DEPARTMENT OF GEOLOGY

SYLLABUS FOR FOUR YEAR UNDERGRADUATE PROGRAMME (FYUGP)

(FIRST – EIGHT SEMESTER)

Approved by Academic Council vide Resolution no. AC – 03/2024/05 Dated: 04 – 05– 2024 and AC – 06/2026/03 dated 28 – 02 - 2026

ARYA VIDYAPEETH COLLEGE (AUTONOMOUS)

ARYA NAGAR, GUWAHATI – 16

CONTENT

PREFACE

“Education is not preparation for life; education is life itself.” —John Dewey

The aim of imparting education is not only to increase the knowledge but also to create the possibilities fora student to invent and discover. The purpose of this syllabus is to establish minimum basic concepts for each course to meet the needs of all our students. All the elements in this syllabus amalgamate to bring out the best in every student and enable them to be on the path of continuous progress.

The syllabus is framed based on Learning Outcome Based Education (LOCF) -the spirit of NEP, 2020. The programmes offered by the college are:

i. Bachelor Degree in Arts
ii. Bachelor Degree in Science
iii. Bachelor Degree in Commerce

Under the above programme, the following courses are offered by the college:

i. Core Course
ii. Minor Course
iii. Skill Enhancement Course
iv. Interdisciplinary Course
v. Ability Enhancement Course
vi. Value Added Course
vii. Internship

Programme outcome of each programme and Programme Specific Outcomes of each discipline/subject offered by the college is mapped with course learning outcome of each course. Graduate attributes of students obtaining Undergraduate Degree from the college are also incorporated in the syllabus.

The syllabus includes eight semesters where there will be 23 Core Courses, 8 Minor Courses, 2 Value Added Courses, 3 SEC Courses, 3 IDC Courses, 4 AEC courses and internship. The total credit offered for eight semesters is160.

The syllabus framed takes into account the different styles of learning – audio, visual and experiential. The syllabus correlates academics to real life situations balancing social and emotional stimulation among the students and imbibe human values. Also, the syllabus gives the opportunity for the theoretical knowledge to be pursued ensuring maximum application of it.

Structure of Four Year Undergraduate Course

Semester	Type	Core	Minor	SEC	IDC	AEC	VAC/FC	IN
	Credit	4	4	3	3	2	4(2 + 2)	2
I		CE-1114	MN-1114	SE-1113	ID-1113	AE-1112	VL-1112 (Two Courses)	-
II		CE-2114	MN-2114	SE-2113	ID-2113	AE-2112	VL-2112 (Two Courses)	-
III		CE-3214 CE-3224	MN-3214	SE-3213	ID-3213	AE-3212	-	-
IV		CE-4214 CE-4224 CE-4234	MN-4214	-	-	AE-4212	-	IN-4212
V		CE-5314 CE-5324 CE-5334 CE-5344	MN-5214	-	-	-	-	-
VI		CE-6314 CE-6324 CE-6334 CE-6344	MN-6214	-	-	-	-	-
VII		CE-7414* CE-7424** CE-7434** CE-7444** CE-7454**	MN-7314	-	-	-	-	-
VIII		CE-8414# CE-8424# CE-8434# CE-8444# CE-8454#	MN-8314	-	-	-	-	-

***Compulsory for all students in the 7th semester.**

****Students are required to choose any three courses from the remaining four core courses in the 7th semesters.**

 # Students who wish to pursue a Bachelor Degree with Honours must choose any four of the five core courses in the 8th semester.

NOTE: Students who secure a minimum of 7.5 CGPA at the end of the 6th semester (without any arrears) may opt for a Bachelor Degree with Honours and Research. Those students shall have to choose one core course out of the given five courses in the 8th semester and have to complete a Research Dissertation of 12 credits.

Course code: **First two letters is the abbreviation of course component**

First digit implies semester number

Second digit implies course level

Third digit implies course number

Fourth digit implies credit points per course.

Digit	Course Level
1	100 - 199
2	200 - 299
3	300 - 399
4	400 - 499

Semester Wise Credit Distribution

Semester	CREDIT DISTRIBUTION							
	CORE	MINOR	SEC	AEC	IDC	VAC/FC	IN	TOTAL
FIRST	1 x 4	1 x 4	1 x 3	1 x 2	1 x 3	2x 2	--	20
SECOND	1 x 4	1 x 4	1 x 3	1 x 2	1 x 3	2x 2	--	20
THIRD	2x 4	1 x 4	1 x 3	1 x 2	1 x 3	--	--	20
FOURTH	3x 4	1 x 4	--	1 x 2	--	--	1 x 2	20
FIFTH	4x 4	1 x 4	--	--	--	--	--	20
SIXTH	4x 4	1 x 4	--	--	--	--	--	20
SEVENTH	4x 4	1 x 4	--	--	--	--	--	20
EIGHT	4x 4	1 x 4	--	--	--	--	--	20

SEC: SKILL ENHANCEMENT COURSE

AEC: ABILITY ENHANCEMENT COURSE

IDC: INTERDISCIPLINARY COURSE

VAC/FC: VALUE ADDED COURSE

IN: INTERNSHIP

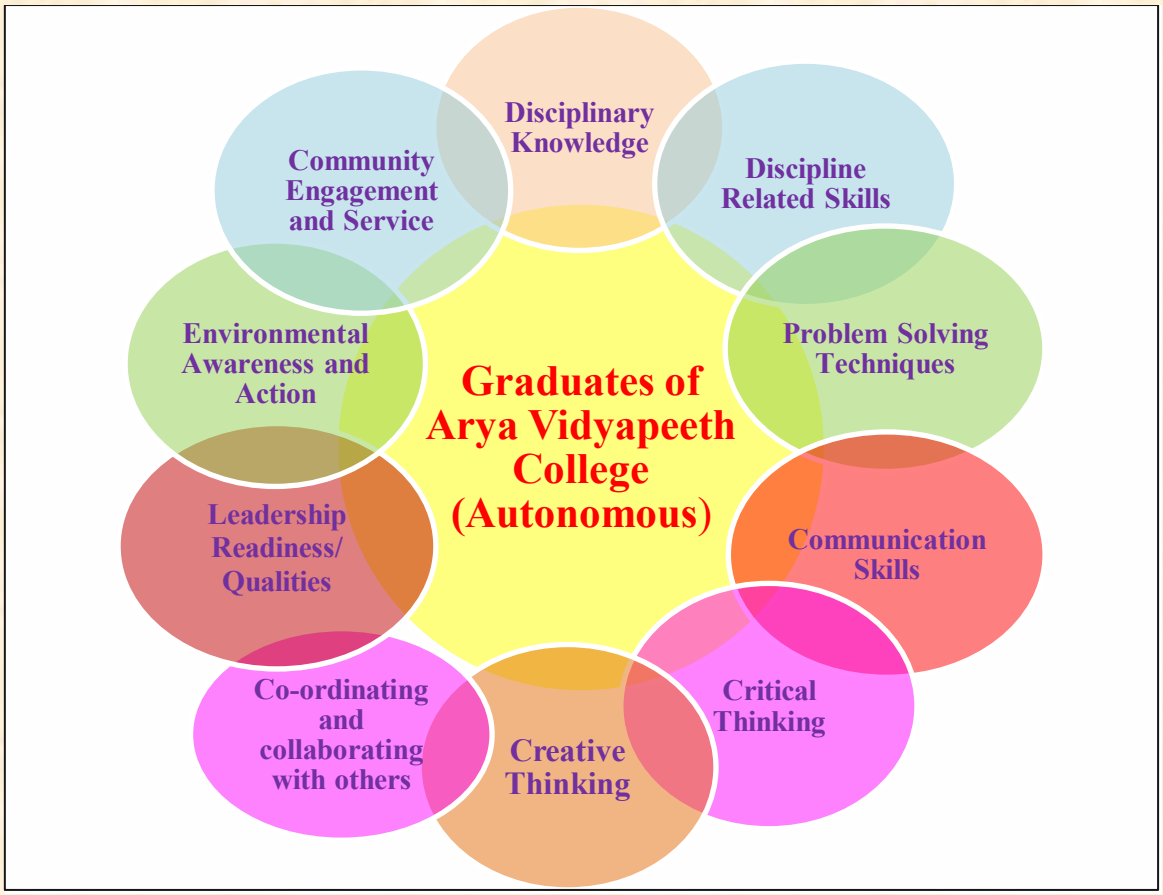
Abbreviation of Course Components:

CE (Core), MN (Minor), SE (Skill Enhancement Course), AE (Ability Enhancement Course), VL (Value added Course), ID (Interdisciplinary Course), IN (Internship)

GRADUATE ATTRIBUTES

Graduate Attributes:

Graduate Attributes are the qualities, skills and understandings that the students should develop during their time with the college. These attributes consequently shape the contribution they are able to make to their profession and society. They are the qualities that also prepare graduates as agents of social good in an unknown future. These attributes set them apart from those without a degree. The graduate attributes of Arya Vidyapeeth College (Autonomous) are:



Model of Graduate Attributes

1. **Disciplinary knowledge:** Graduates shall acquire comprehensive knowledge and understanding of their subject area, the ability to engage with different traditions of thought, and the ability to apply their knowledge in practice including in multi-disciplinary or multi-professional contexts.
2. **Discipline related skills:** Skills in areas related to specialization in the chosen disciplinary/interdisciplinary/major/minor area(s) of learning in a broad multidisciplinary context. In addition, create, select, and apply appropriate modern techniques, resources and IT tools.
3. **Problem solving skills:** A capacity for problem identification, the collection of evidence, synthesis and dispassionate analysis and apply one's learning in real – life situations.

4. **Communication Skills:** Ability to recognize and value communication as the tool for negotiating and creating new understanding, collaborating with others, and furthering their own learning.
5. **Critical thinking:** Graduates acquire the capacity for problem identification, collection of evidence, synthesis and dispassionate analysis. They also acquire the capacity for attentive exchange, informed argument and reasoning.
6. **Creative Thinking:** The graduates acquire an ability to create, perform or think in different and diverse ways about the same objects or scenarios and also the ability to communicate effectively for different purposes and in different contexts. They should also be able to work independently and as part of a team.
7. **Co-ordinating and collaborating with others:** The graduates need to possess the ability to function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. They should also be able to work productively with others, no matter their culture, perspective or background, and complete joint projects and also to work in partnership.
8. **Leadership readiness/qualities:** The graduates should be able to lead and support others by inspiring them with a clear vision and motivating them to achieve goals. They also need to acquire ability to map out the tasks of a team or an organization and setting directions.
9. **Environmental Awareness and action:** The graduates shall earn the capacity to realize the individual's responsibility in protecting and conserving the environment. They need to gain the capacity to understand the impact of the professional solutions in societal and environmental contexts, and demonstrate the knowledge of need for sustainable development.
10. **Community engagement and service:** The graduates need to develop an understanding of social and civic responsibilities, and of the rights of individuals and groups. The graduates should be able to demonstrate the capability to participate in community-engaged services/ activities for promoting the wellbeing of the society which includes participation in NSS, NCC, adult literacy etc

UNDERGRADUATE PROGRAMME OUTCOME (PO)

BACHELOR DEGREE INSCIENCE: (B.Sc.)

1. **SPO-1 Knowledge:** Learners are encouraged to apply the knowledge of mathematics and science fundamentals to various solutions of complex problems. As such, knowledge of the subject is the sole objective of any student learner. A student is exposed to a wide range of topics in various subjects and is given intensive training in each of the courses that have laboratory related work. The learner is encouraged to use various mathematical methods (analytical and numerical) and experimental methods as an application to the acquired concepts and principles that help in studying various branches of sciences. At the end of the program, students are able to gain thorough knowledge in key areas in the subjects offered.
2. **SPO-2 Problem Analyses**: Well, equipped with an understanding of the analytical methods involved, they are in a position to interpret and analyze results so obtained from experiments and draw suitable conclusions against their supported data acquired. At the end of the program, students will be able to identify, formulate and analyze scientific problems and reach concrete solutions using various principles of mathematics and sciences.
3. **SPO-3 Designing Solutions**: Having acquired knowledge of subjects, students are trained to think out of the box, design and conduct an experiment or a series of experiments that demonstrate their understanding of the methods and processes involved.
4. **SPO-4 Modern tool usage**: Learners are trained to create, select, and apply appropriate techniques, resources and IT tools in the analysis and synthesis of data within limitations. (Outcome of final year project).
5. **SPO-5 Effective Communication**: Proficiency in speaking, reading, writing and listening in English and one Indian language and find meaning of the world by connecting people, ideas, books, media and technology.
6. **SPO-6 Employability**: This programme enables the learners to perform the jobs in diverse fields such as science, engineering, industries, survey, education, banking, development-planning, business, public service, self-business etc. efficiently. They will also be able to appear for competitive examinations
7. **SPO-7 Ethics:** While it is necessary to instil the spirit of competitiveness among students in a world of increasing competition, it is equally vital to develop a strong sense of ethics among learners that will help them develop some positive attitudes and values. This includes appreciation of the various principles and theories that evolved in science, the impact that science has on social, economic and environmental issues. One of the main objectives of any academic exercise,

therefore, should be to produce well-groomed individuals who understand the significance of ethical values and abide by them even in the most pressing circumstances. In this programme, this process is enabled through courses and facilitators who integrate the teaching of ethics in everyday pedagogy. As such, at the end of this programme students will be able to develop, internalise and exercise ethics in their professional as well as personal practices.

8. **SPO-8 Environment and Sustainability**: 'Environmental sustainability' has become the watchword of the 21st century. An increased engagement with environment related concerns is appearing tangibly on global fronts; academics cannot and should not remain quarantined from this massive development. Through classroom discussions and research projects, this programme facilitates active dialogues with factors which influence human-ecology interactions. As such, at the end of this programme students will be able to identify and analyze socio-political, cultural and economic problems which act as deterrents to environmental sustainability and provide creative solutions towards the same.

9. **SPO-9 Soft-Skill Development**: Apart from the attainment of knowledge and handson skills in practical applicability of the subject, learners need to be equipped with soft-skills and values which will help them function effectively as an individual, and as a member or leader in diverse teams and in multidisciplinary groups. These soft skills include leadership, teamwork, project-management, positive outlook, innovative approaches and effective articulation. Several soft skill programs are organized for learners through various agencies that tie up with the state government. As such, at the end of this programme, students will be able to hone the soft-skills required in positively enhancing their academic, professional and personal pursuits towards self and societal advancement.

10. **SPO-10 Science and Society**: The learners are encouraged to apply logical reasoning based on the knowledge, skills, designing solutions to assess societal, health, safety issues and the responsibilities that go along with the scientific practice. As an extension activity to society, learners are encouraged to take up specific projects such as impact of salinity on fresh water wells in an adopted village, and provide effective solutions.

11. **SPO-11Life-long learning**: With the pursuit of knowledge for either personal or professional reasons, learners are also encouraged to volunteer and be self-motivated that not only enhances society values, active participation and personality development, but also enhances self-sustainability, competiveness and employability. As such, learners will be able to recognize the need for, and have the preparation and ability to engage in independent and life-long learning in every broad context of technological changes.

CORE

LIST OF COURSES:

Semester	Course Name	Course Code
1	Earth Systems Science	GL – CE – 1114
2	Rocks and Minerals	GL – CE – 2114
3	Elements of Geochemistry& Thermodynamics	GL – CE – 3214
	Structural Geology	GL – CE – 3224
4	Mineral Science	GL – CE – 4214
	Igneous Petrology	GL – CE – 4224
	Sedimentology	GL – CE – 4234
5	Metamorphic Petrology	GL – CE – 5314
	Principles of Stratigraphy and Indian Stratigraphy	GL – CE – 5324
	Paleontology	GL – CE – 5334
	Geomorphology	GL – CE – 5344
6	Ore Geology and Mineral Economics	GL – CE – 6314
	Geology of North East India	GL – CE – 6324
	Hydrogeology	GL – CE – 6334
	Engineering Geology	GL – CE – 6344
7	Research Methodology	GL – CE – 7414
	Fuel Geology	GL – CE – 7424
	Geotectonic and Geodynamics	GL – CE – 7434

	Remote Sensing and GIS in Geology	GL – CE – 7444
	Environmental Geology	GL – CE – 7454
8	Exploration Geology & Mining	GL – CE – 8414
	Fluvial Geomorphology &Quaternary Geology	GL – CE – 8424
	Introduction to Geophysics	GL – CE – 8434
	Application of Statistics in Geology	GL – CE – 8444
	Digital Image Processing	GL – CE – 8454
	Dissertation	GL – DT – 812

Programme Specific Outcome of Bachelor of Science – GEOLOGY: Core (PSO)

PSO No.	Outcome
PSO–1	Acquire a good knowledge relating to earth and earth materials, its relation to Solar System.
PSO–2	Acquire knowledge about mineralogy and crystallography and their significances
PSO–3	Acquire knowledge of different rock types, their origin, and mode of occurrences
PSO–4	Understand about the geological time scale, Stratigraphy, deformational processes, various structural features, geomorphic processes, landforms.
PSO–5	Carry out sample collection, geological mapping
PSO–6	Use various geological tools such as petrological microscopes, ore microscopes, compasses, and survey instruments, images in geological investigation in the field and in laboratory.
PSO–7	Interpret geological map and construct cross section from them. Demonstrate the ability to identify and differentiate rocks, minerals, fossils.
PSO–8	Recognize Earth materials and Earth structures in the field, as hand specimens and using laboratory techniques including microscopy and spectroscopic analysis.
PSO–9	Acquire a good knowledge in ore genesis, mineral economics, Indian mineral deposits, hydrogeology, palaeontology, atmospheric sciences, remote sensing, environmental sciences, engineering geology and soil geology.
PSO–10	Develop the proficiency in oral communication relating to various subject related topics.
PSO–11	Gather knowledge in different fields of geology and can choose his/her own field of interest for future prospect as per skill.

Course Learning Outcome (CLO) – Core

Semester	Course Name & Code	Course Learning Outcome (CLO)	
1	Earth Systems Science GL – CE – 1114	CLO - 1	It will improve students' grasp of the dynamic earth and the processes involved in the earth.
		CLO - 2	It will improve students' understanding of the solid earth and its physics and chemistry.
		CLO - 3	Students Learn about the physical and chemical properties of the atmosphere and the hydrosphere.
		CLO - 4	Students will comprehend climate change and its long and short-term consequences
2	Rocks and Minerals GL – CE – 2114	CLO - 1	Students can learn about the rocks and minerals and their economic importance in the present day context.
		CLO - 2	They can know about the minerals and its relation to crystal, difference between crystal and amorphous substance, different crystal system.
		CLO - 3	They can learn about physical and optical properties of mineral and their usefulness to identify a mineral.
		CLO - 4	Students can get a basic knowledge about various rock types and their significances
3	Elements of Geochemistry& Thermodynamics GL – CE – 3214	CLO - 1	After completion of the course the students will acquire comprehensive knowledge of different geochemical processes that operate in the interior and near-surface environments of the earth.
		CLO - 2	The students will understand the physical and chemical laws governing the abundance, distribution and migration of chemical elements from one sphere to another sphere of the Earth.
		CLO - 3	The students may be engaged as geochemist in exploration sectors, they may be engaged in academic research as well as in teaching position in geochemistry and petrology.

3	Structural Geology GL – CE – 3224	CLO - 1	The course will enable students to prepare profile sections, interpret geological maps as well as the geometries of different structural elements indicating the causes and mechanisms responsible for the formation of different geological structures.
		CLO - 2	Students acquiring sound knowledge of structural geology may be engaged in academic research and teaching profession in the subject
		CLO - 3	Students acquiring sound knowledge in theoretical and practical aspects of structural geology will able to explore its applicability in various fields such as Geodynamics, Exploration geology and civil engineering constructions etc.
4	Mineral Science GL – CE – 4214	CLO - 1	The course will providein understanding the minerals i.e. building blocks of rocks.
		CLO - 2	Students will learn to identification, classification, and interpretation of rock-forming minerals in outcrops as well as in hand specimens.
		CLO - 3	Students will learn to utilize petrological microscopes for identification of rock forming minerals.
	Igneous Petrology GL – CE – 4224	CLO - 1	At the end this course will enable students understand the mechanism of formation of igneous rocks formed throughout the Earth's evolutionary history and their relation with global tectonics.
		CLO - 2	Students will explore experimental and practical aspects of igneous processes in the light of modern phase equilibria and geochemical characteristics.
		CLO - 3	Acquiring sound knowledge of theoretical and practical aspects of igneous petrology students may be engaged in higher studies and academic research in petrology.
	Sedimentology GL – CE – 4234	CLO - 1	Student can learn about sediment, basic processes of sedimentation and influences of fluids.
		CLO - 2	Understand sediment Granulometry, Particle size distribution and statistical treatment
		CLO - 3	Knowledge of sedimentary textures, structures and environmental influence.

4	Sedimentology GL – CE – 4234	CLO - 4	Recognise and study of different types of sedimentary rocks and their significances
		CLO - 5	Knowledge of Palaeocurrent and their analyses.
5	Metamorphic Petrology GL – CE – 5314	CLO - 1	The course will provide understanding in metamorphism of rocks.
		CLO - 2	Students will learn to identify metamorphic rocks and minerals in the field and laboratory, and able to interpret the metamorphic reaction textures.
		CLO - 3	Examine and recognize the essential minerals and significant characteristics of metamorphic rocks using a thin section and a hand specimen.
		CLO - 4	To reconstruct metamorphic conditions, use numerical, graphical, and synthesis techniques using modern software's.
	Principles of Stratigraphy and Indian Stratigraphy GL – CE – 5324	CLO - 1	Understand about the concepts of rock superposition, principles of stratigraphy, dynamic stratigraphy, International Stratigraphic Code, Stratotypes, Concept of Stratigraphic boundaries etc.
		CLO - 2	Knowledge of physiographic and tectonic subdivision of India, Stratigraphy of India and their significances.
		CLO - 3	Practical concepts of geological map, Identification of major stratigraphic units of India, Indian stratigraphic rocks type recognition, Preparation of paleogeographic maps of Precambrian time, Knowledge of different Proterozoicsupercontinent reconstructions.
		CLO - 4	Develop the proficiency in oral communication relating to stratigraphy and Indian stratigraphy.
	Paleontology GL – CE – 5334	CLO - 1	Identify common fossils in hand specimens using diagnostic morphological features
		CLO - 2	Apply the palaeontological knowledge for knowing chronostratigraphic position and depositional conditions of sedimentary rocks.
		CLO - 3	Know about palao-environmental changes through time and space which may enable them for future preparedness in regard to changing scenario of earth's climate.

5	Geomorphology GL – CE – 5344	CLO - 1	This course will give comprehensive knowledge on the processes that led to the formation of present landforms and the ongoing processes sculpting Earth's surface.
		CLO - 2	A student will learn about the geomorphology of India
		CLO - 3	A student will learn various geomorphic techniques
		CLO - 4	After completion of the course student willlearn the role of tectonics in landform building. They will gather sufficient knowledge to carry out first order investigation ofany landform in a tectonically active area.
6	Ore Geology and Mineral Economics GL – CE – 6314	CLO - 1	Understanding about economically important minerals/materials, both theoretically and practically, their ores, origin, occurrence, mineral deposit, ore deposit with other related topics.
		CLO - 2	Acquire knowledge of various academic and economic terms and their significances.
		CLO - 3	Study of important economic mineral deposits of India
		CLO - 4	Preparation of maps showing distribution of important ores and other economic minerals in India and assessment of grade of ore and reserve estimation.
	Geology of North East India GL – CE – 6324	CLO - 1	The course will learnabout the geology of NE India.
		CLO - 2	Students will learn the basic stratigraphic and tectonic subdivisions of NE India.
		CLO - 3	Students will understand the economic importance of NE India in the society.
	Hydrogeology GL – CE – 6334	CLO - 1	The students will learn about occurrence of groundwater, water bearing properties of formations, aquifer types and aquifer parameters.
		CLO - 2	The course imparts knowledge about construction, design and development of water wells, aquifer parameter estimation and the science of groundwater flow under different conditions.
		CLO - 3	The students will learn about the concepts of groundwater exploration in an integrated way and also understand about groundwater chemistry.

6	Engineering Geology GL – CE – 6344	CLO - 1	After completion of the course students will be trained personnel with adequate knowledge on the engineering properties of soils and rocks.
		CLO - 2	After completion of the course students will have adequate skills for conducting geotechnical studies in the field as well as in the laboratory.
		CLO - 3	After completion of the course students have scope of employment as a geotechnical laboratory scientist, engineering geologist, site geologist
7	Research Methodology GL – CE – 7414	CLO - 1	Understand the steps and ethics of scientific research.
		CLO - 2	Identify research problems and formulate simple hypotheses.
		CLO - 3	Apply basic statistical tools for geological data analysis.
		CLO - 4	Use simple computer applications for data processing and plotting.
		CLO - 5	Prepare short research reports and project presentations.
	Fuel Geology GL – CE – 7424	CLO - 1	Student will acquire knowledge on coal, petroleum and other fuels; their formation classification etc.
		CLO - 2	Students will be able to understand about the basics of exploration techniques and utilization of different fuels.
		CLO - 3	Students can learn about different fuels including conventional and unconventional resources, their economic importance in the present-day context.
	Geotectonic & Geodynamics GL – CE – 7434	CLO - 1	Acquiring comprehensive knowledge on dynamic processes shaping the Earth, students will describe and interpret a large variety of geological processes that operate in the earth.
		CLO - 2	Students will understand different geological events, which will help in predicting and preparing for natural disasters such as volcanoes, earthquake, etc.

7		CLO - 3	Students will able to understand and connect the tectonic processes with the resulting phenomena on different scales.
	Remote Sensing and GIS in Geology GL – CE – 7444	CLO - 1	Explain principles of electromagnetic radiation and its interaction with Earth's surface.
		CLO - 2	Identify geological structures, lithology, and geomorphology using satellite imagery.
		CLO - 3	Use GIS tools for spatial data analysis.
		CLO - 4	Apply remote sensing and GIS data in geological studies, Disaster management.
	Environment Geology GL – CE – 7454	CLO - 1	The course will enable students to acquire knowledge about causes of pollution and hazards related to mining.
		CLO - 2	Analyze impact of landslides on environment.
		CLO - 3	Students acquiring sound knowledge to identify different factors of flood in fluvial systems and their management.
		CLO - 4	Students acquiring knowledge to identify the sources of water pollution and suggest remedial measures.
8	Exploration Geology & Mining GL – CE – 8414	CLO - 1	Students can learn fundamental geological knowledge like mineralogy & petrology, structure, stratigraphy, sedimentology with economic geology etc.
		CLO - 2	Students can know a basic understanding about exploration techniques and methodologies.
		CLO - 3	They can learn about mining geology, different mining methods, mine safety, environmental considerations etc.
	Fluvial Geomorphology & Quaternary Geology GL – CE – 8424	CLO - 1	The course will enable students to acquire knowledge about different fluvial system and landforms of the Earth
		CLO - 2	Understand the fluvial landform features in Northeast India.
		CLO - 3	Understand the linkages between the interdisciplinary components of earth systems science and the Quaternary

			geological history and associated issues of concern like climate change, active tectonics.
8		CLO - 4	Imparts knowledge on the thick repository of Quaternary sediments and their stratigraphic framework in NE India
	Introduction to Geophysics GL – CE – 8434	CLO - 1	The students will acquire comprehensive knowledge of different principles of geophysics that can be applied to solve different geological problems.
		CLO - 2	The students will understand the principles and applications of different geophysical methods for exploration of geological resources such as minerals, oil, groundwater etc.
		CLO - 3	The students may be engaged as geophysicists in exploration and Mining sectors, they may also be engaged in academic research as well as in teaching position in geophysics.
	Application of Statistics in Geology GL – CE – 8444	CLO - 1	Explain the fundamental concepts of statistics and graphical representation of geological data.
		CLO - 2	Apply statistical methods (central tendency, dispersion, distributions, correlation, PCA) to analyze geological datasets.
		CLO - 3	Construct and interpret variograms, and apply interpolation techniques for spatial data analysis.
	Digital Image Processing GL – CE – 8454	CLO - 1	Explain the fundamentals of digital images and remote sensing datasets.
		CLO - 2	Perform radiometric, atmospheric, and geometric corrections on images.
		CLO - 3	Apply enhancement techniques to improve visual interpretation.
		CLO - 4	Conduct classification of satellite imagery (supervised & unsupervised).
		CLO - 5	Use image processing for geological applications (lineament mapping, lithology discrimination, mineral exploration, land cover analysis, ground water exploration).

MAPPING OF PROGRAME OUTCOME (PO) AND COURSE LEARNING OUTCOME (CLO)

Attributes: Co-relation Levels

"1" : Minimum Co-relation

"2" : Moderate Co-relation

"3" : Maximum Co-relation

"-" : No Co-relation

Course Code	CLO	PROGRAMME OUTCOME										
		SPO1	SPO2	SPO3	SPO4	SPO5	SPO6	SPO7	SPO8	SPO9	SPO10	SPO11
GL-CE-1114	CLO-1	3	3	3	1	3	3	1	2	-	3	3
	CLO-2	3	3	3	3	2	3	1	1	1	3	3
	CLO-3	3	3	3	1	3	3	1	2	-	3	3
	CLO - 4	3	3	3	3	2	3	1	1	1	3	3
GL-CE-2114	CLO-1	3	3	3	1	3	3	1	3	1	3	3
	CLO-2	3	3	3	2	1	3	1	1	-	3	3
	CLO-3	3	3	3	1	3	3	1	3	1	3	3
	CLO - 4	3	3	3	2	1	3	1	1	-	3	3
GL-CE-3214	CLO-1	1	1	1	1	2	1	2	2	2	1	2
	CLO-2	1	1	1	1	2	1	2	2	2	1	2
	CLO-3	1	1	1	1	2	1	2	1	2	1	1
GL-CE-3224	CLO-1	1	1	1	1	1	1	1	1	1	2	1
	CLO-2	1	1	1	1	1	1	1	1	1	1	1
	CLO-3	1	1	1	1	1	1	1	1	1	1	1
GL-CE-4214	CLO-1	1	1	2	2	1	1					1
	CLO-2	1	1	1	2	1	1					1
	CLO-3	1			1	1	1					1
GL-CE-4224	CLO-1	1	1	1	2	2	1	2	1	2	1	1
	CLO-2	1	1	1	2	2	1	2	1	2	1	2
	CLO-3	1	2	1	1	2	1	2	1	2	1	1
GL-CE-4234	CLO-1	3	1	1	2		1	2	1		3	3
	CLO-2	3	3	1	3		1	2	1		3	3
	CLO-3	3	2	3	2		1	2	2		3	3
	CLO - 4	3	1	2	2		2	2	1		3	3
	CLO - 5	2	2	2	2			2	2		1	3
GL-CE-5314	CLO-1	1	1	2	2	1	1					1
	CLO-2	1	1	1	2	1	1					1
	CLO-3	1			1	1	1					1
	CLO - 4	1	1	1	1	1	1				2	1
GL-CE-5324	CLO-1	3	2	2	2	2	2	2	2		3	3
	CLO-2	3	2	1	2	2	2	2	2		3	3
	CLO-3	3	3	2	2	2	2	2	2		3	3
	CLO - 4	3	3	2	2	3	2	2	2		3	3
GL-CE-5334	CLO-1	1		2	3		2		2	3		2
	CLO-2	1	2	2	2	3	3	3	2	2		2
	CLO-3		2	3		2	2		1	2		1

COURSE CODE	CLO	PROGRAMME OUTCOME										
		SPO1	SPO2	SPO3	SPO4	SPO5	SPO6	SPO7	SPO8	SPO9	SPO10	SPO11
GL-CE-5344	CLO-1	1		2	2	3	3	3	3			3
	CLO-2	1	2	2	2	2	2	3		3	3	2
	CLO-3		2		1		2	2	2	3	2	
	CLO - 4	2		2		3		2	2			1
GL-CE-6314	CLO-1	3	2	2	2	3	2	2	2		3	3
	CLO-2	3	2	1	2	2	2	2	2		2	3
	CLO-3	3	2	2	1	3	2	2	2		3	3
	CLO - 4	3	3	2	2	3	2	2	2		2	3
GL-CE-6324	CLO-1	1	1	2	2	1	1					1
	CLO-2	1	1	3	2	1	1					1
	CLO-3	1			1	1	1		3		1	1
GL-CE-6334	CLO-1	1	1		2		2	1	2		2	
	CLO-2		3	1	1		2	2	2		1	1
	CLO-3	2	2	2	1		3	3	1		3	3
GL-CE-6344	CLO-1	1	2	2		3	2		2	3	2	
	CLO-2	2	1	1	3	3	2		2		3	2
	CLO-3	2	3	3		3	1	3	2		2	2
GL-CE-7414	CLO 1:	3	2	1	1	2	2	3	1	2	2	3
	CLO 2:	3	3	2	1	2	2	2	1	1	2	2
	CLO 3:	3	3	2	3	1	3	1	2	1	2	3
	CLO 4:	2	2	2	3	1	3	1	1	1	1	3
	CLO 5:	2	2	1	2	3	3	2	1	3	2	2
GL- CE- 7414	CLO-1	3	1	1	2		1	2	1		3	3
	CLO-2	3	3	1	3		1	2	1		3	3
	CLO-3	3	2	3	2		1	2	2		3	3
	CLO-4	3	1	2	2		2	2	1		3	3
	CLO-5	2	2	2	2			2	2		1	3
GL - CE - 7434	CLO1	1	1	2	2	3	1	2	3	4	1	1
	CLO2	1	1	1	2	3	1	2	2	4	1	2
	CLO3	1	2	1	2	3	1	2	3	4	1	1
GL-CE-7444	CLO 1:	2	1	1	2	1	1	1	1	1	1	1
	CLO 2:	2	2	2	2	1	1	1	2	2	2	1
	CLO 3:	2	2	2	2	2	1	1	2	2	2	1
	CLO 4:	2	2	2	2	2	2	1	2	2	2	2
GL- CE-7454	CLO1	1	2	3		1	3	1	1	2	1	1
	CLO2	1	1	2	3	1	3	1	1	2	1	1
	CLO3	1	1	1	3	1	2	1	1	2	1	1
	CLO4	1	1	2		1	2	1	1	3	1	1
GL- CE- 8414	CLO-1	3	1	1	2		1	2	1		3	3
	CLO-2	3	3	1	3		1	2	1		3	3
	CLO-3	3	2	3	2		1	2	2		3	3
	CLO-4	3	1	2	2		2	2	1		3	3
	CLO-5	2	2	2	2			2	2		1	3
GL- CE-8424	CLO1	1	3		3	1	3	3	1	3	2	1
	CLO2	1	1	3	2	1	3	2	1	3	1	1
	CLO3	1	1	2	2	1	2	3	2	2	1	1
	CLO 4	1	2	2	2	1	2	2	1	3	1	1

GL - CE - 8434	CLO1	1	1	2	1	1	1	1	3	2	4	2
	CLO2	1	1	2	2	3	2	2	3	2	4	2
	CLO3	1	1	2	1	2	1	2	3	2	4	2
GL-CE-8444	CLO 1:	2	1	1	1	1	1	1	1	1	1	2
	CLO 2:	2	2	2	3	1	1	1	1	1	2	2
	CLO 3:	2	2	2	2	1	1	1	3	1	2	2
GL-CE-8454	CLO1:	2	1	1	1	1	1	1	1	1	1	2
	CLO2:	2	2	3	2	1	1	1	1	1	1	2
	CLO3:	2	2	2	2	1	1	1	2	1	1	2
	CLO4:	2	2	2	3	1	1	1	2	1	2	2
	CLO5:	2	2	2	2	2	2	1	2	1	2	3

MAPPING OF PROGRAME SPECIFIC OUTCOME (PSO) AND COURSE LEARNING OUTCOME (CLO)

Attributes: Co-relation Levels

"1" : Minimum Co-relation
"2" : Moderate Co-relation
"3" : Maximum Co-relation
"-" : No Co-relation

Course Code	CLO	PROGRAMME SPECIFIC OUTCOME										
		PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8	PSO 9	PSO 10	PSO 11
GL-CE-1114	CLO-1	3	3	3	1	3	3	1	2	-	3	3
	CLO-2	3	3	3	3	2	3	1	1	1	3	3
	CLO-3	3	3	3	1	3	3	1	2	-	3	3
	CLO - 4	3	3	3	3	2	3	1	1	1	3	3
GL-CE-2114	CLO-1	3	3	3	1	3	3	1	3	1	3	3
	CLO-2	3	3	3	2	1	3	1	1	-	3	3
	CLO-3	3	3	3	1	3	3	1	3	1	3	3
	CLO - 4	3	3	3	2	1	3	1	1	-	3	3
GL-CE-3214	CLO-1	2	1	1	2	1	1	2	2	1	3	2
	CLO-2	2	2	1	2	3	3	3	2	2	2	3
	CLO-3	1	1	1	2	1	2	2	1	1	2	1
GL-CE-3224	CLO-1	1	1	1	1	1	1	1	1	1	2	1
	CLO-2	1	1	1	1	1	1	1	1	1	1	1
	CLO-3	1	1	1	1	1	1	1	1	1	1	1
GL-CE-4214	CLO-1	1	1	2				1	2		1	
	CLO-2	1	1	1				1	2		1	1
	CLO-3						1		1			
GL-CE-4224	CLO-1	1	1	1	1	1	1	1	1	1	3	1
	CLO-2	1	1	1	2	3	2	2	3	1	3	1
	CLO-3	1	1	1	1	2	1	1	1	1	2	1
GL-CE-4234	CLO-1	1	1	2	2	2	1	2	1	3	2	1
	CLO-2	1	2	1	1	2	1	1	2	2	2	1
	CLO-3	1	1	2	2	2	2	2	2	2	2	1
	CLO - 4	1	2	2	2	1	1	2	1	2	2	1
	CLO - 5	1	1	2	1	2	1		2	2	2	1
GL-CE-5314	CLO-1	2	2	1	1	1		1	1		1	1
	CLO-2	2	2	1	1	1		1	1		1	
	CLO-3			2	1		1		1		1	
	CLO - 4			2	1		1		1		1	
GL-CE-5324	CLO-1	2	1	2	1	1	2		1	3	2	3
	CLO-2	1	2	1	2	2	3		3	3	2	3
	CLO-3	2	3	3	3	2	3	2	3	3	3	3
	CLO - 4	2		2	3	2	2	2	3	3	3	3
GL-CE-5334	CLO-1	3	2	1	1	1	2	2		1	1	2
	CLO-2	2	3	1	1	2	2	1	3	1	2	2
	CLO-3	2	2	2	1	2	3	2		2	1	1

COURSE CODE	CLO	PROGRAMME SPECIFIC OUTCOME										
		PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8	PSO 9	PSO 10	PSO 11
GL-CE-5344	CLO-1	2	2		1		2					2
	CLO-2	2	1	3	1	1		2		2	1	1
	CLO-3	3	2		3		1	2		3	1	
	CLO - 4	2		3		3				2		1
GL-CE-6314	CLO-1	2	1	1	3	2	2	1	3	3	2	3
	CLO-2	1	1	1	2	1	1	2	2	3	2	3
	CLO-3	1	3	1	3	2	2	1	3	3	3	3
	CLO - 4	2	2	1	2	2	3	2	2	3	2	3
GL-CE-6324	CLO-1	1	3	2	2			1				
	CLO-2	1	3	1	1		2	1			1	
	CLO-3	1			2			3	2	1	1	
GL-CE-6334	CLO-1		1	1		2		3	3	1		3
	CLO-2	2	3	2	3	1	1			1	3	2
	CLO-3	2	2	2		2	3		1	2		1
GL-CE-6344	CLO-1	1	2	2	2		2		2	1	1	2
	CLO-2	2	2		2	3	1	3	1	2	2	
	CLO-3	2	3	3	3	2	2		2	2	3	1
GL-CE-7414	CLO-1:	3	2	1	1	2	2	3	1	2	2	3
	CLO-2:	3	3	2	1	2	2	2	1	1	2	2
	CLO-3:	3	3	2	3	1	3	1	2	1	2	3
	CLO-4:	2	2	2	3	1	3	1	1	1	1	3
	CLO-5:	2	2	1	2	3	3	2	1	3	2	2
GL- CE- 7414	CLO-1	1	1	2	2	2	1	2	1	3	2	
	CLO-2	1	2	1	1	2	1	1	2	2	2	
	CLO-3	1	1	2	2	2	2	2	2	2	2	
	CLO-4	1	2	2	2	1	1	2	1	2	2	
	CLO-5	1	1	2	1	2	1		2	2	2	
GL - CE - 7434	CLO1	1	2	1	1	2	1	2	2	1	3	1
	CLO2	1	2	1	1	3	2	2	3	1	3	1
	CLO3	1	2	1	1	2	1	2	2	1	3	1
GL-CE-7444	CLO 1:	3	2	2	3	2	2	1	2	1	2	3
	CLO 2:	3	3	3	3	2	3	1	3	2	3	3
	CLO 3:	3	3	3	3	2	3	1	3	2	2	3
	CLO 4:	3	3	3	3	2	3	1	3	2	3	3
GL- CE-7454	CLO1	1	2	2	2				2	1	1	1
	CLO2	1	1	1	2	2		2	2	1	1	2
	CLO3	1	2	2	1	3	3	3	2	1	1	2
	CLO4	1	2	2		1	3	3	3	1	1	2
GL- CE- 8414	CLO-1	1	1	1	2	1	1	2	1	2	2	
	CLO-2	1	2	1	1	2	1	1	2	3	2	
	CLO-3	1	1	2	2	2	2	2	2	2	2	
	CLO-4	1	2	1	2	1	1	1	1	2	2	
	CLO-5	1	1	2	1	2	1		2	2	2	
GL- CE-8424	CLO1	1	3	3	1		2	2	3	2	1	1
	CLO2	1	3	3	1	3	3	1	3	2	1	1
	CLO3	1	1	1	1	2	3	1	3		1	2
	CLO4	1	1	1	1	2	3	2		2	1	1

GL - CE - 8434	CLO1	1	2	2	2	2	1	2	1	2	4	2
	CLO2	1	1	3	3	2	2	2	3	2	4	2
	CLO3	1	2	1	1	2	1	2	1	2	4	3
GL–CE-8444	CLO 1:	3	2	2	2	2	2	1	2	1	2	3
	CLO 2:	3	3	3	3	2	3	1	2	2	2	3
	CLO 3:	3	3	3	3	2	3	1	3	2	3	3
GL-CE-8454	CLO1	3	2	1	2	2	2	2	3	2	2	3
	CLO2	2	3	2	3	1	3	1	3	1	2	3
	CLO3	2	3	2	3	1	3	1	2	2	2	3
	CLO4	2	3	3	3	2	3	1	2	2	3	3
	CLO5	3	3	3	3	2	3	2	3	3	3	3

COURSE NAME: Earth System Science
COURSE CODE: GL – CE – 1114
Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY: 3 CREDITS

Total Lectures: 45

COURSE OBJECTIVE:

The course is intended to teach the fundamental ideas of dynamic earth. It will go over the fundamental principles and processes that regulate the Earth's system. The course will also go through the various systems that exist on the Earth's surface

Course Learning Outcome:

The course outcomes of this course are as follows:

CLO-01: *It will improve students' grasp of the dynamic earth and the processes involved in the earth.*

CLO-02: *It will improve students' understanding of the solid earth and its physics and chemistry.*

CLO-03: *Students learn about the physical and chemical properties of the atmosphere and the hydrosphere.*

CLO-04: *Students will comprehend climate change and its long and short-term consequences*

Unit- I: Earth as a System (Lectures: 15)

Origin, age and general characteristics of the earth and the solar system; Definition and scope of earth systems science; The subsystems/system components and their interactions; Sources of energy. Laws of uniformitarianism, superposition of strata and faunal succession; The rock cycle, geochemical cycle, erosion cycle, hydrological cycle; Concept of geological time scale. Evolution of the atmosphere and hydrosphere; Biological evolution through geological history of the earth. Human impact on the earth system during Anthropocene.

Unit- II: Solid earth and its dynamics (Lectures: 15)

Internal structure of the earth, mantle convection, genesis of Earth's magnetic field; Concept of plate tectonics, sea floor spreading and continental drift. Earthquake and volcanoes-causes of formation and distribution; Earthquake belts and the Pacific ring of fire; Hot spot; Earthquake zones of India. Origin of the continents and oceans, mountains and rift valleys. The Wilson Cycle. Role of tectonics in landscape development

Unit- III: The atmosphere and hydrosphere (Lectures: 15)

Composition and vertical layered structure of the earth's atmosphere. Insolation and albedo, energy gradient; Hadley cell, the atmospheric pressure belts and circulation, Coriolis effect. The monsoon, upper level waves and jet stream. The meteorological parameters and their spatial and temporal variations, Weather and climate Chemical composition and physical properties of sea water, thermocline, halocline and pycnocline. Surface and deep water circulation, causes and effects. Land – air-sea interaction. Concepts of eustasy**.**

Earth's climate and climate change- short and long term. ENSO, Elnino and La-Nina, Impact of oceanic circulation on climate

Practical:

Total Lectures: 30

1. Model study of different geomorphic features.
2. Study of geomorphological features from topographic maps.
3. Study of major ocean currents of the world.
4. Study of seismic profile of a specific area and its interpretations.
5. Basic statistical analysis of hydro meteorological data

RECOMMENDED BOOKS:

1. Brian J. Skinner, B. J. & Porter, S. C.: (2012). The Blue Planet: An Introduction to Earth System Science. John Wiley & Sons. Inc.
2. Emiliani, C. (1992). Planet earth: cosmology, geology, and the evolution of life and environment. Cambridge University Press.
3. Holmes' Principles of Physical Geology, 1992.Chapman & Hall.
4. Patwardhan, A. M., The Dynamic Earth System, PHI Learning.
5. Bloom A.L.,(1998). Geomorphology: A Systematic Analysis of Late Cenozoic Landforms. Pearson Education.
6. Esterbrook D.J.,(1992).Surface Processes and Landforms, Mac Millan Publ.
7. Kale,V. Sand Gupta A.(2001).1ntoduction to Geomorphology, Orient Longman Ltd.
8. Summerfield. M. A. (1991). Global Geomorphology, Prentice Hall.
9. Environmental Geology by K.S.Valdiya. Tata McGraw Hill Publishing Co. Ltd.
10. Text Book of Environmental Sciences by Subramaniam. V. Narosa International publisher.

COURSE NAME: Rocks and Minerals

COURSE CODE: GL – CE – 2114

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY: 3 Credits

TOTAL LECTURES: 45 COURSE

OBJECTIVE:

The course objectives of this course are as follows:

- *To provide a holistic understanding about the basics of minerals, crystals and rocks.*
- *Students will be able to recognise and differentiate rocks, minerals and crystals.*
- *This paper helps to understand about ore and economic minerals and their significances*

Course Learning Outcome:

The course outcomes of this course are as follows:

CLO-01: *Students can learn about the rocks and minerals and their economic importance in the present day context.*

CLO-02: *They can know about the minerals and its relation to crystal, difference between crystal and amorphous substance, different crystal system.*

CLO-03: *They can learn about physical and optical properties of mineral and their usefulness to identify a mineral.*

CLO-04: *Students can get a basic knowledge about various rock types and their significances.*

Unit- I: Concepts of rocks, minerals and crystals (LECTURES: 15)

Elementary ideas about crystal and amorphous substance, crystal morphology in relation to internal structures, crystal systems. Composition of common rock forming minerals. Silicate and non-silicate structures, CCP and HCP structures, Definition of rocks, types of rocks - Igneous, metamorphic, sedimentary. Rock cycle.

Unit-II: Mineralogy (LECTURES: 15)

Minerals: definition, scope, classification, physical and chemical properties. Optical properties of minerals - Nature of light; Reflection and refraction of rays; Refractive index, Polarization of light; Polarizing Microscope, Cleavage, Extinction, Interference colour, Isotropic and Anisotropic minerals: Uniaxial and Biaxial. Study of optical properties of the following minerals: Quartz, Orthoclase, Microcline, Hypersthene, Hornblende, Garnet, Muscovite, Biotite, Enstatite, Olivine, Kyanite, Sillimanite, Calcite, Plagioclase.

Study of chemical composition and diagnostic physical properties of the following minerals: Quartz, Orthoclase, Microcline, Hypersthene, Hornblende, Garnet, Muscovite, Biotite, Enstatite, Olivine, Kyanite, Sillimanite, Calcite, Plagioclase.

Unit- III: Concepts of petrology (LECTURES: 15)

Igneous petrology: Magma, its composition, origin and types; Crystallization of Magma, Bowen's reaction; Magmatic differentiation; Assimilation. Igneous rocks: Definition; Mode of occurrence; Textures and structures; Classification of igneous rocks on textural, mineralogical and chemical criteria. Significances of different igneous rocks - Granite, Dolerite, Gabbro, Rhyolite, Syenite, Basalt and Diorite.

Sedimentary Petrology: Introduction; Processes of formation of sedimentary rocks weathering, transportation, deposition, diagenesis. Textures and structures of sedimentary rocks; Sedimentary structures: lamination, ripple marks, current bedding, graded bedding, mud cracks, rain prints. Classification of sedimentary rocks; Petrographic description of: sandstone, siltstone, shale, limestone, breccia and conglomerate. Metamorphic Petrology: Metamorphic rocks: Definition; Factors or Agents of Metamorphism; Types of Metamorphism; Grade of Metamorphism, Zones of Metamorphism; Metamorphic facies; Textures and Structures of Metamorphic rocks. Descriptive petrography of Slate, Phyllite, Schist, Gneiss, Quartzite and Marble.

Practical:

Total Lectures: 30

1. Identification of following minerals in hand specimen: Quartz, Orthoclase, Microcline, Hypersthene, Hornblende, Garnet, Muscovite, Biotite, Enstatite, Olivine, Kyanite, Sillimanite, Calcite, Plagioclase.
2. Study of optical properties of the following minerals in thin section: Quartz, Orthoclase, Microcline, Hypersthene, Hornblende, Garnet, Muscovite, Biotite, Enstatite, Olivine, Staurolite, Kyanite, Sillimanite, Calcite, Plagioclase.
3. Identification of following rocks in hand specimen:
   i. Igneous rocks - Granite, Dolerite, Gabbro, Rhyolite, Syenite, Basalt and Diorite.
   ii. Sedimentary rocks -Sandstone, Siltstone, Shale, Limestone, Breccia, Conglomerate.
   iii. Metamorphic rocks -Slate, Phyllite, Schist, Gneiss, Quartzite and Marble.

RECOMMENDED BOOKS:

1. Text of Geology by G.B. Mahapatra.
2. Deer, W. A., Howie, R. A., &Zussman, J. (1992). An introduction to the rock forming minerals (Vol. 696). London: Longman.
3. Mineralogy: Perkins and Henke
4. J.D. Dana. Textbook of Mineralogy
5. Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson.
6. Raymond, L. A. (2002). Petrology: the study of igneous, sedimentary, and metamorphic rocks. McGraw-Hill Science Engineering.
7. Myron G. Best (2001). Igneous and Metamorphic Petrology
8. Fundamentals of Geology by A.B. Roy.
9. Engineering and General Geology by Parbin Singh.

COURSE NAME: ELEMENTS OF GEOCHEMISTRY AND THERMODYNAMICS
COURSE CODE: GL- CE - 3214

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY

Total Lectures: 45

Course Objectives:

The prime objectives of this course are:

- *to introduce the fundamentals of geochemistry and thermodynamics in order to enable the students to understand the basics of geochemistry and thermodynamics applied in earth sciences.*
- *To motivate students to pursue higher studies and academic research in petrology based on their acquired basic knowledge of geochemistry and thermodynamics which may groom them as geochemists and petrologists in different sectors.*

Course Learning Outcome:

After completion of the course

CLO-1: *The students will acquire comprehensive knowledge of different geochemical processes that operate in the interior and near-surface environments of the earth.*

CLO-2: *The students will understand the physical and chemical laws governing the abundance, distribution and migration of chemical elements from one sphere to another sphere of the Earth*

CLO-3: *The students may be engaged as geochemist in exploration sectors, they may be engaged in academic research as well as in teaching position in geochemistry and petrology.*

Unit- I: Fundamentals of geochemistry (Lectures-15)

Properties of elements, The periodic table, Chemical bonding, states of matter and atomic environment of elements, Cosmic abundance of elements, Geochemical classification of elements, concepts of geochemical cycles and principle mass balance.

Concept of partition coefficient (Kd), compatible and incompatible elements. Behaviour of major, trace elements (including REE) during magmatic crystallization, Basic concept ofisotope geochemistry, application of radiogenic and stable isotope geochemistry (C, O, S) in geology, principles of radioactive dating methods (Rb-Sr, Sm-Nd, and C-14)

Unit-II: Geochemistry of solid Earth, surface and subsurface geochemical environment: (Lectures-15)

Formation of solar system, earth in the solar system, Composition of meteorites, geochemical differentiation of the Earth, Composition of the bulk silicate Earth, Composition of core; Composition of mantle: depleted mantle and enriched mantle; Composition of Continental and Oceanic crusts,The solid Earth – geochemical variability of magma and its products.

Concept of Element transport, advection and diffusion, Chromatography, Aqueous geochemistry- basic concepts and speciation in solutions, Eh, pH relations, Abundance of elements in river water and ocean water, Elements of marine geochemistry, Mineral reactions- diagenesis and hydrothermal reactions.

Unit-III: Thermodynamics (Lectures-15)

Concept of geochemical thermodynamics, isolated, close and open geochemical systems, Reversible and irreversible processes, Laws of thermodynamics, thermodynamic variables, Equilibrium, disequilibrium and steady states, concept of Enthalpy and Entropy and Gibb's free energy and thermodynamic potentials, Gibb's Phase Rule.

Concept of Thermodynamics of solution, Clausius-Clapeyron equation, Gibbs-Duhem equation, Ideal and non-ideal solution behaviour and equilibrium constant, Basic concept of geothermo barometry.

Practicals:

Total Lectures: 30

Types of geochemical data analysis and interpretation of common geochemical plots, Construction and interpretation of Harker's variation diagrams. Chemical variation diagrams based on major elements: the alkali-lime index, iron enrichment index, aluminum saturation index and alkalinity index diagrams, Normalization of REEs and trace elements and interpretation of Spider diagrams.

RECOMMENDED BOOKS:

1. Mason, B. and Moore (1986). Principles of Geochemistry. 3rd Edition, Wiley New York.
2. Rollinson, H. (2007). Using geochemical data – evaluation, presentation and interpretation. 2nd Edition. Publisher Longman Scientific & Technical.
3. Walther, J. V. (2009). Essentials of geochemistry. Jones & Bartlett Publishers.
4. Albarède, F. (2003). Geochemistry: an introduction. Cambridge University Press.
5. Wood, B. J. and Fraser, D. G., 1977. Elementary Thermodynamics for Geologists. Oxford University Press, Oxford, 303 p
6. Drever, J. I., 1982. The Geochemistry of Natural Waters. Prentice-Hall, Inc., Englewood Cliffs, N.J., 388 p.
7. Garrels, R.M. and Christ, C.L., 1965. Solutions, Minerals and Equilibria. Harper and Row Pub., New York, 450 p (Call No: QE515 G32)
8. Anderson, G.M., 1996. Thermodynamics of Natural Systems. John Wiley & Sons, Inc., New York, 382 p (Call No: QE515.5.T46A53)
9. Nordstrom, D.K. and Munoz, J.L., 1985 (1st edition). Geochemical Thermodynamics. Menlo Park, Calif. Benjamin/Cummings Publ. 477 p (Call No:QE515 N67)
10. Krauskopf, K.B., and Bird, D.K., 1995 (3rd edition). Introduction to Geochemistry. McGraw-Hill, Boston, 647 p (Call No: QE515 K7 1995)
11. Ganguly, J., (2008). Thermodynamics in earth and planetary Sciences. Berlin Heidelberg: Springer-Verlag

COURSE NAME: Structural Geology

COURSE CODE: GL- CE - 3224

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY

Total Lectures: 45

Course Objective:

The primary objectives of this course is

- To acquire fundamental concepts of Structural Geology and its significance in Earth Sciences.
- To acquire in depth knowledge about stress and strain to understand the physics behind deformation and the mechanisms responsible for the formation of different geological structures
- To enable students to apply concepts of structural geology as geologists in different fields such as Geodynamics, Exploration geology, Engineering geology projects etc.

Course Learning Outcome

The expected outcomes of this course are:

CLO-1: The course will enable students to prepare profile sections, interpret geological maps as well as the geometries of different structural elements indicating the causes and mechanisms responsible for the formation of different geological structures.

CLO-2: Students acquiring sound knowledge of structural geology may be engaged in academic research and teaching profession in the subject.

CLO-3: Students acquiring sound knowledge in theoretical and practical aspects of structural geology will able to explore its applicability in various fields such as Geodynamics, Exploration geology and civil engineering constructions etc.

UNIT-I: Fundamentals of Structural Geology (Lectures: 15)

Introductory Concept: Basic concept of Structural Geology; Primary, secondary and penecontemporaneous geological structures; Concept of non-diastrophic and diastrophic structures; unconformities (types and recognition), Concept of strike, dip, pitch and plunge, Outcrop patterns of different structures, Basic idea of topographic contours, Topographic and structural maps, Relation of geological structures with topography. Concept of stereographic projection and its use in structural geology.

Physics of Deformation: Concept of stress and strain, Types of stress, Mohr's stress circle, relation of stress and strain, Types of strain, strain ellipse and strain ellipsoid, characteristics and geological significance of strain ellipsoids, Rheological behaviour of rocks and their controlling factors, Concept of rock deformation, elementary idea of types of deformation, theory of rock failures.

UNIT-II: Foliation, Lineation and Fold Structures (Lectures: 15)

Foliation and lineation: Concept of foliation and lineation, their morphological features, classification and origin, tectonic significance, and relationship with the other structures. Boudin structures, types and geometry of boudins and boudins as kinematic indicators.

Folds: Concept of folds, structural elements and morphology of folds, geometric and genetic classification of folds. Mechanics of folding: buckling, Bending, Flexural slip and flow folding, superposed folds and fold interference patterns,

UNIT-III: Joints, Fractures, Faults and shear zones (Lectures: 15)

Joints and Fractures: concept of joints and fractures, classification of joints and fractures, relationship of joints and fractures to other structures and their significance.

Faults and Shear zones: Fault Morphology, Geometric and genetic classification of faults, Structural associations of Normal, Reverse/Thrust and Strike slip fault systems, Effects of faulting on the outcrops, Distinguishing criteria (Geologic/geomorphic) for recognition of faults in the field, mechanics of faulting, Anderson's dynamic analysis of faulting, Concept of fault zone/ shear zones and their types.

Practicals:

Total Lectures: 30

Construction of profile sections and interpretation of geological maps of different complexities with unconformity, fault, fold and igneous bodies as well as delineation of geological history, 3-point problems of dip and strike and structural contouring, stereographic projections of planes and lines; Stereographic solutions of true dip and apparent dip problems, fold and fault problems. Identification of different types of fold/fault from block models.

RECOMMENDED BOOKS:

1. Ghosh, S.K., 1993. Structural Geology: Fundamentals and Modern Developments, Pergamon Press, Oxford, p 598.
2. Davis, G. R. and Reynolds G.J. (1996). Structural Geology of Rocks and Region. John Wiley
3. Twiss, R.J. and Moores, E.M. (2007) Structural Geology. Second Edition. W. H. Freeman and Company.
4. Fossan, H. (2010). Structural Geology, Cambridge University Press.
5. Ramsay, J. G., 1967. Folding and fracturing of rocks. McGraw-Hill, New York
6. Park, R. G. (2004). Foundations of Structural Geology. Chapman & Hall.
7. Pollard, D. D. (2005). Fundamental of Structural Geology. Cambridge University Press.
8. Marshak, S. and Mitra, G. (1988). Basic Methods in Structural Geology. Prentice Hall.
9. Ragan, D.M. (2009). Structural Geology: an introduction to geometrical techniques (4th Ed). Cambridge University Press (For Practical).
10. Passchier, C. W., and Trouw, R. A. J., 2005. Microtectonics, 2ndEdn., Springer Verlag, Berlin.

COURSE NAME: Mineral Science

COURSE CODE: GL- CE - 4214

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY

Total Lectures: 45

Course Objective:

Minerals are the basic building units of Earth Material. This course is designed to provide a fundamental understanding of mineral classification, structure, and properties. The student will learn the fundamental principles of crystal chemistry and how they relate to mineral external form, chemical composition, and physical properties.

Course Learning Outcome:

CLO 1: *The course will provide in understanding the minerals i.e. building blocks of rocks.*

CLO 2: *Students will learn to identification, classification, and interpretation of rock-forming minerals in outcrops as well as in hand specimens.*

CLO 3: *Students will learn to utilize petrological microscopes for identification of rock forming minerals.*

Unit-1: Introduction (LECTURES: 15)

Introduction and history of mineralogy, Basic structure of the course, unit cell, point and space groups, Bravais Lattices; crystal systems, Crystal forms and their classification; Hermann Mauguin Notation 32 point group symmetries; Miller's Indicators and stereographic projections. Crystallography employing X-rays; The Bragg Equation and its application in mineralogy.

Unit-2: Common rock forming minerals (LECTURES: 15)

Ortho and ring silicates - Olivines, Garnets, Epidote, Beryl and Tourmaline, Chain silicates - Pyroxene group and Amphibole group, Sheet silicates - Mica group, Framework silicate – Feldspars, Non-silicates - Native elements, sulfides, oxides, halides; Carbonates, sulfates and phosphates.

Unit-3: Optical Mineralogy (LECTURES: 15)

Becky line test, Michael levy chart, accessory plates (Mica, Gypsum and Quartz), and their uses, determination of pleochroic scheme (uniaxial and bi-axial), Interference figure, Optic Sign determination (Uniaxial, Bi-axial)

Practical:

Total Lectures: 30

- Becky line test
- Optic sign determination (Uniaxial, Bi-axial)
- Determination of pleocheric scheme (uniaxial and bi-axial)
- Interpretation of X-ray defractogram for mineral phase identification.

Recommended Books:

1. Putnis, A., 1992, An Introduction to Mineral Science, Cambridge University Press.

2. Klein, C., and Butrow, B., 2008, The 23rd edition of the Manual of Mineral Science (4th Edition), John Wiley and Sons.
3. Wenk, H.-R. and Bulakh, A., 2016, Minerals – Their Constitution and Origin (2nd Edition), Cambridge University Press.
4. Nesse, W. D., 2011, Introduction to Mineralogy (2nd Edition), Oxford University Press.
5. Mottana, A., Crespi, R., and Liborio, G., 1978, Simon and Schuster's Guide to Rocks and Minerals (6th edition), Fireside Books.
6. Dana, J. D., 2008, Manual of Mineralogy and Petrology, Palala Press.
7. Mackenzie, W. S., and Adams, A. E., A Colour Atlas of Rocks and Minerals in Thin Section (2nd Edition), Manson Publishing Ltd.
8. Klein, C., 2007, Minerals and Rocks: Exercises in Crystal and Mineral Chemistry, Crystallography, X-ray Powder Diffraction, Mineral and Rock Identification, and Ore Mineralogy (3rd Edition), Wiley.

COURSE NAME: IGNEOUS PETROLOGY

COURSE CODE: GL- CE - 4224

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY

Total Lectures: 45

Course Objective:

The prime objectives of this course are:

- *To acquire comprehensive knowledge about the magma genesis, nature and evolution of igneous rocks through various magmatic processes.*
- *To understand genesis and nature of magma in diverse tectonic environments.*
- *To explore petrogenesis of igneous rocks in the light of modern phase equilibria and geochemical characteristics*

Course Learning Outcome:

The expected outcomes of this course are:

CLO-1: *At the end this course will enable students understand the mechanism of formation of igneous rocks formed throughout the Earth's evolutionary history and their relation with global tectonics.*

CLO-2: *Students will explore experimental and practical aspects of igneous processes in the light of modern phase equilibria and geochemical characteristics.*

CLO-3: *Acquiring sound knowledge of theoretical and practical aspects of igneous petrology students may be engaged in higher studies and academic research in petrology.*

Unit-I: Magmatic processes and magmatism in different tectonic setting (Lectures: 15)

Heat flow and geothermal gradients, magma generation in the mantle and crust, nature and physical behaviour, ascent, emplacement and evolution of magma, partial melting, processes of crystallization, assimilation, magma mixing and other subsidiary processes, batch melting and Rayleigh fractionation, Role of volatiles in magmatic system.

Present day magmatism and global tectonic processes. Magmatism in the oceanic domains (MORB, OIB). Magmatism along the plate margins (Island arcs, continental arcs). Plume magmatism and hot spots.

Unit- II: Phase equilibria study in igneous systems (Lectures: 15)

Phase rule and its application to eutectic, peritectic and solid solution system. Study of phase equilibria in binary systems (Diopside-Anorthite, Forsterite-Silica, Nepheline-Silica, Forsterite-Fayalite; Albite-Anorthite; Orthoclase-Albite) and ternary systems (Diopside-Nepheline-Silica, Diopside-Albite-Anorthite, Anorthite-Forsterite-Silica; Fayalite-Leucite-Silica, Orthoclase-Albite-Silica and and nepheline - kalsilite –silica) and their petrogenetic significance.

Unit- III: Petrology and petrogenesis of Igneous rocks (Lectures: 15)

Significance of geochemical analyses (major, trace and isotopic composition) of igneous rocks in context of petrogenesis and their tectonic discriminations. Concept of Petrgraphic Province, Petrogenesis and tectonic setting of major igneous rock types and suites: komatiite, lamprophyres, lamproiteskimberlite,

ophiolite, continental flood basalts, anorthosite. granitoids, alkaline rocks and carbonatites with special reference to Indian examples.

Practicals:

Total Lectures: 30

Mineralogical and petrogenetic study of important igneous rocks in thin sections – dunite, peridotite, pyroxenite, anorthosite, gabbro, dolerite, basalt, diorite, andesites, syenite, nephelinesyenite, trachyte, granite, rhyolite.

Construction and interpretation of common geochemical plots based on bulk rock petrochemical data in classification and discrimination of tectonic settings of igneous rocks.

RECOMMENDED BOOKS:

1. Philpotts, A., & Ague, J. (2009). Principles of igneous and metamorphic petrology. Cambridge University Press.
2. John D. Winter, .D. (2001). An Introduction to Igneous and Metamorphic Petrology. Prentice Hall Inc
3. Raymond, L. A. (2002). Petrology: the study of igneous, sedimentary, and metamorphic rocks. McGraw-Hill Science Engineering.
4. Frost, B.R. and Frost, C.D.(2014). Essentials of Igneous and Metamorphic Petrology, Cambridge University Press 31.
5. McBirney, A.R.(1993). Igneous petrology. Jones &Bartlet Publication.
6. Myron G. Best (2001). Igneous and Metamorphic Petrology,
7. K. G. Cox, J. D. Bell. (1979). The Interpretation of Igneous Rocks. Springer/Chapman & Hall.
8. Bose M.K. (1997). Igneous Petrology.
9. Kumar,S, and Singh, R.N.(2014). Modelling of Magmatic and Allied Processes. Springer, Switzerland.
10. Powell, R.(1978).Equilibrium thermodynamics in Petrology: An Introduction, Harper & Row Publishers, London.
11. Gill, R. (2015). Chemical Fundamental of Geology, Wiley Blackwell
12. Hibbard, M. J. (1995). Petrography to petrogenesis. MacMillan USA
13. Hugh Rollinson (2007) Using geochemical data – evaluation, presentation and interpretation. 2nd Edition. Publisher Longman Scientific & Technic

COURSE NAME: Sedimentology

COURSE CODE: GL- CE - 4234

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY

Total Lectures: 45

Course Objective:

Acquire knowledge of different sedimentary rock types, their origin, different processes of formation, mode of occurrences and their significances.

Course Learning Outcome:

CLO 1: *Student can learn about sediment, basic processes of sedimentation and influences of fluids.*

CLO 2: *Understand sediment Granulometry, Particle size distribution and statistical treatment*

CLO 3: *Knowledge of sedimentary textures, structures and environmental influence.*

CLO 4: *Recognise and study of different types of sedimentary rocks and their significances*

CLO 5: *Knowledge of Palaeocurrent and their analyses.*

Unit-1: Sediments (Lectures – 15)

Introduction, scope, origin of sediments, sedimentary flux. Processes of formation of sedimentary rocks – weathering, Erosion, transportation, and deposition, diagenesis, compaction, cementation, lithification & recrystallization. Mineralogical composition of sedimentary rocks. Provenance, Soils and Paleosols. Sediment Granulometry Grain size scales Udden-Wentworth and Krumbein (phi) scale, particle size distribution; mean, median, mode. Environmental connotation; particle shape and fabric (Grain roundness and sphericity).

Unit-2: Sedimentary Environments (Lectures15)

Sedimentary environments - classification of sedimentary environments, physical and chemical parameters of depositional environments. Sedimentary textures, structures - Fluid flow, sediment transport and sedimentary structures: Types of fluids, Laminar vs. turbulent flow, Particle entrainment, transport (bedload, saltation and suspension) and deposition. Inter- and Intra-bed sedimentary structures, Penecontemporaneous Deformation Structures (PCD) and Trace fossils. Palaeocurrent analysis- Scalar and Vector attributes; Palaeocurrent for different sedimentary environments.

Unit 3: Sedimentary Rocks (Lectures – 15)

Classification of sedimentary rocks – clastic and nonclastic; mineralogy of the clastic sediments. Concept of lithofacies and lithofacies assemblage. Petrographic description of sandstone, siltstone, shale, limestone and conglomerate. Carbonate rocks - controls of carbonate deposition, components and classification of limestone, dolomite and dolomitization.

Practical:

Total Lectures – 30

- Thin section petrography of sandstones and limestone; Identification of limestone on the basis of allochems and orthochems.
- Study of sedimentary structures in hand specimen:
- Granulometric analysis and their interpretation.
- Palaeocurrent analysis.

Recommended Books:

1. Prothero, D.R. & Schwab, F (2004) Sedimentary Geology, Macmillan
2. Tucker, M. E. (2006). Sedimentary Petrology, Blackwell Publishing.
3. Collinson, J. D. & Thompson, D. B. (1988). *Sedimentary structures*, Unwin- Hyman, London
4. Nichols, G. (2009). *Sedimentology and Stratigraphy* Second Edition. Wiley Blackwell
5. Sengupta S., *Introduction to Sedimentology*, Oxford & IBH Publishing Co.
6. Sam Boggs, Jr. (2009). *Petrology of Sedimentary Rocks*, Cambridge Univ. Press
7. Applied Sedimentology, Richard C Selley, Academic Press, 521pp.
8. Lewis, D.W. and McConchie, D, (1984) Practical Sedimentology, Wiley Blackwell.

COURSE NAME: Metamorphic Petrology

COURSE CODE: GL- CE - 5314

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY

Total Lectures: 45

Course Objective:

The chemical and physical changes that result from changing pressure, temperature, and chemical environments in the Earth's interior are studied in relation to metamorphic rocks. Various petrogenetic processes involving mineral reactions will be studied in this course. We will also examine the thermodynamic principles associated with metamorphic petrology.

Course Learning Outcome:

CLO 1: *The course will provide understanding in metamorphism of rocks.*

CLO 2: *Students will learn to identify metamorphic rocks and minerals in the field and laboratory, and able to interpret the metamorphic reaction textures.*

CLO 3: *Examine and recognize the essential minerals and significant characteristics of metamorphic rocks using a thin section and a hand specimen.*

CLO 4: *To reconstruct metamorphic conditions, use numerical, graphical, and synthesis techniques using modern softwares.*

Unit-1: Introduction to metamorphism (Lectures: 15)

Definitions, contributing factors, and conditions of metamorphism; variations in Earth's pressure (P) and temperature (T), Types of metamorphism –i) orogenic metamorphism, ii) ocean-floor metamorphism, iii) regional metamorphism, iv) contact metamorphism, iv) cataclastic metamorphism, v) hydrothermal metamorphism etc. Metamorphic rocks and concept of facies. Plate tectonic and metamorphic facies sequences.

Unit-2: Metamorphic Structure, Textures and reactions (Lectures: 15)

Metamorphic rock structures and textures; different kinds of metamorphic reactions; reactions between components in the solid and liquid phases; volatile reactions; effects of temperature, pressure, and chemical composition control on the metamorphic reactions; phase diagrams; the Gibbs phase rule and its applications; time scale of metamorphism.

Unit -3: Quantitative Metamorphic petrology (Lectures: 15)

Phase Rules, Gibbs phase Rule, Goldschmidt's Mineralogical Phase Rule, Phase diagram for metamorphic mineral assemblages (ACF, AKF, AFM). Mafic, ultramafic, pelitic, and calcareous rock, metamorphism. Geothermometer, geobarometer and geothermobarometer applications, Metamorphic P-T path.

Practical:

Total Lectures: 30

- Identifications of Metamorphic rocks in hand specimens.
- Textural and mineralogical studies of Low-grade, medium-grade and high-grade metamorphic rocks under petrological microscopes.

- Geothermo-barometric exercises.

Recommended Books:

1. Winter, J. D., 2010, An Introduction to Igneous and Metamorphic Petrology (2nd Edition), Prentice Hall.
2. Philpotts, A. and Auge, J., 2009, Principles of Igneous and Metamorphic Petrology (2nd Edition), Cambridge.
3. Bucher, K., and Grapes, R., 2011, Petrogenesis of Metamorphic Rocks (8th Edition), Springer.
4. Vernon R. H. and Clarke G. L. 2008. Principles of metamorphic Petrology. Cambridge Publication.

COURSE NAME: Principles of Stratigraphy and Indian Stratigraphy

COURSE CODE: GL- CE - 5324

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY

Total Lectures: 45

Course Objective:

- *Understand about Stratigraphy, its principles, Stratigraphic Units, different techniques of stratigraphic analyses, Interpret geological map*
- *Develop the proficiency in oral communication.*

Course Learning Outcome:

CLO 1: *Understand about the concepts of rock superposition, principles of stratigraphy, dynamic stratigraphy, International Stratigraphic Code, Stratotypes, Concept of Stratigraphic boundaries etc.*

CLO 2: *Knowledge of physiographic and tectonic subdivision of India, Stratigraphy of India and their significances.*

CLO 3: *Practical concepts of geological map, Identification of major stratigraphic units of India, Indian stratigraphic rocks type recognition, Preparation of paleogeographic maps of Precambrian time, Knowledge of different Proterozoic supercontinent reconstructions.*

CLO 4: *Develop the proficiency in oral communication relating to stratigraphy and Indian stratigraphy.*

Unit- 1: Principles of stratigraphy (Lectures – 15)

Concepts of Superposition of strata; Neptunism, Plutonism & Uniformitarianism; Applied Stratigraphy. Lyell's principles of geology. Geological time scale, concept of relative and absolute geochronology. Brief introduction of litho-, bio- and chrono-stratigraphy.

Facies concept of stratigraphy. Stratigraphic correlation. Introduction to concepts of dynamic stratigraphy (chemostratigraphy, seismic stratigraphy, sequence stratigraphy, Magnetostratigraphy).

Code of stratigraphic nomenclature, North American Stratigraphic Code of Nomenclature. Concepts of Stratotypes. Global Stratotype Section and Point (GSSP).

Unit 2: Precambrian stratigraphy of India (Lectures – 15)

Brief introduction to the physiographic and tectonic subdivisions of India. Introduction to Indian Shield and Proterozoic basins of India. A brief study of the Precambrian stratigraphy of the following areas with respect to lithology, tectonics and igneous activity: (a) Dharwar Province (Karnataka); (b) Singhbhum-Orissa Province (Jharkhand & Orissa); (c) Assam- Meghalaya plateau (Shillong plateau); (d) Cuddapah Super Group of Cuddapah basin; (e)Vindhyan Super Group of Sone Valley**.** A brief study of the problems of correlation of the Precambrian rocks occurrences in India.

Unit 3: Phanerozoic Stratigraphy of India (Lectures – 15)

Introduction to Phanerozoic Stratigraphy of India and study of the following areas

i. Palaeozoic stratigraphy of Kashmir and Spiti – Zanskar basin.

ii. Mesozoic stratigraphy of India: Triassic successions of Spiti, Jurassic of Kutch with special reference to their lithology and palaeontology. Cretaceous of South India and NE India – palaeontology, lithology and their relationship.

iii. Gondwana of Peninsular and Extra-peninsular India – lithology, palaeontology, palaeogeography, igneous activity, and structure

iv. Volcanic provinces of India-Deccan Trap and associated inter-, intra – infra – trappean beds; Rajmahal and Sylhet Trap.

v. Cenozoic stratigraphy of India: lithology, palaeontology and economic importance of Assam Arakan Basin. Stratigraphy and palaeontology of Siwalik Basin.

Practical:

Total Lectures – 30

- Study of geological map of India and identification of major stratigraphic units.
- Preparation of lithostratigraphic maps of India showing distribution of important geological formations: Dharwar Province, Shillong Group of rocks, Cuddapah Super Group, Vindhyan Super Group, Jurassic of Kutch, Cretaceous of Trichinopoly, Gondwana Super Group, Deccan Traps.
- Study of rocks in hand specimens from known Indian stratigraphic horizons
- Drawing various paleogeographic maps.
- Interpretation of various stratigraphic logs and their correlation.
- Study of different Proterozoic supercontinent reconstructions.

Recommended Books:

1. Krishnan, M. S. (1982). *Geology of India and Burma*, CBS Publishers, Delhi
2. Doyle, P. & Bennett, M. R. (1996). *Unlocking the Stratigraphic Record*. John Wiley
3. Ramakrishnan, M. &Vaidyanadhan, R. (2008). *Geology of India Volumes 1 & 2*, Geological society of India, Bangalore.
4. Valdiya, K. S. (2010). *The making of India*, Macmillan India Pvt. Ltd.
5. Naqvi, S.M. and Rogers, J.J.W. *Precambrian Geology of India*, Oxford University Press.
6. Kumar, R., *Fundamentals of Historical Geology and Stratigraphy of India*, New Age International Publishers.
7. Boggs, S. (2001): Principles of Sedimentology and Stratigraphy, Prentice Hall.

COURSE NAME: Palaeontology

COURSE CODE: GL- CE - 5334

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY

Total Lectures: 45

Course Objective:

1. To know about the importance of fossils and their modes of preservation
2. To know about origin of life and evolutionary history of the organic world.
3. To know about morphology of some common fossils.
4. To know about uses of fossils for geological understanding and interpretations including palaeobiogeography, palaeoecology, palaeoenvironmental changes etc.

Course Learning Outcome:

After completion of the course students will be able to:

CLO 1: *Identify common fossils in hand specimens using diagnostic morphological features*

CLO 2: *Apply the palaeontological knowledge for knowing chronostratigraphic position and depositional conditions of sedimentary rocks.*

CLO 3: *Know about palaoenvironmental changes through time and space which may enable them for future preparedness in regard to changing scenario of earth's climate.*

Unit-1: Fossilization and fossil record (10 Lectures)

Palaeontology: definition, branches, scopes and applications. Fossil: definition and types. Process of fossilization. Conditions and modes of preservation. Nature and importance of fossil record; Scope of microfossils with special reference to oil exploration, Ichnology, General idea about Palaeobotany, Plant fossils and Palynology. Gondwana Floras of India.

Unit- 2: Taxonomy and Species concept (6Lectures)

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

Unit- 3: Invertebrates (12Lectures)

Brief introduction to important invertebrate groups (Brachiopoda, Bivalvia, Gastropoda, Cephalopoda, Echinoidea, Foraminifera) and their biostratigraphic significance**.** Significance of ammonites in Mesozoic biostratigraphy and their palaeobiogeographic implications, Functional adaptation in ammonoids.

Unit- 4: Vertebrates (10Lectures)

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

Unit-5: Applied Palaeontology (7Lectures)

Biozones, index fossils, Bio correlation, Application of Fossils for palaeoenvironment analysis, Fossils and paleobiogeography, biogeographic provinces, dispersals and barriers. Paleoecology – fossils as a window to the evolution of ecosystems

Practicals

Total Lectures: 30

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

Recommended Books:

1. Shrock, R and Twenhofel, W. H.(2005) Principles of Invertebrate Palaeontology; CBS
2. Raup, D. M., Stanley, S. M., Freeman, W. H. (1971), Principles of Paleontology
3. Clarkson, E. N. K. (2012); Invertebrate paleontology and evolution, 4th Edition by Blackwell Publishing.
4. Benton, M. (2009); Vertebrate paleontology; John Wiley & Sons.
5. Shukla, A. C., &Misra, S. P. (1975); Essentials of paleobotany. Vikas Publisher
6. Armstrong, H. A., &Brasier, M.D. (2005),.Microfossils. Blackwell Publishing.
7. Jain P.C. and Anantharaman M.S. 2022-23 Palaeontology (Palaeobiology) Evolution & Animal Distribution), Vishal Publishing Co.

COURSE NAME: Geomorphology

COURSE CODE: GL- CE - 5344

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY

Total Lectures: 45

Course Objective:

- *To introduce the students to basic understanding of the geomorphology*
- *To introduce different geomorphic processes that led to the formation of present landforms*
- *To introduced various geomorphic technique.*

Course Learning Outcome:

CLO 1: *This course will give comprehensive knowledge on the processes that led to the formation of present landforms and the ongoing processes sculpting Earth's surface*

CLO 2: *A student will learn about the geomorphology of India.*

CLO 3: *A student will learn various geomorphic techniques*

CLO 4: *After completion of the course student will earn the role of tectonics in landform building. They will gather sufficient knowledge to carry out first order investigation of any landform in a tectonically active area.*

Unit 1: Basic Concepts (Lectures 15)

Basic concepts of Geomorphology, Physiography, Physiographic divisions of India, Endogenic and Exogenic processes; Denudation; Weathering-factors and types, Erosion and Mass wasting.

Unit 2: Different aspects of Geomorphology (Lectures 15)

Geoid, Topography, Hypsometry, Global Hypsometry, Major Morphological features, Large Scale Topography - Ocean basins, Plate tectonics overview, Large scale mountain ranges (with emphasis on Himalaya). Overview of Indian Geomorphology, Applied aspects of geomorphology

Unit 3: Processes of Geomorphology (Lectures 15)

Surficial Processes and geomorphology, Fluvial processes and landforms, Aeolian Processes and landforms, Glacial, Periglacial processes and landforms, Coastal Processes and landforms, Karst and speleology. Introduction to planetary geomorphology, Extraterrestrial landforms. Landform associated with Igneous activity.

Practicals:

Total Lectures: 30

- Reading topographic maps
- Concept of scale, Preparation of a topographic profile
- Preparation of longitudinal profile of a river
- Morphometry of a drainage basin
- Preparation of geomorphic map
- Interpretation of geomorphic processes from landform assemblages

Recommended Books:

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

COURSE NAME: Ore Geology and Mineral Economics

COURSE CODE: GL- CE - 6314

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY

Total Lectures: 45

Course Objective:

- *Acquire a good knowledge in ore genesis, mineral economics, Indian mineral deposits and their field of applications.*
- *Develop the proficiency in oral communication relating to various subject related topics.*

Course Learning Outcome:

CLO 1: *Understanding about economically important minerals/materials, both theoretically and practically, their ores, origin, occurrence, mineral deposit, ore deposit with other related topics.*

CLO 2: *Acquire knowledge of various academic and economic terms and their significances.*

CLO 3: *Study of important economic mineral deposits of India.*

CLO 4: *Preparation of maps showing distribution of important ores and other economic minerals in India and assessment of grade of ore and reserve estimation.*

Unit-1: Ore Genesis (Lectures – 15)

Scope of Economic Geology; Definition of ore, ore deposit, gangue, tenor, host rock, grade, lode. Concept of ore genesis, Processes of formation of economic mineral. Classification of economic mineral deposits. Mode of occurrence of ore bodies. Structure and texture of ore deposits: Concordant and discordant ore bodies. Endogenous processes - Magmatic concentration, skarns, greisens, SEDEX and hydrothermal deposits & Exogenous processes - weathering products and residual deposits, oxidation and supergene enrichment, placer deposits, with Indian examples, Concept of paragenesis and zoning of ores. Definition of metallogenetic belts, epoch sand provinces with examples. Wall rock alteration; structural, physico-chemical and stratigraphic control of ore localization with examples.

Unit-2: Indian Ore Deposits (Lectures – 15)

A study of mineralogy, mode of occurrence, origin and uses of the following Indian ore deposits with reference to Indian occurrences:

- Metallic mineral deposits: Aluminum, Copper, Chromite, Iron, Manganese, Lead & Zinc, Gold, Silver, Nickel and Radioactive minerals.
- Non-metallic mineral deposits: Limestone, Mica, Clay, Sillimanite, Asbestos, Diamond.
- Industrial Raw materials: Cement, Glass & Ceramics, Fertilizer, Refractory, Abrasive, Strategic minerals, Gemstones and Building materials

Unit – 3: Mineral Economics (Lectures – 15)

Concept of Mineral Economics; Scope of mineral economics. Resources and reserves- Economic and Academic definitions. Types and uses of some common mineral resources. Concept of mineral exploration, exploration, development and conservation. Strategic, critical & essential minerals; Building materials. National Mineral Policy.

Practicals:

Total Lectures – 30

- Megascopic identification of ore minerals: Iron, copper, Manganese, Lead and Zinc, Aluminum, Chromium.
- Study of microscopic properties of ore forming minerals (Oxides and sulphides).
- Preparation of maps**:** Distribution of important ores and other economic minerals in India.
- Assessment of grade of ore and reserve estimation

Recommended Books:

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

COURSE NAME: Geology of Northeast India

COURSE CODE: GL- CE - 6324

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY

Total Lectures: 45

Course Objective:

The course is designed to spread knowledge about the physiographical and stratigraphical overview, the various geological features of north-eastern India, and the occurrences of various economically important deposits.

Course Learning Outcome:

CLO 1: *The students will learn about the geology of NE India.*

CLO 2: *Students will learn the basic stratigraphic and tectonic subdivisions of NE India.*

CLO 3: *Students will understand the economic importance of NE India in the society.*

Unit-1: Introduction (Lectures: 15)

Geomorphic divisions of NE India (Brahmaputra Plain, Arunachal Himalaya, Naga-Patkai Range, Meghalaya Plateau and Mikir Hill etc.), Tectonic framework of North-East India.

Unit-2: Stratigraphy of NE India (Lectures: 15)

Stratigraphy of Arunachal Pradesh (Precambrian-Paleozoic of Arunachal Pradesh), Ophiolite Sequence of Nagaland, Stratigraphy of Meghalaya, Carbonatites of Northeast India, Tertiary sequence of Northeast India, Quaternary Sediments of NE India.

Unit-3: Economic mineral deposits of NE, India (Lectures: 15)

Oil and Gas distributions in NE India, Sillimanite deposits in NE India, Coal deposits in NE India, Limestone deposits in NE India, Geothermal energy potential in NE India, Hydrothermal energy potential in NE India.

Practical:

Total Lectures: 30

- The study of North-East India's geological maps
- Mineral resource map preparation of NE India
- Study of tectonic framework map of NE India

Recommended Books:

1. Geology of Arunachal Pradesh by Gopendra Kumar.
2. Geodynamics of North East India and adjoining regions By D.R. Nand
3. Geology of Assam by A.K. Biswas and A.B. Dasgupta.

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COURSE NAME: Hydrogeology

COURSE CODE: GL- CE - 6334

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY

Total Lectures: 45

Course Objective:

1. To understand about the fundamentals of Hydrogeology, occurrence of groundwater, water bearing properties of formations etc.
2. To know about the occurrence of groundwater, water bearing properties of formations
3. The objective is to give students a sound understanding of the occurrence, distribution and movement of groundwater.
4. To understand the concepts of groundwater exploration.

Course Learning Outcome:

CLO 1: *The students will learn about occurrence of groundwater, water bearing properties of formations, aquifer types and aquifer parameters.*

CLO 2: *The course imparts knowledge about construction, design and development of water wells, aquifer parameter estimation and the science of groundwater flow under different conditions.*

CLO 3: *The students will learn about the concepts of groundwater exploration in an integrated way and also understand about groundwater chemistry.*

Unit 1: Introduction and basic concepts (Lectures 15)

Definition and scope of hydrogeology, and its societal relevance. Types of water: meteoric, juvenile, magmatic and sea waters. Hydrologic cycle: precipitation, evapo-transpiration, run-off, infiltration and subsurface movement of water. Rock properties affecting groundwater, Vertical distribution of subsurface water. Types of aquifer, aquifer parameters, anisotropy and heterogeneity of aquifers, Water table and piezometric surface; Fluctuations of water table and piezometric surface. Concept of depth to water level and water table contour maps; Concepts of drainage basin and groundwater basin.

Unit 2: Groundwater flow (Lecture 10)

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

Unit 3: Well hydraulics and Groundwater exploration (Lectures 12)

Basic Concepts (drawdown; specific capacity etc), Elementary concepts related to equilibrium and non-equilibrium conditions for water flow toa well in confined and unconfined aquifers. Surface-based groundwater exploration methods. Introduction to subsurface borehole logging methods

Unit 4: Groundwater management (Lecture:08)

Groundwater level fluctuations, Groundwater contamination and pollution from natural and anthropogenic sources. Basic concepts of water balance studies, issues related to groundwater resources development and management, Rainwater harvesting and artificial recharge of groundwater

PRACTICALS:

Total Lecture:30

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

Recommended Books:

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

COURSE NAME: Engineering Geology

COURSE CODE: GL- CE - 6344

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY

Total Lectures: 45

Course Objective:

1. *In order to construct a safe, long lasting and profitable benefit cost ratio structure the application of geological knowledge is very much in demand therefore Selection of most suitable sites for any civil structure, over or underground is very important.*
2. *Use of engineering geological knowledge in design and construction of civil engineering structures.*
3. *Use of geotechnical knowledge in the field*

Course Learning Outcome:

After completion of the course students will be able to:

CLO 1: *Trained personnel with adequate knowledge on the engineering properties of soils and rocks.*

CLO 2: *Adequate skills for conducting geotechnical studies in the field as well as in the laboratory*

CLO 3: *Scope of employment as a geotechnical laboratory scientist, engineering geologist, site geologist.*

Unit 1: Basic Concepts (Lectures 15)

Engineering Geology- Definition and Scope, Role of Engineering geologists in planning, design and construction of major man-made structural features. Engineering Properties of Rock: Moisture content, void ratio, porosity, permeability, degree of saturation, unit weight, density, specific gravity, strength (compressive, shear and tensile), deformability. Atterberg's Limits and consistency of soil, Indian Standard Soil Classification System. Elementary knowledge about soil compaction, compressibility and consolidation, Liquefaction

Unit 2: Dams and Tunnels (Lectures 15)

Dams and Tunnels: Classification and Terminologies. Geological and geophysical investigations associated with construction of Dams. Dam foundation, abutment and reservoir problems, Seepage and leakage, Concept of reservoir triggered seismicity. Geological investigations associated with construction of Tunnels, Groundwater problem associated with tunnel

Unit 3: Rock and Rock aggregates (Lectures 15)

Concept of Intact Rock and Rock aggregates: their significance as Construction material. Relation of rock strength with geological structures. Concept, Mechanism and Significance of: Rock Quality Designation (RQD), Rock Structure Rating (RSR), Rock Mass Rating (RMR), Improvement of Rock Mass properties (Grouting, Rock Bolting, Anchoring).

Practicals:

Total Lectures:30

- Determination of moisture content and unit weight of soil.
- Determination of consistency limits of soil by Casagrande Method or Cone Penetration Method.

- Determination of RQD, RSR, RMR and ‘Q’.

Recommended Books:

1. Krynin, D.P. and Judd W.R. 1957. Principles of Engineering Geology and Geotechnique, McGraw Hill (CBS Publ).
2. Engineering Geology by Duggal, Pandey and Rawal. McGraw Hill Education (India) Pvt. Ltd.
3. Engineering (Soil Mechanics) by Ramamurthy and Sitharam, S.Chand and Company
4. Waltham, T., 2009. Foundations of Engineering Geology (3rd Edn.) Taylor & Francis.
5. Bell, .F.G, 2007. *Engineering Geology,* Butterworth-Heineman
6. Modern Geotechnical Engineering by Alam Singh. CBS Publishers.

Paper Name: Research Methodology

Paper Code: GL-CE-7414

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

L + T / P = 3 + 1 = 4 Credit

Number of Theory Classes: 45 (45 hours)

Number of Practical Classes: 15 (30 hours)

Course Objectives (CO)

- To introduce students to the basics of scientific research in geology.
- To develop skills in formulating research problems, collecting and analyzing data.
- To familiarize students with basic statistical and computer tools used in geoscientific studies.
- To provide basic knowledge on scientific writing and presentation.

Course Outcomes (CLO)

After completing the course, students will be able to:

1. CLO-1: Understand the steps and ethics of scientific research.
2. CLO-2: Identify research problems and formulate simple hypotheses.
3. CLO-3: Apply basic statistical tools for geological data analysis.
4. CLO-4: Use simple computer applications for data processing and plotting.
5. CLO-5: Prepare short research reports and project presentations.

Unit 1: Introduction to Scientific Research **Lecture: 15**

- Meaning, purpose and scope of scientific research.
- Types of research (basic, applied, experimental, field-based).
- Hypothesis: concept, formulation, and testing.
- Review of literature (basic techniques, using online databases).

Unit 2: Research Design and Data Collection **Lecture: 15**

- Research design: objectives and types (descriptive, analytical, experimental).
- Data types: qualitative and quantitative.
- Methods of data collection: field data, lab data, published sources.
- Basics of sampling and data tabulation.

Unit 3: Scientific Writing **Lecture: 8**

- Structure and components of research reports and papers.
- Writing abstracts and summaries.
- Ethics in research and plagiarism awareness.
- Use of quality check tools like Drillbit, Turnitin etc.
- Basics of citation and referencing (APA, GSA).

Unit 4: Statistical Methods in Geoscience **Lecture: 7**

- Mean, median, mode, standard deviation, and variance.
- Correlation and regression.
- Introduction to trend surface analysis and PCA.

Practical **Lab work: 15 (30 hrs)**

- Identification and formulation of a research problem.
- literature review and summarisation.
- Basic computational techniques using MS Excel, Matlab etc.
- Plotting simple geological data (bivariate, ternary, or histogram plots).
- Formulation of a research proposal in Geology.

Recommended Readings

1. Statistical Data Analysis Explained: Applied Environmental Statistics with R. Wiley by Reimann, C. et al. (2008).
2. Research Methodology: Methods and Techniques by Kothari, C.R. (2014) New Age International.
3. Methodology of Research in Social Sciences and Humanities by Krishnaswamy, S. (2014).
4. Statistics and Data Analysis in Geology by Davis, J.C. (2002); Wiley.

Paper Name – Fuel Geology
Paper code: GL- CE - 7424

Credits: 4 (THEORY - 3, RACTICALS - 1)

Course Objectives: (CO)

- To provide a holistic understanding about the basics of fuel, renewable, non-renewable, green energy resources etc.
- Understanding the Origin and Formation of hydrocarbons.
- Identifying and characterizing petroleum systems.
- Some related practical applications, investigations and so on.

Course learning outcomes: (CLO)

- Student will acquire knowledge on coal, petroleum and other fuels; their formation classification etc.
- Students will be able to understand about the basics of exploration techniques and utilization of different fuels.
- Students can learn about different fuels including conventional and unconventional resources, their economic importance in the present-day context.

Unit 1: Coal and shale gas: **Lecture: 15**

- Coal: definition, origin and basic classification of Coal.
- Fundamentals of Coal Petrology - Introduction to lithotypes, microlitho-types and macerals in coal.
- Proximate and Ultimate analysis.
- Coal as a fuel - Coal Bed Methane (CBM): global and Indian scenario, Underground coal gasification, Coal liquefaction.
- Shale gas – occurrence, application, Indian scenario.

Unit 2: Petroleum Geology: **Lecture: 15**

- Petroleum Chemical composition and physical properties of crudes in nature. Origin of petroleum, Maturation of kerogen, Biogenic and Thermal effect.
- Reservoir rocks: general attributes and petrophysical properties. Migration of petroleum. Classification of reservoir rocks - clastic and carbonate.
- Hydrocarbon traps: definition, anticlinal theory and trap theory. Classification of hydrocarbon traps - structural, stratigraphic and combination. Time of trap formation and time of hydrocarbon accumulation.
- Cap rocks - definition and general properties.
- Plate tectonics and global distribution of hydrocarbon reserves. Petroliferous basins of India.
- Gas hydrate: Concept, significances and applications.

Unit 3: Other fuels: Atomic energy, Geothermal energy: **Lecture: 15**

- Nuclear fuels: Concept of atomic energy, Productive geological horizons of atomic minerals in India. Applications of Radioisotopes in Various Industries.
- Geothermal energy: Principles of utilization of Earth's heat – Types of geothermal source. Applications of geothermal sources– Exploration of geothermal sources.
- Helium is a source of energy.

Unit 4: PRACTICALS: **Lab work: 15 (30 hrs)**

- Study of hand specimens of coal; Coal petrography.
- Reserve estimation of coal.
- Interpretation of wireline logs
- Study and interpretation of seismic sections
- Section correlation and identification of hydrocarbon prospect.
- Panel and Fence diagrams

SUGGESTED READINGS:

- Chandra's Textbook on applied coal petrology, Chandra D. Jijnasa Publishing House, 2007.
- Sedimentology and petroleum geology, Bjorlykke, K. Springer-Verlag, 1989.
- Basin evolution and petroleum prospectivity of the continental margins of India (Vol. 59), Bastia, R., & Radhakrishna, M. Newnes. 2012.
- Geology of Petroleum; Levorsen, A.I.; 2ndEdition. CBS, Publishers, 2006.
- Principles of Sedimentary Basin Analysis; Miall, A.D.; Springer, 2000.
- Elements of Petroleum Geology; Richard, C. Selley, Elsevier, 1997.
- Petroleum Geology; North, F.K.; Published by Unwin Hyman; Revised edition – 1990.
- Sedimentary basins of India- ONGC bulleting. Unconventional Petroleum Geology, Caineng Zou et al.; Elsevier, 2013.
- Principles of Nuclear Geology; Aswathanarayana, U; Oxford Press. 1985.
- Geothermal Energy Resources of India: Past and the Present, Chandra sekharam, D ; World Geothermal Congress – 2005; pp.1-9. 2005.
- History of Geothermal Energy in the World to the 20th Century, Cataldi, R and M. Arriaga M.C.S; Think Geo Energy, Iceland. 2020.

PAPER NAME: Geotectonic and Geodynamics

PAPER CODE: GL - CE - 7434

Total Credits: 4 (Theory: 3+ Practical/ Tutorial: 1)

L + T / P = 3 + 1 = 4 Credit

Number of Theory Classes : 45 (45 hours)

Number of Practical Classes : 15 (30 hours)

Course Objectives: The prime objectives of this course are:

- To provide a comprehensive knowledge on dynamic processes shaping the Earth, focusing on Earth's structure, geological processes with emphasis on the principles of plate tectonics.
- To enhance understanding of geological events driven by complex geodynamic mechanisms on different tectonic regimes on Earth.

Course Learning Outcome: After completion of the course

- **CLO-1:** Acquiring comprehensive knowledge on dynamic processes shaping the Earth, students will describe and interpret a large variety of geological processes that operate in the earth.
- **CLO-2:** Students will understand different geological events, which will help in predicting and preparing for natural disasters such as volcanoes, earthquake, etc.
- **CLO-3:** Students will able to understand and connect the tectonic processes with the resulting phenomena on different scales.

Unit- I: **Introduction to Geotectonic and Geodynamics:** **Lectures: 15**

Heat flow and the dynamism of the Earth's interior, Earth's magnetic field, Gravity anomalies and the Concept of isostasy, the theory of Plate Tectonics, Causes of plate motions and driving forces of global geotectonic; Palaeomagnetism and polarity reversals.

Unit- II: **Geotectonic Features:** **Lectures: 15**

Plate boundaries: types and characteristics, Large scale geotectonic environments, such as Mid-Oceanic Ridges, Subduction and Collision zones, Trenches, Volcanic arcs, Island arcs, Transform faults and Triple junctions, Active and Passive continental margins.

Unit-III: Geodynamics and Earth's Structures: **Lectures: 15**

Continental and oceanic lithosphere, Formation of large scale geodynamic features such as formation of mountain, evolution of Himalaya, the spreading of the seafloor, Occurrences of Earthquake and volcanoes. Concept of hot spot and plume magmatism.

UNIT IV-Practical: **Lab work: 15 (30 hrs)**

Study of Tectonic maps of India, interpretation of maps showing tectonic elements on planar and uneven topography. Drawing and interpretation of block diagrams depicting tectonic features. Interpretation of different structural cross sections, Fault plane solution.

RECOMMENDED BOOKS:

1. Geodynamics 2nd edition, by Donald L. Turcotte and Gerald Schubert, Cambridge University Press, 2012, ISBN-13: 978-0521666244

2. Kearey, P., Klepeis, K.A., and Vine, F.J., 2009, Global Tectonics, 3rd Edn., Wiley-Blackwell, Oxford, 482 p

3. Condie, K.C., 1997, Plate tectonics and crustal evolution, 4th Edn., Butterworth-Heinemann, Oxford, 294 p.

4. Skinner, B.J., Porter, S.C. and Park, J., 2003, The Dynamic Earth: An Introduction to Physical Geology , John Wiley & Sons, 631 p.

Paper Name: Remote Sensing and GIS in Geology

Paper Code: GL-CE-7444

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

L + T / P = 3 + 1 = 4 Credit

Number of Theory Classes: 45 (45 hours)

Number of Practical Classes: 15 (30 hours)

Course Objectives

- To introduce fundamentals of remote sensing and GIS as applied to geology.
- To train students in digital image processing and spatial data handling.
- To equip students with practical skills in slope analysis and thematic mapping.

Course Learning Outcomes (CLO)

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

CLO-1: Explain principles of electromagnetic radiation and its interaction with Earth's surface.

CLO-2: Identify geological structures, lithology, and geomorphology using satellite imagery.

CLO-3: Use GIS tools for spatial data analysis.

CLO-4: Apply remote sensing and GIS data in geological studies, Disaster management.

Unit I: Fundamentals of Remote Sensing **Lecture: 15**

Definition and scope of remote sensing in geology; Energy sources for Remote Sensing; Nature of Electro-magnetic energy; Electromagnetic spectrum; Interaction of Electro-magnetic radiation with atmosphere and earth surface features; atmospheric windows; Spectral Response Curves; Remote Sensors and Platforms; Concept of image; Advantages & limitations of Remote Sensing; Satellite orbits; Orbital characteristics of Remote Sensing Satellite; Space remote sensing programme: IRS, Landsat, Sentinel, ASTER.

Unit II: Photographic Remote Sensing and Visual Image Interpretation Lecture: 15

Definition and history of Aerial Photography; Working Principal and Terminologies of Aerial Photography; Components of Photographic System – Camera, Film, Lens and Filter; Scale and of the Aerial Photograph; Types of Aerial Photography; Acquisition of Aerial Photograph; Principles of Stereoscopy; Fundamentals of Photogrammetry; Merits and Demerits of Photographic System; Visual image interpretation : Elements of Image Interpretation; Conversion of evidence; Geotechnical Elements.

Unit III: Fundamentals of GIS **Lecture: 15**

Definition, scope, and components of GIS; Geospatial data; Spatial data structure: raster vs. vector, Organization of Spatial Data in GIS; GIS operational workflow; Introduction to Geospatial Data Analysis; Methods of Geospatial Data Analysis : Database query, Geospatial measurements, Overlay operations, Neighbourhood Operations; Digital Elevation Model (DEM) – Generation and Applications. Geographic and Projected Coordinate System; Necessity of Map Projection; Georeferencing; Areas of GIS application.

Unit- IV Practical **Lab work: 15 (30 hrs)**

Stereo Vision test, Use of Pocket and Mirror Stereoscope; Visual image interpretation of aerial photograph and satellite images for terrain analysis, lineament mapping, lithology, structure, drainage and land use, identification of glacial lakes.

Suggested Readings

1. Remote Sensing and Image Interpretation by Lillesand, T. M., Kiefer, R. W., & Chipman, J. W. (2015). Wiley.
2. Introduction to Remote Sensing by Campbell, J. B., & Wynne, R. H. (2011). Guilford Press.
3. Introductory Digital Image Processing: A Remote Sensing Perspective by Jensen, J. R. (2005); Prentice Hall.
4. Principles of Geographical Information Systems by Burrough, P. A., & McDonnell, R. A. (1998); Oxford Univ. Press.
5. Remote Sensing Geology by Gupta, R. P. (2017); Springer.
6. GIS for Dummies by DeMers, M. N. (2009); Wiley.

Paper Name: Environmental Geology

Paper Code: GL- CE-7454

Total Credits: 4 (Theory: 3+ Practical/Tutorial: 1)

L + T / P = 3 + 1 = 4 Credit

Number of Theory Classes: 45 (45 hours)

Number of Practical Classes: 15 (30 hours)

COURSE OBJECTIVES: (CO)

The primary objectives of this course is

- To acquire fundamental concepts of Environmental Geology and its significance in Earth Sciences.
- To acquire knowledge about different types of pollution- geogenic and anthropogenic
- To enable students to acquire knowledge on causes, factors, impact of landslides and flood on environment
- To acquire detailed knowledge on water pollution-its source and types

COURSE LEARNING OUTCOMES (CLO)

CLO-1: The course will enable students to acquire knowledge about causes of pollution and hazards related to mining.

CLO-2: Analyze impact of landslides on environment.

CLO-3: Students acquiring sound knowledge to identify different factors of flood in fluvial systems and their management.

CLO-4: Students acquiring knowledge to identify the sources of water pollution and suggest remedial measures.

UNIT-I: Fundamentals of Environmental Geology **Lectures: 15**

Definition, fundamental concepts and scope of environmental geology, Natural and anthropogenic environmental hazard; Geological Hazards- Earthquake, Volcanism, Landslide, Avalanches, Floods, Droughts, Tsunami

Geogenic pollution and its types. Pollution and hazards due to mining activities including hill cutting and sand mining, pollution due to radioactive mineral mining. The carbon cycle, concept of global warming and climate change.

UNIT-II: Landslide and flood **Lecture: 15**

Landslides, causes, factors, impact of landslides on environment, landslide hazard zonation, preventive measures, early warning system. Soil erosion and river bank erosion.

Flood – definition, causes, flood in fluvial systems, flood management, structural and non-structural methods of flood management, flood plain zoning, dams and flood, flood in Assam; Glacial lake outburst flood.

UNIT-III: Water pollution **Lecture: 15**

Water pollution - sources of pollution of surface and ground water, water pollution parameters, types of water pollution, Geogenic and Anthropogenic pollution, causal factors, case studies. Parameters of potable water as per Indian and WHO's standards.

UNIT-IV PRACTICAL: **Lab work: 15 (30hrs)**

- Map study of Multi-hazard scenario in NE India: earthquake, landslide, flood and erosion
- Landslide susceptibility mapping
- Geochemical analysis of water samples
- flood frequency analysis
- Erosion estimation

SUGGESTED READINGS:

1. Natural Hazards, 3rd Edition, by Edward A. Keller, Duane E. De Vecchio and Robert H. Blodgett Prentice Hall, 2012, 554pp.
2. Environmental Geology, 9th Edition, by Edward A. Keller, Prentice Hall, 2011.
3. Environmental Geology, 9th Edition, by Carla W. Montgomery, McGraw Hill, 2011.

Paper Name – Exploration Geology & Mining
Paper code: GL - CE - 8414

Credits: 4 (THEORY - 3, RACTICALS - 1)

Course Objectives (CO):

- Students will be able understanding of Earth's processes, mineral resources, and the methods used to discover, evaluate, and extract them responsibly.
- These objectives typically encompass a blend of theoretical knowledge, practical skills, and an awareness of environmental, social, and economic considerations.

Course learning outcomes (CLO):

- Students can learn fundamental geological knowledge like mineralogy & petrology, structure, stratigraphy, sedimentology with economic geology etc.
- Students can know a basic understanding about exploration techniques and methodologies.
- They can learn about mining geology, different mining methods, mine safety, environmental considerations etc.

Unit 1: Mineral resources, Prospecting and Exploration: Lecture: 15

- Concept of mineral resource and reserve. A brief overview of classification of mineral deposits with respect to processes of formation in relation to exploration strategies.
- Prospecting and exploration- conceptualization, principles and stages, Sampling, subsurface sampling including pitting, trenching and drilling.
- Methods of exploration – geophysical and geochemical

Unit 2: Reserve estimation and anomalies: Lecture: 15

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

Unit 3: Mining Lecture: 15

- Introduction to Mining, Mining Terminologies.
- Mining methods:
  Surface mining – Opencast, Open pit, Auger mining, Quarrying, Aqueous extraction methods: Placer mining: Hydraulicking and Dredging, Solution mining.
  Underground mining – Unsupported methods: Room-and-pillar mining, Stope-and-pillar mining, Shrinkage stoping, Sublevel stoping; Supported Methods: Cut-and-fill stoping, Stull stoping, Square-set stoping.
  Caving Methods: Longwall mining, Sublevel caving, Block caving.

- Mining and Its Consequences. Acid mine drainage and its environmental impacts – with special reference to river pollution due to Tertiary coal mining in NE India; Mine ventilation. Dilution in mining.

Unit 4: PRACTICALS **Lab work: 15 (30 hrs)**

- Preparation of geological cross - section for exploration program.
- Geophysical data interpretation – electrical log, seismic section, gravity and magnetic data.
- Identification of anomaly.
- Concept of weighted average in anomaly detection.
- Ore reserve estimation methods: Grid pattern, Polygonal method, Triangular method, Cross-section method.

SUGGESTED READINGS:

- Elements of Mining by Clark, G.B. 1967. 3rd Ed; John Wiley & Sons.
- Courses in Mining Geology by Arogyaswami, R.P.N. 1996, 4th Ed.; Oxford-IBH.
- Introduction to Mineral Exploration by Moon, C.J., Whateley, M.K.G., Evans, A.M., 2006; Blackwell Publishing.
- Mineral Exploration: Principles and Applications by Haldar, S.K., 2018; Publisher: Elsevier.
- Mining of Ores and Non-metallic Minerals by M. Agoshkov, S. Borisev, and V. Boyarsky; Mir Publishers.

Paper Name: Fluvial Geomorphology &Quaternary Geology

Paper Code: GL- CE-8424

Total Credits: 4 (Theory: 3+ Practical/ Tutorial: 1)

L + T / P = 3 + 1 = 4 Credit

Number of Theory Classes: 45 (45 hours)

Number of Practical Classes: 15 (30 hours)

COURSE OBJECTIVES (CO):

The primary objectives of this course is

- To acquire fundamental concepts of Fluvial Geomorphology and its significance in Earth Sciences.
- To acquire knowledge about different types Fluvial landforms
- To enable students to acquire knowledge on Quaternary Geology

COURSE LEARNING OBJECTIVE (CLO)

CLO-1: The course will enable students to acquire knowledge about different fluvial system and landforms of the Earth

CLO- 2: Understand the fluvial landform features in Northeast India.

CLO-3: Understand the linkages between the interdisciplinary components of earth systems science and the Quaternary geological history and associated issues of concern like climate change, active tectonics.

CLO-4: Imparts knowledge on the thick repository of Quaternary sediments and their stratigraphic framework in NE India

Unit- I: Fluvial processes and landforms **Lecture: 15**

Fluvial processes: Evolution of drainage basin, drainage patterns and their significance, hydraulic geometry, classification of fluvial systems, the processes of erosion, transportation and deposition. Structural and active tectonic control on rivers.

Fluvial landforms: erosional and depositional landforms, floodplains and their types, alluvial terraces, alluvial fan and delta, fluvial cycle of erosion. Fluvial landforms in NE India.

Unit-II: The Quaternary Period and Quaternary climate **Lecture: 15**

The Quaternary Period and its divisions, Quaternary dating methods-cosmogenic radionuclides- C14, Be10, Al26, luminescence chronology, dendrochronology (principles, applications and limitations

Quaternary climate and tectonics, Milankovitch theory and quaternary climate fluctuations, glacial-interglacial cycles and sea level changes, uplift-climate connection, spreading rate and uplift- weathering hypothesis duricrusts and their climatic significance.

Unit-III: Quaternary geomorphology **Lecture: 15**

Quaternary geomorphology- the earth as a system, energy flow in the geomorphic system, spatial and temporal scales of landscape analysis, role of structure, tectonics and climate in landform development, neotectonics and active tectonics and landscape response

Quaternary sedimentary records from India- Himalayan foreland, Son-Narmada valley, Gangetic plains, coastal plains, Brahmaputra plains and other parts of NE India. Economic potential of fluvial depositional systems.

UNIT-IV PRACTICAL: **Lab work: 15 (30 hrs)**

- Study of topographic maps and profiles for landscape analysis.
- Identification of landforms from models and satellite images
- Preparation of geomorphological maps
- Soil profile study
- Hypsometry and hack profile analysis.
- Estimation of rate of erosion and sedimentation, deformation.
- Quaternary chronology.
- Preparation of litholog in Quaternary stratigraphic sections/fluvial sequences.

SUGGESTED READINGS

1. Geomorphology: A systematic analysis of late Cenozoic landform by Arthur L Bloom.; Pearson Ed.

2. Tectonic Geomorphology by Douglas W. Burbank and Robert S. Anderson; Blackwell Science.

3. Active tectonics by Edward A. Keller and Nicholas Pinter; Prentice Hall.

4. The Geology of Fluvial Deposits: Sedimentary Facies, Basin Analysis, and Petroleum Geology by Andrew Miall; Springer, 2006.

5. Fluvial Depositional Systems by Andrew Miall; Springer, 2014

PAPER NAME: Introduction to Geophysics

PAPER CODE: GL - CE - 8434

Total Credits: 4 (Theory: 3 + Practical/ Tutorial: 1)

L + T / P = 3 + 1 = 4 Credit

Number of Theory Classes: 45 (45 hours)

Number of Practical Classes: 15 (30 hours)

Course Objectives (CO):

The prime objectives of this course are:

• To introduce the fundamentals of geophysics in order to enable the students to understand the basics of geophysics.

• To motivate students to pursue higher studies and academic research in geophysics based on their acquired basic knowledge on geophysics that may groom them as geophysicists in different sectors of resource exploration.

Course Learning Outcome: **(CLO)**

After completion of the course

CLO-1: The students will acquire comprehensive knowledge of different principles of geophysics that can be applied to solve different geological problems.

CLO-2: The students will understand the principles and applications of different geophysical methods for exploration of geological resources such as minerals, oil, groundwater etc.

CLO-3: The students may be engaged as geophysicists in exploration and Mining sectors, they may also be engaged in academic research as well as in teaching position in geophysics.

Unit- I: **Fundamentals of Geophysics** **Lectures-15**

Introduction to geophysics, Concept of geophysical anomalies, interrelationship between geology, geophysics and geodynamics, Mechanics and Dynamics of Earth's interior, Gravitation, Geoid, Isostasy, Geomagnetic field variations, paleomagnetism, and geomagnetic reversals; seismic anisotropy, global seismicity and tectonics.

Unit-II: Exploration geophysics **Lectures-15**

Different types of geophysical surveys, grid and route surveys, profiling and sounding techniques, Scales of survey, Geophysical methods - Gravity, Magnetic, Seismic, Electrical and, Radiometric methods - their principles and applications in different sectors; Ground penetration radar (GPR) technology and application.

Unit-III: Corrections, Presentation and Interpretation of Geophysical data(Lectures-15)

Processing of Geophysical data. Concepts and usage of corrections in geophysical data, regional and residual (local) geophysical anomalies, Ambiguities in geophysical interpretation.

UNIT-IV PRACTICAL: **Lab work: 15 (30 hrs)**

- Anomaly and background- Graphical method
- Study and interpretation of seismic gravity and magnetic data
- Interpretation of wireline logs

SUGGESTED READINGS

1. Outlines of Geophysical Prospecting - A manual for geologists by Ramachandra Rao, M.B., Prasaranga, University of Mysore, Mysore, 1975.

2. Exploration Geophysics - An Outline by Bhimasarikaram V.L.S., Association of Exploration Geophysicists, Osmania University, Hyderabad, 1990.

3. An introduction to Geophysical Prospecting by Dobrin, M.B. McGraw-Hill, New Delhi, 1984.

4.. Applied geophysics (Vol. 1) by Telford, W. M., Geldart, L. P., & Sheriff, R. E. Cambridge university press, 1990.

5. Fundamentals of geophysics by Lowrie, W; Cambridge University Press, 2007

6. Geophysical methods in Geology-PV Sharma

Paper Name: Application of Statistics in Geology

Paper Code: GL-CE-8444

Total Credits: 4 (Theory: 3+ Practical/ Tutorial: 1)

L + T / P = 3 + 1 = 4 Credit

Number of Theory Classes: 45 (45 hours)

Number of Practical Classes: 15 (30 hours)

Course Objectives (CO)

- To develop a strong foundation in statistical and geostatistical methods for spatially distributed data.
- To introduce the theory of regionalized variables and variogram modeling.
- To train in estimation techniques (kriging, block models) for quantitative evaluation of natural resources.
- To equip students with skills in uncertainty assessment and resource modeling.

Course Learning Outcomes (CLO)

Students completing this course will be able to:

- **CLO 1:** Explain the fundamental concepts of statistics and graphical representation of geological data.
- **CLO 2:** Apply statistical methods (central tendency, dispersion, distributions, correlation, PCA) to analyze geological datasets.
- **CLO 3:** Construct and interpret variograms, and apply interpolation techniques for spatial data analysis.

Unit I: Statistical Analysis **Lecture: 15**

Measures of central tendency and dispersion. Measures of central tendency (mean, median, mode) and dispersion (variance, standard deviation, coefficient of variation). Frequency distributions: normal, lognormal, multimodal. Data transformations: log, Box-Cox, z-score standardization. Correlation, covariance, principal component analysis (PCA).

UnitII: Fundamentals of Statistical methods in Geology **Lecture: 15**

Introduction to statistics in Earth Sciences. Types of geological data: univariate, bivariate, multivariate. Population and sample; Graphical representation of geological data (histograms, boxplots, rose diagrams, ternary plots).

Unit III: Spatial Data & Variogram Theory **Lecture: 15**

Regionalized variables and stationarity assumptions. Experimental variogram construction from sample datasets. Variogram models: spherical, exponential, Gaussian, nested. Deterministic interpolation: nearest neighbor, IDW, trend surface.

UNIT-IV Practical **Lab work: 15 (30 hrs)**

- Descriptive statistics and histogram analysis.
- Computation of mean, median, mode, variance, standard deviation, coefficient of variation for a dataset.
- Probability plots and transformations of skewed data.
- Exercise Correlation & Covariance. trend analysis
- Various statistical tests

Suggested Books

1. Applied Geostatistics by Isaaks, E.H. & Srivastava, R.M. (1989); OUP.
2. Mining Geostatistics by Journel, A.G. & Huijbregts, C.J. (1978); Academic Press.
3. Geostatistics for Natural Resources Evaluation by Goovaerts, P. (1997); OUP.
4. Geostatistics: Modeling Spatial Uncertainty by Chilès, J.P. & Delfiner, P. (2012); Wiley.
5. Geostatistics for Engineers and Earth Scientists by Olea, R.A. (1999); Springer.

Paper Name: Digital Image Processing

Paper Code: GL-CE-8454

Total Credits: 4 (Theory: 3+ Practical/ Tutorial: 1)

L + T / P = 3 + 1 = 4 Credit

Number of Theory Classes: 45 (45 hours)

Number of Practical Classes: 15 (30 hours)

Course Objectives (CO)

To introduce fundamentals of digital images and their processing techniques.

- To train students in image correction, enhancement, transformation, and classification.
- To equip students with hands-on skills in processing remotely sensed satellite data.
- To apply DIP methods for geological applications: lithological mapping, structural studies, alteration mapping, and terrain analysis.

Course Outcomes (CLOs)

After completing this course, students will be able to:

CLO1: Explain the fundamentals of digital images and remote sensing datasets.

CLO 2: Perform radiometric, atmospheric, and geometric corrections on images.

CLO 3: Apply enhancement techniques to improve visual interpretation.

CLO 4: Conduct classification of satellite imagery (supervised & unsupervised).

CLO 5: Use image processing for geological applications (lineament mapping, lithology discrimination, mineral exploration, land cover analysis, ground water exploration).

Unit I: Fundamentals of Digital Image Processing **Lecture: 15**

Concept of Digital Image; Aspects of Sensor Resolutions; Concept of swath and Nadir; Panchromatic, Multi-spectral and Hyperspectral Images; False Colour Composite; Introduction to image histograms.

Unit II: Image Pre-processing and Enhancement **Lecture: 15**

Image rectification and restoration : Geometric corrections, Radiometric corrections and Noise removal; Image mosaicking and subset (clipping); Image Enhancement : Contrast manipulation and Spatial feature Manipulation; Multi-image manipulation : Spectral ratioing, Principal and Canonical Components and vegetation/water/iron-oxide indices.

Unit III: Image Classification & Applications

Classification basics: training sets, signature evaluation. Supervised classification : Minimum distance to mean, Parallelepiped, maximum likelihood classifier; Unsupervised classification (ISODATA, k-means). Geological applications: lithological discrimination, lineament mapping, mineral exploration, land use/land cover change.

Unit- IV Practical **Lab work: 15 (30 hrs)**

Displaying images: layer stacking, band combinations (FCC, natural color), subset, mosaicking. Vegetation/water/iron oxide indices using Landsat/ ASTER. Supervised and unsupervised classification. Geological application exercise: Lineament extraction. Lithological discrimination. Alteration zone mapping (ASTER/Landsat ratios)

Suggested Readings

1. Lillesand, T.M., Kiefer, R.W., & Chipman, J. (2015). *Remote Sensing and Image Interpretation*. Wiley.
2. Richards, J.A., & Jia, X. (2006). *Remote Sensing Digital Image Analysis*. Springer.
3. Gonzalez, R.C., & Woods, R.E. (2018). *Digital Image Processing*. Pearson.

4. Jensen, J.R. (2015). *Introductory Digital Image Processing: A Remote Sensing Perspective*. Pearson.
5. Sabins, F.F. (2007). *Remote Sensing: Principles and Interpretation*. Waveland Press.
6. Drury, S.A. (2001). *Image Interpretation in Geology*. Routledge.

MINOR

Programme Specific Outcome of Bachelor of Science – GEOLOGY: Minor

PSO No.	Outcome
PSO–1	After completion of B.Sc. (Minor) in Geology, students will be able to understand Geology as a most important discipline and its vast scope.
PSO–2	After completion of B.Sc. (Minor) in Geology, students will be able to acquire knowledge about of various aspects of earth, its relation to the Solar System and activities of different endogenic & exogenic processes.
PSO–3	After completion of B.Sc. (Minor) in Geology, students will be able to theoretical & practical study of various deformational processes and their activities.
PSO–4	After completion of B.Sc. (Minor) in Geology, students will be able to study and analyze different aspects of crystallography and mineralogy
PSO–5	After completion of B.Sc. (Minor) in Geology, students will be able to a good knowledge about petrology with different laboratory techniques
PSO–6	After completion of B.Sc. (Minor) in Geology, students will be able to acquire knowledge about geological Field Work and to prepare Field Report
PSO-7	After completion of B.Sc. (Minor) in Geology, students will be able to understand about different rock types, Stratigraphy and paleontology, environmental geology, hydrogeology, engineering geology, soil geology and economic geology and their significances
PSO-8	After completion of B.Sc. (Minor) in Geology, students will be able to enhance skill on geochemical analysis and remote sensing and their applications.
PSO-9	After completion of B.Sc. (Minor) in Geology, students will be able to understand about the different geomorphological processes.
PSO-10	After completion of B.Sc. (Minor) in Geology, students will have knowledge about the relationship between different deformational processes with Geomorphology.
PSO-11	After completion of B.Sc. (Minor) in Geology, students will havepractical knowledge about the study of different geomorphological map.

LIST OF COURSES:

Semester	Course Name	Course Code
1	Earth System Science	GL – MN – 1114
2	Rock and Minerals	GL – MN – 2114
3	Geomorphology	GL – MN – 3214
4	Structural Geology	GL – MN – 4214
5	Principles of Stratigraphy and Indian Stratigraphy	GL – MN – 5214
6	Palaeontology	GL – MN – 6214
7	Hydrogeology	GL – MN – 7414
8	Economic Geology	GL – MN – 8414

Course Learning Outcome (CLO)

Semester	Course Name & Code	Course Learning Outcome (CLO)	
1	Earth Science System GL – MN – 1114	CLO - 01	It will improve students' grasp of the dynamic earth and the processes involved in the earth.
		CLO - 02	It will improve students' understanding of the solid earth and its physics and chemistry.
		CLO - 03	Students Learn about the physical and chemical properties of the atmosphere and the hydrosphere.
		CLO - 04	Students will comprehend climate change and its long and short-term consequences
2	Rock and Minerals GL – MN – 2114	CLO - 01	Students can learn about the rocks and minerals and their economic importance in the present day context.
		CLO - 02	They can know about the minerals and its relation to crystal, difference between crystal and amorphous substance, different crystal system.

		CLO - 03	They can learn about physical and optical properties of mineral and their usefulness to identify a mineral
2	Rock and Minerals GL – MN – 2114	CLO - 04	Students can get a basic knowledge about various rock types and their significances
3	Geomorphology GL – MN – 3214	CLO-01	This course will give comprehensive knowledge on the processes that led to the formation of present landforms and the ongoing processes sculpting Earth's surface.
		CLO-02	Fundamentals of working of earth surface processes
		CLO-03	A student will learn about the geomorphology of India
4	Structural Geology GL – MN – 4214	CLO-01	The course will enable students to prepare profile sections, interpret geological maps as well as the geometries of different structural elements indicating the causes and mechanisms responsible for the formation of different geological structures.
		CLO-02	Students acquiring sound knowledge of structural geology may be engaged in academic research and teaching profession in the subject.
		CLO-03	Students acquiring sound knowledge in theoretical and practical aspects of structural geology will able to explore its applicabilityin various fields such as Geodynamics, Exploration geology and civil engineering constructions etc.
5	Principles of Stratigraphy and Indian stratigraphy GL – MN – 5214	CLO-01	Understand about the fundamental concepts of stratigraphy, rock superposition, stratigraphic principles, dynamic stratigraphy etc.
		CLO-02	Knowledge of physiographic and tectonic subdivision of India, Stratigraphy of India and their significances.
		CLO-03	Understand the concepts of geological map, Identification of major stratigraphic units of India, Indian stratigraphic rocks type recognition.
		CLO - 04	Understand about Isostasy, geosynclines, mountain building, plate tectonics, sea floor spreading, plate boundaries etc.

6	Palaeontology GL – MN – 6214	CLO-01	After completion of the course students will be able to identify common fossils in hand specimens using diagnostic morphological
		CLO-02	After completion of the course students will be able to apply the Palaeontological knowledge for knowing chronostratigraphic position and depositional conditions of sedimentary rocks.
		CLO - 03	After completion of the course students will be able to know about the evolutionary changes through time and space which may enable them for future preparedness in regard to changing scenario of earth's history.
7	Hydrogeology GL – MN – 7414	CLO - 01	The students will learn about occurrence of groundwater, water bearing properties of formations, aquifer types, aquifer parameters and springs.
		CLO - 02	The course imparts knowledge about construction, design and development of water wells, aquifer parameter estimation and the science of groundwater flow under different conditions.
		CLO - 03	The students will learn about the concepts of groundwater exploration in an integrated way and also understand about groundwater chemistry.
8	Economic Geology GL – MN – 8414	CLO - 01	Students can learn fundamental geological knowledges like mineralogy & petrology, structure, stratigraphy, sedimentology with economic geology etc.
		CLO - 02	Students can know a basic understanding about exploration techniques and methodologies.
		CLO - 03	They can learn about economic geology, different controls of ore localization, importance of mineral economics worldwide.

Mapping of Programe Outcome (PO) and Course Learning Outcome (CLO):

Attributes: Co-relation Levels

"1" : Minimum Co-relation
"2" : Moderate Co-relation
"3" : Maximum Co-relation
"-" : No Co-relation

Course Code	CLO	Programme Outcome (SPO)										
		SPO-1	SPO-2	SPO-3	SPO-4	SPO-5	SPO-6	SPO-7	SPO-8	SPO-9	SPO-10	SPO-11
GL-MN-1114	CLO-1	3	3	3	3	3	3	1	3	2	3	3
	CLO-2	3	3	3	3	3	3	1	3	2	3	3
	CLO – 3	3	3	3	3	3	3	2	3	2	3	3
	CLO - 4	3	3	3	3	3	3	2	3	2	3	3
GL-MN-2114	CLO-1	3	3	3	3	3	3	1	3	2	3	3
	CLO-2	3	3	3	3	3	3	1	3	2	3	3
	CLO – 3	3	3	3	3	3	3	1	3	2	3	3
	CLO - 4	3	3	3	3	3	3	2	3	2	3	3
GL-MN-3214	CLO-1	1	2		3	2	3			3	2	2
	CLO-2	2	3	3			3		1		1	
	CLO - 3		2		2			3	2		2	1
GL-MN-4214	CLO-1	1	1	1	1	2	1	2	1	2	1	2
	CLO-2	1	2	1	1	2	1	2	1	2	1	1
	CLO - 3	1	2	1	1	2	1	2	1	2	1	2
GL-MN-5214	CLO-1	3	2	2	2	2	1	2	2	--	3	3
	CLO-2	3	2	1	2	2	1	2	2	---	3	3
	CLO - 3	3	3	2	2	2	2	2	2	---	3	3
	CLO - 4	3	3	2	2	3	2	2	2	---	3	3
GL-MN-6214	CLO-1	1	2	2		2	2	3	2	3	3	
	CLO-2	1	2	3	3	3	2	2	2	2	3	1
	CLO - 3	2	3	2		3	2		1	2	1	2
GL – MN – 7414	CLO1	1	1		2	2	2	1	2		2	1
	CLO2	1	3	1	3	2	2	2	2	3	1	1
	CLO3	2	2	2	3	2	3	3	1	3	3	3
GL- MN- 8414	CLO1	3	2	2	2	3	2	2	2		3	3
	CLO2	3	2	1	2	2	2	2	2		2	3
	CLO3	3	2	2	1	3	2	2	2		3	3
	CLO4	3	3	2	2	3	2	2	2		2	3

Mapping of Programe Specific Outcome (PSO) and Course Learning Outcome (CLO)

Attributes: Co-relation Levels

"1" : Minimum Co-relation
"2" : Moderate Co-relation
"3" : Maximum Co-relation
"-" : No Co-relation

Course code	CLO	Programme Specific Outcome										
		PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8	PSO-9	PSO-10	PSO-11
GL-MN-1114	CLO-1	2	2	1		3		3		2		2
	CLO-2	1	1	1	1	1	1	1	1	1	2	1
	CLO - 3	1	1	1	1	1	1	1	1	1	1	1
	CLO - 4	1	1	1	1	1	1	1	1	1	1	1
GL-MN-2114	CLO-1	2	1	2	2	2	2	1	1	3	2	2
	CLO-2	2	2	2	2	1	2	3	2	3	2	2
	CLO - 3	2	1	2	2	2	2	1	1	3	2	2
	CLO - 4	2	2	2	2	1	2	3	2	3	2	2
GL-MN-3214	CLO-1		1		2	3	2					
	CLO-2	3	1	1	2	1	2		3	2		
	CLO - 3	3	1	1		3		3		2		2
GL-MN-4214	CLO-1	1	1	1	1	1	1	1	1	1	2	1
	CLO-2	1	1	1	1	1	1	1	1	1	1	1
	CLO - 3	1	1	1	1	1	1	1	1	1	1	1
GL-MN-5214	CLO-1	2	1	2	2	2	2	1	1	3	2	2
	CLO-2	2	2	2	2	1	2	3	2	3	2	2
	CLO - 3	1	3	1	2	2	2	1	3	3	3	1
	CLO - 4	2	2	2	2	1	1	1	2	3	2	2
GL-MN-6214	CLO-1	1	2	2	2		2		2	1	1	2
	CLO-2	2	2		2	3	1	3	1	2	2	
	CLO - 3	2	3	3	3	2	2		2	2	3	1
GL – MN – 7414	CLO1	3	1	1	2	2		3	3	1	1	3
	CLO2	2	3	2	3	1	2	3		1	1	2
	CLO3	2	2	2	2	2	3	3	1	1	1	1
GL- MN- 8414	CLO-1	2	1	1	3	2	2	1	3	3	2	
	CLO-2	1	1	1	2	1	1	2	2	3	2	
	CLO-3	1	3	1	3	2	2	1	3	3	3	
	CLO-4	2	2	1	2	2	3	2	2	3	2	

COURSE NAME: Earth System Science

COURSE CODE: GL – MN – 1114

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY: 3 CREDITS

Total Lectures: 45

COURSE OBJECTIVE:

The course is intended to teach the fundamental ideas of dynamic earth. It will go over the fundamental principles and processes that regulate the Earth's system. The course will also go through the various systems that exist on the Earth's surface

Course Learning Outcome:

The course outcomes of this course are as follows:

CLO-01: *It will improve students' grasp of the dynamic earth and the processes involved in the earth.*

CLO-02: *It will improve students' understanding of the solid earth and its physics and chemistry.*

CLO-03: *Students learn about the physical and chemical properties of the atmosphere and the hydrosphere.*

CLO-04: *Students will comprehend climate change and its long and short-term consequences*

Unit- I: Earth as a System (Lectures: 15)

Origin, age and general characteristics of the earth and the solar system; Definition andscope of earth systems science; The subsystems/system components and their interactions;Sources of energy.Laws of uniformitarianism, superposition of strata and faunal succession; The rock cycle,geochemical cycle, erosion cycle, hydrological cycle; Concept of geological time scale.Evolution of the atmosphere and hydrosphere; Biological evolution through geological history of the earth. Human impact on the earth system during Anthropocene.

Unit- II: Solid earth and its dynamics (Lectures: 15)

Internal structure of the earth, mantle convection, genesis of Earth’s magnetic field; Concept of plate tectonics, sea floor spreading and continental drift. Earthquake and volcanoes-causes of formation and distribution; Earthquake belts and the Pacific ring of fire; Hot spot; Earthquake zones of India. Origin of the continents and oceans, mountains and rift valleys. The Wilson Cycle. Role of tectonics in landscape development

Unit- III: The atmosphere and hydrosphere (Lectures: 15)

Composition and vertical layered structure of the earth’s atmosphere. Insolation and albedo, energy gradient; Hadley cell, the atmospheric pressure belts and circulation, Coriolis effect. The monsoon, upper level waves and jet stream. The meteorological parameters and their spatial and temporal variations, Weather and climate Chemical composition and physical properties of sea water, thermocline, halocline and pycnocline. Surface and deep water circulation, causes and effects. Land – air-sea interaction. Concepts of eustasy**.**

Earth’s climate and climate change- short and long term. ENSO, Elnino and La-Nina, Impact of oceanic circulation on climate

Practical:

Total Lectures: 30

1. Model study of different geomorphic features.
2. Study of geomorphological features from topographic maps.
3. Study of major ocean currents of the world.
4. Study of seismic profile of a specific area and its interpretations.
5. Basic statistical analysis of hydro meteorological data

RECOMMENDED BOOKS:

1. Brian J. Skinner, B. J. & Porter, S. C.: (2012). The Blue Planet: An Introduction to Earth System Science. John Wiley & Sons. Inc.
2. Emiliani, C. (1992). Planet earth: cosmology, geology, and the evolution of life and environment. Cambridge University Press.
3. Holmes' Principles of Physical Geology, 1992.Chapman & Hall.
4. Patwardhan, A. M., The Dynamic Earth System, PHI Learning.
5. Bloom A.L., (1998). Geomorphology: A Systematic Analysis of Late Cenozoic Landforms. Pearson Education.
6. Esterbrook D.J., (1992). Surface Processes and Landforms, Mac Millan Publ.
7. Kale,V. Sand Gupta A. (2001).1ntoduction to Geomorphology, Orient Longman Ltd.
8. Summerfield. M. A. (1991). Global Geomorphology, Prentice Hall.
9. Environmental Geology by K.S. Valdiya. Tata McGraw Hill Publishing Co. Ltd.
10. Text Book of Environmental Sciences by Subramaniam. V. Narosa International publisher.

COURSE NAME: Rocks and Minerals

COURSE CODE: GL – CE – 2114

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY: 3 Credits

TOTAL LECTURES: 45

OBJECTIVE:

The course objectives of this course are as follows:

- *To provide a holistic understanding about the basics of minerals, crystals and rocks.*
- *Students will be able to recognise and differentiate rocks, minerals and crystals.*
- *This paper helps to understand about ore and economic minerals and their significances*

Course Learning Outcome:

The course outcomes of this course are as follows:

CLO-01: *Students can learn about the rocks and minerals and their economic importance in the present day context.*

CLO-02: *They can know about the minerals and its relation to crystal, difference between crystal and amorphous substance, different crystal system.*

CLO-03: *They can learn about physical and optical properties of mineral and their usefulness to identify a mineral.*

CLO-04: *Students can get a basic knowledge about various rock types and their significances.*

Unit- I: Concepts of rocks, minerals and crystals (LECTURES: 15)

Elementary ideas about crystal and amorphous substance, crystal morphology in relation to internal structures, crystal systems. Composition of common rock forming minerals. Silicate and non-silicate structures, CCP and HCP structures, Definition of rocks, types of rocks - Igneous, metamorphic, sedimentary. Rock cycle.

Unit-II: Mineralogy (LECTURES: 15)

Minerals: definition, scope, classification, physical and chemical properties. Optical properties of minerals - Nature of light; Reflection and refraction of rays; Refractive index, Polarization of light; Polarizing Microscope, Cleavage, Extinction, Interference colour, Isotropic and Anisotropic minerals: Uniaxial and Biaxial. Study of optical properties of the following minerals: Quartz, Orthoclase, Microcline, Hypersthene, Hornblende, Garnet, Muscovite, Biotite, Enstatite, Olivine, Kyanite, Sillimanite, Calcite, Plagioclase.

Study of chemical composition and diagnostic physical properties of the following minerals: Quartz, Orthoclase, Microcline, Hypersthene, Hornblende, Garnet, Muscovite, Biotite, Enstatite, Olivine, Kyanite, Sillimanite, Calcite, Plagioclase.

Unit- III: Concepts of petrology (LECTURES: 15)

Igneous petrology: Magma, its composition, origin and types; Crystallization of Magma, Bowen's reaction; Magmatic differentiation; Assimilation. Igneous rocks: Definition; Mode of occurrence; Textures and structures; Classification of igneous rocks on textural, mineralogical and chemical criteria. Significances of different igneous rocks - Granite, Dolerite, Gabbro, Rhyolite, Syenite, Basalt and Diorite.

Sedimentary Petrology: Introduction; Processes of formation of sedimentary rocks weathering, transportation, deposition, diagenesis. Textures and structures of sedimentary rocks; Sedimentary structures: lamination, ripple marks, current bedding, graded bedding, mud cracks, rain prints. Classification of sedimentary rocks; Petrographic description of: sandstone, siltstone, shale, limestone, breccia and conglomerate. Metamorphic Petrology: Metamorphic rocks: Definition; Factors or Agents of Metamorphism; Types of Metamorphism; Grade of Metamorphism, Zones of Metamorphism; Metamorphic facies; Textures and Structures of Metamorphic rocks. Descriptive petrography of Slate, Phyllite, Schist, Gneiss, Quartzite and Marble.

Practical:

Total Lectures: 30

1. Identification of following minerals in hand specimen: Quartz, Orthoclase, Microcline, Hypersthene, Hornblende, Garnet, Muscovite, Biotite, Enstatite, Olivine, Kyanite, Sillimanite, Calcite, Plagioclase.
2. Study of optical properties of the following minerals in thin section: Quartz, Orthoclase, Microcline, Hypersthene, Hornblende, Garnet, Muscovite, Biotite, Enstatite, Olivine, Staurolite, Kyanite, Sillimanite, Calcite, Plagioclase.
3. Identification of following rocks in hand specimen:
   i. Igneous rocks - Granite, Dolerite, Gabbro, Rhyolite, Syenite, Basalt and Diorite.
   ii. Sedimentary rocks -Sandstone, Siltstone, Shale, Limestone, Breccia, Conglomerate.
   iii. Metamorphic rocks -Slate, Phyllite, Schist, Gneiss, Quartzite and Marble.

RECOMMENDED BOOKS:

1. Text of Geology by G.B. Mahapatra.
2. Deer, W. A., Howie, R. A., & Zussman, J. (1992). An introduction to the rock forming minerals (Vol. 696). London: Longman.
3. Mineralogy: Perkins and Henke
4. J.D. Dana. Textbook of Mineralogy
5. Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson.
6. Raymond, L. A. (2002). Petrology: the study of igneous, sedimentary, and metamorphic rocks. McGraw-Hill Science Engineering.
7. Myron G. Best (2001). Igneous and Metamorphic Petrology
8. Fundamentals of Geology by A.B. Roy.
9. Engineering and General Geology by Parbin Singh.

COURSE NAME: Geomorphology

COURSE CODE: GL- MN - 3214

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY

Total Lectures: 45

Course Objectives:

- *To introduce the students to basic understanding of the geomorphology*
- *To introduce different geomorphic processes that led to the formation of present landforms*
- *To introduced various geomorphic technique*.

Course Learning Outcome:

CLO 1: *This course will give comprehensive knowledge on the processes that led to the formation of present landforms and the ongoing processes sculpting Earth's surface.*

CLO 2: *Fundamentals of working of earth surface processes*

CLO 3: *A student will learn about the geomorphology of India*

Unit 1: **Basic concepts of Geomorphology (Lectures: 15)**

Basic concepts of Geomorphology; Endogenic and Exogenic processes, Weathering-factors and types; Erosion and Mass wasting.

Unit 2: Surficial Processes and geomorphology (Lectures: 15)

Surficial Processes and geomorphology, fluvial processes and landforms, Aeolian Processes and landforms, Glacial processes and landforms, Coastal Processes and landforms, Karst and speleology.

Unit 3: **Indian Geomorphology and Extra-terrestrial Landforms (Lectures: 15)**

Overview of Indian Geomorphology, Landforms associated with igneous activities, Extra-terrestrial landforms.

Practicals:

Total Lectures: 30

- Reading topographic maps
- Concept of scale Preparation of a topographic profile
- Preparation of longitudinal profile of a river
- Interpretation of geomorphic processes from the geomorphology of the area

Recommended Books:

1. Robert S. Anderson and Suzzane P. Anderson (2010): *Geomorphology - The Mechanics and Chemistry of Landscapes*. Cambridge University Press.
2. Bloom A.L., (1998). *Geomorphology: A Systematic Analysis of Late Cenozoic Landforms,* Pearson Education.
3. Esterbrook D.J., (1992). *Surface Processes and Landforms,* MacMillan Publ.

4. Kale, V.S. and Gupta A. (2001). *1ntoduction to Geomorphology,* Orient Longman Ltd.
5. Summerfield M.A. (1991). *Global Geomorphology* Prentice Hall.

COURSE NAME: Structural Geology

COURSE CODE: GL- MN - 4214

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY

Total Lectures: 45

Course Objectives:

The primary objectives of this course is

- *to acquire fundamental concepts of Structural Geology and its significance in Earth Sciences.*
- *to acquire in depth knowledge about stress and strain to understand the physics behind deformation and the mechanisms responsible for the formation of different geological structures*
- *to enable students to apply concepts of structural geology as geologists in different fields such as Geodynamics, Exploration geology, Engineering geology projects etc.*

Course Learning Outcome:

The expected outcomes of this course are:

CLO 1: *The course will enable students to prepare profile sections, interpret geological maps as well as the geometries of different structural elements indicating the causes and mechanisms responsible for the formation of different geological structures.*

CLO 2: *Students acquiring sound knowledge of structural geology may be engaged in academic research and teaching profession in the subject.*

CLO 3: *Students acquiring sound knowledge in theoretical and practical aspects of structural geology will able to explore its applicability in various fields such as Geodynamics, Exploration geology and civil engineering constructions etc.*

Unit-1: Fundamentals of Structural Geology (Lectures: 15)

Definition and scope of Structural Geology; Primary and secondary and structures, Concept of non-diastrophic and diastrophic structures, Outcrops, effects of various structures on outcrop, contours, topographic and geological maps, Planar and linear structures; Strike direction, dip angle, dip direction, Clinometer/Brunton compass and its use. Concept of Stress and Strain, relation of stress and strain, Mohr's stress circle; types of straina, concept of rock deformation, elementary idea of types of deformation.

Unit-2: Diastrophic and Non-diastrophic structures (Lectures: 15)

Non diastrophic structures in igneous sand sedimentary rocks types and significance of unconformity. Folds: Structural elements and types of folds; Foliation and Lineation: Basic concepts and their types; Joints and Fractures: types and significance, Faults: structural elements, geometric and genetic classifications, normal, thrust and strike slip faults.

Unit 3: Geotectonics (Lectures: 15)

Concept of Isostasy, geosyncline, origin of mountains. Plate Tectonics: definition, nature and types of plate boundaries- convergent (subduction & collision), divergent and conservative (Transform fault), Triple junction, deep sea trenches, island arcs and volcanic arcs. Sea-floor spreading and mid-oceanic ridges. Concepts of Paleomagnetism and its application.

Practicals:

Total Lectures-30

Use of Stereographic net and exercises on structural problems, Identification and interpretation of different types of folds/faults from models. Interpretation of geological maps, Preparation of cross-section profile from geological map.

Recommended Books:

1. Davis, G.R., 1984. Structural Geology of Rocks and Region. John Wiley
2. Hills, E.S., 1963. Elements of Structural Geology. Farrold and Sons, London.
3. Singh, R. P., 1995. Structural Geology, A Practical Approach. Ganga Kaveri Publ., Varanasi.
4. Billings, M.P., 1972. Structural Geology. Prentice Hall.

COURSE NAME: Principles of Stratigraphy and Indian Stratigraphy

COURSE CODE: GL- MN - 5214

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY

Total Lectures: 45

Course Objectives:

- *Understand about fundamental aspects of Stratigraphy, its principles, Stratigraphic Units, different techniques and tools of stratigraphic analyses, Interpret geological map.*
- *The student will get to learn about Indian Stratigraphy.*
- *Develop the proficiency in oral communication on stratigraphy.*
- *Understand about fundamentals of plate tectonics.*

Course Learning Outcome:

CLO 1: *Understand about the fundamental concepts of stratigraphy, rock superposition, stratigraphic principles, dynamic stratigraphy etc.*

CLO 2: *Knowledge of physiographic and tectonic subdivision of India, Stratigraphy of India and their significances*

CLO 3: *Understand the concepts of geological map, Identification of major stratigraphic units of India, Indian stratigraphic rocks type recognition.*

CLO 4: *Understand about Isostasy, geosynclines, mountain building, plate tectonics, sea floor spreading, plate boundaries etc.*

Unit- 1: Principles of stratigraphy (Lectures – 15)

Definition, Scope, Concepts of Superposition of strata; Neptunism, Plutonism& Uniformitarianism; Applied Stratigraphy. Lyell's principles of geology. Standard Geological time scale, concept of relative and absolute geochronology. Stratigraphic classification – introduction to litho-, bio- and chrono-stratigraphy with concepts of dynamic stratigraphy (chemostratigraphy, seismic stratigraphy, sequence stratigraphy, Magnetostratigraphy) Facies concept of stratigraphy. Stratigraphic correlation. Brief introduction to the physiographic and tectonic subdivisions of India.

Unit 2: Precambrian Indian Stratigraphy (Lectures – 15)

A brief study of the Precambrian stratigraphy of the following areas with respect to lithology, tectonics and igneous activity: (a) Dharwar Province (Karnataka); (b) Singhbhum-Orissa Province (Jharkhand & Orissa); (c) Assam- Meghalaya plateau (Shillong plateau); (d) Cuddapah Super Group of Cuddapah basin; (e)Vindhyan Super Group of Sone Valley**.**

Unit 3: Phanerozoic Indian Stratigraphy (Lectures – 15)

Gondwana of Peninsular and Extra-peninsular India – lithology, palaeontology, palaeogeography, igneous activity, structure and hydrocarbon potential of Gondwana basin.
Lithology, palaeontology and economic importance of Assam Arakan Basin. Stratigraphy and palaeontology of Siwalik Basin.

Practical:

Total Lectures: 30

- Preparation of lithostratigraphic maps of India showing distribution of important geological formations: Dharwar Province, Shillong Group of rocks, Cuddapah Super Group, Vindhyan Super Group, Jurassic of Kutch, Cretaceous of Trichinopoly, Gondwana Super Group, Deccan Traps.
- Study of rocks in hand specimens from known Indian stratigraphic horizons.

Recommended Books:

1. Krishnan, M. S. (1982). *Geology of India and Burma*, CBS Publishers, Delhi.
2. Ramakrishnan, M. &Vaidyanadhan, R. (2008). *Geology of India Volumes 1 & 2*, Geological society of India, Bangalore.
3. Kumar, R., *Fundamentals of Historical Geology and Stratigraphy of India*, New Age International Publishers.
4. Patwardhan, A. M., 1999. The Dynamic Earth System. Prentice Hall.
5. Summerfied, M.A., 2000. Geomorphology and Global tectonic. Springer Verlag.
6. Keary, P. and Vine, F.J., 1997. Global Tectonics. Blackwell and crustal evolution. Butterworth-Heinemann.

COURSE NAME: Palaeontology

COURSE CODE: GL- MN - 6214

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY

Total Lectures: 45

Course Objective:

1. *To know about the importance of fossils and their modes of preservation*
2. *To know about origin of life and evolutionary history of the organic world.*
3. *To know about morphology of some common fossils.*

Course Learning Outcome:

After completion of the course students will be able to:

CLO 1: *Identify common fossils in hand specimens using diagnostic morphological*

CLO2: *Apply the Palaeontological knowledge for knowing chronostratigraphic position and depositional conditions of sedimentary rocks.*

CLO 3: *Know about the evolutionary changes through time and space which may enable them for future preparedness in regard to changing scenario of earth's history.*

Unit-1: Fossilization and fossil record (15 Lectures)

- Palaeontology: definition, branches, scopes and applications.
- Fossil: definition and types. Process of fossilization. Conditions and modes of preservation. Nature and importance of fossil record. Scope of microfossils with special reference to oil exploration, ichnology.

Unit- 2: Invertebrates (20Lectures)

Brief introduction to important invertebrate groups (Brachiopoda, Bivalvia, Gastropoda, Cephalopoda,) and their biostratigraphic significance

Unit- 3: Vertebrates (10 Lectures)

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

Practicals:

Total Lectures: 30

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

Recommended Books:

1. Shrock, R and Twenhofel, W. H. (2005) Principles of Invertebrate Palaeontology, CBS
2. Raup, D. M., Stanley, S. M., Freeman, W. H. (1971), Principles of Paleontology
3. Clarkson, E. N. K. (2012), Invertebrate paleontology and evolution, 4th Edition by Blackwell Publishing.
4. Benton, M. (2009), Vertebrate Paleontology, John Wiley & Sons.
5. Jain P.C. and Anantharaman M.S. 2022-23 Palaeontology (Palaeobiology) Evolution & Animal Distribution), Vishal Publishing Co.

PAPER NAME: Hydrogeology

PAPER CODE: GL – MN – 7414

Total Credits: 4 (Theory: 3+ Practical/ Tutorial: 1)

L + T / P = 3 + 1 = 4 Credit

Number of Theory Classes: 45 (45 hours)

Number of Practical Classes: 15 (30 hours)

Course Objective (CO):

1.To understand about the fundamentals of Hydrogeology, occurrence of groundwater, water bearing properties of formations etc.

2. To know about the occurrence of groundwater, water bearing properties of formations

3. The objective is to give students a sound understanding of the occurrence, distribution and movement of groundwater.

4. To understand the concepts of groundwater exploration.

Course Learning Outcomes (CLO):

1. The students will learn about occurrence of groundwater, water bearing properties of formations, aquifer types, aquifer parameters and springs.

2. The course imparts knowledge about construction, design and development of water wells, aquifer parameter estimation and the science of groundwater flow under different conditions.

3. The students will learn about the concepts of groundwater exploration in an integrated way and also understand about groundwater chemistry.

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

Definition and scope of hydrogeology, and its societal relevance. Types of water: meteoric, juvenile, magmatic and sea waters; Hydrologic cycle: precipitation, evapo-transpiration, run-off, infiltration and subsurface movement of water; Rock properties affecting groundwater, Vertical distribution of subsurface water; Types of aquifer, aquifer parameters, anisotropy and heterogeneity of aquifers; Water table and piezometric surface; Fluctuations of water table, piezometric surface, artesian well;; Concepts of drainage basin and groundwater basin.

Unit 2: Groundwater flow and Well hydraulics **Lecture: 15**

Darcy's law and its application; Intrinsic permeability and hydraulic conductivity; Groundwater flow rates and flow direction; Laminar and turbulent groundwater flow; Basic Concepts (drawdown; specific capacity etc.); Elementary concepts related to equilibrium and non-equilibrium conditions for water flow to a well in confined and unconfined aquifers; perched water table.

Unit 3: Groundwater exploration and Groundwater management **Lecture: 15**

Surface-based groundwater exploration methods; Introduction to subsurface borehole logging methods; Groundwater level fluctuations; Groundwater contamination and pollution from geogenic and anthropogenic sources; Basic concepts of water balance studies, issues related to groundwater resources development and management; Natural ground water recharging; Rainwater harvesting and artificial recharge of groundwater; Sea water incursion in to aquifers in coastal region.

UNIT- IV PRACTICAL **Lab work: 15 (30hrs)**

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

SUGGESTED READINGS:

1. Groundwater hydrology by Todd, D. K. 2006. 2nd Ed.; John Wiley & Sons, N.Y.

2. Hydrogeology by Davis, S. N. and De Weist, R.J.M. 1966; John Wiley & Sons Inc., N.Y.

3. Groundwater: Assessment, Development and management by Karanth K.R., 1987; Tata McGraw-Hill Pub. Co. Ltd.

4. Evaluation and Development of Groundwater by Mahajan G. (2008); APH Publishing Corporation, New Delhi

Paper Name – Economic Geology
Paper code: GL – MN – 8414

Total Credits: 4 (Theory: 3+ Practical/ Tutorial: 1)

L + T / P = 3 + 1 = 4 Credit

Number of Theory Classes: 45 (45 hours)

Number of Practical Classes: 15 (30 hours)

Course Learning Objectives:

- Students will be able understanding of Earth's processes, mineral resources, and the methods used to discover and extract them responsibly.
- Acquire a good knowledge in ore genesis, mineral formation, mineral deposits, mineral economics, Indian mineral deposits and their various fields of application.

Course Learning outcomes:

- Students can learn fundamental geological knowledges like mineralogy & petrology, structure, stratigraphy, sedimentology with economic geology etc.
- Students can know a basic understanding about exploration techniques and methodologies.
- They can learn about economic geology, different controls of ore localization, importance of mineral economics worldwide.

Unit 1: Ores and ore genesis **Lecture: 15**

- Concept of ore, gangue, tenor, grade, host rock, mineral formation, mineral deposits, mineral resource and ore reserve.
- Classification of economic mineral deposits.
- Mode of occurrence of ore bodies.
- Processes of formation of mineral deposits - Magmatic concentration: Ortho magmatic, pegmatites; Hydrothermal deposits; Residual and secondary (weathering) deposits: Residual and mechanical concentration and supergene enrichment deposits; Metamorphic deposits.
- Concept of paragenesis and zoning of ores; Metallogenetic belts, epoch sand provinces with examples; Wall rock alteration, and control of ore localization with examples.

Unit-2: Indian Ore Deposits

- A study of mineralogy, mode of occurrence, origin and uses of the following Indian ore deposits with reference to Indian occurrences:
- Metallic mineral deposits: Aluminium, Copper, Chromite, Iron, Manganese, Lead & Zinc, Gold, Silver, Nickel and Radioactive minerals.
- Non-metallic mineral deposits: Limestone, Mica, Clay, Sillimanite, Asbestos, Diamond.

- Industrial Raw materials: Cement, Glass & Ceramics, Fertilizer, Refractory, Abrasive, Strategic minerals, Critical minerals, Gemstones and Building materials.
- REE – importance and uses.

Unit 3: Mineral exploration and mineral economics: **Lecture**: **15**

- Concept of mineral prospecting and exploration – geological mapping and remote sensing; drilling and sampling; geochemical and geophysical prospecting.
- Concept Strategic, critical, essential minerals & Building materials.
- National Mineral Policy.
- Basic principles of mineral commodity markets, supply, demand, valuation, and the importance of mineral resources to the global economy.

Unit 4: PRACTICALS: **Lab work: 15 (30 hrs)**

- Megascopic identification of ore minerals: Iron, copper, Manganese, Lead and Zinc, Aluminium, Chromium.
- Study of microscopic properties of ore forming minerals (Oxides and sulphides).
- Preparation of maps**:** Distribution of important ores and other economic minerals in India. ·
- Assessment of grade of ore and reserve estimation.
- Preparation of geological cross-section for exploration program.

SUGGESTED READINGS:

- Economic Geology – Principles & Practice; Pohl, W.L.; Wiley Blackwell; 2011.
- Bateman, A.M. and Jensen, M.L. (1990) Economic Mineral Deposits. John Wiley. 2. Guilbert, J.M. and Park Jr., C.F. (1986) The Geology of Ore deposits. Freeman & Co. 3. Laurence Robb. (2005) Introduction to ore forming processes. Wiley.
- Gokhale, K.V.G.K. and Rao, T.C. (1978) Ore deposits of India their distribution and processing, Tata-McGraw Hill, New Delhi.
- Deb, S. (1980) Industrial minerals and rocks of India. Allied Publishers.
- Sinha, R.K. and Sharma, N.L.: Mineral Economics.
- Halder, S.K.: Mineral Exploration – Principles and Applications.
- Evans, A.M. (1993) Ore Geology and Industrial minerals. Wiley
- Sarkar, S.C. and Gupta, A. (2014) Crustal Evolution and Metallogeny in India. Cambridge Publications.
- Banerjee, D.K.: Mineral Resources of India.
- Moon, C.J., Whateley, M.K.G., Evans, A.M., 2006, Introduction to Mineral Exploration, Blackwell Publishing.
- M. Agoshkov, S. Borisev, and V. Boyarsky, Mining of Ores and Non-metallic Minerals; Mir Publishers.

SKILL ENHANCEMENT COURSE (SEC)

Programme Specific Outcome of Bachelor of Science – Geology (Skill Enhancement Course)

After completion of B.Sc. with SEC in Geology, students will be able to–

PSO No.	Outcome
PSO–1	Acquire a good knowledge about the field related studies
PSO–2	Acquire knowledge about mineralogy and crystallography and their significances.
PSO–3	Acquire knowledge of different rock types, their origin, and mode of occurrences
PSO–4	Understand about the deformational processes, various structural features, geomorphic processes, landforms.
PSO–5	Knowledge about sample collection, geological mapping
PSO-6	Use various geological tools such as petrological microscopes, ore microscopes etc
PSO-7	Use compasses, and survey instruments, images in geological investigation in the field and in laboratory.
PSO-8	Interpret geological map and construct cross section from them.
PSO-9	Recognize Earth materials and Earth structures in the field, as hand specimens and using laboratory techniques including microscopy and spectroscopic analysis.
PSO-10	Acquire a good knowledge in palaeontology and Stratigraphy.
PSO-11	Gather knowledge in different fields of geology and can choose his/her own field of interest for future prospect as per skill.

Basic Syllabus Structure of SEC

Semester	Course Name	Course code
1	Surveying and map making	GL – SE – 1113
2	Basic field training	GL – SE – 2113
3	Geological Mapping	GL – SE – 3213

Course Learning Outcome – Skill Enhancement Course (SEC)

Semester	Course Name & Code	Course Learning Outcome (CLO)	
1	Surveying and map making GL-SE-1113	CLO-01	The course will improve in understanding about land surveying theory and principles.
		CLO-02	Students will become familiar with land surveying methods.
		CLO - 03	Students will be able to use different types of land surveying instruments.
		CLO - 04	Digital survey techniques will enhance the capability of students in preparing maps.
2	Basic field training GL-SE-2113	CLO-01	Develop skills to identify rocks and minerals in fields.
		CLO-02	Develop skills to identify the different small to large scale deformational structures in the outcrop
		CLO - 03	Develop skills to carry out individual measurements during field and develop idea to prepare geological maps.
3	Geological Mapping GL-SE-3213	CLO-01	The course will improve in understanding in field geology and field relationships of rocks
		CLO-02	Students will learn to identification, and interpretation ofdifferent rocks in the field.
		CLO - 03	Students will learn to handle various software's and tolls e.g. GPS, GIS software's, geological software's, Brunton, etc.
		CLO - 04	Students will develop skill to carry out their individual fieldworks and will prepare geological maps and finally the field reports.

Mapping of Course Learning Outcome and Programme Outcome

Attributes: Co-relation Levels

"1" : Minimum Co-relation
"2" : Moderate Co-relation
"3" : Maximum Co-relation
"-" : No Co-relation

Course Code	CLO	PROGRAMME OUTCOME										
		SPO-1	SPO-2	SPO-3	SPO-4	SPO-5	SPO-6	SPO-7	SPO-8	SPO-9	SPO-10	SPO-11
GL-SE-1113	CLO1	3	3	3	3	3	3	2	3	3	3	3
	CLO 2	3	3	3	3	3	3	2	3	3	3	3
	CLO 3	1	2	2	1	1	1	2		1	2	1
	CLO 4	1	1	1	1	1	1	1	2	1	2	1
GL-SE-2113	CLO1	3	3	3	3	3	3	1	3	2	3	3
	CLO 2	3	3	3	3	3	3	1	3	2	3	3
	CLO 3	1	1	1	1	1	1	1	2	1	2	1
GL-SE-3213	CLO1	1	1	2		1	1	2		1	2	1
	CLO 2	1	1	2		1	1	2	2	2		1
	CLO 3	1	2	2	1	1	1	2		1	2	1
	CLO 4	1	1	1	1	1	1	1	2	1	2	1

Mapping of Course Learning Outcome and Programme Specific Outcome

Attributes: Co-relation Levels

"1" : Minimum Co-relation
"2" : Moderate Co-relation
"3" : Maximum Co-relation
"-" : No Co-relation

Course Code	CLO	PROGRAMME SPECIFIC OUTCOME										
		PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8	PSO-9	PSO-10	PSO-11
GL-SE-1113	CLO1	3	3	3	3	3	3	2	3	3	3	3
	CLO 2	3	3	3	3	3	3	2	3	3	3	3
	CLO 3	2	2	1	1	1		1	1	1	1	1
	CLO 4	2	2	1	1	1		1	1	1	1	1
GL-SE-2113	CLO1	3	3	3	3	3	3	1	3	2	3	3
	CLO 2	3	3	3	3	3	3	1	3	2	3	3
	CLO 3	2	2	1	1	1		1	1	1	1	1
GL-SE-3213	CLO1	2	2	1	1	1		1	1	1	1	1
	CLO 2	2	2	1	1	1		1	1	1	1	1
	CLO 3	2	1	1			1					
	CLO 4	1	1	1	1	1		1			1	1

COURSE NAME: Surveying and Map making

Course CODE:GL-SE-1113

Total Credits: 3 (Theory: 2 + Practical/Tutorial: 1)

THEORY: 2 Credits

TOTAL LECTURES: 30

Course Objective:

The course is proposed to be introducing for the student to understand the principles and methods of surveying and associated map production techniques. As an earth science student they will be always connected with maps in field. Thus elementary plane surveying procedures need to be emphasized in this course. Geodetic principles will also be incorporated into the discussion of the Global Positioning System and digital mapping techniques.

Course Learning Outcome:

CLO–01: *The course will improve in understanding about land surveying theory and principles*

CLO–02: *Students will become familiar with land surveying methods.*

CLO – 03*: Students will be able to use different types of land surveying instruments.*

CLO – 04: *Digital survey techniques will enhance the capability of students in preparing maps.*

Unit-I: Basic principles of Surveying and mapping (Lectures: 15)

Definition and principle of surveying, aim and objective of surveying, importance of surveying in Geology. Important surveying terminologies – datum (MSL), reduced level (RL), benchmark (BM), temporary bench mark (TBM), back sight (BS), foresight (FS), intermediate sight (IS), elevation of line of sight, etc. Classification of survey- land based – topographical, cadastral, urban or city, marine based - hydrographical survey, astronomical survey etc. Application of surveying in engineering, military, mine, geology, archaeology etc. Levelling dumpy level, theodolite with tripod, prismatic compass with tripod.

Unit-II: Digital surveying techniques (Lectures: 15)

Remote Sensing & Image processing, Total Station Survey, Global Positioning System Survey

Practical:

Total Lectures: 30

1. ETS/GPS Survey (Traverse, Triangulation, DGPS)
2. Plane Table Survey
3. Digital map preparation using Remote Sensing software's.

RECOMMENDED BOOKS:

1. Elements Of Geological Maps For Geology, Geography & Civil Engineering, 2Nd Edition by Chadha S K, CBS Publishers.

2. A Guide to Field Geology (Pb 2015) By Gokhale N. W, CBS Publishers.
3. Basic Geological Mapping (Geological Field Guide Book 43) 5th Edition, Kindle Edition. Wiley Publisher .
4. Exercises On Geological Maps And Dip Strike Problems For B.Sc Students (Pb 2019) By Gokhale N. W. CBS Publishers.
5. A Textbook on Surveying and Mapping: Answers to Questions, 2018 by International Correspondence Schools.
6. Coordinates of Elementary Surveying Paperback by John Charles Lounsbury Fish. Kessinger Pub (15 March 2009)

COURSE NAME: Basic Field Training

COURSE CODE: GL-SE-2113

Total Credits: 3 (Theory: 2 + Practical/Tutorial: 1)

THEORY

Total Lectures: 30

Course Objectives:

Basic Field Training (BFT) is a fundamental course designed for the students of Geology to improve the understanding the geology in the real world. Primary focus is to improve the quality the future geologist of the nation. It includes all the necessary fundamental field techniques related to any geological fieldwork.

Course Learning Outcome:

CLO – 01: *Develop skills to identify rocks and minerals in fields.*

CLO – 02: *Develop skills to identify the different small to large scale deformational structures in the outcrop.*

CLO – 03: *Develop skills to carry out individual measurements during field and develop idea to prepare geological maps*

Unit-I: Topographic Sheets (Lectures: 15)

Methods of orientation of topographic sheet in field, Marking location in topo-sheet, methods of taking bearing (front & back), Concepts of map reading. Reading contours and topography.

Unit-II: Rock Types (Lectures: 15)

Identification of rock types in field. Identification of different structural elements in field. Basic field measurement techniques: bedding, dip and strikes etc. Litholog measurement.

Practical:

Total Lectures: 30

1. Duration of field work is to be minimum 7 days and is compulsory for all students.
2. An area with good rock exposures in the vicinity of the institution (Local) is to be selected for this field trip.
3. Students are to be trained how to take readings like strike direction, amount and direction of dip, plunge, and bearing (front and back) with the help of clinometer and Brunton comp

Recommended Books:

1. Field Geology–F.H. Lahee.
2. Introduction to Sedimentology – S.N. Sengupta.
3. An Introduction to igneous and sedimentary rocks–John D. Winter.
4. A Guide to Field Geology - N. W. Gokhale,
5. Sedimentary Rocks in the Field - M. E. Tucker, Wiley-Blackwell
6. The Field Description of Igneous Rocks - D. Jerram and N. Petford, Wiley-Blackwell
7. The Field Description of Metamorphic Rocks - N. Fry, Wiley-Blackwell 10.

COURSE NAME: Geological Mapping

COURSE CODE: GL-SE-3213

Total Credits: 3 (Theory: 2 + Field Report/Practical/Tutorial: 1)

THEORY

Total Lectures: 30

Learning Objectives

Earth scientists utilize diverse field methods to put together Earth's past, enabling them to comprehend the processes occurring both above and below the planet's surface. This course will cover the principles of field geology and highlight the importance of conducting extensive geological field observations for the Earth sciences.

Learning outcomes

CLO1: The course will improve in understanding in field geology and field relationships of rocks.
CLO 2: Students will learn to identification, and interpretation of different rocks in the field.

CLO 3: Students will learn to handle various softwire's and tolls e.g. GPS, GIS software's, geological software's, Brunton, etc.

CLO 4: Students will develop skill to carry out their individual fieldwork and will prepare geological maps and finally the field reports.

Unit-1: Pre field studies

Understanding remote sensing data and images from satellites; learning how to read a toposheet; learning how to use a GPS, Brunton, and clinometer; gaining knowledge about field notebook maintenance.

Unit 2: Trend, plunge, Rake/Pitch, stereographic plots of linear and planar structure, Plotting of structural elements on map, construction of geological cross -section.

Unit 3: Fieldwork & Field report preparation

Completing the final field report and creating maps with geological software's.

Suggested Readings

- Compton, R. R., 1982, Geology in the Field, John Wiley and Sons.
- Coe, A. L., 2010, Geological Field Techniques, Wiley-Blackwell.
- Lisle, R. J., Brabham, P., Barnes, J. W., 2011, Basic Geological Mapping (5th Edition), Wiley Publications.

INTER-DISCIPLINARY COURSE (IDC)

Programme Specific Outcome of Bachelor of Science – Geology (IDC)

After completion of B.A., B.Com with ID in Geology, students will be able to–

PSO No.	Outcome
PSO–1	Understand the preliminary concept of Earth Sciences.
PSO–2	Acquire knowledge about the relationship of various branches of earth science with environment.
PSO–3	Theoretical knowledge about Environmental Geology.
PSO–4	Preliminary concept of Global warming and climate change.
PSO-5	Understand the concept of Natural and man made hazard and disaster.
PSO-6	Knowledge about Disaster Management
PSO-7	Application of remote sensing and GIS in disaster management.
PSO-8	Acquire a good knowledge about the effect of some toxic element on our health.
PSO-9	Acquire a preliminary knowledge about climate science
PSO-10	Acquire knowledge about the mechanism and essential elements of the climate system.
PSO-11	Gather knowledge on Earth's heat budget and water cycle and their effect on atmosphere.

Basic Syllabus Structure of IDC

Semester	Course Name	Course Code
1	ENVIRONMENTAL GEOLOGY	GL-ID-1113
2	DISASTER MANAGEMENT	GL-ID-2113
3	CLIMATE SCIENCE	GL-ID-3213

Course Learning Outcome (CLO)

Semester	Course Name & Code	Course Learning Outcome (CLO)	
1	ENVIRONMENTAL GEOLOGY GL-ID-1113	CLO-01	After the successful completion of this course, students will be able to understand fundamentals of Environmental geology
		CLO-02	After the successful completion of this course, students will be able to develop skills to identify the natural and anthropogenic geological activities related to environment. The course will improve the understanding about the Physicochemical conditions of different spheres of the Earth. And, boost the students in understanding the interrelationship between the spheres.
		CLO - 03	Studies related to different biogeochemical cycles will enhance the understanding about the Earth and environment
		CLO - 04	Studies of the Heavy metals will allow the students to rethink about the toxicity level and potential health hazards prevailing in the society.
2	DISASTER MANAGEMENT GL-ID-2113	CLO-01	After completion of the course, the learners will be able to define and analysis factors contributing to disasters, threats to development, life and nature
		CLO-02	After completion of the course, the learners will be able to demonstrate and practice disaster risk reduction activities towards sustainable development

2	DISASTER MANAGEMENT GL-ID-2113	CLO -03	After completion of the course, the learners will be able toFormulate, organize and access disaster risk reduction activities according to the nature of disaster and factors of vulnerabilities.
3	CLIMATE SCIENCE GL-ID-3213	CLO-01	The course will give students a fundamental understanding of climate science and how it affects modern society.
		CLO-02	Students will learn the mechanisms and essential elements of the climate system and their interactions.
		CLO - 03	Students will learn in details about climate change, climate variability and IPCC reports

Mapping of Course Learning Outcome (CLO) and Programme Outcome (PO)

Attributes: Co-relation Levels

"1" : Minimum Co-relation
"2" : Moderate Co-relation
"3" : Maximum Co-relation
"-" : No Co-relation

Course Code	CLO	Programme Outcome (PO)										
		SPO-1	SPO-2	SPO-3	SPO-4	SPO-5	SPO-6	SPO-7	SPO-8	SPO-9	SPO-10	SPO-11
GL-ID-1113	CLO - 1	3	2	2	1	3	3	3	3	2	3	3
	CLO - 2	3	3	2	1	3	3	2	3	2	3	3
	CLO - 3	1	2			1	2	1	1		1	1
	CLO - 4	1	1			1			1		1	1
GL-ID-2113	CLO - 1	3	3	3	2	3	3	3	3	2	3	3
	CLO - 2	3	3	3	2	3	3	3	3	2	3	3
	CLO - 3	3	3	2	1	3	3	2	3	2	3	3
GL-ID-3213	CLO - 1	1	2			1	2	1	1		1	1
	CLO - 2	1	1			1			1		1	1
	CLO - 3	1				1		1	1		1	1

Mapping of Course Learning Outcome (CLO) and Programme Specific Outcome (PSO)

Attributes: Co-relation Levels

"1" : Minimum Co-relation
"2" : Moderate Co-relation
"3" : Maximum Co-relation
"-" : No Co-relation

Course Code	CLO	Programme Specific Outcome (PSO)										
		PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8	PSO-9	PSO-10	PSO-11
GL-ID-1113	CLO - 1	3	2	2	1	3	3	3	3	2	3	3
	CLO - 2	3	3	2	1	3	3	2	3	2	3	3
	CLO - 3	1	2			1	2	1	1		1	1
	CLO - 4	1	1			1			1		1	1
GL-ID-2113	CLO - 1	3	3	3	2	3	3	3	3	2	3	3
	CLO - 2	3	3	3	2	3	3	3	3	2	3	3
	CLO - 3	3	3	2	1	3	3	2	3	2	3	3
GL-ID-3213	CLO - 1	1	2		3	1	2	1	1	1	1	1
	CLO - 2	1	1		3	1			1	1	1	1
	CLO - 3	1			3	1		1	1	1	1	1

COURSE NAME: Environmental Geology

COURSE CODE: GL – ID – 1113

TOTAL CREDITS: 3 (Theory: 3)

THEORY

Total Lectures - 45

Course Objective:

This course will introduce students about the natural and anthropogenic geological activities related to environment and possible solutions about the environmental related geological problems. This paper helps to understand the chemistry of different spheres of the earth such as atmosphere, hydrosphere, lithosphere, and their interactions. Additionally, concepts of toxic elements and related health hazards are also considered for the studies.

Course Learning Outcome:

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

CLO–01: *Understand fundamentals of Environmental geology.*

CLO – 02: *Develop skills to identify the natural and anthropogenic geological activities related to environment. The course will improve the understanding about the Physicochemical conditions of different spheres of the Earth. And, boost the students in understanding the interrelationship between the spheres.*

CLO – 03: *Studies related to different biogeochemical cycles will enhance the understanding about the Earth and environment.*

CLO – 04: *Studies of the Heavy metals will allow the students to rethink about the toxicity level and potential health hazards prevailing in the society.*

Unit-I: Basics of Environmental Geology (Lectures: 15)

Definition and scope of environmental geology. Natural and anthropogenic environmental hazards. Impact of geological hazards: Earthquakes, Volcanism, flood, landslide and mining on environment**.**

Unit-II: Introduction to Environmental Chemistry (Lectures: 15)

Atmosphere: Troposphere air composition, aerosol in troposphere (sources, composition, chemistry, transport, residence times, and sinks). Chemistry of stratosphere, formation and destruction of O3. Lithosphere: Weathering (physical and chemical), dissolution and precipitation of solids, stable and meta-stable processes, Soil composition and characteristics. Hydrosphere: Freshwater and Sea water and their composition, physico-chemical processes, redox reactions. Biosphere: Natural processes in the biosphere and processes associated**.**

Unit-III: Environmental pollution, Toxic Elements and Health hazard(Lectures: 15)

Environmental pollution. Toxic elements such as As, Cd, Pb, Hg, and SOx, NOx, in the environment, carcinogens. Concept of global warming and climate change. Carbon cycles (short and long term), atmospheric and marine Carbon; Nitrogen - forms of nitrogen, Nitrogen biochemistry, fertilization, human influences on nitrogen cycling.

Recommended Books:

1. E. A. Keller (2010), Environmental Geology. Pearson.
2. C.W. Montogomery (2002), Environmental Geology.
3. K.S. Valdiya (2013), Environmental Geology: Ecology, Resource and Hazard Management. McGraw Hill Education (India) Private Limited, New Delhi.
4. V. Subramaniam. Text Book in Environmental Sciences, Narosa International
5. Manahan, S. E., 2009, Environmental Chemistry, CRC Press.
6. Andrews, J. E., Brimblecombe, P., Jickells, T. D., Liss, P. S., and Reid. B. J., 2004, Introduction to Environmental Chemistry, Blackwell Publications.
7. Schlesinger, W. H., 1997, Biogeochemistry: An Analysis of Global Change, Academic Press.
8. Kumar, U. Geochemistry and Environmental Geology

COURSE NAME: Disaster Management

COURSE CODE: GL – ID – 2113

TOTAL CREDITS: 3 (Theory: 3)

THEORY

Total Lectures - 45

Course Objective:

The objectives of the course are:

- *To impart knowledge and concepts of disaster and disaster management.*
- *To enhance the students understanding on Hazard, Vulnerability and Risk.*
- *To develop positive attitude towards practical response to different stages of disaster management.*
- *To ensure disaster response skills,*

Course Learning Outcome:

After completion of the course, the learners will be able to:

CLO–01: *Define and analysis factors contributing to disasters, threats to development, life and nature.*

CLO–02: *Demonstrate and practice disaster risk reduction activities towards sustainable development.*

CLO – 03: *Formulate, organize and access disaster risk reduction activities according to the nature of disaster and factors of vulnerabilities.*

Unit- I: Concepts of Disaster and Vulnerability (LECTURES: 15)

Hazard, disaster, vulnerability and risk. Types of hazard and disaster – Natural (Earthquake, flood and landslide) & anthropogenic hazard and disasters. Causes and impacts of disasters; impact on – natural ecosystem, physical, psychological and social impact. Concept of GIS and Remote sensing application. Disaster vulnerability profile of India with specific reference to North- east India

Unit-II:Disaster Intervention Practices (LECTURES: 15)

Disaster Management Cycle-Rescue, relief, rehabilitation, reconstruction, prevention, mitigation and preparedness. Disaster risk reduction (DRR)- Community based DRR, Institutions concerned with safety, Disaster mitigation and construction techniques as per Indian Standard. Early warning systems.Trauma and Stress management. First-aid and emergency procedures.

Unit-III: Disaster Management (LECTURES: 15)

Components of disasters management-Preparedness of rescue & relief, mitigation, rehabilitation & reconstruction. Institutional framework of disaster management in India (NDMA-SDMA-DDMA, NDRF, Civic volunteers, NIDM), Phases of disasters/risk management and post-disaster responses. Applications of remote sensing & GIS in disaster management. Disaster Management Act-2005.

Recommended Books:

1. Singh, R.(2017),"Disaster Management Guidelines for Earthquakes, Landslides, Avalanches and Tsunami". Horizon Press Publications
2. Taimpo (2016),"Disaster Management and Preparedness "CRC Press Publications.
3. Nidhi, G.D.(2014),"Disaster Management Preparedness". CBS Publications Pvt .Ltd.
4. Keller E.A. (2012) Introduction to Environmental Geology, Pearson Prentice Hall. Fifth Edition Types of hazards-Earthquake, flood, Tsunami, other water related hazards and events cyclone etc.
5. Clark, T. D. (2017). Natural Disasters, Vulnerability, and Resilience in Indigenous Communities: Literature Review and Conceptual Framework. (PDF)
6. Natural Disasters, Vulnerability and Resilience in Indigenous Communities: Literature Review and Conceptual Framework I Timothy, David Clark–Academic

COURSE NAME: Climate Science

COURSE CODE: GL – ID – 3213

TOTAL CREDITS: 3 (Theory: 3)

THEORY

Total Lectures - 45

Course Objective:

Giving the students a fundamental understanding of the climate system—its characteristics, underlying mechanisms, and the forces driving climate change—is the goal of this course. Additionally, educating students about the different elements of the climate system and how they interact with the atmosphere, hydrosphere, and lithospheric layers will stir up their curiosity about climate system modeling and climatic vulnerability.

Course Learning Outcome:

CLO 1: *The course will give students a fundamental understanding of climate science and how it affects modern society.*

CLO 2: *Students will learn the mechanisms and essential elements of the climate system and their interactions.*

CLO 3: *Students will learn in details about climate change, climate variability and IPCC reports*

Unit-1: Introduction (Lectures: 15)

Basic concepts of meteorology; vertical profiles of the atmosphere's microphysical processes, temperature, wind, pressure, and water vapor; The earth climate system and mutual interaction of the system components- solid earth, atmosphere, hydrosphere, cryosphere, and biosphere.

Unit-2: Climatology and Meteorology (Lectures: 15)

Budget and balance for radiation; solar constant, and lapse rate; the water cycle and its role in weather, wind development mechanism; wind patterns, jet streams, Pressure Gradient & Coriolis Effect.

Unit-3: Climate variability and climate change (Lectures: 15)

Long term climate variability and forcing factors (tectonism, astronomical cycles), the relationship between anthropogenic forcing and natural variability, greenhouse gas emissions and global warming, The basics of the climate system and climate change, a synopsis of reports from the Inter-governmental Panel on Climate Change (IPCC), and potential paths for mitigation.

Recommended Books:

1. Marshall J. and plumb R.A.(2001) Atmosphere, Ocean and Climate, Elsevier, Amsterdam
2. Climate Change Science: An analysis of some ket questions- National Academy Press, Washington, DC, (2001).
3. Oliver J.E. and Hidore J.J. (2008) Climatology: An Atmospheric Science, Prentice - Hall