2.	https://limk.springer.com/chapter/10
3.	https://www.geo.mtu.edu/UPSeis/hazards.html
4.	https://www.omafra.gov.on.ca/english/engineer/facts/
5.	https://geology.com/rocks/rock-salt.shtml

Course Outcome:
CO1: Understand the need and significance of studying disaster management
CO2: Understand the different types of disasters and causes for disasters.
CO3: Gain knowledge on the impacts Disasters on environment and society
CO4: Study and assess vulnerability of a geographical area.
CO5: Students will be equipped with various methods of risk reduction measures and risk mitigation

Mapping with Programme Outcomes:
Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	3	3	3	2	3	3	3	2	3	3
CO 2	3	3	3	3	3	3	3	3	3	3
CO 3	3	3	3	3	3	3	2	2	3	2
CO 4	3	3	3	3	2	3	3	3	3	3
CO 5	3	3	2	3	3	2	3	3	2	3

S-Strong-3 ; M-Medium -2 ; L-Low-1.

Program Specific Outcomes

CO/PSO	***PSO 1***	***PSO 2***	***PSO 3***	***PSO 4***	***PSO 5***
CO 1	3	3	3	3	3
CO 2	3	3	3	3	3
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course contribution to Pos	3.0	3.0	3.0	3.0	3.0

SEMESTER-III: INTERNSHIP (II year)

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
24UPGEO1I01	**INTERNSHIP**	Core	Y	-	-	-	2	--	25	75	100

Course Objectives

CO1	The students will enhance their writing skills.
CO2	They will acquire knowledge about writing their assignments.
CO3	They will delve into unchartered territory with regard to Scientific/Technical writing of research papers/reports.
CO4	The students will understand what is Bibliography, how to cite references and how to quote them in the text.
CO5	They will be trained in how to avoid redundancies, which constitute a major problem while writing a Scientific Paper/Technical Report.

UNIT	Details	No. of Hours	Course Objectives
I	THE PRE-WRITING STAGE: Why Write?-What is a Scientific Paper?-What is a Technical Report? PLANNING THE SCIENTIFIC PAPER OR REPORT: Structure-Headings-Note for Framework-Format-Keeping a Card Index-Assembling the Data. CONTENTS OF SCIENTIFIC PAPERS; The Parts of a Scientific Paper-Preliminaries-Text-End Material	12	CO1
II	CONTENTS OF TECHNICAL REPORTS: Types of Reports-Investigations-Proposals-Progress Reports-Information-Feasibility Study-Alternative Order. ILLUSTRATIONS AND TABLES: Maps-Line Drawings-Graphs-Photographs-Current Practices on Illustrations-tables.	12	CO2
III	STYLE AND FORM: Accuracy of Content-Clarity and simplicity of Expression-Coherence-Conciseness-Logical Sequence. AIDS TO WRITING: Grammar and Usage-Abbreviations-Compounding of words-Placement of Phrases- Italics-Numerical Expressions-Units and Symbols-Punctuation-Spelling-Conclusion.	12	CO2
IV	WRITING PRACTICES: Rewriting-Readability-Checklist-Preparation of Final Manuscript. ON PROOF READING: Proof reading Requirements-Proof Reading Symbols- Modern Methods of MS Preparation. ABOUT PUBLISHING: Procedures-Double Publishing-Authorship-Copyright- Cataloguing- Guarantees-Reproduction of Published Material-Royalty-Conference Proceeding.	12	CO2
V	REFREES, FORMATS AND PROOFS: Duties of a Referee-Standard Format Requirements-Editing of Proofs. ORAL AND POSTER PRESENTATIONS: Preamble-Mode of Oral Presentation-Aids to Oral Presentation-Poster Presentation. PROJECT PROPOSALS: Types of Project Proposals- The Strategy Project Proposals-Some formats of Project Proposals- Project Proposal Evaluation- Examples of Evaluations.	12	CO2

	Text Books
1.	Whitesides, G. Writing a Scientific Paper Full text. Originally presented at the 231st National Meeting of the American Chemical Society (ACS) in Atlanta, GA, March 26-30, 2006. Division

	of Chemical Information, CINF 17.
2.	The Science of Scientific Writing Full textan article by George Gopen and Judith Swan, published in American Scientist, Vol. 78, No. 6 (November-December 1990), pp. 550-558.
References Books (Latest editions, and the style as given below must be strictly adhered to)	
1.	Guide to Scientific and Technical Writing - P. G. Cooray 1992. ISBN - 9559543407, 9789559543404, 159 pages
Web Resources	
1.	https://www.springer.com/journal/12594

Course Outcome:
CO1: students understand the basis of writing skills.
CO2: students practice how to write the technical reports
CO3: Students learn about the styles and form, grammar, spelling and conclusion
CO4: Student gain about the writing practices
CO5: Understand to prepare the poster presentation and preparation of project proposals
Mapping with Programme Outcomes:
Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low

	PO 1	*PO 2*	*PO 3*	*PO 4*	*PO 5*	*PO 6*	*PO 7*	*PO 8*	*PO 9*	*PO 10*
CO 1	3	3	3	2	3	3	3	2	3	3
CO 2	3	3	3	3	3	3	3	3	3	3
CO 3	3	2	3	3	3	3	3	1	3	3
CO 4	2	3	3	3	2	3	3	3	3	3
CO 5	3	3	2	3	3	3	3	3	2	3

S-Strong-3 ; M-Medium -2 ; L-Low-1.
Program Specific Outcomes

CO/PSO	*PSO 1*	*PSO 2*	*PSO 3*	*PSO 4*	*PSO 5*
CO 1	3	3	3	3	3
CO 2	3	3	3	3	3
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course contribution to Pos	3.0	3.0	3.0	3.0	3.0

Semester-IV

Semester-IV: Engineering and Mining Geology (II Year)

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
24UPGEO1C12	Engineering and Mining Geology	Core	Y	-	-	-	4	5	25	75	100

Course Objectives

CO1	To enumerate the different aspects of engineering geology
CO2	To briefly summarise the properties and significance of different Earth materials on the basis of engineering geology
CO3	To briefly summarise the properties and significance of different Earth materials on the basis of engineering geology
CO4	To employ the students in geotechnical investigations and make them understand the various mining methods adopted in addition to estimation of ore reserves
CO5	To theories the knowledge

UNIT	Details	No. of Hours	Course Objectives
I	Engineering geology: Engineering properties of rocks, soft sediments and soils – Geological investigations pertaining to bridges, buildings, dams, highways and airfields – Types of reservoirs – Geological investigations of reservoir sites.	12	CO1
II	Problems pertain to tunneling in hard and soft grounds – Geological investigations preceding tunneling – Geological investigations pertaining to harbors, docks, coastal erosion – Shoreline engineering – Construction of retaining walls – Problems and solutions.	12	CO2
III	Mining geology: Terminology used in metal mines – Terminology used in coal mines – Prospecting and exploration – Alluvial mining methods – Quarrying – Opencast mining – Mine supports – Mine atmosphere.	12	CO2
IV	Methods of underground metal mining: Without artificial supports – With artificial supports – Cut and fill methods – Shrinkage stoping – Caving methods.	12	CO2
V	Coal mining: Longwall advancing – Longwall retreating – Board and Pillar method – Horizon mining.	12	CO2

Text Books

1.	Arogyaswamy, R.N.P. (1996) *Courses in Mining Geology*. 4th Edition. Oxford and & IBH Publishing Co., New Delhi.
2.	Peters, W.C. (1978) *Exploration and Mining Geology*. 2nd Edition. John Wiley & Sons, New York
3.	VitousekP.M, Global Change and Natural Resource Management, Beyond global warming:Ecology and global change. Ecology 75, 1861-1876.
4.	Miller T.G. Jr, Environmental Science, Wadsworth Publishing Co. (TB)
5.	Thomas,R.T, Introduction to Mining methods, McGraw Hill, New York(1986)

References Books

(Latest editions, and the style as given below must be strictly adhered to)

1.	Blyth, F.G.H. (1963) *A Geology for Engineers*. 4^{th} Edition. The ELBS & Edward Arnold (Publishers) Ltd., London
2.	Legget, H.F. and Hatheway, A.W. (1988) *Geology and Engineering*. 3^{rd} Edition. McGraw-Hill Book Co., New York
3.	ArogyaswamyR.N.P,Courses in Mining Geology, Oxford &IBH, New Delhi(1988)
4.	Singh,R.D, Coal Mining, New Age Publishers, Delhi(1998)
5.	Hartman,H.L, SME Mining Engineering Handbook, SME Colorado, USA (1992)
Web Resources	
1.	https://link.springer.com/chapter/10.1007/
2.	https://www.sciencedirect.com/sciencedirect.com/science/article/pii/
3.	https://www.google.com/ur1?sa=t&source=web&rct=j&ur1=https//mines.gov.in/
4.	https://www.ncbi.nml.gov/books/
5.	https://www.sciencedirect.com/sciencedirect.com/science/article/pii/

Course Outcome:
CO1: Students can understand the Engineering properties of rocks
CO2: student can apply the knowledge and ideals on geological investigations for constructions
CO3: Getting knowledge about the alluvial mining methods
CO4: Study themethods of underground metal mining
CO5: Understand the knowledge about the coal mining methods and techniques

Mapping with Programme Outcomes:
Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low

	PO 1	*PO 2*	*PO 3*	*PO 4*	*PO 5*	*PO 6*	*PO 7*	*PO 8*	*PO 9*	*PO 10*
CO 1	2	3	3	1	2	3	1	2	1	3
CO 2	2	3	3	1	2	3	1	2	1	3
CO 3	2	3	3	1	2	3	1	2	1	3
CO 4	2	3	3	1	2	3	1	2	1	3
CO 5	2	3	3	1	2	3	1	2	1	3

S-Strong-3 ; M-Medium -2 ; L-Low-1.
Program Specific Outcomes

CO/PSO	*PSO 1*	*PSO 2*	*PSO 3*	*PSO 4*	*PSO 5*
CO 1	3	3	3	3	3
CO 2	3	3	3	3	3
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course contribution to Pos	3.0	3.0	3.0	3.0	3.0

Semester-IV: Applied Geochemistry (II Year)

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
24UPGEO1C13	**Applied Geochemistry**	Core	Y	-	-	-	4	5	25	75	100

Course Objectives			
CO1	To study the chemical properties of earth and application of chemistry in geology		
CO2	To understand rock chemistry and evolution of various rock types through geochemical differentiation		
CO3	To briefly summarise the IsiotopeGeochemsirty		
CO4	To understand various surface guides for exploration of economical ores and minerals		
CO5	To theories and the knowledge of Environmental Geochemistry		
UNIT	**Details**	**No. of Hours**	**Course Objectives**
I	Principles Of Geochemistry: Introduction – Periodic table, Geochemistry of the Earth; Formation of the solar system and geochemical history of the earth. The geochemical cycle-Distribution of elements in rocks and soils.	12	CO1
II	Geochemistry Of Minerals, Rocks And Waters: Mineral stability, compositional changes in minerals. River water, Seawater, Seafloor hydrothermal systems; Groundwater and Lakes. Characteristics of Magma, Melting of rocks, Water in Magmas, eutectic and melting. Distribution of trace components between rocks and melts.	12	CO2
III	IsiotopeGeochemsirty: Radioactive Decay, Determining Isotope Decay time, Potassium-Argon Systematics, Uranium-Thorium-Lead Systematics. Types of Isotope- Fractionation, isotope Exchange between minerals and water, Carbon, Oxygen and Sulphur isotopes, First-order decay and growth equations.	12	CO2
IV	Exploration Geochemistry: Introduction – Primary dispersion pattern, Secondary dispersion pattern – background values. Geochemical anomaly – geochemical sampling. Principles and techniques used in the design and implementation of an exploration geochemical survey.	12	CO2
V	Environmental Geochemistry: Anthrosphere aquatic environment – Marine, fluvial, lacustral, aerosols. Perturbations caused by human activity.	12	CO2
1.	Arthur Brownlow, Geochemistry (Second edition), Pearson Education, INC., Australia, 1996		
2.	Faure, G, Principles and applications of Geoche4msitry, Pearson Education, 1998, INC, Australia		
3.	Criss, R.E. Principles of stable Isotope distributions. Oxford University Press, U.K., 1999		
4.	Lajtha, J. and Michener, R. Stables isotopes in ecology and environmental Science, Blackwell, U.K., 1994		
5.	Mason, B.and Moore, and C.B.: - Introduction to Geochemistry		
References Books			

(Latest editions, and the style as given below must be strictly adhered to)	
1.	John V. Walther, Essentials of Geochemistry, Jones and Bartlett Publishers, 2005, Boston
2.	Girard, Principles of Environmental Chemistry, Jones and Bartlett Publishers, 2005, Boston
3.	Nelson EBY, G., Principles of Environmental Geochemistry, Thomson Brooks/Cole, UK,2004
4.	Govett, G. J.S.: -Handbook of Exploration Geochemistry
5.	Kraustopf, K.B.: - Introduction to Geochemistry
Web Resources	
1.	https://earthref.org/GERM/#gsc.tab=0
2.	https://georoc.eu/georoc/new-start.asp
3.	https://www.geochemsoc.org/
4.	https://www.usgs.gov/centers/gggsc/science/geochemistry
5.	https://www.internetchemistry.com/chemistry/geochemistry.php

Course Outcome:
CO1: The student is introduced to a detailed discussion, study, and Principles of Geochemistry
CO2: Student can learn the formulas for Estimation of ore reserves
CO3: Student learn the mining geology calculations
CO4: Students can understand the sophisticated instrumental operations for analysis
CO5: Student apply the techniques for analysis of rocks/minerals/ores.

Mapping with Programme Outcomes:
Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low

	PO 1	*PO 2*	*PO 3*	*PO 4*	*PO 5*	*PO 6*	*PO 7*	*PO 8*	*PO 9*	*PO 10*
CO 1	2	3	3	1	2	3	1	2	1	3
CO 2	2	3	3	1	2	3	1	2	1	3
CO 3	2	3	3	1	2	3	1	2	1	3
CO 4	2	3	3	1	2	3	1	2	1	3
CO 5	2	3	3	1	2	3	1	2	1	3

S-Strong-3 ; M-Medium -2 ; L-Low-1.
Program Specific Outcomes

CO/PSO	*PSO 1*	*PSO 2*	*PSO 3*	*PSO 4*	*PSO 5*
CO 1	3	3	3	3	3
CO 2	3	3	3	3	3
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course contribution to Pos	3.0	3.0	3.0	3.0	3.0

Semester-IV: Engineering, Mining Geology and Geochemistry Practical (II year)

PSO Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
24UPGEO1L04	Engineering, Mining Geology and Geochemistry Practical	Core	Y	-	-	-	3	6	40	60	100

Course Objectives			
	To enumerate need of practical knowledge in the field		
	To conduct the field surveys for mineral exploration		
	To briefly summarise the various mining methods adopted in addition to estimation of ore reserves		
	To employ the students in geotechnical investigations		
	To critically assess the properties of rocks, minerals and ores		
UNIT	**Details**	**No. of Hours**	**Course Objectives**
I	Engineering Geology: Determination of specific gravity, porosity, void ratio, moisture content, degree of saturation, Atterberg limits, and unit weights. Granulometric curves – Uniformity co-efficient – Dry and wet density curves – Mohr's stress circle – Ultimate and safe bearing capacity of cohesive and non-cohesive soils.	12	CO1
II	Mining Geology: Assaying – Determination of average grade – Determination of average width – Uniform sampling – Variable sampling – Influence of interval. Drilling: Core and sludge recovery – Estimation of ore reserves – Determination of coal pillar size – Determination of ideal shaft location.	12	CO2
III	Geochemistry: Analysis of rocks/minerals/ores – Analysis of water – Elemental analysis – Flame photometry – Spectrophotometry –Analysis of trace elements using AAS – ICPMS – radioactive dating methods	12	CO2
	Text Books		
1.	Krynine, D.P. and Judd, W.R. (1957) *Principles of Engineering and Geotechniques*. McGraw-Hill Book Co., New York		
2.	Legget, H.F. (1962) *Geology and Engineering*. McGraw-Hill Book Co., New York		
3.	Dobrin. M.B– introduction to Geophysical prospecting. McGraw–Hill, 1981		
4.	Mason. B, Principles of geochemistry– Willey Toppan, 1966.		
5.	H.E. Hawkes and Webb, ,Geochemistry in Mineral Exploration, Harper and Row Publishers1965.		
References Books (Latest editions, and the style as given below must be strictly adhered to)			
1.	Zaruba, Q. and Menci, V. (1976) *Engineering Geology*. Elsevier Scientific Publishing Co., Amsterdam		
2.	Arogyaswamy, R.N.P. (1980) *Courses in Mining Geology*. 2nd Edition. Oxford and & IBH Publishing Co., New Delhi.		
3.	Govett, G.J.S.Handbook of Exploration Geochemistry.(Ed) , 1983.		
4.	Craig,R.C& D.V. Vaughan. Ore Microscopy and Ore Petrography. Wiley. New York.(1985)		
5.	Aiyengar, N.K.N, Minerals of Madras, Dept.of Industries &Commerce. Guindy, Madras, (1964).		

Web Resources	
1.	1. https://www.Sciencedirect.com
2.	https://www.geos.iitb.ac.in
3.	https://pubs.usgs.gov
4.	https://www.britannica
5.	https://www.intechopen.com

Course Outcome:
CO1:The student is introduced to a detailed discussion, study, and application ofengineering properties of rocks
CO2: Student can learn the formulas for Estimation of ore reserves
CO3: Student learn the mining geology calculations
CO4: Students can understand the sophisticated instrumental operations for analysis
CO5: Student apply the techniques for analysis of rocks/minerals/ores.

Mapping with Programme Outcomes:

Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low

	PO 1	*PO 2*	*PO 3*	*PO 4*	*PO 5*	*PO 6*	*PO 7*	*PO 8*	*PO 9*	*PO 10*
CO 1	2	2	3	2	1	3	2	3	2	2
CO 2	2	2	3	2	1	3	2	3	2	2
CO 3	2	2	3	2	1	3	2	3	2	2
CO 4	2	2	3	2	1	3	2	3	2	2
CO 5	2	2	3	2	1	3	2	3	2	2

S-Strong-3 ; M-Medium -2 ; L-Low-1.

Program Specific Outcomes

CO/PSO	*PSO 1*	*PSO 2*	*PSO 3*	*PSO 4*	*PSO 5*
CO 1	3	3	3	3	3
CO 2	3	3	3	3	3
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course contribution to Pos	3.0	3.0	3.0	3.0	3.0

Semester-IV: Oceanography and Climatology (II year)

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
24UPGEO1E07	**Oceanography and Climatology**	Elective	Y	-	-	-	3	4	25	75	100

Course Objectives

CO1	To learn the physical and chemical components and phenomena related to oceanography and climatology
CO2	To understand the morphologic and tectonic domains of the ocean floor
CO3	Compare and Contrast cloud physics and Physical Meteorology
CO4	Critically assess the ocean current patterns and cloud-climate classifications
CO5	To differentiate and understand the different Oceanic Currents

UNIT	Details	No. of Hours	Course Objectives
I	Oceans and Atmosphere Hypsography of the continents and ocean floor –continental shelf, slope, rise and abyssal plains. Physical and chemical properties of sea water and their spatial variations. Residence times of elements in sea water. Ocean currents, waves and tides, important current systems, thermohaline circulation and the oceanic conveyor belt. Major water masses of the world's oceans. Biological productivity in the oceans.	12	CO1
II	Structure and chemical composition of the atmosphere, lapse rate and stability, scale height, geopotential, greenhouse gases and global warming. Cloud formation and precipitation processes, heat budget, radiation balance. El Nino Southern Oscillation (ENSO). General weather systems of India, - Monsoon system, cyclone and jet stream, Western disturbances and severe local convective systems, distribution of precipitation over India. . Marine and atmospheric pollution, ozone depletion.	12	CO2
III	Morphologic and tectonic domains of the ocean floor. Structure, composition and mechanism of the formation of oceanic crust. Hydrothermal vents-. Ocean margins and their significance. Ocean Circulation, Coriolis Effect and Ekman spiral, convergence, divergence and upwelling, El Nino – La Nina, Indian Ocean Dipole Thermohaline circulation and oceanic conveyor belt.	12	CO3
IV	Physical Meteorology: Thermal structure of the atmosphere and its composition. Radiation: basic Laws - Rayleigh and Mie scattering, multiple scattering, radiation from the sun, solar constant, effect of clouds, surface and planetary albedo. Emission and absorption of terrestrial radiation, radiation windows, radiative transfer, Greenhouse effect, net radiation budget; Clausius – Clapeyron equation.	12	CO4
V	Cloud Physics: Cloud classification, condensation nuclei, growth of cloud drops and ice-crystals, precipitation mechanisms: Bergeron, Findeisen process, coalescence process. Atmospheric turbulence: Mixing length theory, planetary boundary layer equations, surface	12	CO5

	layer, Ekman layer, eddy transport of heat. Richardson criterion.		
	Text Books		
1.	Kennett, J.P. (1982) *Marine Geology*. Prentice Hall, London.		
2.	Seibold, E. and Berger, W.H. (1982) *The Sea Floor*. Springer Verlag, Berlin		
3.	Sverdrup, HaraldUlrik; Johnson, Martin Wiggo; Fleming, Richard H. (1942). The Oceans, Their Physics, Chemistry, and General Biology. New York: Prentice-Hall.		
4.	Rice, A. L. (1999). "The Challenger Expedition". Understanding the Oceans: Marine Science in the Wake of HMS Challenger. Routledge.		
5.	Benjamin Franklin's 'Sundry Maritime Observations'". Archived from the original on 18 December 2005.		
	References Books (Latest editions, and the style as given below must be strictly adhered to)		
1.	Strahler, A.N. and Strahler, A.H. (1987) *Modern Physical Geography*. 3rd Edition. John Wiley & Sons, New York.		
2.	Strahler, A.N. (1974) *Physical Geography*. 4thEdition.John Wiley & Sons, New York.		
3.	Boling Guo, Daiwen Huang. Infinite-Dimensional Dynamical Systems in Atmospheric and Oceanic Science, 2014, World Scientific Publishing, ISBN 978-981-4590-37-2.		
4.	Hamblin, Jacob Darwin (2005) Oceanographers and the Cold War: Disciples of Marine Science. University of Washington Press. ISBN 978-0-295-98482-7		
5.	Lang, Michael A., Ian G. Macintyre, and Klaus Rützler, eds. Proceedings of the Smithsonian Marine Science Symposium. Smithsonian Contributions to the Marine Sciences, no. 38. Washington, D.C.: Smithsonian Institution Scholarly Press (2009) Roorda, Eric Paul, ed. The Ocean Reader: History, Culture, Politics (Duke University Press, 2020) 523 pp. [http://www.h-net.org/reviews/showrev.php?id=58118		
	Web Resources		
1.	https://en.wikipedia.org/wiki/British_Oceanographic_Data_Centre		
2.	https://psl.noaa.gov/data/gridded/tables/ocean.html		
3.	http://www.vega.org.uk/video/		
4.	https://unesdoc.unesco.org/ark:/48223/pf0000030893		
5.	http://www.mcirano.ufba.br/ftp/books/baum_04.pdf		

Course Outcome:

CO1: Students can introduce into the Physical and chemical properties of sea water

CO2:Students learn about the Structure and chemical composition of the atmosphere

CO3:Gain knowledge in the Morphologic and tectonic domains of the ocean floor Structure

CO4:Students can introduce into Physical Meteorology

CO5:Studied and gain knowledge on Cloud Physics

Mapping with Programme Outcomes:

Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low

	PO 1	*PO 2*	*PO 3*	*PO 4*	*PO 5*	*PO 6*	*PO 7*	*PO 8*	*PO 9*	*PO 10*
CO 1	3	3	3	2	3	3	3	2	3	3
CO 2	3	3	3	3	3	3	3	3	3	3
CO 3	3	2	3	3	3	3	3	1	3	3
CO 4	2	3	3	3	2	3	3	3	3	3
CO 5	3	3	2	3	3	3	3	3	2	3

S-Strong-3 ; M-Medium -2 ; L-Low-1.

Program Specific Outcomes

CO/PSO	*PSO 1*	*PSO 2*	*PSO 3*	*PSO 4*	*PSO 5*
CO 1	3	3	3	3	3
CO 2	3	3	3	3	3
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course contribution to Pos	3.0	3.0	3.0	3.0	3.0

Semester-IV: Petroleum Exploration and Mud logging (II Year)

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
24UPGEO1E08	Petroleum Exploration and Mud logging	Elective	Y	-	-	-	3	4	25	75	100

Course Objectives

CO1	To Identify and enumerate the methods of drilling. To describe and explain the oil resources. To summarize the whole procedure involved in exploitation of oil resources
CO2	To interpret and select the prospering area for exploitation of
CO3	Compare and contrast the differences between prosperous and non-economical sites.
CO4	Critically assess and review the ideas at strategic situation at the drilling site
CO5	Can make hypothesis to achieve the target

UNIT	Details	No. of Hours	Course Objectives
I	Petroleum Exploration – Petroleum Geology - Applied Mathematics in Petroleum Engineering. Oil Field Drilling – Onshore and Offshore Drilling - Drilling Rigs – Well Types - The Drill String – Drill Bits – Well Profile- Bore-hole volume Calculation and Displacement – Lag time – Basic Hydraulics - Drilling Fluids - Formation Pressure –Bore Hole Problems - Coring –Objective of Coring and Core Analysis- Casing and Cementing – Fishing - Well Completion – Well Testing.	12	CO1
II	Basics of Mudlogging –Surface Logging - Tasks and Responsibilities - Geological Surveillance – Cutting Sampling - Collection, Examination – Lithological and Mineralogical Description–Calcimetry - Oil Shows- Fluorescence and Cut Fluorescence – Thin Sections – Chemical Tests – Gas Sampling – Hydrocarbon Gas Analysis – Pore Pressure calculation - Cutting Evaluation – Sample Examination Procedure - Wellsite Geo-Chemistry - Gases other than Hydrocarbons, Communication Skill - QHSE – Worksite Environmental Hazards – Offshore Safety - Quality Control.	12	CO2
III	MudloggingServices, Mudlogging Sensors –Operations – Maintenance - Inspection and calibrations–Trouble shooting - Technical Specification - Reporting - Final Well Reports - Mudlogging Unit Installation and Maintenance.PracticalMudlogging, Lab Training on Rig up and Rig Down of Sensors, Equipment and Monitoring Realtime drilling followed by a Rig site Visit.	12	CO3
IV	Down-hole Measurement - Measuring While Drilling (MWD) – MWD Principle – Telemetry Types – Formation Evaluation MWD-Sensor information – Natural Gama ray – Formation resistivity – Focused Current Resistivity (FCR) – Toroidal Resistivity – Electromagnetic Wave Propagation Resistivity – Multiple Propagation Resistivity (MPR) – Geo-Steering- Neutron Porosity MWD Tools – Formation Density MWD Tools – Drilling Performance MWD.	12	CO4

V	Down-hole Logging - Logging While Drilling (LWD) – Temperature Logs – Caliper Logs – Self Potential Logs (SP) – Resistivity & Conductivity Logs – Gama ray and Spectral Gama ray logs – Sonic Logs – Density and Photo Electric factor Logs – The Neutron Log – The dip meter – Imaging Logs –MDT Sampling - Lithology reconstruction from Logs- Facies Sequences and depositional environments from Logs – Sequence Stratigraphy and Stratigraphy.	12	CO5
	Text Books		
1.	Levorsen, A.J. (2004). *Geology of Petroleum*, CBS Publishers and Distributors Pvt Ltd., Chennai. 2nd Edition.		
2.	BhagwanSahay. (1997). *Petroleum Exploration and Exploitation Practices*, Allied Publishers Limited, Chennai. 2nd Edition.		
3.	Geology& Mineral Resources of the States of India. Misc Pub.No.30.Geological Survey of India. Kolkota. (Several individual volumes available online at GSI portal) GSI(2005).		
4.	The Mudlogging Handbook – Alun Whittaker		
5.	Brian Frehner. Finding Oil: The Nature of Petroleum Geology, 1859–1920 (University of Nebraska Press; 2011) 232 p		
References Books (Latest editions, and the style as given below must be strictly adhered to)			
1.	Mudlogging Training Manuals – GEOLOG International B.V		
2.	The Mudlogging Handbook – Alun Whittaker		
3.	An Introduction in Stratigraphy, Stamp L.D, (1964), Thomas Murby, Museum St, WCI, London.		
4.	Stratigraphic Principles and Practices, Weller, J.M, (1962), Harper & Bros, New York		
5.	Wadia,D.N, Geology of India, McMillan India Delhi(1953)		
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/		

Course Outcome:

CO1: Students gain knowledge about the Petroleum Exploration

CO2 Students learn about theBasics of Mudlogging

CO3: Students get knowledge on MudloggingServices, Mudlogging Sensors –Operations – Maintenance

CO4: Students know about the Down-hole Measurement

CO5: Students able to learn on Down-hole Logging

Mapping with Programme Outcomes:

Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low

	PO 1	***PO 2***	***PO 3***	***PO 4***	***PO 5***	***PO 6***	***PO 7***	***PO 8***	***PO 9***	***PO 10***
CO 1	2	3	3	3	3	3	3	3	2	3
CO 2	2	3	3	3	3	3	3	3	2	3
CO 3	2	3	3	3	3	3	3	3	2	3
CO 4	2	3	3	3	3	3	3	3	2	3
CO 5	2	3	3	3	3	3	3	3	2	3

S-Strong-3 ; M-Medium -2 ; L-Low-1.

Program Specific Outcomes

CO/PSO	*PSO 1*	*PSO 2*	*PSO 3*	*PSO 4*	*PSO 5*
CO 1	3	3	3	3	3
CO 2	3	3	3	3	3
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course contribution to Pos	3.0	3.0	3.0	3.0	3.0

SUPPORTIVE COURSES (NME-II)

EARTH AND ENVIRONMENT

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
24UPGEO1N01	**EARTH AND ENVIRONMENT**	Supportive	Y	-	-	-	2	4	25	75	100

Course Objectives	
CO1	To explore the fundamental interactions of the geosphere, hydrosphere, atmosphere and biosphere.
CO2	The unit is designed to provide a strong scientific foundation for understanding and contextualizing studies of the environment, human impacts and sustainable practice and management of resources.
CO3	Describe the connections and feedback between the Earth's spheres.
CO4	A basic understanding of the Earth as an holistic system knowledge of the main components of the Earth system and their interactions
CO5	The interactions between biological, chemical, and physical processes that shape and define the Earth System.

UNIT	Details	No. of Hours	Course Objectives
I	Space Science:Introduction to various branches of Earth Sciences. Solar System, Age of the Earth, Origin of Solar system. Meteors and Meteorites. Earth Dynamics : Interior of the Earth, Composition of the Earth, Seismic waves, Seismograph, Plate Tectonics, Basics of Earthquake Engineering, Landslides, Volcanoes.	12	CO1
II	Geological Oceanography:Hypsography of the continents and ocean floor –continental shelf, slope, rise and abyssal plains.Physical and chemical properties of sea water and their spatial variations. Residence times of elements in sea water. Ocean currents, waves and tides, important current systems, thermohaline circulation and the oceanic conveyor belt.	12	CO2
III	Hydrogeology: Water table- Aquifer- Groundwater fluctuations and groundwater composition, Hydrological cycle. Glaciology: Glacier types, Different type of glaciers, Landforms formed by glacier. Petrology - Geological bodies and their structures: Rock, mineral, batholiths, dyke, sill, fold fault, joint, unconformity.	12	CO3
IV	Earth’s Atmosphere: Structure and composition of atmosphere, Atmospheric circulation, Geological work of wind, Greenhouse effect and global warming, Carbon dioxide sequestration. Steps to maintain clean and pollution free atmosphere with governing laws, precautionary measures against disasters.	12	CO4
V	Environmental Earth Sciences: Properties of water; hydrological cycle; water resources and management. Energy resources, uses, degradation, alternatives and management; Ecology and biodiversity.Impact of use of energy and land on the environment.Exploitation and conservation of mineral and other	12	CO5

	natural resources.Naturalhazards.Elements of Remote Sensing.		
	Text / Reference Books		
1.	Holme's Principles of Physical Geology. (1992). Chapman & Hall.		
2.	Emiliani, C, (1992). Planet Earth, Cosmology, Geology and the Evolution of Life and Environment. Cambridge University Press		

Course Outcome

CO1 The interaction between the Earth's spheres, relevant processes and environmental changes.

CO2 Knowledge and understanding Recapitulate processes in the different spheres

CO3 Describe the connections and feedback between the Earth's spheres Explain the connection between Earth System processes and global environmental changes

CO4 A basic understanding of the Earth as an holistic system knowledge of the main components of the Earth system and their interactions

CO5 The interactions between biological, chemical, and physical processes that shape and define the Earth System

Outcome Mapping

POs& PSOs/COs	***PO1***	***PO2***	***PO3***	***PO4***	***PO5***	***PSO1***	***PSO2***	***PSO3***	***PSO4***	***PSO5***	***PSO6***	***PSO7***
CO 1	3	2	1	1	2	3	2	1	2	2	1	1
CO 2	3	2	1	1	2	3	2	1	2	2	1	1
CO 3	3	2	1	1	2	3	2	2	3	2	2	1
CO 4	3	2	1	1	2	3	1	2	2	2	1	1
CO 5	3	2	1	1	2	3	2	2	2	1	2	1

Note: POs-Program Outcomes, PSOs -Program Specific Outcomes and CO-Course Objective & Cognitive level: K1- Remembering, K2- Understanding , K3- Applying

S-Strong-3 ; M-Medium -2 ; L-Low-1.

Program Specific Outcomes

CO/PSO	***PSO 1***	***PSO 2***	***PSO 3***	***PSO 4***	***PSO 5***
CO 1	3	3	3	3	3
CO 2	3	3	3	3	3
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course contribution to Pos	3.0	3.0	3.0	3.0	3.0

WATER RESOURCES MANAGEMENT

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
24UPGEO1N02	**WATER RESOURCES MANAGEMENT**	Supportive	Y	-	-	-	2	4	25	75	100

Course Objectives

CO1	To know about the nature and occurrence of water, its spatial and temporal variability, quantity and quality considerations and human influence.
CO2	To define the water resources endowment on which development and use of water resources must be planned.
CO3	To develop a sound foundation on dynamics of water in the nature and human interferences.
CO4	To develop wider perspectives on integrated water resources management.
CO5	To Analyze the human interferences on hydrologic processes and the resulting consequences in terms of quantity and quality

UNIT	Details	No. of Hours	Course Objectives
I	Introduction: Definition, concepts of watershed, major objectives of watershed management, effects of watershed on community, ecosystem, Monitoring and evaluation of watershed.	12	CO1
II	Principles of watershed management: Delineating the watershed. naturalprocessesat work in watershed, common elements of watershed management, multidisciplinary approach in watershed management, participatory resources mapping and appraisal, benefits of watershed approach.	12	CO2
III	Degradation agents in watershed: Flood, drought, fire, wind storms, erosion anddeposition. Climate change.Glacial movement, Tectonic activity.Volcaniceruption.Human–induced changes.Impact of the degradation of watersheds in hydrology.	12	CO3
IV	Engineering measures for soil conservation: Rainfall parameters. Types of soilerosion.contourbunding, Surplussing structures contour and straggled trenching, gully control structures, graded bunding, bench terracing, land leveling and grading.	12	CO4
V	Water Conservation and Harvesting: Water conservation methods for crop land,Treatment of catchments. Rainwater harvesting structures: Check dam, farm pond, percolation tank, basin, ditch and furrow, channel, flooding, irrigation, subsurface dyke, Nalla bund and pit methods. Ecosystem assessments, Environmental flows, Future freshwater challenges, Eco tourism, Social and political issues of water use - Sustainable Ecosystems - Environmental governance	12	CO5

	Text Books
1.	Rajora,R.,(1998), Integrated Watershed Management, Rewat Publications, New Delhi.
2.	Tideman.E.M., (1996), Watershed Management: Guideline for Indian Conditions, Omega, Scientific Publishers,372p. New Delhi
3.	Lal.S., (2004), Watershed, Development, Management and Technology, Mangal Deep

	Publications,358p.
4.	Paranjape,S.et.al.,(1998), Watershed Based Development: A Source Book, Bharat GyanVigyanSamathi, New Delhi.
5.	Kakade,B.K.,(2002), Soil and Water Conservation Structures in Watershed Development Programs ,BAIF Development Research Foundation, Pune.

Course Outcome

CO1 Appreciate the circulation of water in earth-atmosphere system and the hydrologic processes over a river basin and emerging quality and quantity concerns thereto.
CO2 Quantify the occurrence and variability of rainfall, runoff, flood and sediment transport processes.
CO3Quantify the occurrence and distribution of groundwater to plan potential groundwater usage.
CO4 Analyze the human interferences on hydrologic processes and the resulting consequences in terms of quantity and quality.

Outcome Mapping

POs& PSOs/COs	***PO1***	***PO2***	***PO3***	***PO4***	***PO5***	***PSO1***	***PSO2***	***PSO3***	***PSO4***	***PSO5***	***PSO6***	***PSO7***
CO 1	3	2	1	1	2	3	2	1	2	2	1	1
CO 2	3	2	1	1	2	3	2	1	2	2	1	1
CO 3	3	2	1	1	2	3	2	2	3	2	2	1
CO 4	3	2	1	1	2	3	1	2	2	2	1	1
CO 5	3	2	1	1	2	3	2	2	2	1	2	1

Note: POs-Program Outcomes, PSOs -Program Specific Outcomes and CO-Course Objective & Cognitive level: K1- Remembering, K2- Understanding , K3- Applying

S-Strong-3 ; M-Medium -2 ; L-Low-1.

Program Specific Outcomes

CO/PSO	***PSO 1***	***PSO 2***	***PSO 3***	***PSO 4***	***PSO 5***
CO 1	3	3	3	3	3
CO 2	3	3	3	3	3
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course contribution to Pos	3.0	3.0	3.0	3.0	3.0

GEMMOLOGY

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
24UPGEO1N03	**GEMMOLOGY**	Supportive	Y	-	-	-	2	4	25	75	100

Course Objectives

CO1	To learn and to examine the nature, quality, rarity of gemstones
CO2	To understand the physical and optical properties of gemstones.
CO3	To summarize the origin, classification of gems.
CO4	To give an idea about the gem testing instruments.
CO5	To gain knowledge and to provide skills to become a successful gemologist.

UNIT	Details	No. of Hours	Course Objectives
I	Introduction to Gems - Basic properties of gems.Formation of gem stones. Nature of gem material: quality necessary in gems-beauty, rarity, durability. Distinction between crystalline, amorphous and metamict materials. Crystal form and habit. Classification of gem stones. Observations with hand lens (10x)-importance and uses. Units of measurement: metric scale, carat, pearl and grain.	12	CO1
II	Nature of crystals: distinction between crystalline and amorphous material, crystal symmetry, Twinning, parallel growth, crystal form, crystal habit, seven crystal system. Identification of rough stones.Imitation stones.	12	CO2
III	Physical properties: hardness its applications in gemmology and limitations. Cleavage, Fracture, parting, and their importance in gemology and lapidary work.Specific gravity-utility and determination by hydrostatic weighing, heavy liquids, floation and pycnometer.Inclusions and other features of gemstones.Generalities, Description, Properties and Identification of Biogenic Gem Materials.	12	CO3
IV	Optical properties: The electromagnetic spectrum, reflection and its importance in gemology-lustre, aventurescence, sheen, chatoyancy, asterism, luminescence, play of colors, labradorescence, inclusions etc.. Laws of refraction, refractive index (R.I), total reflection- in design of refractometer. Construction and use of refractometer.Polariscope-construction and use in gemmology. Dichroscope-construction, use of Chelsea colour filter, Infra-red ultraviolet and x-rays in gem identification.	12	CO4
V	Enhancement and treatments- enhancement methods - coloured and colourless impregnation, dyeing, bleaching and its identification. Methods of treatment – laser drilling, irradiation, heat treatment, surface modifications, diffusion treatment and its identification. Composites - types, classification and identification.	12	CO5

	Text Books
1.	Karanth K.V.(2000),Gem and gem industry in India, Memoir 45,Geological Society of India, Bangalore.,

2.	Anderson,B.W(1990).Gem testing (10th edition),Butterworth Scientific, London
3.	Babu,T.M.(1998) Diamonds in India. Geological society of India, Bangalore
4.	Hall,C.(1994).Gemstone, Dorling Kingsley, London.
5.	Deer,W.A., Houre,R.AabdZussman.S.(1992). An introduction to rock forming minerals, ELBS, London
References Books (Latest editions, and the style as given below must be strictly adhered to)	
1.	Kerr, P.F.(1997).Optical mineralogy,4th Ed. McGraw Hill Book & Co New York., Gemmology 2nd Ed.-Peter Read (1991) Butter worth-Heinemann Ltd.Lundu., Gems 5th Ed. Peter Read. Butterworth, London
2.	Richard Laddicoat (1987), Hand book of gem identification- G.I.A
3.	Santa Monica., Edward Gubelin (1986) Photo Atlas of Including in Gem Stones- ABC Edition Zurich., Gem Testing 10th Ed
4.	B.W. Anderson (1990) Butterworth Scientific London., Gemstone Enhancement 2nd Edition
5.	Nassan K. (1994)Butterworths London., Gems 5th Ed. Webster Butter worths London., Hall, C. Gemstones. ISBN 1564584992.

Course Outcomes

CO1 The course is focused on a comprehensive learning in gemology.
CO2 Understands the formation, classification to final grading and evaluation.
CO3 Apply Basic gemological techniques will be learned from this course
CO4 Knowledge and order to identify gemstones and simulants.
CO5 The students will acquire skills which will be useful to them in gem industry

.***Outcome Mapping***

POs& PSOs/COs	*PO1*	*PO2*	*PO3*	*PO4*	*PO5*	*PSO1*	*PSO2*	*PSO3*	*PSO4*	*PSO5*	*PSO6*	*PSO7*
CO 1	3	2	1	1	2	3	2	1	2	2	1	1
CO 2	3	2	1	1	2	3	2	1	2	2	1	1
CO 3	3	2	1	1	2	3	2	2	3	2	2	1
CO 4	3	2	1	1	2	3	1	2	2	2	1	1
CO 5	3	2	1	1	2	3	2	2	2	1	2	1

Note: POs-Program Outcomes, PSOs -Program Specific Outcomes and CO-Course Objective & Cognitive level: K1- Remembering, K2- Understanding , K3- Applying

S-Strong-3 ; M-Medium -2 ; L-Low-1.

Program Specific Outcomes

CO/PSO	*PSO 1*	*PSO 2*	*PSO 3*	*PSO 4*	*PSO 5*
CO 1	3	3	3	3	3
CO 2	3	3	3	3	3
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course contribution to Pos	3.0	3.0	3.0	3.0	3.0

RAINWATER HARVESTING AND ARTIFICIAL GROUNDWATER RECHARGE

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
24UPGEO1N04	**RAINWATER HARVESTING AND ARTIFICIAL GROUNDWATER RECHARGE**	Supportive	Y	-	-	-	2	4	25	75	100

Course Objectives	
CO1	To understand the importance of rainwater harvesting for water supply and will learn about different types of rainwater harvesting systems.
CO2	To get familiar with different potential uses of rainwater and understand the advantages and limitations.
CO3	To get familiar with different components of Groundwater management strategy.
CO4	To make them understand about the Artificial groundwater recharge structures.
CO5	To understand and explain the main quality concerns with respect to BIS and WHO standards.

UNIT	Details	No. of Hours	Course Objectives
I	Hydrological cycle and its components.Surface water and groundwater.Vertical distribution of groundwater. Over-exploitation of groundwater - Need for artificial recharge and rainwater harvesting - types of wells - drilling technology - design, construction and development of water wells: dug, bore and tube wells.	12	CO1
II	Types of pumps - various artificial recharge structures: recharge ponds - recharge pits - percolation ponds - basin spreading - surface and subsurface dykes - recharge wells - recharge bore wells. Rainwater harvesting in urban areas : RWH structures - design - construction.	12	CO2
III	Estimation of probable runoff from an area including from rooftops - maintenance and monitoring of RWH structures - benefits - effects on local groundwater environments - remedial measures. Recycling of domestic water - sources of water to recharge in urban areas.Aquifer and its types.	12	CO3
IV	Water table and its fluctuations.water quality parameters. BIS and WHO standards. watershed management strategy. Salt water intrusion and remedial measures.Interlinking of rivers in India.Indian monsoon pattern.Role of meteorological department.Integrated Water Resources Management (IWRM) Approach: IWRM Principles: Modern principles for water management and planning, definition, components, and critique of IWRM.	12	CO4
V	Groundwater management strategy, recycling of effluent water, sources of water contamination and remedial measures. Impact of urbanization on water resources.Definition for river basin, sub	12	CO5

	basin, watershed and micro watershed. Role of public in watershed management practices at village level.Sustainable Water Resources Management: Concept of sustainable development, sustainability principles for water management, goals for guiding sustainable water resource management.		
	Text Books		
1.	Rajora,R.,(1998), Integrated Watershed Management, Rewat Publications, New Delhi.		
2.	.Lal.S., (2004), Watershed, Development, Management and Technology, Mangal Deep Publications,358p.		
3.	Paranjape,S.et.al.,(1998), Watershed Based Development: A Source Book, Bharat GyanVigyanSamathi, New Delhi.		
4.	Suresh.R.,(2002), Soil and Water Conservation Engineering, Standard Publishers and Distributers, Delhi.		
5.	Kakade,B.K.,(2002), Soil and Water Conservation Structures in Watershed Development Programmes ,BAIF Development Research Foundation, Pune		

Course Outcomes

CO1 Understands different potential uses of rainwater advantages and limitations.

CO2 Students get a exposure of different components of Groundwater management strategy

CO3 Learned about the potential of rainwater harvesting under different circumstances

CO4 To have preliminary ideas pertaining to watershed development and management strategies.

CO5 Enhance the distribution and movements of groundwater resources on global scenario

POs& PSOs/COs	***PO1***	***PO2***	***PO3***	***PO4***	***PO5***	***PSO1***	***PSO2***	***PSO3***	***PSO4***	***PSO5***	***PSO6***	***PSO7***
CO 1	3	2	1	3	2	3	2	1	3	2	1	1
CO 2	3	1	2	3	2	3	1	1	2	2	2	1
CO 3	3	2	1	3	2	3	1	3	3	1	1	1
CO 4	3	2	1	3	2	3	2	2	3	2	1	1
CO 5	3	2	1	3	2	3	2	2	2	2	1	1

Note: POs-Program Outcomes , PSOs -Program Specific Outcomes and CO-Course Objective & Cognitive level: K1- Remembering, K2- Understanding , K3- Applying

S-Strong-3 ; M-Medium -2 ; L-Low-1.

Program Specific Outcomes

CO/PSO	***PSO 1***	***PSO 2***	***PSO 3***	***PSO 4***	***PSO 5***
CO 1	3	3	3	3	3
CO 2	3	3	3	3	3
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course contribution to Pos	3.0	3.0	3.0	3.0	3.0

GEOHAZARDS

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
24UPGEO1N05	**GEOHAZARDS**	Supportive	Y	-	-	-	2	4	25	75	100

Course Objectives	
CO1	To explain students about the physical and geological processes causing geohazards.
CO2	To discuss the methods for quantifying geohazards
CO3	To understand the possible consequences as well as risk and disaster management
CO4	To make them aware about landslides, floods, tsunamis and earthquakes, for which the geological and physical process were to be discussed
CO5	To discuss potential interlinkages between different types of geohazards, disaster prevention and management and quantification and communication of uncertainties.

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.-Seismic Gap.	12	CO2
III	Volcanoes-Definition-structure - types –Global distribution - mitigation measures and management. Avalanche – Definition – types – mitigation. Flood- Definition - causes - vulnerable zones in India-Mitigation measures and management. Monitoring and prediction of eruptions: short term, long term. 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. Weather, temperature and pressure differences, trade and westerly winds, adiabatic cooling, cold and warm fronts.	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.Waves, beaches, coastal erosion: wave characteristics, summer and winter beaches, wave refraction and longshore drift; sand supply and cliff erosion.	12	CO5

	Text/ Reference Books
1.	Geology, environment, Society K.S.Valdiya (2004) Universities Press (India) Private Limited, Hyderabad,India
2.	Coping with natural hazards: Indian context K.S.Valdiya (2004) Orient Longman Private Limited, Hyderabad,India.
3.	Engineering and General Geology, Parbin Singh (2003) S.K.Kataria and sons Delhi India
4.	General Geology V.Radhakrishnan (1996) V.V.P.Publishers, Tuticorin,India.
5.	Lundgren (1986). Environment Geology, Prentice Hall Publishers, New Jersey.

Course Outcomes

CO1 Explain the physical and geological processes causing geohazards such as landslides, floods, tsunamis and earthquakes.

CO2 Describe methods for quantifying hazard for the individual geohazards and factors controlling their uncertainty.

CO3 Explain possible consequences of geohazards as well as risk and disaster management.

CO4 Complete a basic hazard assessment for selected geohazards.

CO5 Gain an additional knowledge on possible interactions between geohazards and their consequences

Outcome Mapping

POs& PSOs/COs	*PO1*	*PO2*	*PO3*	*PO4*	*PO5*	*PSO1*	*PSO2*	*PSO3*	*PSO4*	*PSO5*	*PSO6*	*PSO7*
CO 1	3	2	1	1	2	3	2	1	2	2	1	1
CO 2	3	2	1	1	2	3	2	1	2	2	1	1
CO 3	3	2	1	1	2	3	2	2	3	2	2	1
CO 4	3	2	1	1	2	3	1	2	2	2	1	1
CO 5	3	2	1	1	2	3	2	2	2	1	2	1

Note: POs-Program Outcomes, PSOs -Program Specific Outcomes and CO-Course Objective & Cognitive level: K1- Remembering, K2- Understanding , K3- Applying

S-Strong-3 ; M-Medium -2 ; L-Low-1.

Program Specific Outcomes

CO/PSO	*PSO 1*	*PSO 2*	*PSO 3*	*PSO 4*	*PSO 5*
CO 1	3	3	3	3	3
CO 2	3	3	3	3	3
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course contribution to Pos	3.0	3.0	3.0	3.0	3.0

VALUE ADDED COURSES
(CERTIFICATE COURSE – EXTRA CREDITS)

HYDROLOGY AND WATER MANAGEMENT

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
24UPGEO1VA1	**HYDROLOGY AND WATER MANAGEMENT**	VALUE ADDED COURSES	Y	-	-	-	2	30	25	75	100

Course Objectives			
CO1	To learn the fundamental components of hydrological cycle and distribution of fresh and salt water of the Earth		
CO2	To impart theoretical, practical and field knowledge pertaining to Hydrogeological domain		
CO3	To understand the physical, chemical and biological characteristics of water with special emphasis on pollution and contamination.		
CO4	To understand the relationship in between water and rock interaction and salt water intrusion and its remedial measures in the coastal aquifers		
CO5	An ability to ethical, social, health and sustainable consumption of water resources.		
UNIT	**Details**	**No. of Hours**	**Course Objectives**
I	Introduction to Groundwater, Hydro meteorology, Groundwater in Hydrologic Cycle, Occurrence of groundwater, zone of Aeration and Saturation, Hydrogeology, Types of aquifers soil sample analysis - Water bearing materials, Aquifer parameters and its determination. Evaporation and its measurement-Evapotranspiration and its measurement- Penman Monteith method-Infiltration- Factors affection infiltration-Hyetograph-Runoff- drainage basin characteristics- Hydrograph concepts assumptions and limitations of unit hydrograph.	12	CO1
II	Occurrence and movement of groundwater- Darcy’s law-governing ground water flow equations-Factors governing ground water flow-Types of aquifers- porosity- specific yield specificretention - storage coefficient-permeability- hydraulic conductivity- hydraulic transmissibility-Conjunctive use and it’s necessity. Types of Investigations- Site selection- Zones of storage - Safe yield-Reservoir capacity- Reservoir sedimentation and control.	12	CO2
III	Indian rivers and floods- Causes of flooding- Alleviation- Leeves and flood walls Floodways-Channel improvement- Flood damage analysis-Design flood- Flood estimation- Frequency analysis-Flood routing through reservoirs and open channels- Storm drainage design.	12	CO3
IV	Definition of drought- Causes of drought- measures for water conservation an augmentation-drought contingency planning-Water harvesting: rainwater collection-small dams-runoff enhancement-runoff collection- ponds- tanks- natural and artificial ground water	12	CO4

	recharge methods		
V	Introduction - Components of Hydroelectric Power Plant-Levels in planning-Functional requirements of water resources projects-steps in water resources planning- Environmental aspects in water resources planning	12	CO5
	Text / Reference Books		
1.	Garg S.K., Hydrology and Water Resources Engineering		
2.	Subramanya, K., Engineering Hydrology, Tata McGraw Hill, New Delhi.		
3.	Raghunath, H.M., Groundwater, 1987, Wiley Eastern Ltd., New Delhi.		
4.	Modi, P.N., Irrigation Water Resources and Water Power Engineering, Standard Book House, New Delhi		
5.	Todd, D.K., Groundwater Hydrology, 1993 John Wiley & Sons..		
References Books (Latest editions, and the style as given below must be strictly adhered to)			
1.	Raghunath, H.M., Hydrology – Principles, Analysis and Design, 1986, Wiley		
2.	Dr. P.Jaya Rami Reddy, A Textbook of Hydrology, University Science Press.		

Course Outcomes

CO1 Capable of understanding the impact of water conservation methods in regional and national context.

CO2 An ability to understand the importance of groundwater augmentation strategies.

CO3 To perform socio economic analysis to evaluate the intangible benefits of artificial structures.

CO4 Formulate and solve deterministic and optimization models for water resources.

CO5 To get familiarization of principles and applications of various groundwater exploration techniques

Outcome Mapping

POs& PSOs/COs	*PO1*	*PO2*	*PO3*	*PO4*	*PO5*	*PSO1*	*PSO2*	*PSO3*	*PSO4*	*PSO5*	*PSO6*	*PSO7*
CO 1	3	2	1	1	2	3	2	1	2	2	1	1
CO 2	3	2	1	1	2	3	2	1	2	2	1	1
CO 3	3	2	1	1	2	3	2	2	3	2	2	1
CO 4	3	2	1	1	2	3	1	2	2	2	1	1
CO 5	3	2	1	1	2	3	2	2	2	1	2	1

Note: POs-Program Outcomes, PSOs -Program Specific Outcomes and CO-Course Objective & Cognitive level: K1- Remembering, K2- Understanding , K3- Applying

S-Strong-3 ; M-Medium -2 ; L-Low-1.

Program Specific Outcomes

CO/PSO	*PSO 1*	*PSO 2*	*PSO 3*	*PSO 4*	*PSO 5*
CO 1	3	3	3	3	3
CO 2	3	3	3	3	3
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course contribution to Pos	3.0	3.0	3.0	3.0	3.0

ENVIRONMENTAL STUDIES AND EARTH SCIENCES

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
24UPGEO1VA2	**ENVIRONMENTAL STUDIES AND EARTH SCIENCES**	VALUE ADDED COURSES	Y	-	-	-	2	30	25	75	100

Course Objectives

CO1	To learn the fundamental components of hydrological cycle and distribution of fresh and salt water of the Earth.
CO2	To impart theoretical, practical and field knowledge pertaining to Hydrogeological domain.
CO3	To understand the physical, chemical and biological characteristics of water with special emphasis on pollution and contamination
CO4	To understand the relationship in between water and rock interaction and salt water intrusion and its remedial measures in the coastal aquifers.
CO5	An ability to ethical, social, health and sustainable consumption of water resources

UNIT	Details	No. of Hours	Course Objectives
I	Renewable and non-renewable resources: Natural resources and associated problems-Forest resources: deforestation- Timber extraction, mining, dams and their effects on forest -Water resources - Use and over-utilization of surface and groundwater- floods- Energy resources - Growing energy needs-renewable and nonrenewable-energy sources- use of alternate energy sources- man induced landslides- desertification- Human Settlements and their impact on Environment.	12	CO1
II	Structure and function of an ecosystem- Principles of Ecology: Composition and various Types of Ecosystem - Ecological succession-Food chains-food webs and ecological pyramids- Introduction-types- characteristic features- structure and function of the Forest ecosystem-Grassland ecosystem-Desert ecosystem- Aquatic ecosystems	12	CO2
III	Definition-Cause effects and control measures of Air pollution- Water pollution-Soil pollution-Marine pollution-Noise pollution- Thermal pollution-Nuclear hazards-Solid waste Management – Causes- effects and control measures of urban and Industrial wastes-Disaster Management -floods- earthquake- cyclone and landslides.National and Global Environmental Issues. Environmental Impact Assessment (EIA), general guidelines for the preparation of environmental impact statement (EIS), scope and types of environmental audit, cost benefit analysis, environmental management plan (EMP), international organization for standardization (ISO).	12	CO3
IV	Mechanical layering of the Earth-lithosphere- asthenosphere- mantle and core-Earthquake and earthquake belts: seismic waves and internal constitution of the Earth-Volcanoes and volcanism-	12	CO4

	distribution of volcanoes-Concept of Isostasy, Formation of core-mantle- crust- atmosphere-hydrosphere and biosphere-Convection in Earth's core.		
V	Origin and Age of the Earth, Historical development of the concept of continental drift and plate tectonics-Plates and plate boundaries-Geodynamic elements of Earth- mid oceanic ridges- trenches-transform faults and island arcs-Plate tectonics- mountain belts and rift valleys	12	CO5
	Text Books		
1.	Agarwal, K.C. 2001 Environmental Biology, Nidi Publ. Ltd. Bikaner. BharuchaErach, The Biodiversity of India, Map in Publishing Pvt. Ltd., Ahmedabad – 380 013, India.		
2.	Brunner R.C., 1989, Hazardous Waste Incineration, McGraw Hill Inc. 480p Clark R.S., Marine Pollution, Clanderson Press Oxford (TB).		
3.	Cunningham, W.P. Cooper, T.H. Gorhani, E & Hepworth, M.T. 2001, Environmental Encyclopedia, Jaico Publ. House, Mumbai, 1196p		
4.	Gleick, H.P. 1993. Water in crisis, Pacific Institute for Studies in Dev., Environment & Security. Stockholm Env. Institute Oxford Univ. Press. 473p		
5.	Hawkins R.E., Encyclopedia of Indian Natural History, Bombay Natural History Society, Bombay (R)		
References Books (Latest editions, and the style as given below must be strictly adhered to)			
1.	Heywood, V.H &Waston, R.T. 1995. Global Biodiversity Assessment Cambridge Univ. Press 1140p.		
2.	Mhaskar A.K., Matter Hazardous, Techno-Science Publication (TB)		
3.	Miller T.G. Jr. Environmental Science, Wadsworth Publishing Co. (TB)		
4.	Odum, E.P. 1971. Fundamentals of Ecology. W.B. Saunders Co. USA, 574p 10. Duff, P. M. D. and Duff, D. (Eds.) (1993). Holmes' principles of physical geology. Taylor and Francis.		
5.	Emiliani, C. (1992). Planet Earth: cosmology, geology, and the evolution of life and environment. Cambridge University Press.		

Course Outcomes

CO1 Capable of understanding the impact of water conservation methods in regional and national context.

CO2 An ability to understand the importance of groundwater augmentation strategies.

CO3 To perform socio economic analysis to evaluate the intangible benefits of artificial structures.

CO4 Formulate and solve deterministic and optimization models for water resources.

CO5 To get familiarization of principles and applications of various groundwater exploration techniques.

Outcome Mapping

POs& PSOs/COs	*PO1*	*PO2*	*PO3*	*PO4*	*PO5*	*PSO1*	*PSO2*	*PSO3*	*PSO4*	*PSO5*	*PSO6*	*PSO7*
CO 1	3	2	1	1	2	3	2	1	2	2	1	1
CO 2	3	2	1	1	2	3	2	1	2	2	1	1
CO 3	3	2	1	1	2	3	2	2	3	2	2	1
CO 4	3	2	1	1	2	3	1	2	2	2	1	1
CO 5	3	2	1	1	2	3	2	2	2	1	2	1

Note: POs-Program Outcomes, PSOs -Program Specific Outcomes and CO-Course Objective & Cognitive level: K1- Remembering, K2- Understanding , K3- Applying

S-Strong-3 ; M-Medium -2 ; L-Low-1.

Program Specific Outcomes

CO/PSO	***PSO 1***	***PSO 2***	***PSO 3***	***PSO 4***	***PSO 5***
CO 1	3	3	3	3	3
CO 2	3	3	3	3	3
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course contribution to Pos	3.0	3.0	3.0	3.0	3.0

ADD ON COURSES

MEDICAL GEOLOGY

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
24UPGEO1AO1	**MEDICAL GEOLOGY**	ADD ON COURSES	Y	-	-	-	2	30	25	75	100

Course Objectives

CO1	The geochemistry of the environments has a marked influence on their health, giving rise to diseases that affect millions of people.
CO2	To expose the students on the interaction of Human beings with the geochemistry of the earth environment.
CO3	To learn the fundamental components of Medical Geology
CO4	To Capable of understanding the impact of health due to water borne diseases.
CO5	To perform socio economic analysis to evaluate the intangible benefits of artificial structures

UNIT	Details	No. of Hours	Course Objectives
I	General characteristics of tropical, subtropical environments, arid zone, seasonally dry tropics and sub-tropics, humid tropics, and sub-tropics zone and mountainous zone. Rock weathering and soil formation, weathering of mineralized terrains, weathering profiles.Weathering and formation of secondary minerals.Chemistry of weathering of ultra-basic rocks.	12	CO1
II	Medical Geology- Perspectives and Prospects, Public Health and Geological Processes: An Overview of a Fundamental Relationship. Environmental Biology-Natural Distribution and Abundance of Elements, Anthropogenic Sources, Uptake of Elements on Chemical and Biological Perspective and its functions, Geological Impacts on Nutrition.	12	CO2
III	Pathways and Exposure- Volcanic Emissions and Health, Radon in Air and Water, Arsenic in Groundwater and the Environment.WHO and BIS Standards for drinking water. Fluoride in Natural Waters, soils, sediments, plants. Fluorides and health: Bioavailability of fluoride, Dental fluorosis, Skeletal fluorosis, Dental fluorosis in India, source, nature, cause and extent. Water Hardness and Health Effects, Geochemical basis for tropical endomyocardial fibrosis (EMF), Effect of water hardness on urinary stone formation. Types of stones: Calcium oxalate, Calcium phosphate, Uric acid, Magnesium ammonium phosphate stones, Cysteine	12	CO3
IV	Iodine and health: The iodine cycle in the environment, Iodine in drinking water, Iodine in food, Iodine Deficiency Disorders (IDD), Endemic cretinism, Goitrogens. The nitrogen cycle, Nitrate as fertilizers and environment, Nitrogen loading in rice fields, Nitrates from human and animal wastes, Nitrates and health, Nitrates and Methemoglobinemia, Nitrates and cancer. Bioavailability of	12	CO4

	Elements in Soil, Selenium Deficiency and Toxicity in the Environment, Soils and Iodine Deficiency, Natural Aerosolic Mineral Dusts and Human Health, Animals and Medical Geology.The Impact of Micronutrient Deficiencies in Agricultural Soils and Crops on the Nutritional Health of Humans.		
V	Environmental Toxicology, Environmental Epidemiology, Environmental Medicine, Environmental Pathology, Speciation of Trace Elements. Techniques and Tools GIS in Human Health Studies, Investigating Vector-Borne and Zoonotic Diseases with Remote Sensing and GIS. Mineralogy of Bones, Inorganic and Organic Geochemistry Techniques, Histochemical and Microprobe Analysis in Medical Geology.	12	CO5
	Text / Reference Books		
1.	C.B. Dissanayake and R.Chandrajith (2009). Introduction to Medical Geology, Springer, London		
2.	H.Catherine, W.Skinner, Antony R. Berger(2003). Geology and Health: Closing gap, Oxford Univ. press, New York.		
3.	IosifF.Volfson (2010). Medical Geology: Current Status and Perspectives, 2010. Russian Geological Society (ROSGEO) Publisher. Moscow.		
4.	K.S. Valdiya (2004). Geology, environment, Society, University press (India), Hyderabad		
5.	Lawrence K. Wang, Jiaping Paul Chen, Yung-Tse Hung, Nazih K. Shammas (2009). Heavy Metals in the Environment , CRS Press, Taylor & Francis Group, Boca Raton, FL		

Course Outcomes

CO1 Capable of understanding the impact of health due to water borne diseases.

CO2 An ability to understand the importance of Pathways and Exposure.

CO3 To perform socio economic analysis to evaluate the intangible benefits of artificial structures.

CO4 The study of the Agricultural, Soil and Crops on the Nutritional Health of Humans.

CO5 To get familiarization of principles and applications of Microprobe Analysis in Medical Geology

Outcome Mapping

POs& PSOs/COs	***PO1***	***PO2***	***PO3***	***PO4***	***PO5***	***PSO1***	***PSO2***	***PSO3***	***PSO4***	***PSO5***	***PSO6***	***PSO7***
CO 1	3	2	2	3	3	3	1	2	3	2	2	1
CO 2	3	3	2	2	3	3	3	2	2	2	1	1
CO 3	3	2	2	2	3	3	2	2	3	1	1	1
CO 4	3	3	2	2	3	3	2	2	2	1	2	2
CO 5	3	2	2	1	3	3	2	2	3	2	2	1

Note: POs-Program Outcomes , PSOs -Program Specific Outcomes and CO-Course Objective & Cognitive level: K1- Remembering, K2- Understanding , K3- Applying.

S-Strong-3 ; M-Medium -2 ; L-Low-1.

Program Specific Outcomes

CO/PSO	***PSO 1***	***PSO 2***	***PSO 3***	***PSO 4***	***PSO 5***
CO 1	3	3	3	3	3
CO 2	3	3	3	3	3
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course contribution to Pos	3.0	3.0	3.0	3.0	3.0

PETROLEUM GEOLOGY

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
24UPGEO1AO2	**PETROLEUM GEOLOGY**	ADD ON COURSES	Y	-	-	-	2	30	25	75	100

Course Objectives

CO1	To solving technical challenges connected to the development and production of hydrocarbon reservoirs on a regional to reservoir scale.
CO2	Petroleum is one of the most important resources of energy therefore the basic understanding of petroleum is important.
CO3	To understand the concept of petroleum system.
CO4	To understand the Geographic and Stratigraphic distributions of oil and gas.
CO5	An ability to infer the Petroleum economics, production and development

UNIT	Details	No. of Hours	Course Objectives
I	Physical and Chemical Properties of Petroleum Origin and composition of petroleum and natural gas, source rocks, reservoir rocks and traps.Migration and accumulation of oil and gas. Introduction to Petroleum Geology, History of Petroleum, Energy Resources, Renewable Energy, Non-Renewable Energy, fossil Fuels.	12	CO1
II	Concept of petroleum system. Reservoir rocks clastic and non-clastic reservoir rocks, development and types of porosity in these rocks. Controls of permeability. Types of petroliferous basins and their relation to hydrocarbon potential Generation of Petroleum, Migration of Petroleum: primary and secondary; Reservoir Characteristics: Porosity and permeability.	12	CO2
III	Geographic and stratigraphic distributions of oil and gas.Methods and techniques for petroleum exploration, Surface indications and direct detection of hydrocarbons Subsurface Environments. Source Rock Origins, Hydrocarbon Traps: Structural Traps, Stratigraphic traps, hydrodynamic traps; Combination traps, Oil Exploration, Application of microfossils in petroleum.	12	CO3
IV	Sub-surface geological methods and brief idea about geologic interpretations of seismic data. Drilling methods, drilling equipments, drilling fluids, well-logs. Exploration Methods Reservoirs, Traps and Seals Nonconventional Petroleum Resources Sedimentary Basins and Petroleum Systems Well logging: SP log, Gamma Log, Sonic log, gas drive, gas cap drive, gas hydrate.	12	CO4
V	Estimation of reserves and resources.Petroleum economics, production and development geology. Petroleum traps. Cap rocks (seals). Occurrence, surface indications and direct detection of hydrocarbons.Petroleum habitats. An outline of the oil belts of the world Oil producing basins of India: Assam, Krishna-Godavari, Bombay, Cambay, and Rajasthan.	12	CO5

	Text / Reference Books
1.	Tissot, B.P. and Welte, D.H. Petroleum Formation and Occurrence, 2nd Edition, Springer- Verlag, Berlin, 1984
2.	North, F.K. Petroleum Geology, Allen &Unwin, London, 1985
3.	Hunt, J.M. Petroleum Geochemistry and Geology, 2nd Edition, W.H. Freeman, San Fransisco, 1996
4.	Sahay, B., Rai, A. and Ghosh, M. Wellsite Geological Techniques for Petroleum Exploration, Oxford & IBH, New Delhi, 1984
5.	Selley, R.C. Elements of Petroleum Geology, 2nd Edition, Academic Press, London, 1997

Course Outcomes

CO1 Capable of understanding the Renewable and Non-Renewable Energy.

CO2 An ability to understand the importance of hydrocarbon potential generation of Petroleum.

CO3 To perform Petroleum source rock origins, Hydrocarbon Traps.

CO4 Formulate and solve deterministic and optimization models of Petroleum Resources Sedimentary Basins.

CO5 To get familiarization of principles and applications of estimation of reserves and resources.

Outcome Mapping

POs& PSOs/COs	*PO1*	*PO2*	*PO3*	*PO4*	*PO5*	*PSO1*	*PSO2*	*PSO3*	*PSO4*	*PSO5*	*PSO6*	*PSO7*
CO 1	3	2	2	3	3	3	1	2	3	2	2	1
CO 2	3	3	2	2	3	3	3	2	2	2	1	1
CO 3	3	2	2	2	3	3	2	2	3	1	1	1
CO 4	3	3	2	2	3	3	2	2	2	1	2	2
CO 5	3	2	2	1	3	3	2	2	3	2	2	1

Note: POs-Program Outcomes , PSOs -Program Specific Outcomes and CO-Course Objective & Cognitive level: K1- Remembering, K2- Understanding , K3- Applying.

S-Strong-3 ; M-Medium -2 ; L-Low-1.

Program Specific Outcomes

CO/PSO	*PSO 1*	*PSO 2*	*PSO 3*	*PSO 4*	*PSO 5*
CO 1	3	3	3	3	3
CO 2	3	3	3	3	3
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course contribution to Pos	3.0	3.0	3.0	3.0	3.0

GROUNDWATER EXPLORATION

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
24UPGEO1AO3	**GROUNDWATER EXPLORATION**	ADD ON COURSES	Y	-	-	-	2	30	25	75	100

Course Objectives

CO1	To learn the fundamental components of hydrology and basin characteristics.
CO2	To impart theoretical, practical and field knowledge pertaining to Hydrogeological domain
CO3	To understand the subsurface methods of groundwater exploration.
CO4	To interpret the conditions of water resources and to select some areas where the groundwater is being exploited against the natural laws
CO5	To critically assess different factors/aspects involve

UNIT	Details	No. of Hours	Course Objectives
I	Renewable resourceRenewable resource, Hydrology and basin characteristics, run-off and stream flow, aquifer characteristics, geology of groundwater occurrence, trans-boundary aquifers, groundwater quality, saline water intrusion.	12	CO1
II	Esoteric method: Water divining, Soil and Micro-Biological Methods Biophysical.	12	CO2
III	Surface investigation: Geologic method, geomorphological method, hydrogeological method, electrical resistivity method, Vertical electrical sounding. Profiling, Wenner array, Schlumberger array, Dipole-dipole array, Interpretation of data, electromagnetic method, seismic method, gravity and magnetic method, geobotanical methods, geochemical methods	12	CO3
IV	Subsurface methods: test drilling, water level measurements. Application of Geophysical logging in Groundwater exploration, tracer techniques.	12	CO4
V	Aerial method, Photogeology, Landsat / IRS Infrared imagery, Electromagnetic techniques.Remote sensing methods, artificial recharge, groundwater modeling, groundwater law, watershed management.	12	CO5

	Text / Reference Books
1.	Davies, S.N. and De Wiest, D.R., (1966), Hydrogeology-John Wiley& sons, Inc, New York, 463p.
2.	Fetter, C.W., (1990), Applied Hydrogeology-McGraw Hill, Publisher, New Delhi.
3.	Handa.O.P (1984), Groundwater Drilling, Oxford & I.B.H. Publishing Co.
4.	.Hiscock,K.,(2005), Hydrogeology, Principles and Practice, Blackwell Publishing,389p.
5.	Karanth, K.R., (1987), Groundwater Assessment, Development and Management-Tata McGraw Hill New Delhi 720p

Course Outcomes

CO1 Capable of understanding the impact of water conservation methods.

CO2 An ability to understand the importance of groundwater augmentation strategies.

CO3 To get familiarization of principles and applications of various groundwater exploration techniques

CO4: Occurrence and movement of Groundwater

CO5: Groundwater wells, types and methods

Outcome Mapping

POs& PSOs/COs	***PO1***	***PO2***	***PO3***	***PO4***	***PO5***	***PSO1***	***PSO2***	***PSO3***	***PSO4***	***PSO5***	***PSO6***	***PSO7***
CO 1	3	2	2	3	3	3	1	2	3	2	2	1
CO 2	3	3	2	2	3	3	3	2	2	2	1	1
CO 3	3	2	2	2	3	3	2	2	3	1	1	1
CO 4	3	3	2	2	3	3	2	2	2	1	2	2
CO 5	3	2	2	1	3	3	2	2	3	2	2	1

Note: POs-Program Outcomes, PSOs -Program Specific Outcomes and CO-Course Objective & Cognitive level: K1- Remembering, K2- Understanding, K3- Applying.

S-Strong-3 ; M-Medium -2 ; L-Low-1.

Program Specific Outcomes

CO/PSO	***PSO 1***	***PSO 2***	***PSO 3***	***PSO 4***	***PSO 5***
CO 1	3	3	3	3	3
CO 2	3	3	3	3	3
CO 3	3	3	3	3	3
CO 4	3	3	3	3	3
CO 5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course contribution to Pos	3.0	3.0	3.0	3.0	3.0
