COURSE STRUCTURE AND SYLLABUS of Five Year Integrated Post Graduate Programme (FYIPGP), NEP 2020 APPLIED GEOLOGY

(Recommended by B.O.S.in Applied Geology, DU in its meeting held on 28.12.2023 and **reviewed by the B.O.S. in Applied Geology, DU in its meeting held on 12.03.2026 to include topics related to Basic studies of minerals, rocks and fossils, Critical minerals, Brahmaputra studies, and other modifications**)

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PREAMBLE

The prime objective of this five years degree course in Geology of Dibrugarh University is to generate efficient and skilled human resources who can serve the society at larger extent and play a major role in preserving the Mother Planet. This model curriculum for Master of Science in Applied Geology is prepared following the guidelines of NEP 2020 includes basic foundation, core and the theoretical as well as applied components of the Geology course. It aims at to empower the Post graduate students to explore and understand various aspects of the Planet Earth. A Learning Outcome-based Curriculum Framework (LOCF) is approached so that the students can experience the prime objectives of the course, engage themselves in the programme of their choice, acquire advance knowledge and perform better at examination level. This postgraduate curriculum is expected to prepare the students academia, industry employability. The student will unfold decisive thinking, analytical and interdisciplinary skills which can be applied to various scientific and environmental contexts and gain a deeper appreciation in the subject. This course is also designed to counselling the postgraduate students for maintaining the physical and mental well-being, emotional stability, stress management and social justice and sustainability.

INTRODUCTION

The Post Graduate (PG) syllabus of Applied Geology in light of New Education Policy (NEP), 2020 consists of Major (Core) disciplines, Minor disciplines, Generic Elective Courses (GEC), Ability Enhancement Courses (AEC), Value Added Courses (VAC), Skill Enhancement Courses (SEC), Environmental Education (EE), YOGA, Community Based Engagement (NCC/NSS/Adult Education/Student Mentoring/NGO/Govt. Institutions, etc.), Digital and Technological Solutions/Digital Fluency (DTS/DF),Geological Fieldwork, Internship, Project, Research Ethics and Methodology, Research Project (Development of Project/Research Proposal, Review of related literature), Dissertation Project Work and Discipline Specific Electives (DSE).

The PG degree programme offers certificates, diplomas and degrees as follows:

1. **UG Certificate**: Students who opt to exit after completion of the first year (Two Semesters) and have secured 44 credits will be awarded a UG certificate. These students are allowed to re-enter within three years and complete the degree programme within the stipulated maximum period of seven years.

   Certificate course consists of two Major disciplines, two Minor disciplines, two

GEC, two AEC, four VAC, two SEC, YOGA and Environmental Education with emphasis on community-based activities.

2. **UG Diploma**: Students who opt to exit after completion of the second year (Four Semesters) and have secured 88 credits will be awarded the UG diploma. These students are allowed to re-enter within a period of three years and complete the degree programme within the maximum period of seven years.

   Diploma course consists of eight Major disciplines, four Minor disciplines, three GEC, three AEC, five VAC, three SEC, YOGA, Environmental Education with emphasis on community-based activities and Digital and Technological Solutions/Digital Fluency and Community engagement.

3. **3-year UG Degree:** Students who wish to undergo a 3-year (Six Semesters) UG programme will be awarded UG Degree in the Major discipline after successful completion of three years, securing 132 credits.

   3-year UG degree course consists of sixteen Major disciplines, six Minor disciplines, three GEC, three AEC, five VAC, three SEC, YOGA, Environmental Education with emphasis on community-based activities, Digital and Technological Solutions/Digital Fluency, Community engagement, Internship and Project.

4. **4-year UG Degree (Honours with Research):** Students who secure 75% marks and above in the first six semesters and wish to undertake research at the undergraduate level can choose a research stream in the fourth year (Two Semesters). They should do a research project or dissertation under the guidance of a faculty member of the University/College. The research project/dissertation will be in the major discipline. The students who secure 176 credits, including 12 credits from a research project/dissertation, are awarded UG Degree (Honours with Research).

   4-year UG degree course consists of twenty-two Major disciplines, eight Minor disciplines, three GEC, three AEC, five VAC, three SEC, YOGA, Environmental Education with emphasis on community-based activities, Digital and Technological Solutions/Digital Fluency, Community engagement, Internship, Project, Research Ethics and Methodology, Research Project or one DSE and Dissertation or two DSE.

5. **UG Degree Programme with Single Major:** A student has to secure a minimum of 50% credits from the major discipline for the 3-year/4-year UG degree to be awarded a single major.
6. **UG Degree Programme with Double Major:** A student has to secure a minimum of 40% credits from the second major discipline for the 3-year/4-year UG degree to be awarded a double major.
7. **Interdisciplinary UG Programme**: The credits for core courses shall be distributed among the constituent disciplines/subjects so as to get core competence in the interdisciplinary programme.
8. **Multidisciplinary UG Programme**: In the case of students pursuing a multidisciplinary programme of study, the credits to core courses will be distributed among the broad disciplines such as Earth and Energy Sciences, Life sciences, Physical Sciences, Mathematical and Computer Sciences, Social Sciences, Humanities, etc.

Five Year Integrated Post Graduate Programme (FYIPGP)

Students who secure 75% marks and above in the first eight semesters and wish to undertake postgraduate level can choose a post graduate stream in the fifth year (Two Semesters). They will complete four DSC and five DSE courses in ninth and tenth semester. They should do a research project or dissertation under the guidance of a faculty member of the University. The research project/dissertation will be in the major discipline. The students on exit shall be awarded a PG Degree (in the Field of Study/Discipline), or Integrated 5 years PG

Degree) after securing the requisite 200 Credits on completion of Semester 10.

The statutory bodies of the Universities and Colleges such as the Board of Studies and Academic Council will decide on the list of courses under major category and credit distribution for double major, interdisciplinary and multidisciplinary programmes.

AIM

The aims of Five-Year Integrated Post Graduate Programme (FYIPGP) in Applied Geology are:

1. To know the fundamentals of Geology, its scope and its various branches.
2. To introduce fundamental aspects of Earth and Planetary system and its related changes with time. This course will mainly emphasize to provide knowledge on the Mineralogy, Petrology, Structural Geology and Plate Tectonics, Stratigraphy, Paleontology, various mineral exploration methods etc.
3. To introduce about the different sources of natural resources such as hydrocarbons, ground water and ores.
4. To associate the naturally occurring landforms with erosive and depositional action of the rivers, wind and glaciers.
5. Students will be able to understand scientific methodologies and by applying the methods finding solutions to selected problems in different fields of Geology.

Eligibility Criteria for Admission into FYIPGP in Applied Geology

Candidates who have passed the final examination under the 10+2 system or its equivalent with a minimum of 50% of marks in aggregate and with physics, chemistry along with geology/mathematics/biology/computer-science/statistics/geography/any other as a subject of study, are eligible to apply for admission to the Five-year Integrated PG Degree programme. However, the eligibility criterion is subject to modification, as per the directives of competent authorities.

Eligibility for Lateral Entry to VII Semester

A three-year UG degree in Geology after successful completion of three years (6 semesters) obtained from Dibrugarh University or any other University/institution recognized by Dibrugarh University. These students are to complete the Degree within the stipulated maximum period of seven years.

GRADUATE ATTRIBUTES OF THE FYIPGP IN APPLIED GEOLOGY

Graduate attributes include both disciplinary knowledge related to the particular

discipline and generic attributes that the graduates of all the disciplines of study should acquire and demonstrate.

Graduate attributes of the FYIPGP in Applied Geology are:

1. **Disciplinary Knowledge**: The graduates should have the ability to demonstrate the attribute of comprehensive knowledge and understanding of the discipline of Geology.
2. **Communication Skills**: Capability to express various Geological ideas clearly through computational methods, graphical methods, examples and their graphical representations; ability to use Geology effectively as a precise language of communication in other fields; ability to pay close attention, read texts and research papers critically, and communicate complicated information clearly and concisely to a variety of organizations and audiences.

3. **Moral and Ethical Awareness/Reasoning**: Ability to recognize ethical issues that are pertinent to one's work and pledge not to engage in unethical behavior such as plagiarism, copyright and infringement of intellectual property rights; ability to appreciate recent developments in various fields and one’s research with honesty and integrity in all aspects.

4. **Multi-cultural Competence**: Ability to correlate and compare recent developments in various branches of Geology in a variety of organizations worldwide; ability to collaborate research in various fields of geology with other researchers from a variety of communities and organizations; ability to effectively participate in a multicultural group or society and interact politely with diverse groups, and the acquisition of knowledge of the values and beliefs of multiple cultures, and a global view point to honour diversity.

5. **Information/Digital Literacy**: Ability to access, asses and utilize Information and Communications Technology (ICT) tools. Ability to understand, read and write programming language/packages/modules (MATLAB, C) for computation, simulation, graphs and solutions.

6. **Reflective Thinking**: An understanding of how a researcher or an investigator influences and shapes the information one creates; ability to formulate appropriate questions pertaining to the ideas in various branches of Geology in order to propose new solutions using the domain knowledge of Geology; ability to interpret the findings

and use them to solve a variety of problems found in numerous fields of Geology and real-life.

7. **Cooperation/Team Work**: During field work ability to collaborate with diverse teams in an effective and respectful manner; capacity to cooperate with people from varied backgrounds in the interests of a common goal.
8. **Research Related Skills**: To formulate appropriate questions, problems, and hypotheses by analyzing and interpreting the ideas from various branches of Geology; ability to demonstrate the results, theories, techniques and proofs using the concepts of various fields of Geology; ability to develop methodology and design research proposals.
9. **Problem Solving**: To work independently and do in-depth study to find ways that Geology is used in various industries and in daily life to improve job possibilities in a wide range of fields and academic study; ability to use innovative, imaginative, lateral thinking, interpersonal skills, and emotional intelligence; ability to tackle various challenges in both familiar and unfamiliar circumstances, then apply what they've learned to actual scenarios.
10. **Critical Thinking**: Capability to analyze and synthesize theoretical and applied problems, as well as acquire knowledge and skills through logical reasoning, analytical thinking and evaluations; ability to find gaps and logical faults in arguments; inculcate a healthy attitude to be a lifelong learner.

PROGRAM OUTCOMES

1. Students will understand the genesis of Geology and its importance.
2. The students will gain fair knowledge of understanding of the subject concerned and also recent trends developed in the subject.
3. The University expects maximum involvement of the student fraternity in utilizing the benefits of such a flexible yet rigorous curriculum framework at the undergraduate level and reaping the benefits of it through enrichment of their skills in their area of interest which will eventually help them in gaining employment, entrepreneurship, start-ups and various other ways of a dignified life and living as a global citizen with contemporary global demands.
4. Students, after completing this course, are expected to be well prepared to pursue future studies and research in the field of Geology. The Pursuit of higher studies in the subject

will help in the academic upliftment of the subject and society as a whole.

5. Further, the students will be benefited in preparing for the various competitive examinations.
6. The course will impart life skills such as communication, cooperation, team work, and resilience.

TEACHINGLEARNINGPROCESS

The programme allows to use varied pedagogical methods and techniques both within classroom and beyond.

1. Lecture
2. Tutorial
3. Power point presentation
4. Documentary film on related topic
5. Project Work/Dissertation
6. Group Discussion and debate
7. Seminars/workshops/conferences
8. Field visits and Report/Excursions
9. Mentor/Mentee

TEACHING LEARNING TOOLS

1. Projector
2. Smart Television for Documentary related topic
3. LCD Monitor
4. WLAN
5. White/Green/Black Board
6. Fieldwork

ASSESSMENT

1. Home assignment
2. Project Report
3. Class Presentation: Oral/Poster/PowerPoints
4. Group Discussions
5. In semester & End Semester examinations
6. Field work

FYIPGP Course Structure

Year	Semester	Course	Title of the paper and paper code	Total Credit
Year 01	1st Semester	**AGC-1.1**	Earth System Science	4
		AGM- 1.1	Essentials of Earth Science	4
		AGG- 1A	Minerals, Rocks and Ores	3
		AEC01	Modern Indian Language	4
		VAC(Anyone)	Understanding India (VAC01)	2
			Health and Wellness (VAC02)	
		AGSEC-1.1	Basic studies of minerals, rocks and fossils	3
	Total			**20**
	2nd Semester	**AGC-2.1**	Mineralogy and Crystallography	4
		AGM- 2.1	Mineralogy and Crystallography	4
		AGG- 2A	Earthquake Studies	3
		AEC02	English Language and Communication Skills	4
		VAC(Anyone)	Environmental Science (VAC03)	2
			Yoga Education (VAC04)	
		AGSEC-2.1	Basic Surveying Techniques and GIS	3
	Total			**20**
The students on exit shall be awarded Undergraduate Certificate (in the Field of Study/Discipline) after securing the requisite 40 Credits in Semester 1 and 2 provided they secure 4 credits in work based vocational courses offered during summer and winter internship/Apprenticeship in addition to 6credits from skill-based courses earned during 1st and 2nd Semester.				
Year 02	3rd Semester	**AGC-3.1**	Principles of Structural Geology	4
		AGC-3.2	Paleontology	4
		AGM- 3.1	Fundamentals of Petrology	4
		AGG- 3A	Geo-heritage and Geo-tourism	3
		AGSEC-3.1	Geological Mapping	3
		VAC(Anyone)	Digital and Technological Solutions/Digital Fluency (VAC05)	2
			Communicative English/Mathematical Ability (VAC06)	
	Total			**20**
	4th Semester	**AGC-4.1**	Stratigraphic Principles and Applications	4
		AGC-4.2	Sedimentary Petrology	4
		AGC-4.3	Igneous Petrology	4
		AGC-4.4	Thermodynamics & Geochemistry	4
		AGM- 4.1	Structural Geology and Tectonics	4

		Total		**20**
GrandTotal (Semester I, II, III and IV)				**80**

The students on exit shall be awarded Undergraduate Diploma (in the Field of Study/Discipline) after securing the requisite 80 Credits on completion of Semester IV provided they secure additional 4 credit in skill based vocational courses offered during First Year or Second Year summer term or Internship/Apprenticeship.				
Year 03	5th Semester	**AGC-5.1**	Economic Geology	4
		AGC-5.2	Indian Stratigraphy and Geology of NE India	4
		AGC-5.3	Geomorphology	4
		AGM- 5.1	Stratigraphy and Paleontology	4
			Internship and/or Community Engagement [2+2(I+CE)] or [4 (I/4 CE)]	4
		Total		**20**
	6th Semester	**AGC-6.1**	Advanced Structural Geology and Tectonics	4
		AGC-6.2	Metamorphic Petrology	4
		AGC-6.3	Geophysical Exploration	4
		AGC-6.4	Remote Sensing and GIS	4
		AGM- 6.1	Economic Geology	4
		Total		**20**
GrandTotal (Semester I, II, III, IV, V and VI)				**120**
The students on exit shall be awarded Bachelor's Degree (in the Field of Study/Discipline) (3 years) after securing the requisite 120 Credits on completion of Semester 6.				
Year 04	7th Semester	**AGC-7.1**	Engineering Geology	4
		AGC-7.2	Petroleum Geology	4
		AGC-7.3	Geoscientific Data Analysis with MATLAB	4
		AGM-7.1	Geomorphology and Remote Sensing	4
		Research	Research Ethics and Methodology	4
		Total		**20**
	8th Semester	**AGC-8.1**	Hydrogeology	4
		AGC-8.2	Coal Geology	4
		AGM-8.1	Essentials of Exploration Geology	4
		Dissertation /DSE	Dissertation (Collection of Data, Analysis and Preparation of Report) / 2 DSE Courses of 4 credits each in lieu of Dissertation **1.** Analytical techniques in Geology/Oceanography and Climatology (AGDSE8.1) **2.** Fluvial Geomorphology and Seismology/ Advanced Micro-palaeontology (AGDSE 8.2)	8/(4+4)
		Total		**20**
GrandTotal (Semester I, II, III, IV, V, VI, VII and VIII)				**160**

The students on successful exit after 4 years shall be awarded Bachelor's Degree in the Field of Study/Discipline (Honours) and (Honours with Research) after securing the requisite 160 Credits on completion of Semester 8.				
	9th Semester	**AGDSC-9.1**	Geological and Geochemical Exploration	4
Year 05		**AGDSC-9.2**	Sequence Stratigraphy and Hydrocarbon Exploration	4
		AGDSC-9.3	Geological Field Work and Mapping	4
		AGDSE-9.1	Non-conventional Energy/Himalayan Geology/ Petroleum Micropaleontology/Critical Minerals & Strategic Resources: Foundations, Technologies & Policy	4
		Project (P)	Industrial Training	4
		Total		**20**
	10th Semester	**AGDSC-10.1**	Principles and Applications of Geo-statistics& Seismology	4
		AGDSC-10.2	Mineral Optics and Advanced Petrology	4
		AGDSE-10.1	Isotope Geochemistry/ Machine Learning and Artificial Intelligence for Geoscientific Applications/ Applied Paleopalynology	4
		Dissertation OR DSE (2 nos.) – DSE10.2&DSE 10.3	Dissertation (Collection of Data, Analysis and Preparation of Report)/2 DSE Courses of 4 credits each in lieu of Dissertation **1.** Hydrology/GIS/Mud Logging (AGDSE10.2) **2.** Coal Resources of India/Brahmaputra Studies (AGDSE 10.3)	8
		Total		**20**
GRANDTOTAL (Sem1 + Sem 2 + Sem3 + Sem 4 +Sem 5 +Sem 6 + Sem7 + Sem 8 +Sem 9 + Sem 10)				**200**
The students on successful exit shall be awarded a PG Degree (in the Field of Study/Discipline) after securing the requisite 200 Credits on completion of Semester 10.				

DETAILED SYLLABUS OF 1st SEMESTER

Course Title : **Earth System Science**
Course Code : **AGC- 1.1**
Nature of Course : **Major (Core)**
Total Credits : **04 credits**
Distribution of Marks : **60 (End-Sem) + 40 (In-Sem.)**

COURSE OBJECTIVES: Earth system science programme aims to explore, understand, communicate and teach the earth as a planet, its complex processes, past and future evolution and interaction with society. In short language, it provides integrated understanding of the earth system. It also deals with complex interaction among lithosphere, biosphere and atmosphere.

UNITS	CONTENTS	L	T	P	Total Hours
I (20 Marks)	**Universe, Solar and Earth System** Formation and evolution of the Universe, meteorites and asteroids; theories of origin of the earth, brief geological history and age of earth. Planet Earth, moon, planetary properties, orbital and rotational characteristics of the earth, physical characteristics; atmosphere, hydrosphere, lithosphere, biosphere and cryosphere; gravitational and magnetic field of the earth, Interior of the Earth: core, mantle and crust. **IKS in Earth System Science** Concept of globe, universe in ancient Indian scriptures, Historical evidence of Earthquakes in Ancient India, Impact of geological processes on the rise and fall of Ancient Indian Civilizations (geo-hazards – earthquakes, climate change, river migrations, sea level oscillations etc.)	**16**	**04**		**20**
II (10 Marks)	**Basics of Geology** Various branches of geology and its interdisciplinary and multidisciplinary perspectives Minerals and rocks: concept of native elements, mineraloids, rock forming minerals. Brief introduction to rocks: igneous, metamorphic and sedimentary rocks, the rock cycle Brief idea about different geomorphic processes and their products; Rock weathering; Soil: formation, soil profile and soil types;	**08**	**02**		**10**

III (15 Marks)	Deformation of rocks: Folds, Faults, and other Records of Rock Deformation Concept of plate tectonics, origin of oceans, continents, mountains and rift valleys. Earthquake and earthquake belts. Volcanoes- types, products and their distribution. Earth's heat budget, land-air-sea interactions; atmospheric and ocean circulation, Coriolis effect, concepts of eustasy. Stratigraphy and historical geology – basic principles; Introduction to the geology of India.	**12**	**03**		**15**
IV (15Marks)	Basic Field training			**15**	**30**
					75
Where, L: Lectures, T: Tutorials, P: Practical					

MODES OF INTERNAL ASSESSMENT **(40 Marks)**

- Two Internal Examination- 15 + 15
- Others (Anyone) - 10
- Group Discussion
- Seminar presentation on any of the relevant topics
- Debate
- Home Assignment

COURSE OUTCOMES (COs):

Student will be able to:

CO01: Understand the Formation and Evolution of the Universe

- LO 1.1: Describe the major theories regarding the formation and evolution of the universe.
- LO 1.2: Identify the role and significance of meteorites and asteroids in the solar system.
- LO 1.3: Summarize the main theories of Earth's origin.
- LO1.4: Outline the key events in Earth's geological history and methods for determining its age.
- LO 1.5: Compare the physical and orbital characteristics of Earth, the moon, and other planets.
- LO 1.6: Explain the structure and composition of Earth's atmosphere, hydrosphere, lithosphere, biosphere, and cryosphere.
- LO 1.7: Analyze the gravitational and magnetic fields of Earth.
- LO 1.8: Describe the structure of Earth's core, mantle, and crust.

CO02: Understand the Basics of Geology

- LO2.1: Identify and explain the various branches of geology and their interdisciplinary

and multidisciplinary perspectives.

- LO2.2: Define native elements, mineraloids, and rock-forming minerals.
- LO2.3: Distinguish between igneous, metamorphic, and sedimentary rocks and explain the rock cycle
- LO 2.4: To know the processes involving Rock Weathering and describe soil formation, soil profiles, and different soil types

CO03: Gain knowledge of Advanced Concepts of Geology

- LO3.1: Discuss various geomorphic processes and their resultant landforms.
- LO3.2: Identify and describe the geomorphic divisions of the Indian subcontinent.
- LO 3.3: Explain the concept of plate tectonics and its role in the origin of oceans, continents, mountains, and rift valleys.
- LO 3.4: Describe the causes and effects of earthquakes and the distribution of earthquake belts.
- LO 3.5: Identify different types of volcanoes, their products, and their global distribution.
- LO 3.6: Explain Earth's heat budget and the interactions between land, air, and sea.
- LO 3.7: Describe atmospheric and ocean circulation patterns and the Coriolis effect.
- LO 3.8: Define the concept of eustasy and its implications.
- LO3.9: Explain the basic principles of stratigraphy.

CO04: Understand Geology of India

- LO4.1: Provide an overview of the geological history of India.

CO05: Acquire Practical Skills

- LO 5.1: Identify common minerals and rocks in hand specimens.
- LO 5.2: Recognize and identify mega fossils.
- LO5.3: Identify and interpret geological structural models.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge	**CO01, CO02, CO04**	**CO02, CO03**	**CO05**			
Conceptual Knowledge		**CO02, CO03, CO05**	**CO05**	**CO03, CO04, CO05**	**CO05**	
Procedural Knowledge		**CO05**	**CO05**	**CO05**		
Metacognitive Knowledge						

Mapping of Course Outcomes to Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	S	M	M	S	S	M
CO2	S	M	M	S	S	M
CO3	S	M	M	S	S	M
CO4	S	M	M	S	S	M
CO5	M	S	M	S	S	M

Where, S=Strong Correlation and M=Medium Correlation

SUGGESTED READINGS

Brian J. Skinner, B.J. & Porter, S.C.: (2012). The Blue Planet: An Introduction to Earth System Science. John Wiley & Sons. Inc.

Thompson G.R.R., Turk J. (1997) Introduction to Physical Geology. Brooks Cole.

Tarbuck,E.J.&Lutgens, F.K.(1998). Earth: An Introduction to Physical Geology. Pearson

Charles, C.P., Carlson, D., & Mcgeary, D. (2009) Physical Geology. McGraw-Hill Higher Education

Duff, P. M. D., & Duff, D. (Eds.) (1993). Holmes' principles of physical geology. Taylor & Francis.

Emiliani, C. (1992). Planet earth: cosmology, geology, and the evolution of life and environment. Cambridge University Press.

Varāhamihira. (1996). *BṛhatSaṃhitā of Varāhamihira* (M. Ramakrishna Bhat, Trans.). (2nd ed., 2 vols.). Motilal Banarsidass.

Course Title : **Essentials of Earth Science**
Course Code : **AGM-1.1**
Nature of Course : **Minor**
Total Credits : 04 credits
Distribution of Marks : 60(End-Sem.) + 40 (In-Sem.)

COURSE OBJECTIVES: The "Essentials of Earth Science" course aims to provide students with a foundational understanding of Earth's systems, including geology. Students will explore the dynamic processes shaping our planet, such as plate tectonics, weather patterns, and climate change. Emphasis is placed on scientific inquiry, critical thinking, and the application of earth science principles to real-world issues.

UNITS	CONTENTS	L	T	P	Total Hours
I (15Marks)	**Introduction:** **Origin of the Earth:** The Origin of Planets, Early Earth and Formation of a Layered Planet, Earth as a System of interacting Components, Earth through Geologic Time. **Plate Tectonics:** The Discovery of Plate Tectonics, The Mosaic of Plates, Rates and History of Plate Motions, The Grand Reconstruction, The Engine of Plate Tectonics. **IKS in Essentials of Earth Sciences** Historical evidence of Earthquakes in Ancient India, Impact of geological processes on the rise and fall of Ancient Indian Civilizations, Time and Space in Vedic Thought	**10**	**05**		**15**
II (15Marks)	**Earth Materials** **Minerals:** The Atomic Structure of Minerals. Rock-Forming Minerals, Physical properties of Minerals. **Rocks:** Igneous Rocks, Sedimentary Rocks, Metamorphic Rocks. The Rock Cycle, Rock and Fossil Record and the Geological Time Scale. **Mineral Resources:** Geology of Mineral Deposits and its distributions.	**10**	**05**		**15**
III (15Marks)	**Earth Processes** **Endogenic and Exogenic processes.** **Weathering and Erosion:** Physical weathering, Chemical and Biological weathering, Mass Wasting. **Dynamic Processes of Solid Earth:** Folds, Faults, and other Records of Rock Deformation, Evolution of the Continents, Tectonics of Indian Plate, Origin of Himalayas Groundwater and Hydrological Cycle. Waves and Tides, Physical and chemical sedimentation in the ocean. **Natural Hazards:** Flood, Landslide, Earthquakes, Tsunamis, Volcano.	**10**	**05**		**15**

Unit IV (15Marks)	**Energy, Environment and Global Change** **Energy Resources:** Oil and Natural Gas, Coal, Alternatives to Fossil Fuels, Conservation of Energy Policy. Environment: Global Change and Human Impacts, The Climate System: Natural Climate Variability, The Carbon Cycle: Human Activity and Global Change.	**10**	**05**		**15**
	Total				**60**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- **Two Internal Examination- 15 + 15**
- **Others (Anyone) - 10**
- **Group Discussion**
- **Seminar presentation on any of the relevant topics**
- **Debate**
- **Home Assignment**

COURSEOUTCOMES (COs):

Student will be able to:

CO01: Get an idea about the origin of earth and plate tectonics

- **LO 1.1:** Explain the processes involved in the origin of planets and the early formation of Earth as a layered planet.
- **LO 1.2:** Describe Earth as a system of interacting components, including the lithosphere, atmosphere, hydrosphere, and biosphere.
- **LO 1.3:** Summarize the major events in Earth's history through geologic time and understand methods used to date these events.
- **LO 1.4:** Discuss the discovery and development of plate tectonics theory, including the identification and movement of Earth's tectonic plates, the history of plate motions, and the forces driving plate tectonics.

CO 02: Gaina comprehensive understanding of Earth's origin, structure, dynamic processes, and the classification and significance of minerals and rocks.

- **LO2.1:** Explain the atomic structure and physical properties of minerals, including the identification of common rock-forming minerals.
- **LO2.2:** Classify and describe the formation processes of igneous, sedimentary, and metamorphic rocks, and understand their roles in the rock cycle.
- **LO2.3:** Interpret the rock and fossil record, and explain its importance in the geological timescale.
- **LO2.4:** Discuss the geology of mineral deposits, their formation, and global distribution.

CO 03: Gain a deep understanding of Earth's dynamic processes, including weathering, erosion, tectonic activity, sedimentation, groundwater dynamics, and natural hazards.

- **LO 3.1:** Describe the processes of physical, chemical, and biological weathering. Analyze the impact of weathering on landscape evolution. Explain the mechanisms and consequences of mass wasting.
- **LO 3.2:** Differentiate between endogenic and exogenic geological processes. Illustrate how these processes shape Earth's surface and affect geological formations.
- **LO 3.3:** Identify and interpret folds, faults, and other records of rock deformation. Analyze the evolution of continents and the tectonics of the Indian Plate. Explain the geological processes leading to the formation of the Himalayas.
- **LO 3.4:** Describe the characteristics and causes of floods, landslides, earthquakes, tsunamis, and volcanic eruptions. Evaluate the impact of these natural hazards on human populations and environments.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge	**CO01**	**CO02, CO03**				
Conceptual Knowledge		**CO02, CO03**		**CO03**		
Procedural Knowledge		**CO03**				
Metacognitive Knowledge						

Mapping of Course Outcomes to Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	S	M	M	S	S	M
CO2	S	M	M	S	S	M
CO3	S	M	M	S	S	M

Where, S=Strong Correlation and M=Medium Correlation

Suggested books:

1. Frank Press Raymond Siever: Understanding Earth(3rded). W. H. Freeman and Company. New York .2000
2. B.J. Skinner and S. C. Porter: The Dynamic Earth– AnIntroductiontoPhysicalGeology3rd edition. John Wiley & Sons, New York. 1995
3. P. Mc L. D. Duff: Holme's Principles of Physical Geology (4thed). Chapman & Hall. London. 1996
4. Cox & R.B. Hart Plate Tectonics How it works. Blackwell Scientific Publ. Co. Boston. 1986.
5. Philip A. Allen Earth Surface Processes Blackwell Sciences Ltd, Oxford 1997
6. B.W. Murck, B. J . S kinner & S. C. Porter Dangerous Earth – An Introduction to

Geologic Hazards John Wiley & Sons New York 1996

7. Varāhamihira. (1996). *BṛhatSaṃhitā of Varāhamihira* (M. Ramakrishna Bhat, Trans.). (2nd ed., 2 vols.). Motilal Banarsidass.
8. B.W. Murck, B.J. Skinner & S.C. Porter, Environmental Geology. John Wiley & Sons, New York, 1996

Course Title : **Minerals, Rocks and Ores**
Course Code : **AGG-1A**
Nature of Course : **Multi- Disciplinary Generic Elective**
Total Credits : 3 credits
Distribution of Marks : 60 (End- Sem.) + 40 (In-Sem.)

COURSE OBJECTIVES: The course will provide an introduction to mineralogy, petrology, and related ore deposits**.** Basic principles of mineralogy and microscopy will be built upon to describe and interpret igneous, metamorphic, and economically important rocks and minerals.

UNITS	CONTENTS	L	T	P	Total Hours
I **(20 Marks)**	**Minerals** Definition and different categories of minerals and classification; Common rock forming minerals of Igneous, Sedimentary and Metamorphic rocks. Physical properties of minerals: characters depending on light, senses, heat, magnetism, electricity and radioactivity; Macroscopic identification of Minerals. Minerals used in the industry.	**16**	**03**		**20**
II **(22 Marks)**	**Rocks** The three groups of rocks: Igneous rocks: intrusive and extrusive rocks-their forms with examples. Classification and description of Igneous Rocks. Sedimentary Rocks: classification and description. clastic and non-clastic, Sedimentary rocks and natural resources. Metamorphic Rocks: metamorphism, naming of metamorphic rocks; Types of metamorphic rocks. Commercial use of rocks.	**18**	**04**		**22**
III **(18 Marks)**	**Ores** Definition of ore, ore minerals and average crustal composition; Economic deposit. Ore minerals in human concerns. Metallic and non-metallic ore minerals, gemstones. Use of ores in different mineral industries, refractory, ceramic, cement, fertilizer, chemical industries etc. **IKS in Minerals, Rocks and Ore** Introduction to Iron and Bronze age, Precious stones in Harappan Civilization, ancient mining practices in Rajasthan, Meghalaya etc. Classical texts like *Rasasastra* discussing mineral classification, purification techniques.	**15**	**03**		**18**
	Total				**60**

Where, L: Lectures; T: Tutorials; P: Practicals

MODESOFIN-SEMESTERASSESSMENT: (40Marks)

Two Internal Examination 15+15

Others (Anyone) 10

- **Group Discussion**
- **Seminar presentation on any of the relevant topics**
- **Debate**
- **HomeAssignment**

Course Outcomes (COs):

Students will be able to:

CO01: Classify and describe different types of minerals, understand their formation in various rock types, and identify their physical properties.

- **LO1.1:** Classify and Describe Mineral Types and Rock-Forming Minerals**.**
- **LO1.2:** Identify Physical Properties and Techniques for Mineral Identification.

CO 02: Understand the industrial uses of minerals and evaluate their economic importance and impact on society and the environment.

- **LO2.1:** Evaluate the Industrial Uses and Economic Importance of Minerals.
- **LO2.2:** Understand the Role of Technology and Innovation in Mineral Utilization.

CO 03: Classify and describe the major types of rocks (igneous, sedimentary, and metamorphic), understand their formation processes, and recognize their commercial and geological significance.

- **LO 3.1:** Classify Igneous Rocks based on their mineral composition and texture and describe various types and forms of intrusive and extrusive igneous rocks.
- **LO 3.2:** Classify sedimentary rocks into clastic and non-clastic categories, describe their formation processes and analyze the depositional environments of sedimentary rocks and their significance in interpreting Earth's history.
- **LO 3.3:** Explain the processes of metamorphism, including the factors of heat, pressure, and chemically active fluids, and classify metamorphic rocks based on their texture (foliated vs. non- foliated) and mineral composition.

CO 04: Develop the skills to recognize and analyze the economic and commercial uses of rocks, and understand their significance in various industries and natural resource management.

- **LO4.1:** Evaluate the Economic and Commercial Uses of Igneous Rocks.
- **LO 4.2:** Understand and Analyze the Commercial Uses and Economic Significance of Sedimentary and Metamorphic Rocks

CO 05: Gain a thorough understanding of the nature and significance of ores, including their classification, economic importance, and applications in various industries, and will be able to assess their impact on human society and the environment.

- **LO5.1:** Define ores and ore minerals, explain their classification and describe their physical and chemical properties that make them valuable for extraction and use.
- **LO5.2:** Evaluate the Industrial Applications and Economic Importance of Ores
- **LO5.3:** Assess the Environmental and Societal Impacts of Ore Extraction and Use

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge	**CO01, CO03**	**CO01, CO02**	**CO04**			
Conceptual Knowledge	**CO05**	**CO01, CO03**			**CO02, CO04**	
Procedural Knowledge		**CO03, CO04, CO05**		**CO05**		
Metacognitive Knowledge						

Mapping of Course Outcomes to Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	S	S	M	S	S
CO2	M	S	S	M	S	S
CO3	S	S	S	S	S	S
CO4	M	S	S	S	S	S
CO5	S	M	S	S	M	S

Where, S = Strong Correlation and M = Medium Correlation

SUGGESTED READINGS:

1. Alexander, P.O.2009 A Handbook of Minerals, Crystals, Rocks and Ores. New India Pub. Agency, New Delhi.
2. Ehlers & Blatt. (1999). Petrology, Igneous, Sedimentary, Metamorphic. CBS.
3. Winter. (2015). Principles of Igneous and Metamorphic Petrology. Pearson Education India
4. Perkins, D. (2015). Mineralogy. Pearson Education India.
5. Earth Materials - Introduction to Mineralogy and Petrology, Cornelis Klein and Anthony Philpotts,
6. Varāhamihira. (1996). *Bṛhat Saṃhitā of Varāhamihira* (M. Ramakrishna Bhat, Trans.). (2nd ed., 2 vols.). Motilal Banarsidass
7. Understanding Earth (Sixth Edition), John Grotzinger and Thomas H. Jordan, 2010, W.H. Freeman and company, New York

Course Title : **Basic studies of minerals, rocks and fossils**

Course Code : **AGSEC-1.1**

Nature of Course : **Skill Enhancement**

Total Credits :3 credits

Distribution of Marks :60(End-Sem.)+40 (In-Sem.)

COURSEOBJECTIVES:

1. To introduce students to the physical properties and identification of common rock-forming minerals and rocks using hand specimen characteristics.
2. To provide basic knowledge of fossils and their types and train students in the identification of common mega fossils.

UNITS	CONTENTS	L	T	P	Total Hours
I (20 Marks)	Physical properties of minerals; Identification of following common rock forming minerals based on their physical properties: Quartz, Microcline, Orthoclase, Plagioclase feldspar, Biotite, Muscovite, Amphibole, Pyroxene, Olivine, Garnet, Calcite, Kyanite, Sillimanite etc. Gemstones and their identification.	**15**	**05**		**20**
II (20 Marks)	Physical properties of rocks; Identification of common rock types in hand specimen based on their physical properties: Igneous rocks: Granite, Rhyolite, Basalt, Gabbro, Dolerite, Diorite, Pegmatite, Obsidian etc. Sedimentary Rocks: Sandstone, Shale, Limestone, Mudstone etc. Metamorphic rocks: Slate, Phyllite, Quartzite, Marble, Various types of Gneiss and Schist.	**15**	**05**		**20**
III (20 Marks)	Introduction to fossils, their types, modes of preservation, and geological significance. Identification of common mega fossils based on their morphological characteristics.	**15**	**05**		**20**
	Total				**60**

Where,L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40Marks)

Two Internal Examination 15 + 15 Marks

Others (Anyone) 10 Marks

- **Group Discussion**
- **Seminar presentation on the Field Report**
- **Viva-voce**

COURSE OUTCOMES:

Students will be able to-

CO01: Understand and apply the physical properties of minerals to identify common rock-forming minerals and interpret their occurrence.

- LO 1.1: Explain the key physical properties of minerals such as color, streak, luster, hardness, cleavage, fracture, and crystal form.
- LO 1.2: Identify common rock-forming minerals based on their diagnostic physical properties.
- LO 1.3: Differentiate between similar minerals by comparing their physical characteristics during hand specimen examination.

CO 02: Understand the physical properties of rocks and apply them to identify common igneous, sedimentary, and metamorphic rocks in hand specimen.

- LO 2.1: Explain the key physical properties of rocks such as color, texture, grain size, mineral composition, hardness, and structure used in hand specimen identification.
- LO 2.2: Identify common rock types: igneous, sedimentary and metamorphic based on their diagnostic physical properties.
- LO 2.3: Differentiate between similar rock types by comparing their texture, mineral composition, and structural features during hand specimen examination.

CO 03: Understand the basic concepts of fossils, their types, modes of preservation, and geological significance, and apply this knowledge to identify common mega fossils based on morphological characteristics.

- LO 3.1: Explain the concept of fossils, their major types, and the different modes of fossil preservation.

- LO 3.2: Describe the geological significance of fossils in interpreting age, environment, and evolution of life through geological time.
- LO 3.3: Identify common mega fossils based on their external morphological characteristics and diagnostic features.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge	**CO01, CO02, CO03**	**CO01, CO02, CO03**	**CO01, CO02**			
Conceptual Knowledge		CO01, CO02, CO03	CO01, CO02	CO02, CO03		
Procedural Knowledge		**CO01**	C01, CO02, CO03	**CO01, CO02**		
Metacognitive Knowledge				CO02	CO03	

Mapping of Course Outcomes to Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	S	S	M	S	S	S
CO2	S	S	M	S	S	S
CO3	S	S	M	S	S	S

Where, S = Strong Correlation and M = Medium Correlation

SUGGESTEDREADINGS

1. Alexander, P.O. 2009 A Handbook of Minerals, Crystals, Rocks and Ores. New India Pub. Agency, New Delhi.
2. Michael O'Donoghue, Gems- Their sources, description and identification, 6th edition, 2006
3. Perkins, D. (2015). Mineralogy. Pearson Education India.
4. Earth Materials- Introduction to Mineralogy and Petrology, Cornelis Klein and Anthony Philpotts,

5. Tucker, M.E. Sedimentary Petrology,3rd Edn., Blackwell Science,2001
6. Lindholm Roy C. A practical approach to Sedimentology, 1980
7. Tucker, M. E. (2011). Sedimentary Rocks in the Field: A Practical Guide (4th ed.). Wiley-Blackwell, Chichester, UK.
8. Jerram, D. A., & Petford, N. (2011). The Field Description of Igneous Rocks. Wiley-Blackwell, Oxford, UK.
9. Jerram, D. A., & Caddick, M. J. (2013). The Field Description of Metamorphic Rocks. Wiley-Blackwell, Oxford, UK.
10. Nield, E. W., & Tucker, V. C. T. (1985). Palaeontology: An Introduction. Pergamon Press, Oxford.

DETAILED SYLLABUS OF 2nd SEMESTER

Course Title : **Mineralogy and Crystallography**
Course Code :**AGC-2.1**
Nature of Course : **Major(Core)**
Total Credits :04 credits
Distribution of Marks :60(End-Sem.)+40(In-Sem.)

COURSE OBJECTIVES: Minerals are the basic building blocks of the solid Earth materials and also used as raw materials for mineral based industries. This requires a fundamental knowledge in mineral genesis, associations and occurrence to understand the mineralogical processes. This course is designed to gain basic principles and concepts behind the arrangement of atoms to form crystal structures and how this is reflected in the external form, chemical composition and mineral properties.

UNITS	CONTENTS	L	T	P	Total Hours
I **(18 Marks)**	**Crystallography** Crystal, Characteristics of crystal: Faces, Edges, Solid angle, Zone and Zone axis. Crystal symmetry: Planes, Axes and centre of symmetry. Faces, Intercepts and Symbols: Unit face, Parameters, Axial ratio, Miller indices. Fundamental laws of crystallography, crystal habits. Seven crystal system: Cubic, Tetragonal, Hexagonal, Trigonal, Orthorhombic, Monoclinic and Triclinic. Study of elements of symmetry and forms of the holosymmetric class of each crystal system. Crystal aggregates and twinned crystals. Twin laws, types of twins.	**15**	**03**		**18**
II **(18 Marks)**	**Mineralogy** Definition of mineral, Classification and physical properties of minerals, Isomorphism, Polymorphism and Pseudomorphism, Atomic substitution. Crystal structures of Silicate minerals. Common rock forming mineral Groups and their Structural formula, Physical and optical properties, mode of occurrence. **IKS in Mineralogy:** Historical and Cultural Perspectives on Minerals; Gemstones, vedic mentions of stones and ores, including *ayas* (metal), *shila* (rock), and *mani* (gem).	**15**	**03**		**18**
III **(09 Marks)**	**Optical Mineralogy** Nature of light, ordinary and plane polarized light. Optical properties of minerals.	**07**	**02**		**09**

IV Practical (15Marks)	Identification of crystal models Study of crystals and symmetry elements of given crystal models Study and identification of rock forming minerals in hand specimens Mineral thin section study under microscope. Note Book Viva-voce			**15**	**30**
	Total				**75**

Where, L:Lectures T:Tutorials P:Practicals

MODESOFIN-SEMESTERASSESSMENT: (40Marks)

Two Internal Examination- 15+15

Others (Anyone) - 10

- **Group Discussion**
- **Seminar presentation on any of the relevant topics**
- **Debates**
- **HomeAssignment**

COURSE OUTCOMES:

Students will be able to-

CO01: Gain comprehensive knowledge of crystal structures and symmetry.

- **LO 1.1:** Identify and describe the different characteristics of crystals such as faces, edges, solid angles, zones, and zone axes.
- **LO1.2:** Explain the principles of crystal symmetry including planes, axes, and centers of symmetry.
- **LO1.3:** Utilize Miller indices to determine and describe the orientation of crystal faces.
- **LO1.4:** Apply the fundamental laws of crystallography to classify and describe various crystal habits.

CO02: Acquire the ability to classify and understand the properties of minerals.

- **LO2.1:** Define and categorize minerals based on physical and chemical properties.
- **LO2.2:** Describe and differentiate between isomorphism, polymorphism, and pseudomorphism in minerals.
- **LO2.3:** Explain atomic substitution and its impact on mineral properties.
- **LO2.4.** Identify and describe the crystal structures of silicate minerals and their significance in rock formation.

CO03: Develop skills to analyze the optical properties of minerals using microscopy.

- **LO3.1:** Explain the nature of light and its interaction with minerals.
- **LO3.2:** Distinguish between ordinary and plane polarized light and their applications in optical mineralogy.

- **LO3.3:** Identify and describe the optical properties of minerals, such as birefringence, pleochroism, and interference colors.
- **LO3.4:** Utilize a polarizing microscope to study and identify minerals in thin sections.

CO 4: Demonstrate practical skills in identifying and analyzing crystal models and minerals.

- **LO 4.1:** Identify crystal models and their symmetry elements through hands-on examination.
- **LO4.2:** Conduct studies of rock-forming minerals in hand specimens, recognizing key physical properties.
- **LO4.3:** Prepare and analyze mineral thin sections using a microscope, recording observations in a detailed notebook.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	**CO01, CO02, CO03**	**CO01, CO02**	**CO01, CO02, CO03**			
Conceptual Knowledge		**CO01, CO02**	**CO01, CO02**	**CO01, CO02, CO03**		
Procedural Knowledge		**CO03, CO04**	**CO03, CO04**	**CO03, CO04**		
Metacognitive Knowledge					**CO01, CO02, CO03, CO04**	

Mapping of Course Outcomes to Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	M	M	M	M	M
CO2	M	S	M	M	S	M
CO3	S	S	M	M	S	M
CO4	M	S	M	M	S	M

Where, S = Strong Correlation and M = Medium Correlation

SUGGESTED READINGS:

1. Perkins, D. (2015). Mineralogy. Pearson Education India.
2. Klein, C., Dutrow, B., Dwight, J., & Klein, C. (2007). The 23rd Edition of the Manual of Mineral Science (after James D. Dana). J. Wiley & Sons.
3. Deer, W.A., Howie, R.A., & Zussman, J. (1992). An introduction to the rock forming minerals (Vol. 696). London: Longman.
4. Gribble, C.D. (2005). Rutley's Elements of Mineralogy. CBS.

Course Title : **Mineralogy and Crystallography**
Course Code : **AGM-2.1**
Nature of Course : **Minor**
Total Credits : **04 credits**
Distribution of Marks :**60 (End-Sem.) + 40 (In-Sem.)**

COURSE OBJECTIVES: Minerals are the basic building blocks of the solid Earth materials and also used as raw materials for mineral based industries. This requires a fundamental knowledge in mineral genesis, associations and occurrence to understand the mineralogical processes. This course is designed to gain basic principles and concepts behind the arrangement of atoms to form crystal structures and how this is reflected in the external form, chemical composition and mineral properties.

UNITS	CONTENTS	L	T	P	Total Hours
I **(20 Marks)**	**Crystallography** Introduction to crystals, Characteristics of crystal: Faces, Edges, Solid angle, Zone and Zone axis. Crystal symmetry: Planes, Axes and centre of symmetry. Faces, Intercepts and Symbols: Unit face, Parameters, Axial ratio, Miller indices. Fundamental laws of crystallography, crystal habits. Seven crystal system: Cubic, Tetragonal, Hexagonal, Trigonal, Orthorhombic, Monoclinic and Triclinic. Twinning in crystals: types, causes and laws.	**16**	**04**		**20**
II **(25 Marks)**	**Mineralogy** Mineral: Definition & classification, Physical properties of minerals, Isomorphism, Polymorphism and Pseudomorphism, Atomic substitution. Crystal structures of Silicate minerals. Common rock forming mineral Groups and their Structural formula. Optical Mineralogy: Nature of light, ordinary and plane polarized light. Optical properties of minerals. **IKS in Mineralogy:** Historical and Cultural Perspectives on Minerals; Gemstones and pottery, precious stones in Harappan and subsequent times	**20**	**05**		**25**

III **Practical** **(15Marks)**	Identification of crystal models Study of crystals and symmetry elements of given crystal models Study and identification of rock forming minerals in hand specimens and in thin sections under microscope Note Book Viva-voce			**15**	**30**
	Total				**75**

Where, L:Lectures T:Tutorials P:Practicals

MODESOFIN-SEMESTERASSESSMENT: (40Marks)

- **Two Internal Examination- 15+15**
- **Others (Anyone) - 10**
  - **Group Discussion**
  - **Seminar presentation on any of the relevant topics**
  - **Debate**
  - **Home Assignment**

COURSEOUTCOMES:

Students will be able to-

CO01: Gain comprehensive knowledge of crystal structures and symmetry.

LO 1.1: Identify and describe the different characteristics of crystals such as faces, edges, solid angles, zones, and zone axes.

LO1.2: Explain the principles of crystal symmetry including planes, axes, and centers of symmetry.

LO1.3: Utilize Miller indices to determine and describe the orientation of crystal faces.

LO1.4: Apply the fundamental laws of crystallography to classify and describe various crystal habits.

CO02: Acquire the abilityto classify andunderstandthepropertiesof minerals.

LO2.1: Define and categorize minerals based on physical and chemical properties.

LO2.2: Describe and differentiate between isomorphism, polymorphism, and pseudomorphism in minerals.

LO2.3: Explain atomic substitution and its impact on mineral properties.

LO2.4. Identify and describe the crystal structures of silicate minerals and their significance in rock formation.

CO03: Develop skills to analyze the optical properties of minerals using microscopy.

LO3.1: Explain the nature of light and its interaction with minerals.

LO3.2: Distinguish between ordinary and plane polarized light and their applications in optical mineralogy.

LO3.3: Identify and describe the optical properties of minerals, such as birefringence, pleochroism, and interference colors.

LO3.4: Utilize a polarizing microscope to study and identify minerals in thin sections.

LO3.5: Identify crystal models and their symmetry elements through hands-on examination.

LO3.6: Conduct studies of rock-forming minerals in hand specimens, recognizing key physical properties.

LO3.7: Prepare and analyze mineral thin sections using a microscope, recording observations in a detailed notebook.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	**CO01,CO 02,CO03**	**CO01,CO 02**	**CO01, CO02, CO03**			
Conceptual Knowledge		**CO01,CO 02**	**CO01, CO02**	**CO 01, CO 02, CO03**		
Procedural Knowledge		**CO03**	**CO03**	**CO03**		
Metacognitive Knowledge					**CO01,CO 02,CO03**	

Mapping of Course Outcomes to Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	M	M	M	M	M
CO2	M	S	M	M	S	M
CO3	S	S	M	M	S	M

Where, S=Strong Correlation and M=Medium Correlation

SUGGESTEDREADINGS:

1. Perkins, D.(2015). Mineralogy. Pearson Education India.
2. Klein,C., Dutrow, B., Dwight,J., &Klein,C. (2007). The 23rd Edition of the Manual of Mineral Science (after James D. Dana). J. Wiley & Sons.
3. Deer,W.A., Howie,R.A., &Zussman,J. (1992). An introduction to the rock forming minerals (Vol. 696). London: Longman.

4. Gribble,C.D. (2005). Rutley's Elements of Mineralogy. CBS.
5. Mason & Berry (2004). Mineralogy. CBS.
6. Rabindra,H.N. (2012). Practical Approach to Crystallography and Mineralogy. CBS.
7. Sands,D. E. (1994). Introduction to Crystallography. Dover PublicationsI nc.
8. Schwarzenbach,D. (1997). Crystallography. Willey

Course Title :**Earthquake Studies**
Course Code :**AGG2A**
Nature of Course :**Multi-Disciplinary Generic Elective**
Total Credits : 03 credits
Distribution of Marks :60(End-Sem.)+40(In-Sem.)

COURSE OBJECTIVES: The course is designed to provide students the basic concepts of earthquakes, along with some practice in analyzing seismological database.

UNITS	CONTENTS	L	T	P	Total Hours
I (15 Marks)	Theory of elasticity, Generalized Hooke's law, Different types of elastic waves	**12**	**03**		**15**
II (20Marks)	Earthquakes: Causes and effects, Various magnitude and intensity scales, Elastic rebound theory.	**16**	**04**		**20**
III (25 Marks)	Earthquake belts of the world. Classification of earthquakes, Seismometers, Analysis of seismograms, Seismic networks and arrays, Earthquake forecasting. Seismicity and seismo-tectonics of India, Seismic hazard map of India. **Introduction to IKS** Historical evidence of Earthquakes in Ancient India, Impact of geological processes on the rise and fall of Ancient Indian Civilizations, Architectural Damage and Reconstructions with special emphasis on ancient temples, drying of Saraswati River	**20**	**05**		**25**
	Total				**60**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40Marks)

- **Two Internal Examination- 15+15**
- **Others(Anyone) - 10**
  - **Group Discussion**
  - **Seminar presentation on any of the relevant topics**
  - **Debate**
  - **Home Assignment**

COURSE OUTCOME (COs):
Students will be able to:

CO01: Develop a solid foundation in the theory of elasticity and the behavior of elastic waves.

LO1.1: Explain the fundamental concepts of the theory of elasticity and its significance in geophysics.

LO1.2: Apply Generalized Hooke's law to describe the relationship between stress and strain in elastic materials.

LO 1.3: Differentiate between various types of elastic waves, such as P-waves, S-waves, and surface waves, and understand their propagation through the Earth.

CO02: Gain comprehensive knowledge about earthquakes, their causes, effects, and measurement techniques.

LO 2.1: Identify and explain the causes and effects of earthquakes, including the mechanisms behind them.

LO2.2: Understand and utilize various magnitude and intensity scales to quantify earthquakes.

LO2.3: Describe the Elastic Rebound Theory and its role in understanding the earthquake cycle.

CO03: Acquire the skills to classify, analyze earthquakes, with a focus on seismicity and seismo-tectonics.

LO3.1: Classify different types of earthquakes and explain their characteristics.

LO3.2: Operate seismometers, analyze seismograms, and understand the functioning of seismic networks and arrays.

LO3.3: Explore the seismicity and seismotectonics of India, interpret the seismic hazard map of India, and discuss methods of earthquake forecasting.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge	**CO01, CO02, CO03**	**CO01, CO02, CO03**	**CO03**	**CO03**		
Conceptual Knowledge		**CO01, CO02, CO03**	**CO03**	**CO03**		
Procedural Knowledge		**CO01, CO02, CO03**	**CO01, CO02**			
Metacognitive Knowledge					**CO01, CO02, CO03**	

Mapping of Course Outcomes to Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	M	M	M	S	M
CO2	S	S	M	S	S	M
CO3	S	S	S	S	S	M

Where, S=Strong Correlation and M=Medium Correlation

SUGGESTEDREADINGS:

1. Shearer, P.M. (2009). Introduction to Seismology. Cambridge University Press.

2. Lowrie, W. (2007). Fundamentals of Geophysics. Cambridge University Press.

3. Scholz, C.H. (2002). The Mechanics of Earthquakes and Faulting. Cambridge University Press.

4. Bullen, K.E. and Bolt, B.A. (1985). An Introduction to the Theory of Seismology. Cambridge University Press.

5. Varāhamihira. (1996). Bṛhat Saṃhitā of Varāhamihira (M. Ramakrishna Bhat, Trans.). (2nd ed., 2 vols.). Motilal Banarsidass.

6. Gubbins, D. (1990). Seismology and Plate Tectonics. Cambridge University Press.

Course Title	**:Basic Surveying Techniques and GIS**
Course Code	**:AGSEC-2.1**
Nature of Course	**: Skill Enhancement**
Total Credits	**:** 03credits
Distribution of Marks	**:**60(End-Sem.)+40 (In-Sem.)

COURSE OBJECTIVES: This course is intended to impart knowledge on various field-based techniques of surveying, their principles, history and development, instrument and techniques and their applications.

UNITS	CONTENTS	L	T	P	Total Hours
I **(15 Marks)**	**Principles of Surveying** History of development of surveying, applications of surveying in the field of geography, geology and engineering. Great Trigonometric Survey of India. Concept of Geodetic and Plan Survey: Datum, Control Points, Horizontal and Vertical Controls, Geoid: topo surface, geodetic surface, ellipsoidal surface and its significance in maps, Azimuth and bearing. Triangulation and Traversing.	**12**	**03**		**15**
II **(15 Marks)**	**Surveying and Levelling** Compass, Chain and Plane Table Surveying. Electronic Distance Measurement System. Theodolite and Total Stations. Global Positioning System and its use in surveying. Level, Types of levels and Methods of Levelling: direct method, trigonometrical method, differential leveling, reciprocal method, barometric method Contouring from leveling: triangular intersection method, DEM and DTM. **Applications** Application of surveying in Geological Mapping and Sampling	**12**	**03**		**15**
III **(15 Marks)**	**GIS** Introduction to Coordinate systems: Cartesian Coordinate System, Geographic Coordinate system, Map Projection. Introduction and definitions of GIS, components, application areas of GIS, advantages and disadvantages of GIS Data formats, Raster data model and vector data model. **IKS in Basic Surveying Techniques and GIS** Historical evolution of Indian cartography, Navigation and Astronomy using stars and coastal sketches	**12**	**03**		**15**

IV Practical (15Marks)	Visual Image Interpretation Working with GIS Software. Note Book Viva Voce			**15**	**30**
	Total				**75**

Where, L:Lectures T:Tutorials P:Practicals

MODESOFIN-SEMESTERASSESSMENT: (40Marks)

- **Two Internal Examination- 15+15**
- **Others (Anyone) - 10**
  - **Group Discussion**
  - **Seminar presentation on any of the relevant topics**
  - **Debate**
  - **Home Assignment**

COURSE OUTCOME:
Students will be able to-

CO01: Acquire a comprehensive understanding of the principles and historical development of surveying and its applications.

LO1.1: Describe the history of the development of surveying and its applications in geography, geology, and engineering.

LO1.2: Understand and differentiate between geodetic and plane surveys, including concepts such as datum, control points, and horizontal and vertical controls.

LO1.3: Explain the significance of geoid, topo surface, geodetic surface, and ellipsoidal surface in mapping, and discuss the concepts of azimuth and bearing, triangulation, and traversing.

CO02: Develop practical skills in various surveying and leveling techniques and understand their applications.

LO 2.1: Operate traditional surveying instruments such as compass, chain, and plane table, and understand the basics of electronic distance measurement systems.

LO 2.2: Utilize advanced surveying instruments like theodolites, total stations, and the Global Positioning System (GPS) for accurate measurements.

LO 2.3: Apply different methods of leveling, including direct, trigonometrical, differential, reciprocal, and barometric methods, and use contouring techniques to create Digital Elevation Models (DEM) and Digital Terrain Models (DTM).

CO 03: Gain foundational knowledge and practical skills in Geographic Information Systems (GIS) and their applications.

LO3.1: Understand the basics of coordinate systems,I ncluding Cartesian and

Geographic Coordinate Systems, and the principles of map projection.

LO 3.2: Define GIS, its components, application areas, advantages, and disadvantages, and differentiate between raster and vector data models.

LO3.3: Demonstrate proficiency in visual image interpretation and working with GIS software to analyze spatial data and create maps, supported by practical notebook work and a viva voce.

CO04: Develop practical skills in visual image interpretation and GIS software for spatial data analysis.

LO 4.1: Demonstrate proficiency in visual image interpretation for extracting meaningful information from spatial data.

LO 4.2: Work effectively with GIS software to analyze spatial data, create maps, and present findings in a well-documented notebook, culminating in a viva voce to demonstrate practical knowledge and skills.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	**CO01,CO 02,CO03**	**CO01,CO 02,CO03**	**CO01, CO02, CO03, CO04**			
Conceptual Knowledge		**CO02,CO 03**	**CO02, CO03**	**CO 02, CO03**		
Procedural Knowledge		**CO02,CO 03,CO04**	**CO02, CO03, CO04**			
Metacognitive Knowledge					**CO01,CO 02,CO03, CO04**	

Mapping of Course Outcomes to Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	M	M	M	S	M
CO2	S	S	M	S	S	M
CO3	S	S	S	S	S	M
CO4	M	S	S	M	M	M

Where, S=Strong Correlation and M=Medium Correlation

SUGGESTEDREADINGS:

1. Surveying and Levelling by N.N. Basak.
2. Surveying and Levelling by Rangwala.
3. GIS Fundamentals: A First Text on Geographic Information Systems by Paul Bolstad.

DETAILED SYLLABUS OF 3rd SEMESTER

Title of the Course : **PRINCIPLES OF STRUCTURAL GEOLOGY**
Course Code : **AGC 3.1**
Nature of The Course : **Core**
Total Credits : **04 Credits**
Distribution of Marks :**60 (End Sem) + 40 (In-Sem)**

COURES OBJECTIVES: The primary objective of structural geology is to learner's understanding of the history of deformation in rocks. The deformation of the lithosphere by tectonic forces can be learnt through this subject. Further, this subject helps us to understand the geodynamics in the regional and global scale. Students can acquire knowledge about the structural control on ore localization and landscape evolution are also learnt through this subject. To help students to understand the application of structural geology in the civil engineering geology projects is huge.

UNITS	CONTENTS	L	T	P	Total Hours
I (12marks)	**Geological Structures and Topography:** Topographic and structural maps Importance of scale of the map. **Introduction to Rock Mechanics:** **Introduction to Rock Mechanics:** Concept of rock deformation. Stress and Strain in rocks. Strain ellipses of different types and their significances. Stress at a point: Mohr diagram.	**10**	**2**		**12**
II (16marks)	**Folds, foliation and lineations:** Fold morphology; Geometric and genetic classification of folds; Mechanics and causes of folding: Buckling, Bending and Flexural slip folding. Description and origin of foliations: axial plane cleavage and its tectonic significance. Description and origin of lineation and relationship with the major structures	**13**	**03**		**16**
III (17marks)	**Faults, Joints, shear zones and unconformities:** Geometric and genetic classification of fractures and faults. Effects of faulting on the outcrops. Criteria for recognition of faults. Geometric and genetic classification of joints. Introduction shear zones: significance of mylonite and cataclasites. Unconformities: classification and significance **Orogeny:** Concept of Orogeny and orogenesis. Important Orogenic belts of the world. Structural framework of NE-India, Assam and Assam-Arakan basin. **IKS in Structural Geology:** Descriptions of	**14**	**03**		**17**

	mountains and oceans as interpreted in ancient Indian literature.				
IV **Practical** **(15marks)**	Drawing profile sections and interpretation of geological maps of different complexities. Exercises of stereographic projections of mesoscopic structural data (planar, linear, folded etc.) Solving problems through geometric methods.			**15**	**30**
	Total				**75**

L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- **Two Internal Examination - 2**

  0 + 10
- **Others (Any one) - 5**
  - **Group Discussion**
  - **Seminar presentation on any of the relevant topics**
  - **Debate**
  - **Home Assignment**
- **One practical In-sem 5**

COURSE OUTCOMES:
Students will be able to:

CO 01: Develop a thorough understanding of geological structures, topographic mapping, and rock mechanics, with a focus on stress and strain in rocks.

LO 1.1: Explain the importance of scale in topographic and structural maps and interpret these maps for geological analysis.
LO 1.2: Understand the basic concepts of rock mechanics, including rock deformation, and describe how stress and strain affect rock structures.
LO 1.3: Illustrate the significance of strain ellipses and analyze stress conditions in rocks using the Mohr diagram.

CO 02: Gain knowledge of the morphology, classification, and mechanics of folds, as well as the origin and significance of foliations and lineations.

LO 2.1: Describe fold morphology and classify folds based on geometric and genetic criteria; understand the mechanics and causes of folding, including buckling, bending, and flexural slip folding.
LO 2.2: Explain the description and origin of foliations, particularly axial plane cleavage, and its tectonic significance.
LO 2.3: Describe the origin of lineations and their relationship with major geological structures.

CO 03: Acquire comprehensive knowledge of the classification and significance of faults, joints, shear zones, and unconformities, and understand orogeny and

structural frameworks.

LO 3.1: Classify fractures and faults geometrically and genetically, recognize the effects of faulting on outcrops, and identify criteria for recognizing faults.
LO 3.2: Classify joints geometrically and genetically, and understand the significance of shear zones, including mylonites and cataclasites.
LO 3.3: Explain the concept and significance of unconformities, orogeny, and describe important orogenic belts of the world and the structural framework of NE-India, Assam, and the Assam-Arakan basin.

Co 04: Develop practical skills in drawing profile sections, interpreting geological maps, and solving structural geology problems.

LO 4.1: Draw and interpret profile sections of geological maps of varying complexities.

LO 4.2: Conduct exercises in stereographic projections of mesoscopic structural data, including planar, linear, and folded structures.
LO 4.3: Solve geological problems using geometric methods and interpret the results effectively**.**

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	**CO 01**	**CO 01, CO 02, CO 03**	**CO 01, CO 02, CO 03, CO 04**	**CO 01, CO 02, CO 03, CO 04**		
Conceptual Knowledge		**CO 02, CO 03, CO 04**	**CO 02, CO 03, CO 04**	**CO 02, CO 03, CO 04**		
Procedural Knowledge		**CO 04**	**CO 04**	**CO 04**		
Metacognitive Knowledge					**CO 01, CO 02, CO 03, CO 04**	

Mapping of Course Outcomes to Program Outcomes

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	S	S	M	S	S	M
CO2	S	S	M	S	S	M
CO3	S	S	M	S	S	M
CO4	S	S	S	S	S	M

Where, S= Strong Correlation and M= Medium Correlation

SUGGESTED READING:

1. Pluijm, B. A. V.D., and Marshak, S, 2003. Earth Structure. Second Edition. W.W. Norton and Company. ISBN 0-393-92467-X.
2. Fossen, H. 2010. Structural Geology, Cambridge University Press, ISBN: 978-0-521-51664- 8,
3. Ghosh, S.K., 1993. Structural Geology: Fundamentals and Modern Developments, Pergamon Press, Oxford, p 598.
4. Pollard, D. D. (2005) Fundamental of Structural Geology. Cambridge University Press.

Course Title : **Palaeontology**
Course Code :**AGC3.2**
Nature of Course :**Core**
Total Credits : **04 credits**
Distribution of Marks :**60 (End-Sem.) + 40 (In-Sem.)**

COURSE OBJECTIVES: Palaeontology deals with identification, classification and taxonomic description of past life forms as fossils. It aids in their construction of palaeoenvironment, palaeoclimate, palaeoecology, palaeoceanography and palaeobiogeography. It is an important tool applied for hydrocarbon exploration.

UNITS	CONTENTS	L	T	P	Total Hours
I (15 Marks)	**Introduction to Palaeontology, Fossil Nomenclature and Taxonomy** Palaeontology: definition, branches, scopes and applications. Fossil: definition and types. Process of fossilization. Conditions and modes of preservation. Fossil: Nomenclature, Type specimens, Concept of species, Taxonomy, Taxonomic hierarchy, Binomial system of nomenclature, Naming of genera and species. General principles of Palaeontology: Phylogenetic and Phenetic classification Theory of organic evolution interpreted from fossil records.	**12**	**03**		**15**
II (15 Marks)	**Vertebrate and Invertebrate Fossils** General idea of vertebrate fossils: Origin of vertebrates and their evolution. Mesozoic reptiles with special reference to origin, diversity and extinction of dinosaurs. Evolution of horse and intercontinental migrations. Human evolution. Brief introduction to important invertebrate groups: Brachiopoda, Pelecypoda, Gastropoda, Cephalopoda, Trilobita, Echinoidea, Anthozoa and Foraminifera and their biostratigraphic significance. **Microfossils** Microfossils, what are they? Classification of microfossils	**12**	**03**		**15**
III (15 Marks)	**Palaeobotany** General idea about Palaeobotany, Plant fossils and Palynology. Gondwana Floras of India. **Applied Palaeontology** Biostratigraphy, Biozones and Correlation Application of Fossils for palaeoenvironment analysis, palaeoclimatic interpretation, reconstruction of palaeobiogeography and hydrocarbon exploration. Palaeoecology-fossils as a window to the evolution of ecosystems. **IKS in Paleontology:** Fossils in Indian traditional culture	**12**	**03**		**15**
IV Practical (15Marks)	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. Note Book Viva Voce			**15**	**30**

	Total				75

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- **Two Internal Examination - 20 (T) + 10 (P)**
- **Others (Any one) - 10**
  - **Group Discussion**
  - **Seminar presentation on any of the relevant topics**
  - **Debate**
  - **Home Assignment**

COURSE OUTCOMES:
Students will be able to:

CO 01: Develop a foundational understanding of palaeontology, fossil nomenclature, taxonomy, and the interpretation of organic evolution from fossil records.

LO 1.1: Define palaeontology and explain its branches, scopes, and applications.
LO 1.2: Describe the process of fossilization, conditions, and modes of preservation.
LO 1.3: Explain fossil nomenclature, including type specimens, the concept of species, taxonomy, taxonomic hierarchy, and the binomial system of nomenclature.
LO 1.4: Compare and contrast phylogenetic and phenetic classifications in palaeontology.
LO 1.5: Discuss the theory of organic evolution as interpreted from fossil records.

CO 02: Gain knowledge of vertebrate and invertebrate fossils, their evolution, and their significance in palaeontology.

LO 2.1: Explain the origin and evolution of vertebrates, with a focus on important groups and their evolutionary trends.
LO 2.2: Discuss Mesozoic reptiles, particularly dinosaurs, covering their origin, diversity, and extinction.
LO 2.3: Trace the evolution of the horse and analyze intercontinental migrations in vertebrate evolution.
LO 2.4: Provide a brief introduction to important invertebrate groups such as Brachiopoda, Pelecypoda, Gastropoda, Cephalopoda, Trilobita, Echinoidea, Anthozoa, and Foraminifera, emphasizing their biostratigraphic significance.
LO 2.5: Define microfossils and classify them based on their types.

CO 03: Understand the principles and applications of palaeobotany and applied palaeontology in geological sciences.

LO 3.1: Describe the field of palaeobotany, including plant fossils and palynology.
LO 3.2: Discuss Gondwana Floras of India, focusing on their composition and significance.
LO 3.3: Explain biostratigraphy, biozones, and correlation using fossils.
LO 3.4: Apply fossils for palaeoenvironmental analysis, palaeoclimatic interpretation, reconstruction of palaeobiogeography, and hydrocarbon exploration.
LO 3.5: Explore palaeoecology and how fossils provide insights into the evolution of ecosystems.

CO 04: Acquire practical skills in studying fossils, including modes of preservation, morphological characters, systematic position, and stratigraphic and chronological placement.

LO 4.1: Analyze fossils showing various modes of preservation and their implications for interpretation.
LO 4.2: Identify diagnostic morphological characters of various invertebrate, vertebrate, and plant fossils.
LO 4.3: Determine the systematic position of fossils within taxonomic classifications.

LO 4.4: Establish the stratigraphic position and age of fossils through stratigraphic and chronostratigraphic methods.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	**CO 01, CO 02, CO 03**	**CO 02, CO 03**	**CO 01, CO 02, CO 03, CO 04**	**CO 01, CO 02, CO 03, CO 04**		
Conceptual Knowledge		**CO 01, CO 02, CO 03**	**CO 01, CO 02, CO 03**	**CO 01, CO 02, CO 03, CO 04**		
Procedural Knowledge						
Metacognitive Knowledge					**CO 01, CO 02, CO 03, CO 04**	

Mapping of Course Outcomes to Program Outcomes

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	S	S	M	S	S	M
CO2	S	S	M	S	S	M
CO3	S	S	S	S	S	M
CO4	M	M	S	S	S	S

Where, S= Strong Correlation and M= Medium Correlation

SUGGESTEDREADINGS:

1. Dasgupta A. An Introduction to Palaeontology, World Press.
2. Jain & Anantharaman (2016). Palaeontology, Palaeobiology. Vishal Publishing Co.
3. Benton, M. (2014). Vertebrate Palaeontology 4th Edition.Wiley-Blackwell
4. Raup, D.M., Stanley, S. M., Freeman, W. H.(1971)Principles of Paleontology
5. Clarkson, E. N. K. (2012) Invertebrate paleontology and evolution 4th Edition by Blackwell Publishing.
6. Benton, M.(2009).Vertebrate paleontology. John Wiley & Sons.
7. Shukla, A.C., & Misra, S.P.(1975).Essentials of paleobotany. Vikas Publisher
8. Shrock R. R. and Twenhofel W. H. Principles of Invertebrate Palaeontology, CBS Publishers & Distributors
9. Armstrong, H.A., & Brasier, M.D.(2005) Microfossils. Blackwell Publishing.
10. Kathal P. K., Applied Geological Micropalaeontology: Scientific Publishers, India

11. Nield E.W. and Tucker V.C.T. Palaeontology – An Introduction,Pergamon Press
12. Jain P.C. and Anantharaman M.S. Palaeontology (Palaeobiology) Evolution and Animal Distribution Vishal Publishing Co.

Course Title : **Fundamentals of Petrology**
Course Code : **AGM 3.1**
Nature of Course : **Minor**
Total Credits : **04 credits**
Distribution of Marks :**60 (End-Sem.) + 40 (In-Sem.)**

COURSE OBJECTIVES: The course aims to provide a comprehensive understanding of the origin, composition, structure, and classification of rocks, with a focus on igneous, sedimentary, and metamorphic processes. Students will learn to identify and interpret petrologic features, gaining insights into Earth's geological history and its implications for resource exploration and environmental studies.

UNITS	CONTENTS	L	T	P	Total Hours
I (15 Marks)	**Igneous petrology**: General idea of igneous petrology. Magma & Lava: Definitions, origin and generation of magma, physical properties, composition & chemical properties, types of lava flows. Evolution of Magma, Magmatic differentiation, Mixing and Assimilation. Textures, structures and mode of occurrences of igneous rocks. Classification of Igneous rocks: Textural, mineralogical and chemical. IUGS Classification of igneous rocks.	**12**	**03**		**15**
II (15 Marks)	**Sedimentary petrology:** Origin of Sediments: weathering and erosion, physical and chemical weathering, transportation of sediments by running water, wind, ice, gravity and sea waves. Diagenesis and lithification. Sedimentary textures and structures. Use of textures and structures in interpreting depositional conditions. Sedimentary environments and facies. Classification of sedimentary rocks: textural and genetic classification of clastic and non-clastic sedimentary rocks.	**12**	**03**		**15**
III (15 Marks)	**Metamorphic Petrology:** Metamorphism: definition and controlling factors. Types of metamorphism: contact, regional, fault zone metamorphism, impact metamorphism. Texture and structure of metamorphic rocks. Classification of metamorphic rocks: pelitic, basic, calcic and calc-silicates. Concept of metamorphic zones and facies: Index minerals, Metamorphic zones and isograds. Concept of metamorphic facies and grade. **IKS in Petrology:** Use of different types of rocks for making traditional equipment and monuments, descriptions of rocks and ores in ancient Indian literature	**12**	**03**		**15**

IV Practical (15 Marks)	Study of igneous, sedimentary and metamorphic rocks in hand specimens. Study of igneous, sedimentary and metamorphic rocks in thin section (mineralogy, texture and petrogenesis). Note Book and Viva Voce			**15**	**30**
	Total				**75**

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- **Two Internal Examination - 20 (T) + 10 (P)**
- **Others (Any one) - 10**
  - **Group Discussion**
  - **Seminar presentation on any of the relevant topics**
  - **Debate**
  - **Home assignment**

COURSE OUTCOMES:
Students will be able to:

CO 01: Understand the principles of igneous petrology, including the origin of magma, types of lava flows, magmatic evolution, and the classification of igneous rocks.

LO 1.1: Define magma and lava, and describe their origin and generation processes.
LO 1.2: Explain the physical and chemical properties of magma and lava, and their compositions.
LO 1.3: Discuss the processes of magmatic differentiation, mixing, and assimilation.
LO 1.4: Identify and describe the textures, structures, and occurrences of igneous rocks.
LO 1.5: Classify igneous rocks based on textural, mineralogical, and chemical criteria, following the IUGS classification system.

CO 02: Gain knowledge of sedimentary petrology, covering sediment origin, transportation, diagenesis, lithification, and the classification of sedimentary rocks.

LO 2.1: Explain the origin of sediments through weathering and erosion processes.
LO 2.2: Describe physical and chemical weathering processes and the transportation of sediments by various agents.
LO 2.3: Discuss diagenesis and lithification processes in sedimentary rocks.
LO 2.4: Identify and interpret sedimentary textures and structures and their implications for depositional environments.
LO 2.5: Classify sedimentary rocks based on textural and genetic criteria for both clastic and non-clastic rocks.

CO 03: Understand metamorphic petrology, including the definition of metamorphism, types of metamorphism, texture and structure of metamorphic rocks, and the classification of metamorphic rocks.

LO 3.1: Define metamorphism and identify its controlling factors.
LO 3.2: Differentiate between contact, regional, fault zone, and impact metamorphism.
LO 3.3: Describe the textures and structures characteristic of metamorphic rocks.
LO 3.4: Classify metamorphic rocks into pelitic, basic, calcic, and calc-silicate categories.
LO 3.5: Explain the concept of metamorphic zones, facies, index minerals, metamorphic zones, isograde, and metamorphic grade.

CO 04: Develop practical skills in the identification and study of igneous, sedimentary, and metamorphic rocks using hand specimens and thin sections.

LO 4.1: Identify and describe the characteristics of igneous rocks in hand specimens, including mineralogy, texture, and petrogenesis.
LO 4.2: Analyze sedimentary rocks in hand specimens, interpreting their depositional environments based on texture and structure.
LO 4.3: Study metamorphic rocks in hand specimens, identifying textures, structures, and petrogenetic processes.
LO 4.4: Analyze thin sections of igneous, sedimentary, and metamorphic rocks, describing mineralogy, texture, and petrogenetic features under a microscope.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge		**CO 01, CO 02, CO 03**	**CO 01, CO 02, CO 03, CO 04**	**CO 01, CO 02, CO 03, CO 04**		
Conceptual Knowledge		**CO 01, CO 02, CO 03, CO 04**	**CO 01, CO 02, CO 03**	**CO 01, CO 02, CO 03, CO 04**		
Procedural Knowledge						
Metacognitive Knowledge					**CO 01, CO 02, CO 03, CO 04**	

Mapping of Course Outcomes to Program Outcomes

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	S	S	M	S	S	M
CO2	S	S	M	S	S	M
CO3	S	S	M	S	S	M
CO4	S	S	S	S	S	S

Where, S= Strong Correlation and M= Medium Correlation

SUGGESTEDREADINGS:

1. "Igneous and Metamorphic Petrology" by Myron G. Best
2. "Petrology: Igneous, Sedimentary, and Metamorphic" by Harvey Blatt, Robert J. Tracy, and Brent Owens
3. "Principles of Igneous and Metamorphic Petrology" by John D. Winter
4. "Metamorphic Petrology" by Bruce Yardley
5. Ehlers & Blatt. (1999). Petrology, Igneous, Sedimentary, Metamorphic.

Course Title : **Geo-heritage and Geo-tourism**
Course Code : **AGG 3A**
Nature of Course : **Multi-Disciplinary Generic Elective**
Total Credits : 03 credits
Distribution of Marks :60 (End-Sem.) + 40 (In-Sem.)

COURSE OBJECTIVES: The primary objective of offering the course of Geotourism is to understand the various aspects of Geoheritage sites and their tourism potential.

UNITS	CONTENTS	L	T	P	Total Hours
I (15 Marks)	Introduction and history of geoheritage concept, geoheritage resources, geosites, geodiversity, heritage stone. Geoparks: creation, management and outputs.	**12**	**03**		**15**
II (20 Marks)	Global geoheritage. National Geological Monuments: fossil parks, rock monuments, geological marvels, other monuments. National Geological Monuments/ Geological type- sections in Northeast India.	**16**	**04**		**20**
III (25 Marks)	Definition of geotourism and modern geotourism, scope of geotourism, methods of geotourism, potentiality for a geotourism site The Geotourism Industry in the 21st Century: A futuristic approach; Geotrails. Visit to geotourism sites.	**20**	**05**		**25**
	Total				**60**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- **Two Internal Examination - 15 + 15**
- **Others (Any one) - 10**
  - **Group Discussion**
  - **Seminar presentation on any of the relevant topics**
  - **Debate**
  - **Home Assignment**

COURSE OUTCOMES:
Students will be able to:

CO 01: Understand the concept of geoheritage, geoparks, and their management, including the significance of heritage stones and geodiversity.

LO 1.1: Explain the concept and historical development of geoheritage.
LO 1.2: Identify geoheritage resources and geosites, and describe their importance.
LO 1.3: Define geodiversity and discuss its role in geoheritage conservation.
LO 1.4: Describe heritage stones and their significance in architectural and cultural contexts.
LO 1.5: Outline the creation, management strategies, and outputs of geoparks.

Co 02: Explore global geoheritage and focus on national geological monuments, including their types and significance in Northeast India.

LO 2.1: Analyze global geoheritage sites and their geological significance.
LO 2.2: Identify and classify national geological monuments such as fossil parks, rock monuments, and geological marvels.
LO 2.3: Describe specific geological type-sections and their importance in Northeast India.

LO 2.4: Evaluate the preservation and management strategies of national geological monuments.

CO 03: Define geotourism, explore its scope, methods, and potential for development as a sustainable tourism industry.

LO 3.1: Define geotourism and modern approaches to promoting geological attractions.
LO 3.2: Discuss the scope and potential for geotourism development at various sites.
LO 3.3: Analyze methods used in geotourism to enhance visitor experience and environmental conservation.
LO 3.4: Explore the futuristic approach of the geotourism industry in the 21st century.
LO 3.5: Plan and design geo-trails to facilitate educational and recreational visits to geotourism sites.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	**CO 01, CO 02, CO 03**	**CO 01, CO 02, CO 03**	**CO 01, CO 03**	**CO 02, CO 03**		
Conceptual Knowledge	**CO 01, CO 02, CO 03**		**CO 03**			
Procedural Knowledge						
Metacognitive Knowledge					**CO 01, CO 02, CO 03**	

Mapping of Course Outcomes to Program Outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	S	M	M	S	M
CO2	S	S	M	M	S	M
CO3	M	S	M	M	S	M

Where, S= Strong Correlation and M= Medium Correlation

SUGGESTED READINGS:

1. Geoheritage and Geotourism resources edited by N. Santangeolo and E. Valente
2. Principles of Geotourism by A. Chen, Y. Lu, Young C.Y.NG

Course Title : **Geological Mapping**
Course Code : **AGSEC 3.1**
Nature of Course : **Skill Enhancement Course**
Total Credits : 3 credits
Distribution of Marks : 60 (End-Sem.) + 40 (In-Sem.)

COURSE OBJECTIVES: Geological mapping deals with use of the different instruments and techniques in the field and enhance the skill of understanding the earth through measurement, plotting, sketching, correlating etc.

UNITS	CONTENTS	L	T	P	Total Hours
I (20 Marks)	Geological mapping, Identification and field documentation of primary (scalars and vectors) and secondary structures (linear and planar); Stratigraphic correlation Trend, plunge, Rake/Pitch of geological structures, Stereo plots of linear and planar structures, Orientation analyses	**10**	**05**		**15**
II (20 Marks)	Field work				**45**
III (20 Marks)	Field Report	**10**	**05**		**15**
	Total				**75**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (30 Marks)

- **One Internal Examination - 10**
- **Others (Any one) - 20**
  - **Group Discussion**
  - **Seminar presentation on Field Report**
  - **Viva-voce**

COURSE OUTCOMES:

Syudents will be able to:

CO 01: Develop proficiency in geological mapping techniques and structural analysis, including the identification, documentation, and interpretation of geological structures.

LO 1.1: Perform geological mapping, identifying primary structures (scalars and vectors) and secondary structures (linear and planar).

LO 1.2: Document geological structures in the field, including their orientation, trend, plunge, and rake/pitch.

LO 1.3: Apply stratigraphic correlation techniques to establish relationships between rock units.

LO 1.4: Construct stereo plots of linear and planar structures using field data.

LO 1.5: Analyze orientation data using statistical methods and interpret geological structures.

CO 02: Gain practical experience in conducting fieldwork, applying theoretical knowledge to real-world geological settings.

LO 2.1: Demonstrate proficiency in field techniques for geological mapping and structural analysis.

LO 2.2: Apply fieldwork skills to identify and document geological features and structures accurately.

LO 2.3: Collaborate effectively with peers and instructors during field exercises.

LO 2.4: Practice safety protocols and ethical considerations during fieldwork operations.

CO 03: Develop skills in compiling and presenting comprehensive field reports based on geological fieldwork observations and analyses.

LO 3.1: Compile field observations, measurements, and interpretations into a structured field report.

LO 3.2: Analyze and interpret geological data collected during fieldwork.

LO 3.3: Present findings clearly and concisely, using appropriate terminology and diagrams.

LO 3.4: Incorporate recommendations and conclusions based on field observations and analyses.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge		**CO 01**	**CO 02, CO 03**	**CO 01, CO 02, CO 03**		
Conceptual Knowledge	**CO 01, CO 02, CO 03**	**CO 01, CO 02, CO 03**	**CO 02**			
Procedural Knowledge						
Metacognitive Knowledge					**CO 01, CO 02, CO 03**	

SUGGESTED READINGS:

1. Lahee, F.H. 1916. Field Geology.
2. Compton, R.R, 1985. Geology in the Field.
3. Barnes, J.W. 4th Edition, Basic Geological Mapping.
4. Mathur, S.M (2001). Guide to Field Geology. Prentice Hall India Learning Private Limited.
5. Gokhale, N.W. (2009). A Guide to Field Geology.CBS.

Course Title **: Stratigraphic Principles and Applications**

Course Code **:AGC4.1**

Nature of Course **:Major (Core)**

Total Credits **:** 04 credits

Distribution of Marks **:**60 (End-Sem.) + 40 (In-Sem.)

COURSE DESCRIPTION: The course is designed to:

- Assess rocks and interpret their meaning in the larger context of Earth‟s history.
- Demonstrate in-depth knowledge and understanding of stratigraphic concepts and terminologythrough analysis, classification, and identification
- Gain hands-on laboratory techniques and field experience
- Organize ideas, summarize teachings, and describe findings for academic writing in the EarthSciences

COURSE OBJECTIVES: *The principles of stratigraphy help us to understand the order of superposition of rocks in space and time. Indian stratigraphy helps us to know distribution of different stratigraphic horizons in India and their significances.*

UNITS	CONTENTS	L	T	P	Total Hours
I (12 Marks)	**Principles of Stratigraphy** Principles of stratigraphy: Fundamentals of litho-, bio- and chrono-stratigraphy; Introduction to concepts of dynamic stratigraphy (chemostratigraphy, seismic stratigraphy, sequence stratigraphy).	**08**	**02**		**10**
II (13 Marks)	**Stratigraphic Nomenclature & Laws of Facies** Codes of stratigraphic nomenclature: International Stratigraphic Code - development of a standardized stratigraphic nomenclature. Concepts of Stratotypes. Global Stratotype Section and Point (GSSP). Codes of lithostratigraphy, biostratigraphy, chronostratigraphy, magnetostratigraphy. Principles of stratigraphic analysis. Facies concept in stratigraphy: Walther's Law of Facies. Concept of paleogeographic reconstruction.	**14**	**03**		**17**

III (20 Marks)	**Sequence Stratigraphy** Historic perspective – Evolution, Concepts and principles – Relative sea-level, tectonics and Eustasy – Sediment supply – Sequences and Systems tracts- Seismic Stratigraphy – Recognition of Systems tracts: Outcrop and subsurface data – Sequence stratigraphy of outcrops and subsurface data. Applications of Biostratigraphy and Chronostratigraphy in Sequence Stratigraphy. Paleo-environmental analysis.	**15**	**03**		**18**
IV Practical (15 Marks)	Study of geological map and identification of major stratigraphic units. Construction of Chronostratigraphic charts from seismic data. Drawing various paleogeographic maps. Identification of Systems tract. Note Book and Viva Voce			**15**	**30**
	Total				**75**

Where, ***L: Lectures*** ***T: Tutorials*** ***P: Practicals***

MODES OF IN-SEMESTER ASSESSMENT: (40Marks)

- **Two Internal Examination - 20 (T) +10 (P)**
- **Others (Any one) - 10**
  - **Group Discussion**
  - **Seminar presentation on any of the relevant topics**
  - **Debate**
  - **Home Assignment**

COURSE OUTCOMES (COs)

Student will able to

CO1: Develop a foundational understanding of the principles of stratigraphy.

LO1.1: Describe the basic concepts and methods used in lithostratigraphy, biostratigraphy and chronostratigraphy.

LO1.2: Gain familiarity with dynamic stratigraphic concepts such as chemostratigraphy, seismic stratigraphy and sequence stratigraphy.

CO2: Develop a comprehensive understanding of stratigraphic nomenclature, laws of facies, and principles of stratigraphic analysis.

LO2.1: Interpret and apply codes of stratigraphic nomenclature including the International Stratigraphic Code.

LO2.2: Define and explain the concepts of stratotypes and the Global Stratotype Section and Point (GSSP).

LO2.3: Analyze the codes of lithostratigraphy, biostratigraphy, chronostratigraphy, magnetostratigraphy, and sequence stratigraphy.

LO2.4: Apply the principles of stratigraphic analysis to understand relationships between different facies.

LO2.5: Demonstrate understanding of the concept of paleogeographic reconstruction.

CO3: Develop a comprehensive understanding of the sequence stratigraphy.

LO3.1: Learn the historic perspective – Evolution, Concepts and principles
LO3.2: Explore the effect of Relative sea-level, tectonics and Eustasy – Sediment supply.

LO3.3: Analyze the Paleozoic succession of Kashmir and its correlatives from Spiti and Zanskar.

LO3.4: Evaluate the structures and hydrocarbon potential of Gondwana basins.

LO3.5: Examine the Mesozoic stratigraphy of India, including Triassic, Jurassic, and Cretaceous successions.

LO3.6: Investigate the Cenozoic stratigraphy Siwalik basin and Northeast India and stratigarpgy of Deccan, Rajmahal and Sylhet traps

LO3.7: Explain important stratigraphic boundaries in India

CO4: Develop practical skills in the study.

LO4.1: Gain Proficiency in Interpreting geological maps of India and identify major stratigraphic units.

LO4.2: Analyze hand specimens of rocks collected from various stratigraphic horizons in India.

LO4.3: Draw paleogeographic maps

LO4.4: Study various reconstructions of Proterozoic supercontinents and analyze the assembly and breakup of these supercontinents

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	**CO1**	**CO2**				
Conceptual Knowledge		**CO1, CO3**	**CO2**	**CO2, CO3**	**CO3**	
Procedural Knowledge			**CO4**	**CO4**		
Metacognitive Knowledge						**CO4**

Mapping of Course Outcomes to Program Outcomes

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	S	S	M	S	S	M
CO2	M	S	M	S	S	M
CO3	M	S	M	S	S	M
CO4	S	S	S	S	S	S

SUGGESTED READINGS:

1. Andrew D. Miall. (1990). Principles of Sedimentary Basin Analysis. Springer-Verlag New York.
2. Boggs, S. (Jr). (2016). Principles of Sedimentology and Stratigraphy. Pearson.
3. Doyle, P. & Bennett, M. R. (1996) Unlocking the Stratigraphic Record. John Wiley
4. Kumar, R. (2010). Fundamentals of Historical Geology and Stratigraphy of India. New AgeInternational Publishers Ltd.- New Delhi
5. Valdiya, K. S. (2010). The making of India, Macmillan India Pvt. Ltd.
6. Krishnan M.S. (1982): Geology of India and Burma. 6th Edition. CBS Publishers & DistributorsPrivate Limited. New Delhi.

Course Title : **Sedimentology**
Course Code : **AGC 4.2**
Nature of Course : **Major (core)**
Total Credits : 4 credits
Distribution of Marks : 60 (End-Sem.) + 40 (In-Sem.)

Course Objectives: The Sedimentology course aims to provide students with a fundamental understanding of sedimentary processes, rock classification, and depositional environments. The course aims to develop analytical skills in sediment transport mechanisms, sedimentary textures and structures, and provenance analysis. Additionally, students will gain practical experience in identifying sedimentary rocks, performing grain size analysis, and conducting petrographic studies. By integrating theoretical concepts with hands-on laboratory work, this course prepares students for advanced research and professional careers in geosciences.

UNITS	CONTENTS	L	T	P	Total Hours
I (16 Marks)	➢ Introduction - Overview of sedimentology ➢ Role of weathering in sedimentation: Effect of weathering under different climatic conditions ➢ Simple fluid flow concepts; ➢ Transport of sediment grains; Mechanics of sediment transport and transport laws ➢ Textures of clastic and non-clastic rocks: Grain size parameters and distribution, Grain shape; Grain fabric and packing	**10**	**02**		**12**
II (15 Marks)	➢ Primary and secondary sedimentary structures ➢ Composition and classification of different types of sedimentary rocks and their genetic importance. ➢ Paleocurrent analysis ➢ Heavy minerals study ➢ Provenance analysis	**10**	**03**		**13**
III (14 Marks)	➢ Depositional environments. ➢ Introduction to carbonate rocks. ➢ Major controls on carbonate sedimentation ➢ Petrography: Carbonates and clastic sediments. ➢ Basic concepts of lithification and diagenesis ➢ Introduction to carbon sequestration and CCUS studies	**16**	**04**		**20**
IV (15 Marks)	**Practical** ➢ Study of clastic and non-clastic sedimentary rocks in hand specimen and thin section. ➢ Grain size Analysis ➢ Heavy mineral identification ➢ Viva Voce			**15**	**30**
	Total				**75**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- **One Internal Examination - 20 Marks**

Others (Any one) - 20 Marks

Group Discussion
Assignment
Seminar presentation

Viva-voce

Course Outcomes:

Student will be able to classify sedimentary structures and rock types, conduct paleocurrent and provenance analyses, and interpret their geological significance. Additionally, students will develop an understanding of depositional environments, carbonate sedimentation, lithification, and diagenesis, as well as the role of carbon sequestration in environmental sustainability. Through practical applications, they will gain hands-on experience in sedimentary rock identification, grain size analysis, and heavy mineral studies, equipping them with essential skills for further studies and careers in geology.

CO1: Explain the fundamental concepts of sedimentology, including weathering processes, sediment transport mechanisms, and textural characteristics of sedimentary rocks.

LO1.1: Explain the fundamental principles of sedimentology and its significance in geology.

LO1.2: Describe the role of weathering in sedimentation and how different climatic conditions affect weathering processes.

LO1.3: Apply basic fluid flow concepts to understand sediment grain transport and transport laws.

LO1.4: Differentiate between the textures of clastic and non-clastic rocks, including grain size, shape, fabric, and packing.

CO2: Identify and classify sedimentary structures and rock types, conduct paleocurrent and provenance analysis, and interpret their genetic significance.

LO2.1: Identify primary and secondary sedimentary structures and explain their formation processes.

LO2.2: Classify different types of sedimentary rocks based on composition and genetic significance.

LO2.3: Perform paleocurrent analysis to interpret past depositional environments.

LO2.4: Analyze the composition of heavy minerals and their role in determining sediment provenance.

LO2.5: Explain provenance analysis techniques and their significance in understanding sediment sources.

CO3: Understand depositional environments, carbonate sedimentation, lithification, and diagenesis, along with their impact on sedimentary rock formation.

LO3.1: Describe different types of depositional environments and their characteristic sedimentary features.

LO3.2: Explain the formation and significance of carbonate rocks in sedimentology.

LO3.3: Identify major controls on carbonate sedimentation and how they influence rock formation.

LO3.4: Differentiate between lithification and diagenesis and their roles in sedimentary rock development.

LO3.5: Understand the basic concepts of carbon sequestration and the role of CCUS (Carbon Capture, Utilization, and Storage) in environmental sustainability.

CO4: Develop basic practical skills in sedimentary rock identification, grain size analysis, and heavy mineral studies through laboratory techniques

LO4.1: Identify and differentiate clastic and non-clastic sedimentary rocks using hand specimens and thin sections.

LO4.2: Perform grain size analysis to determine sediment distribution and depositional characteristics.

LO4.3: Identify and analyze heavy minerals in sedimentary rocks to infer provenance and sediment transport history.

Suggested readings:

1. Boggs, Sam (Jr.) 2006: *Principles of Sedimentology and Stratigraphy*, 4th Ed. Pearson/Prentice Hall.
2. Collinson, J. and Mountney, N., 2019. *Sedimentary structures*. Liverpool University Press.
3. Lindholm, R. C. 1980. *A practical approach to Sedimentology.*
4. Miall, A.D., 1990. *Principles of Sedimentary Basin Analysis*, Springer Verlag
5. Nichols, G. 2009: *Sedimentology and Stratigraphy*, 2nd Ed. Wiley-Blackwell
6. Prothero, D.R. and Schwab, F. 2003: *Sedimentary Geology, 2nd edition*. Freeman.
7. Tucker, M.E.: *Sedimentary Petrology- An Introduction*. Blackwell Scientific Publ., Oxford.
8. Reineck, H.E. and Singh, I.B., 2012. *Depositional sedimentary environments: with reference to terrigenous clastics*. Springer Science & Business Media.
9. Reading, H.G. ed., 2009. *Sedimentary environments: processes, facies and stratigraphy*. John Wiley & Sons.
10. Pettijohn, F.J., Potter, P.E. and Siever, R., 2012. *Sand and sandstone*. Springer Science & Business Media.

Title of the Course : **Igneous Petrology**
Course Code : **AGC 4.3**
Nature of the Course : **Major (Core)**
Core Total Credits : **04 Credits**
Distribution of Marks : **60 (End Sem) + 40 (In-Sem)**
Objectives:

- The objective of Igneous petrology as a core subject is to understand the generation and mode of occurrence of igneous rocks.
- In fact, the primary objective is to understand the processes involved in the melting (magma) and the subsequent rise, evolution, crystallisation, eruption and emplacement of rocks.
- It also expands our knowledge about the earth's internal composition and the physical conditions that exists in the interior of the earth.
- It is to be understood that the igneous processes are the most dominant for the segregation of the crust from the mantle and origin of many natural resources.

UNITS	CONTENTS	L	T	P	Total Hours
I (Marks: 15)	**Magma-composition and evolution** Definition of Magma, Constitution of Magmas, Generation of Magmas, source rock composition: upper mantle and lower crust, evolution of magma **Classification of igneous rocks** Classification of magmatic rocks-based on fabric, field relations, mineralogical and modal, and whole rock compositions, IUGS classification of plutonic, hypabyssal and volcanic rocks.	2	1		3
II (Marks: 15)	**Major, minor and trace elements in magma** Application of major and trace elements in petrogenesis, construction of variation diagrams, classification of trace elements, Rare -earth elements and their applications to petrogenesis. **MORB and Subduction related magmatism** Crystallization of basaltic and granitic magmas: Mid oceanic ridge volcanism, continental flood basalts, Deccan basalts, oceanic island arcs.	4	4		8
		6	2		8
		8	4		12
III (Marks: 15)	**Mantle plume, Large Igneous Provinces (LIP)** Heat flow and magma generation: (mantle plume /hot spots; large igneous provinces). Role of fluids in magma generation. Concept of mantle metasomatism. **Association of igneous rocks** Igneous rocks associated with convergent plate boundaries, continental flood basalts, continental alkaline rocks, ophiolite, granites and granitoids, continental rift associations.	4	2		6
		4	4		8
IV (Marks:15) Practical	**Practical** 1. Identification of Igneous rocks in hand specimen 2. Study of the Mineralogy & Textures of Igneous rocks under microscope. 3. Determination of modal composition of igneous rocks.			15	30
					75

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- **Two Internal Examination - 20 + 10**
- **Others (Any one) - 5**
- **Group Discussion**
- **Seminar presentation on any of the relevant topics**
- **Debate**

- **Home Assignment**
- **One practical In-sem- 5**

Course description

Igneous Petrology deals with the magmatism in regard to origin, ascent and emplacement and its association in relation to diverse tectonic settings. It also deals with the thermodynamics of magmatic crystallization, phase equilibrium, interpretation of textures in terms of rate of nucleation and crystal growth. It further deals with the generation of large igneous bodies in terms of space and time. In addition to, petrology and petrogenesis of major igneous rock types are also discussed. It also describes the plume magmatism and hot spots.

Course delivery

The course is delivered through a series of teaching modules and makes students accustomed with the common igneous suits, evolutionary trends. Further, characteristics for classification and description of common igneous rocks in the field and in thin sections are also emphasized.

COURSE OUTCOMES (COs)

Student will able to

CO1: Develop a comprehensive understanding of igneous petrology

LO1.1: Explain the general concepts of igneous petrology and the principles of heat flow and geothermal gradients.

LO1.2: Describe the origin and generation of magma.

LO1.3: Analyze the physical and chemical properties of magma and lava.

LO1.4: Classify magma and lava based on physical and chemical contents.

LO1.5: Understand the source rock composition of magmas from the upper mantle and lower crust.

CO2: Develop a thorough understanding of thermodynamic principles in igneous petrology and the processes involved in the evolution and differentiation of magma.

LO2.1: Explain the basic thermodynamic concepts including state functions, intensive and extensive variables, and the laws of thermodynamics.

LO2.2: Understand the concept of components, phases, phase equilibrium, degrees of freedom, and the phase rule for open and closed systems.

LO2.3: Interpret phase diagrams of one, two, and three-component systems and understand congruent and incongruent melting.

LO2.4: Analyze the principles of magma evolution, including magmatic differentiation, mixing, and assimilation.

LO2.5: Examine the role of volatiles in magma, and understand concepts like rock association, petrographic province, and variation diagrams.

LO2.6: Understand the relationship between igneous rocks and continental margins.

CO3: Gain an in-depth understanding of the textures, structures, and classifications igneous rocks

LO3.1: Identify and describe the textures, structures, and modes of occurrences of igneous rocks.

LO3.2: Classify igneous rocks based on textural, mineralogical, and chemical criteria,

LO3.3: Understand magmatism in different tectonic settings

LO3.4: Explain the petrogenesis of felsic and mafic igneous rocks

LO3.5: Analyze the geological significance and formation processes of the Sylhet Traps and Abor Volcanics.

CO4: Develop practical skills in the study and analysis of igneous rocks through hands-on examination of hand specimens and thin sections

LO4.1: Learn to Identify and describe igneous rocks in hand specimens.

LO4.2 : Analyze the mineralogy, texture, structure, and petrogenesis of igneous rocks in thin sections.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	**CO1, CO2**	**CO1**				
Conceptual Knowledge		**CO2, CO3**		**CO2, CO3**		
Procedural Knowledge			**CO4**			
Metacognitive Knowledge				**CO4**		

Mapping of Course Outcomes to Program Outcomes

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	S	S	M	S	S	M
CO2	S	S	M	S	S	M
CO3	S	S	M	S	S	M
CO4	S	S	S	S	S	S

Suggested readings

1. Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson.
2. Rollinson, H. R. (2014). Using geochemical data: evaluation, presentation, interpretation. Routledge.
3. Raymond, L. A. (2002). Petrology: the study of igneous, sedimentary, and metamorphic rocks. McGraw-Hill Science Engineering.

4. McBirney, A. R. (1984). Igneous Petrology. San Francisco (Freeman, Cooper & Company) and Oxford (Oxford Univ. Press).
5. Myron G. Best (2001). Igneous and Metamorphic Petrology.
6. K. G. Cox, J. D. Bell. (1979). The Interpretation of Igneous Rocks. Springer/Chapman & Hall.
7. Bose M.K. (1997). Igneous Petrology.
8. G W Tyrrell. (1926). Principles of Petrology. Springer
9. Philpotts, A., & Ague, J. (2009). Principles of igneous and metamorphic petrology. Cambridge University Press.

Course Title : **Thermodynamics and Geochemistry**
Course Code : **AGC- 4.4**
Nature of Course : **Major (Core)**
Total Credits : 04 credits
Distribution of Marks : 60 (End-Sem.) + 40 (In-Sem.)

COURSE OBJECTIVES:
Thermodynamics is an important component in igneous and metamorphic petrology that can be considered as chemical systems. Understanding thermodynamic laws, properties, phase rules, and phase diagrams, as well as trace element fractionation is essential for comprehending both igneous and metamorphic petrology. These concepts are essential for studying their petrogenesis, geothermometry and geobarometry. The course is framed in such a way to make the students understand the thermodynamic properties, different laws and their applications in different fields of petrology.

UNITS	CONTENTS	L	T	P	Total Hours
I (20 Marks)	**Thermodynamics** Introduction to thermodynamics: Fundamental thermodynamic equations: 1st, 2nd and 3rd laws, Gibbs free energy, Chemical potential, partial molar properties, standard states, activities, fugacities. The phase rule – one, two and three component systems and their significance in petrogenesis. Free energy and phase equilibria: Concept of Equilibrium, Gibbs – Duhem Equation, Free energy of formation at any temperature and pressure, Free energy surface at Gibbs Free energy, PT-space, Plotting of univariant lines in P.T. diagrams. Solutions: Introduction, Ideal and Non- ideal solutions, Dilute solution and Henry's law, Range of applicability of Henry's law, Duhem – Margule's Equation for binary solution. Trace components as monitors of igneous rocks.	18	02		**20**
II (25 Marks)	**Geochemistry** Geochemical classifications, The atomic nucleus and isotopes. Major and minor element geochemistry: Basics, Methods for analysis, Major and minor elements in the crust, Normative minerals, Variation diagrams. Trace element geochemistry: Basics, Element distribution, The rare earth elements: a special group of trace elements, Isotopes: radioactive & stable. Geochemistry of igneous, sedimentary and metamorphic rocks. Petroleum Geochemistry: Carbon cycle, origin composition and structure of organic matter.	22	03		**25**

III Practical (15 Marks)	1. Sample preparation techniques 2. CIPW Normative calculations 3. Interpretation of Geochemical major element data using Tri-linear, Harker type variation diagrams 4. Interpretation of REE data **Notebook**			**15**	**30**
Total					**75**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- **Two Internal Examination - 15 + 15**
- Others (Any one) - 10
  - Group Discussion
  - Seminar presentation on any of the relevant topics
  - Debate
  - Home Assignment

COURSE OUTCOMES (COs):
Student will be able to: -

CO1: Apply fundamental thermodynamic equations to geochemical systems
LO1.1: Define and explain the 1st, 2nd, and 3rd laws of thermodynamics.
LO1.2: Derive and apply the Gibbs free energy equation to geochemical systems.
LO1.3: Explain the concept of chemical potential and its relationship to Gibbs free energy.
LO1.4: Calculate partial molar properties and standard states in geochemical systems.

CO2: Analyze phase equilibria using thermodynamic principles
LO2.1: Explain the concept of equilibrium and the Gibbs-Duhem equation.
LO2.2: Calculate the free energy of formation at any temperature and pressure.
LO2.3: Plot univariant lines in P.T. diagrams and interpret their significance.
LO2.4: Apply the phase rule to one, two, and three-component systems.

CO3: Evaluate the behavior of solutions in geochemical systems
LO3.1: Define and explain ideal and non-ideal solutions.
LO3.2: Apply Henry's law to dilute solutions and explain its range of applicability.
LO3.3: Derive and apply the Duhem-Margules equation for binary solutions.
LO3.4: Analyze the behavior of trace components in igneous rocks.

CO4: Apply thermodynamic principles to geochemical problems
LO4.1: Apply Gibbs free energy calculations to predict phase equilibria in geochemical systems.
LO4.2: Use the phase rule to predict the behavior of multi-component systems.
LO4.3: Analyze the thermodynamic properties of solutions in geochemical systems.
LO4.4: Evaluate the significance of thermodynamic principles in understanding geochemical processes.

CO5: Understand the fundamental principles of geochemistry
LO5.1: Explain the structure of the periodic table and its relevance to geochemistry.
LO5.2: Describe the different types of chemical bonding and their significance in geochemical processes.
LO5.3: Define and explain geochemical classifications and their application in understanding Earth's composition.
LO5.4: Discuss the concept of isotopes and their importance in geochemistry.

CO6: Apply major and minor element geochemistry to understand Earth's composition
LO6.1: Explain the basics of major and minor element geochemistry and their methods of analysis.
LO6.2: Describe the distribution of major and minor elements in the Earth's crust.
LO6.3: Apply normative mineral calculations to understand the composition of rocks.
LO6.4: Interpret variation diagrams to understand geochemical processes and trends.

CO7: Analyze trace element geochemistry and its applications
LO7.1: Explain the basics of trace element geochemistry and their distribution in different geological environments.
LO7.2: Describe the unique characteristics of rare earth elements and their significance in geochemistry.
LO7.3: Discuss the principles of radioactive and stable isotopes and their applications in geochemistry.
LO7.4: Apply trace element geochemistry to understand geological processes and solve problems.

CO8: Apply geochemical principles to petrology and petroleum geochemistry
LO8.1: Explain the chemical composition of magmas and igneous rocks and their variation diagrams.
LO8.2: Describe the geochemical processes involved in sedimentation and the composition of sedimentary rocks.
LO8.3: Discuss the principles of petroleum geochemistry, including the carbon cycle and origin of organic matter.
LO8.4: Apply geochemical methods to characterize source rocks and assess their maturation.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	**CO 01, CO 02, CO 04**	**CO 02, CO 03**	**CO 05**			
Conceptual Knowledge		**CO 02, CO 03, CO 05**	**CO 05**	**CO 03, CO 04, CO 06**	**CO 07**	
Procedural Knowledge		**CO 04**	**CO 05**	**CO 07**		
Metacognitive Knowledge						

Mapping of Course Outcomes to Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	S	M	M	S	S	M
CO2	S	M	M	S	S	M
CO3	S	M	M	S	S	M
CO4	S	M	M	S	S	M
CO5	M	S	M	S	S	M
CO6	S	M	M	S	S	M
CO7	M	S	M	S	S	M
CO8	S	M	M	S	S	M

Where, S= Strong Correlation and M= Medium Correlation

SUGGESTED READINGS

- Wood, B.J. and Fraser, D.G., Elementary Thermodynamics for Geologists, Oxford University Press, 1976.
- Lakhenpal, M.L., Fundamentals of Chemical Thermodynamics, Tata McGraw-Hill Publishing

Company Limited, New Delhi, 1983.
- Best, M.G., Igneous and Metamorphic Petrology, CBS Publishers & Distributors, New Delhi, 1986.
- Rao, B., Metamorphic Petrology, IBH Publishing Company Pvt. Ltd., New Delhi, Bombay & Calcutta, 1986.
- Tunner, F.J. & Verhoogen, J., Igneous and Metamorphic Petrology, McGraw-Hill Book Company, INC Yew York, 1960.
- Philpotts A.R., Principles of Igneous and Metamorphic Petrology, Prentice Hall India Pvt. Ltd., New Delhi, 1994.
- Ernst, W.G., Petrologic Phase Equilibria, W.H. Freeman & Company, San Francisco, 1976.
- Mason B., Moore C.B. (1982): Principles of geochemistry 4th edition.
- Rollinson H.R. (1993): Using Geochemical Data.
- Konard B.K. (1979): Introduction to Geochemistry, 2nd edition. McGraw Hill

White W.M. (2009): Geochemistry.

Title of the Course : STRUCTURAL GEOLOGY AND TECTONICS
Course Code : AGM4.1
Nature of The Course : Minor
Core Total Credits : 04 Credits
Distribution of Marks : 60 (End Sem) + 40 (In-Sem)

Objectives:

- The objective of structural geology as a minor subject is to understand the deformation in rocks through the mesoscopic, regional and continental scale.
- The deformation of the lithosphere by tectonic forces can be learnt through this subject. Further, this subject helps us to understand and appreciate the geodynamics in the regional and global scale.
- The subject helps us to understand the controls of rock-structures on ore entrapment are crucial.
- Further, an understanding on structural controls on landscape evolution can also be developed through this subject. Structural geology has a pivotal role in the engineering geology projects.

UNITS	CONTENTS	L	T	P	Total Hours
1 (Marks: 12)	**Topography and geological structures** Effects of structural features on topography, topographic and structural maps. **Deformation of rocks** Concept of stress and strain. Ductile and brittle behavior of rocks; Stress-strain relationships; Theory of rock failures.	8	4		12
2 (Marks: 17)	**Folds: classification and mechanics** Definition. Classification of folds: Geometric, morphological and genetic. Mechanics of folding. **Fractures, faults and shear zones** Geometric and genetic classification of fractures and faults. Criteria for recognition of faults. Mechanics of faulting. Joints: classification and origin. Shear zones and their significance in crustal evolution	12	05		17
3 (Marks:16)	**Foliations, lineations & Unconformities** Definition and Classification of foliations and lineations. Classification of unconformities. Distinguishing characteristics of fault and unconformity. **Plate Tectonics &Tectonics of NE India** Theory of the Plate Tectonics, Plate Boundaries, Mechanics of Plate Movement, Island arc System. Structural framework of NE India with special emphasis on eastern Himalaya, Assam and Assam-Arakan Fold belt.	10	06		16
8 (Marks:15)	**Practical** Preparation of cross sections and interpretations of geological maps representing different structural settings. Completion of outcrops in a map: three- point problems. Geometric solution of problems involving inclined strata.			15	30
					75

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- **Two Internal Examination - 20 + 10**
- **Others (Any one) - 5**
- **Group Discussion**
- **Seminar presentation on any of the relevant topics**
- **Debate**
- **Home Assignment**
- **One practical In-sem- 5**

COURSE DESCRIPTION: This course "Structural Geology and Tectonics" is design to provide knowledge to be proficient in analyzing rock deformations, understanding the mechanics of tectonic processes, and interpreting geological structures. The course deals with application of structural geology principles to geological mapping, resource exploration, and assessing geohazards, preparing students for careers in geosciences and related fields.

COURSE OUTCOMES (COs)

Student will be able to

CO1: Attain a fundamental understanding of topography, structures, stress, and strain in rocks, including their effects and relationships.

LO1.1: Understand the effects of topography on structural features and interpret topographic and structural maps.
LO1.2: Define stress and strain in rocks and differentiate between ductile and brittle behavior.
LO1.3: Explain stress-strain relationships and interpret Mohr diagrams for stress.

CO2: Develop a comprehensive understanding of deformation and structural features in rocks, including folds, joints, faults, shear zones, foliations, and lineations.

LO2.1: Define folds, classify them, and explain the mechanisms of folding.
LO2.2: Define joints and faults, classify them, and describe their mechanisms.
LO2.3: Define shear zones, classify them, and explain their significance.
LO2.4: Define foliations and lineations, classify them, and explain their origins.

CO3: Attain a comprehensive understanding of geodynamics and tectonics

LO3.1: Describe the internal structures of the Earth and explain the seismic shadow zone.
LO3.2: Explain the theory of plate tectonics and identify different types of plate boundaries.
LO3.3: Analyze the mechanics of plate movement and the formation of island arc systems.
LO3.4: Understand the structural framework of Northeast India.

CO4: Develop proficiency in geological mapping, interpretation of geological profiles, stereographic projections of structural data, and problem-solving using geometric methods.

LO4.1: Interpret geological maps of varying complexities and draw profile sections.
LO4.2: Perform stereographic projections of mesoscopic structural data.
LO4.3: Solve geological problems using geometric methods.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	**CO1, CO2**	**CO3**				
Conceptual Knowledge		**CO1, CO2,**		**CO1, CO2**		
Procedural Knowledge			**CO4**	**CO3**		
Metacognitive Knowledge				**CO4**		**CO4**

Mapping of Course Outcomes to Program Outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	S	S	M	S	S	M
CO2	S	S	M	S	S	M
CO3	M	S	M	S	S	M
CO4	S	S	S	S	S	S

Suggested readings

1. Fossen, H. 2010. Structural Geology, Cambridge University Press, ISBN: 978-0-521-51664-8,
2. Pluijm, B. A. V.D., and Marshak, S, 2003. Earth Structure. Second Edition. W.W. Norton and Company. ISBN 0-393-92467-X.
3. Ramsay, J. G., 1967. Folding and fracturing of rocks. McGraw-Hill, New York
4. Ramsay, J.G., and Huber, M.I., 1983. The techniques of modern structural geology, Vol.1, Strain Analysis. Academic Press, pp.1-308.
5. Ghosh, S.K., 1993. Structural Geology: Fundamentals and Modern Developments, Pergamon Press, Oxford, p 598.
6. Passchier, C. W., and Trouw, R. A. J., 2005. Microtectonics, 2nd Edn., Springer Verlag, Berlin.
7. Pollard, D. D. (2005) Fundamental of Structural Geology. Cambridge University Press.

Course Title **: Economic Geology**
Course Code **: AGC 5.1**
Nature of Course **: Major (Core)**
Total Credits **:** 04 credits
Distribution of Marks **:**60 (End-Sem.) + 40 (In-Sem.)

COURSE OBJECTIVES:

The subject Economic geology provides an intimate knowledge of the country's mineral wealth in relation to its industrial applicability. The main objective of this paper is to introduce the students with the mode of formation and occurrence of deposits of useful minerals and rocks having an economic value and importance. It also helps to conveniently explore the deposits and make their economic use. The paper also details with the National Mineral policy of India.

UNITS	CONTENTS	L	T	P	Total Hours
I (12 Marks)	**Principles of Economic geology**: Definition of ore, ore minerals, gangue and tenor Morphology of mineral deposit Global Tectonics and metallogeny Controls on ore localization Processes of formation of Mineral deposits.	**07**			**07**
II (15 Marks)	**Types of Mineral Deposits :** Classification of mineral deposits. Introduction to various types of ore deposits in specific rock associations : Orthomagmatic deposits of chromium and platinum inbasic and ultrabasic rocks. Diamond deposits in Kimberlites and lamproites. Pegmatitic deposits. Carbonatite and skarn deposits. Magmatic hydrothermal deposits of porphyry copper-gold, tin-tungsten. Sedimentary deposits. Residual and Supergene deposits. SedEx : Sedimentary Exgalative IOCG : Iron Oxide Copper Gold VHS : Volcanogenic Massive Sulphide VHMS: Volcanic Hosted Massive Sulphide	**18**			**18**

III (18 Marks)	**Mineral Deposits of India :** Origin, occurrence and distribution in India and uses of the economic minerals/ores of Aluminium, chromium, copper, gold, lead, zinc, iron, manganese and atomic minerals. Deposits of minerals used as abrasives, refractories and in ceramics, cement, fertilizer, glass industries and their occurrences. **National Mineral Policy:** National Mineral Policy. Strategic, Essential and Critical minerals of India. Conservation and Utilization of mineral resources MMDR: Mines and Minerals Development & Regulation Act NMET: National Mineral Exploration Trust DMF: District Mineral Foundation	**20**			**20**
IV Practical (15 Marks)	Economic Mineral Identification, Industrial Mineral assemblage, Ore Reserve Estimation, Note book and Viva-voce			**15**	**30**
	Total				**75**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- **Two Internal Examination - 15 + 15**
- **Others (Any one) - 10**
  - **Group Discussion**
  - **Seminar presentation on any of the relevant topics**
  - **Debate**
  - **Home Assignment**

COURSE OUTCOME:

On completion of this Course, a student will be able to

CO 01: Understand the Origin, Occurrence, and Distribution of Economic Minerals in India

LO 1.1: Describe the geological processes involved in the formation of economic minerals/ores like aluminium, chromium, copper, gold, lead, zinc, iron, manganese, and atomic minerals.

LO 1.2: Identify the major mining regions in India for each of these minerals.

LO 1.3: Explain the uses of these minerals in various industries.

CO 02: Comprehend the Principles of Economic Geology

LO 2.1: Define key terms such as ore, ore minerals, gangue, and tenor.

LO 2.2: Understand the morphology of mineral deposits and their global tectonic and metallogenic controls.

LO 2.3: Describe the processes of mineral deposit formation and the factors controlling ore localization.

CO 03: Understand and Apply the National Mineral Policy and Related Acts

LO 3.1: Explain the objectives and key components of the National Mineral Policy.

LO 3.2: Discuss the strategic, essential, and critical minerals of India and the strategies for their conservation and utilization.

LO 3.3: Understand the provisions of the Mines and Minerals Development & Regulation Act (MMDR), the role of the National Mineral Exploration Trust (NMET), and the District Mineral Foundation (DMF).

CO 04: Classify and Describe Various Types of Mineral Deposits

LO 4.1: Classify mineral deposits based on their genesis and rock associations.

LO 4.2: Describe the characteristics of orthomagmatic deposits of chromium and platinum in basic and ultrabasic rocks, diamond deposits in kimberlites and lamproites, and pegmatitic deposits.

LO 4.3: Explain the formation of carbonatite, skarn, magmatic hydrothermal deposits of porphyry copper-gold, tin-tungsten, and various sedimentary, residual, and supergene deposits.

CO 05: Understand the Economic and Industrial Importance of Specific Mineral Deposits

LO 5.1: Identify the types of mineral deposits used in abrasives, refractories, ceramics, cement, fertilizer, and glass industries.

LO 5.2: Explain the geological conditions and locations where these mineral deposits occur in India.

LO 5.3: Discuss the economic and industrial significance of these minerals and their impact on various industries.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	**CO1, CO3,**	**CO2,**				
Conceptual Knowledge	**CO4**	**CO1, CO2, CO3, CO5**	**CO4**	**CO2, CO5**	**CO4, CO5**	
Procedural Knowledge		**CO3, CO5**	**CO3, CO5**			
Metacognitive Knowledge						

Mapping of Course Outcomes to Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	S	S	M	S	S	M
CO2	S	S	S	S	S	M

CO3	M	M	M	S	S	M
CO4	S	S	M	S	S	M
CO5	S	M	M	S	S	S

Where, S= Strong Correlation and M= Medium Correlation

SUGGESTED READINGS

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

Course Title Course **:Indian Stratigraphy and Geology of North East: India**
Code Nature of **:AGC5.2**
Course Total Credits **:Major (Core)**
Distribution of **:**04 credits
Marks **:**60 (End-Sem.)+40(In-Sem.)

COURSEDESCRIPTION: The course is design to:

- Assess rocks and interpret their meaning in the larger context of Earth's history.
- Demonstrate in-depth knowledge and understanding of stratigraphic concepts and terminology through analysis, classification, and identification
- Gain hands-on laboratory techniques and field experience
- Organize ideas, summarize teachings, and describe findings for academic writing in the Earth Sciences

COURSE OBJECTIVES: *Indian stratigraphy helps us to know distribution of different stratigraphic horizons in India and their significances.*
Geology of NE India aims to impart the knowledge about the Geology of the North east India, its physiographical and stratigraphical overview, understanding of the different geological features, occurrences of different economic minerals, seismic and flood associated hazards and disasters.

UNITS	CONTENTS	L	T	P	Total Hours
I (25Marks)	**Stratigraphy of India** Physiographic and tectonic subdivisions of India. Introduction to Indian Shield. Introduction to Proterozoic basins of India. Geology of Vindhyan and Cudappah basins of India. Paleozoic Succession of Kashmir and its correlatives from Spiti and Zanskar Stratigraphy. Stratigraphy of Gondwana basins in peninsular and extra peninsular India. Mesozoic stratigraphy of India: Triassic successions of Spiti, Jurassic of Kutch, Cretaceous, successions of Cauvery basins, Mesozoic rocks of NE India. Cenozoic stratigraphy of Siwalik basin and NE-India. Stratigraphy of Deccan, Rajmahal and Sylhet Traps. Stratigraphic boundaries: Important Stratigraphic boundaries in India- Precambrian-Cambrian boundary, Permian-Triassic boundary and Cretaceous-Paleogene boundary.	**22**	**03**		**25**
II (10 Marks)	Physiography of North-East India: Brahmaputra Plain, Sikkim-Arunachal Himalaya, Mishmi Hills, Naga-Patkai Range, Manipur Plain, Tripura-Cachar Fold Belt, Meghalaya Plateau and Mikir Hills. Tectonic framework of North-East India and its control in physiographical development.	**07**	**03**		**10**

III (10 Marks)	Stratigraphical units of North-East India: Sikkim and Arunachal Himalayas, Ophiolite Suite of Nagaland – Manipur. Cretaceous and Cenozoic stratigraphy of different physiographic divisions of Northeast India, Quaternary stratigraphy of NE India.	**07**	**03**		**10**
IV Practical (15Marks)	Study of geological maps of India Study of geological structures of important oil fields of North-East India Study of tectonic map of different areas of North-East India			15	30
					75

Where, ***L:Lectures*** ***T: Tutorials*** ***P:Practicals***

MODESOF IN-SEMESTER ASSESSMENT: (40Marks)

- **Two Internal Examination-20(T)+10 (P)**
- **Others(Anyone) -10**
  - **Group Discussion**
  - **Seminar presentation on any of the relevant topics**
  - **Debate**
  - **Home Assignment**

COURSE OUTCOMES(COs)

Student will able to

CO1: Develop a foundational understanding of the principles of stratigraphy.

LO1.1:Describe the basic concepts and methods used inl ithostratigraphy, biostratigraphy and chronostratigraphy.

LO1.2:Gain familiarity with dynamic stratigraphic concepts such as chemostratigraphy, seismic stratigraphy and sequence stratigraphy.

CO2: Develop a comprehensive understanding of stratigraphic nomenclature, laws of facies, and principles of stratigraphic analysis.

LO2.1:Interpret and apply codes of stratigraphic nomenclature including the International Stratigraphic Code.

LO2.2:Define and explain the concepts of stratotypes and the Global Stratotype Section and Point (GSSP).

LO2.3:Analyze the codes of lithostratigraphy,biostratigraphy,chronostratigraphy, magnetostratigraphy, and sequence stratigraphy.

LO2.4:Apply the principles of stratigraphic analysis to understand relationships between different facies.

LO2.5:Demonstrate understanding of the concept of paleogeographic reconstruction.

CO3:Develop a comprehensive understanding of the stratigraphy of India.

LO3.1:Identify and describe the physiographic and tectonic subdivisions of India.

LO3.2:Explore the geological characteristics of the Indian Shield and Proterozoic basins.

LO3.3: Analyze the Paleozoic succession of Kashmir and its correlatives from Spiti and Zanskar.

LO3.4:Evaluate the structures and hydrocarbon potential of Gondwana basins.

LO3.5: Examine the Mesozoic stratigraphy of India, including Triassic, Jurassic, and Cretaceous successions.

LO3.6: Investigate the Cenozoic stratigraphy Siwalik basin and Northeast India and stratigarphy of Deccan, Rajmahal and Sylhet traps

LO3.7:Explain important stratigraphic boundaries in India

CO4:Develop practical skills in the study.

LO4.1:Gain Proficiency in Interpreting geological maps of India and identify major stratigraphic units.

LO4.2:Analyze hand specimens of rocks collected from various stratigraphic horizons in India.

LO4.3:Draw paleogeographic maps

LO4.4:Study various reconstructions of Proterozoic supercontinents and analyze the assembly and breakup of these supercontinents

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	**CO1**	**CO2**				
Conceptual Knowledge		**CO1, CO3**	**CO2**	**CO2, CO3**	**CO3**	
Procedural Knowledge			**CO4**	**CO4**		
Metacognitive Knowledge						**CO4**

Mapping of Course Outcomes to Program Outcomes

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	S	S	M	S	S	M
CO2	M	S	M	S	S	M

CO3	M	S	M	S	S	M
CO4	S	S	S	S	S	S

COURSEOUT COMES(COs):

Students will beable to-

CO01:Master the Physiographical Characteristics of North-East India

LO1.1: Identify and describe the key physiographic units of North-East India, such as the Brahmaputra Plain, Sikkim-Arunachal Himalaya, and Meghalaya Plateau.

LO1.2: Explain the major drainage systems of North-East India and their geographical significance.

LO1.3:Analyze how the tectonic framework influences the physiographical development of the region.

CO02:Understand the Stratigraphical Layers and Historical Geology of North-East India

LO2.1:Identify and explain the stratigraphical unitsof North-East India from the Archean to the Recent-Quaternary periods.

LO2.2: Discuss the geological characteristics and significance of formations such as the Lower Gondwana Group and Cretaceous Alkaline-Carbonatite complexes.

LO2.3:Evaluate the distribution and composition of Tertiary and Quaternary sediments in North-East India.

CO 03: Analyze the Major Geological Features and Tectonic Structures of North-EastIndia

LO3.1: Describe the processes and outcomes of the Indo-Eurasian and Indo-Myanmar collisions and accretions.

LO3.2:Identify major faults and thrusts such as the ITSZ, MCT,MBT,and Naga-Patkai Range and explain their geological significance.

LO3.3:Assess the impact of tectonic features like the Eastern Himalayan Syntaxis, Po-Chu Fault, and Lohit Thrust on the regional geology.

CO04:Develop Practical Skills in Geological Mapping and Structural Analysis

LO4.1:Interpret geological maps of North-East India to identify key geological features.

LO4.2:Analyze geological structures of important oilfields in Assam through practical exercises.

LO4.3: Utilize tectonic maps to understand the geological structures and fault systems in different areas of North-East India.

CO05:Enhance Research and Analytical Skills in Regional Geology

LO5.1:Conduct detailed research projects on specific geological aspects of North-East India.

LO5.2: Present research findings clearly and accurately, using appropriate geological terminology and data visualization techniques.

LO5.3: Critically evaluate geological data from multiple sources to draw comprehensive and informed conclusions about the region's geology.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remembe r	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	CO1	CO2				
Conceptual Knowledge	CO3	CO1, CO4	CO2	CO1, CO4		

ProceduralKnowledge			CO3, CO4, CO5	CO3	CO2, CO5	
Metacognitive Knowledge					CO5	

Mappingof CourseOutcomesto Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	M	M	S	S	M
CO2	S	S	M	S	S	M
CO3	S	S	S	S	S	S
CO4	S	S	S	S	M	S
CO5	M	M	M	S	S	S

SUGGESTED READINGS:

1. Andrew D.Miall.(1990). Principles of Sedimentary Basin Analysis. Springer-Verlag New York.
2. Boggs,S.(Jr).(2016).Principles of Sedimentology and Stratigraphy. Pearson.
3. Doyle,P.& Bennett, M.R.(1996)Unlocking the Stratigraphic Record. JohnWiley
4. Kumar,R.(2010).Fundamentals of Historical Geology and Stratigraphy of India. New Age International Publishers Ltd.-New Delhi
5. Ramakrishnan, M. &Vaidyanadhan, R. (2008) Geology of India Volumes1&2, GeologicalSocietyofIndia, Bangalore.
6. Valdiya,K.S.(2010).The making of India, Macmillan India Pvt.Ltd.
7. Krishnan M.S.(1982):Geology of India and Burma. 6thEdition.CBS Publishers & Distributors Private Limited. New Delhi.
8. Geologyof Arunachal Pradesh by GopendraKumar.
9. Geologyof Assam by A.K. Biswas and A.B. Dasgupta.
10. Geodynamics of North East India and adjoining regions ByD.R.Nandy

Course Title : **Geomorphology**
Course Code : **AGC- 5.3**
Nature of Course : **Major (Core)**
Total Credits : **04 credits**
Distribution of Marks : **60 (End-Sem.) + 40 (In-Sem.)**

COURSE OBJECTIVE: Geomorphology is the study of surface features of earth's surfaces, description of landforms, their origin, development and the processes that caused their development. The main objective of the course is to introduce students to basic concepts of landforms and the processes that produce and modify them. The main aim of the course is the understanding of natural processes, the mechanics of geomorphic processes and the relationships between properties of earth materials and the forces applied to them by gravity, wind, ice, water, waves and humans.

Unit	Topic	L	T	P	Total Hours
I (12 marks)	Basic concept of Geomorphology, Endogenic and Exogenic processes, Geomorphic cycle. Control of geomorphological features by geological structure, lithology & Climate. Physical, chemical, and biological processes in weathering, Soil profiles and nomenclature of horizons, Classification of soils, Role of soil in geomorphology. Mass movement and hillslope evolution, Classification of mass movements.	10	02		12
II (20 marks)	Fluvial system, drainage basin and networks, River and channel geometry, Longitudinal profile of river, Fluvial processes and related landforms. Morphometric analysis of basins. Concept of basin morphometry. Laws of drainage composition. Linear aspects aerial aspects, relief aspects Types of glaciers, Movement of glacier. Glacial and Periglacial processes and landforms Formation of deserts, desert characteristics , Aeolian processes and landforms. Energetics of shore-zone processes – waves, tides and currents. Coastal processes and landforms. Coastal submergence and emergence-shoreline development.	16	04		20

III **(13 marks)**	Quaternary geomorphology, The Quaternary Period and its divisions Cycles of climatic changes and landforms. Geomorphological subdivisions of Indian subcontinents, Geomorphology of lndo-Gangetic plain, Peninsula, and Brahmaputra Valley. Tectonic Geomorphology: Concept, topographic markers and geomorphic indices of active tectonics.	11	2		13
III (Practical) (15 marks)	Study of geomorphic models and topographic maps Measurement of morphometric parameters for drainage basins. Interpretation of topography and geological structures from contour maps Longitudinal profile of a river Hypsometric analysis			**15**	**30**
					75

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examination - 15 + 15
- Others (Any one) - 10
  - Group Discussion
  - Seminar presentation on any of the relevant topics
  - Home Assignment

COURSE OUTCOME: At the end of semester students will be able to:

CO 01: Understand Basic Concepts of Geomorphology

LO 1.1: Define geomorphology and describe its scope and significance.

LO 1.2: Differentiate between endogenic (internal) and exogenic (external) geomorphological processes.

LO 1.3: Explain how geological structure, lithology, and climate influence geomorphological features.

CO 02: Analyze Weathering Processes, Soil Formation and Mass Movement

LO 2.1: Describe physical, chemical, and biological weathering processes.

LO 2.2: Understand soil profiles, nomenclature of soil horizons, and soil classification.

LO 2.3: Explain the factors affecting soil formation, distribution and its importance in geomorphology

LO 2.4: Understand mass movement, its classification and evolution of hillslope

CO 03: Understand Fluvial Systems and Related Geomorphological Features

LO 3.1: Describe the components of a fluvial system, including drainage basins and networks.

LO 3.2: Explain river and channel geometry and the processes of fluvial erosion, transportation, and deposition.

LO 3.3: Identify and describe landforms created by fluvial processes.

LO 3.4: Understand the concept of basin morphometry and its application in geomorphology.

CO 04: Understand Glacial, Desert, and Coastal Geomorphology

LO 4.1: Describe the types of glaciers, their movement, and the landforms they create.

LO 4.2: Explain the formation and characteristics of deserts, aeolian processes, and related landforms.

LO 4.3: Identify and describe coastal landforms and the processes that create them.

CO 05: Analyze and interpret Quaternary geomorphological processes, climatic cycles and tectonic influences in shaping landforms and comprehend Geomorphological Subdivisions of India

LO 5.1: Explain the Quaternary Period, its divisions, and the impact of climatic changes on landform development.

LO 5.2: Understand the concept of tectonic geomorphology and the significance of topographic markers and geomorphic indices of active tectonics.

LO 5.3: Analyze how tectonic activity influences landform development in different regions.

LO 5.2: Identify and describe the geomorphological subdivisions of the Indian subcontinent, including the Indo-Gangetic Plain, Peninsular region, and Brahmaputra Valley.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	**CO2**	**CO1, CO3**				
Conceptual Knowledge		**CO1, CO2, CO3, CO4**	**CO5**	**CO5**		
Procedural Knowledge						
Metacognitive Knowledge						

Mapping of Course Outcomes to Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	S	S	M	M	M	M
CO2	S	S	M	S	S	M
CO3	M	S	M	S	S	M
CO4	M	S	M	S	S	M
CO5	M	M	M	S	S	M

Where, S= Strong Correlation and M= Medium Correlation

Suggested Books (Geomorphology)

- Bloom, A.L., 2003, Geomorphology – A systematic analysis of late Cenozoic landforms - Pearson Education
- Singh, S., 2016, Geomorphology – Pravalika Publication Allahabad
- Thornbury, W.D., 2002, Principles of Geomorphology – CBS Publishers & Distributions Pvt. Ltd.
- Spark, B.W., 1986, Geomorphology – Longman scientific & Technical
- Dayal, P., 2001, A textbook of Geomorphology – Shukla Book depot
- Burbank, D.W. and Anderson, R.S., 2008, Tectonic Geomorphology – Balckwell science

Course Title : **Stratigraphy and Palaeontology**
Course Code : **AGM- 5.1**
Nature of Course : **Minor**
Total Credits : 04 credits
Distribution of Marks : 60 (End-Sem.) + 40 (In-Sem.)

COURSE OBJECTIVES: The course is designed to assess rocks and interpret their meaning in the larger context of Earth's history. Demonstrate in-depth knowledge and understanding of stratigraphic concepts and terminology through analysis, classification, and identification. Gain hands-on laboratory techniques and field experience. Organize ideas, summarize teachings, and describe findings for academic writing in Earth Sciences.

Palaeontology deals with identification, classification and taxonomic description of past life forms as fossils. It aids in their construction of palaeoenvironment, palaeoclimate, palaeoecology, palaeoceanography and paleobiogeography. It is an important tool applied for hydrocarbon exploration.

UNITS	CONTENTS	L	T	P	Total Hours
I **(22 Marks)**	Principles of Stratigraphy: Fundamentals of litho-, bio- and chrono-stratigraphy. Stratigraphic Nomenclature & Laws of Facies: Codes of stratigraphic nomenclature: International Stratigraphic Code - development of a standardized stratigraphic nomenclature. Principles of stratigraphic analysis. Facies concept in stratigraphy: Walther's Law of Facies. Concept of paleogeographic reconstruction. Stratigraphy of India: Physiographic and tectonic subdivisions of India. Introduction to Proterozoic basins of India. Paleozoic Succession of Spiti. Jurassic of Kutch, Cretaceous of Trichinopoly. Stratigraphy of Siwalik basin and NE-India. Stratigraphy of Deccan and Sylhet Traps. Stratigraphic boundaries: Important Stratigraphic boundaries of India	**20**	**02**		**22**
II **(23 Marks)**	**Introduction to Palaeontology, Fossil Nomenclature andTaxonomy** Palaeontology: definition, branches, scopes andapplications. Fossil: definition and types. Process of fossilization. Conditions and modes of preservation. Fossil: Nomenclature, Type specimens, Concept of species, Taxonomy, Taxonomic hierarchy, Binomial system of nomenclature, Naming of genera and species. General principles of palaeontology: Phylogenetic and Phenetic classification. Theory of organic evolution interpreted from fossil records. Vertebrate and Invertebrate Fossils. Palaeobotany: General idea about Palaeobotany, Plant fossils and Palynology. Gondwana Floras of India. Application of Fossils for palaeoenvironment analysis, palaeoclimatic interpretation and hydrocarbon exploration.	**20**	**03**		**23**
III **(Practical 15 Marks)**	• Study of diagnostic morphological characters, systematic position, stratigraphic position and age of various invertebrate, vertebrate and plant fossils. • Study of fossils showing various modes of preservation. • Study of geological map of India and identification			**15**	**30**

	major stratigraphic units. • Note Book and Viva Voce				
Total					**75**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- **Two Internal Examination - 15 + 15**
- Others (Any one) - 10
  - Group Discussion
  - Seminar presentation on any of the relevant topics
  - Debate
  - Home Assignment

COURSE OUTCOMES (COs):
Students will be able to: -

CO1: Understand the fundamental principles of stratigraphy

LO1.1: Define and explain the concepts of litho-, bio-, and chrono-stratigraphy. LO1.2: Identify and describe the different types of stratigraphic boundaries.

CO2: Analyze the stratigraphy of India

LO2.1: Describe the physiographic and tectonic subdivisions of India.
LO2.2: Explain the stratigraphic succession of different geological periods in India.

CO3: Comprehend the principles of paleontology

LO3.1: Define and explain the concepts of fossils, fossilization, and preservation. LO3.2: Identify and describe the different types of fossils and their significance.

CO4: Apply paleontological principles to real-world problems

LO4.1: Analyze the role of fossils in palaeoenvironmental analysis and palaeoclimatic interpretation. LO4.2: Explain the significance of fossils in hydrocarbon exploration.

CO5: Integrate stratigraphic and paleontological principles

LO5.1: Correlate stratigraphic principles with paleontological concepts.
LO5.2: Apply integrated stratigraphic and paleontological principles to solve real-world problems.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	**CO 01, CO 02, CO 04**	**CO 02, CO 03**	**CO 03**			
Conceptual Knowledge		**CO 02, CO 03, CO 04**	**CO 04**	**CO 03, CO 04**	**CO 03,CO5**	

Procedural Knowledge		**CO 04**	**CO 03**	**CO 04, CO5**		

Metacognitive Knowledge						

Mapping of Course Outcomes to Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	S	M	M	S	M	M
CO2	S	M	M	S	M	M
CO3	S	M	M	S	M	M
CO4	S	M	M	S	M	M
CO2	S	M	M	S	M	M

Where, S= Strong Correlation and M= Medium Correlation

SUGGESTED READINGS:

1. Dasgupta A. An Introduction to Palaeontology, World Press.
2. Jain & Anantharaman (2016). Palaeontology, Palaeobiology. Vishal Publishing Co.
3. Benton, M. (2014). Vertebrate Palaeontology 4th Edition.Wiley-Blackwell
4. Raup, D.M., Stanley, S. M., Freeman, W. H.(1971)Principles of Paleontology
5. Clarkson, E. N. K. (2012) Invertebrate paleontology and evolution 4th Edition by Blackwell Publishing.
6. Benton, M.(2009).Vertebrate paleontology. John Wiley & Sons.
7. Shukla, A.C., & Misra, S.P.(1975).Essentials of paleobotany. Vikas Publisher
8. Shrock R. R. and Twenhofel W. H. Principles of Invertebrate Palaeontology, CBS Publishers
9. & Distributors
10. Armstrong, H.A., & Brasier, M.D.(2005) Microfossils. Blackwell Publishing.
11. Kathal P. K., Applied Geological Micropalaeontology: Scientific Publishers, India
12. Nield E.W. and Tucker V.C.T. Palaeontology – An Introduction,Pergamon Press
13. Jain P.C. and Anantharaman M.S. Palaeontology (Palaeobiology) Evolution and Animal
14. Distribution Vishal Publishing Co.
15. Bigg, G., 1999 Ocean and Climate. Springer-Verlag
16. Boyd et al. 1989. Relation of sequence stratigraphy to modern sedimentary environments Shanley et al. 1991. Predicting facies architecture through sequence stratigraphy
17. Bradley, F., 2000. Paleoclimatology: Reconstructing Climates of the Quaternary. Springer-Verlag
18. Doyle, P. & Bennett, M.R. 1996. Unlocking the Stratigraphic Record. John Wiley
19. Krishnan, M.S. 1982. Geology of India and Burma, CBS Publishers, Delhi
20. Maher and Thompson, 2000. Quaternary Climates, Environments and Magnetism. Cambridge University Press.
21. Mathur and Evans, 1964. Oil in India. Proc. 18th Int. Geol. Cong. New Delhi: 1-85.
22. Maurice E. Tucker, 2006, Sedimenary Petrology, BlackweI J Publishing, 262p.
23. McCarthy et al. 1998. Recognition of interfluvial sequence boundaries
24. Mial A.D. 1999. Principles of Sedimentary Basin Analysis. 3rdedition.Springer-Verlag.
25. Naqvi S.M. 2007: Geology and evolution of Indian Plate
26. Pascoe, E.H. 1968. A manual of the Geology of India and Burma (Vol.I-IV), Govt. of India Press, Delhi.
27. Plint et al. 1992. Controls of Sea Level Change
28. Ramakrishnan, M. &Vaidyanadhan, R. 2008. Geology of India Volumes 1 & 2, geological

society of India, Bangalore.
29. Sam Boggs, 1995, Pricnciples of Sedimentology and Statigraphy, Printice Hall, New Jersey, 765p.
30. Schoch, R. M. 1989. Stratigraphy, principles and methods.
31. Vaidyanadhan R and Ramakrishnan M. 2010. Geology of India. GSI.
32. Valdiya, K.S. 2010. The making of India, Macmillan India Pvt. Ltd.

33. Van Nostrand Reinhold. Roy R. Lemon. 1990 Principles of Stratigraphy, 512 pages, Publisher: Longman Higher Education.
34. Van Wagoner, Mitchum, Campion &Rahmanian (1990) Siliciclastic Sequence Stratigraphy in Well Logs, Cores & Outcrops
35. Weller, J. Marvin 1960. Stratigraphic principles and practice. Harper's Geoscience series.
36. Williams, Durnkerley, Decker, Kershaw and Chhappell, 1998. Quaternary Environments. Wiley and Sons.

Title of the Course : Advanced Structural Geology and Tectonics
Course Code : AGC6.1
Nature of The Course : Major (Core)
Core Total Credits : 04 Credits
Distribution of Marks : 60 (End Sem) + 40 (In-Sem)

OBJECTIVES:

- The primary objective of Advanced structural geology is to further increase learner's understanding of the history of deformation in rocks.
- The deformation of the lithosphere by tectonic forces is further elaborated. Further, the geodynamics in the regional and global scale is further emphasized
- The structural control on ore localization can be understood by acquiring advanced concepts of shear zones and fractures
- The application of structural geology in the engineering geology projects is further highlighted through the knowledge of paleo stress analysis in rocks.

UNITS	CONTENTS	L	T	P	Total Hours
1 **(Marks:12)**	**Deformation and Rheology** Stress at a point in a solid body: 3-D Stress Tensor; Concept of deformation: distortion, rotation, dilatation etc; Deformation Tensor; Analysis of homogeneous deformation: strain ellipses of different types and their geological significance; Mohr diagrams for stress and strain and their use. Behaviour of rocks under stress: elastic, plastic, viscous and viscoelastic responses and their geological significance. Mechanics of rock fracturing: fracture initiation and propagation; coulomb's criterion and Griffith's theory;	8	4		12
2 **(Marks:15)**	**Superposed Folds** Fold interference and superposed folds. Strain distribution in a folded layer and its significance. Evolution of axial planar and transected cleavages with folds fold related lineations. **Faults and Joints:** Mechanics of faulting: Anderson's theory and its limitations. Complex geometry of normal, strike slip and thrust faults with natural examples. Palaeostress analysis using fault-slip data. Geometric analyses of joints -Fracture analyses.	10	5		15
	Brittle and Ductile Shear Zones Shear zones: their significance in continental crustal evolution. Shear/fault zone rocks: mylonite, cataclasite and pseudotachylyte.	14	4		18

3 **(Marks:18)**	Kinematics of flow in a shear zone: flow eigenvectors and their significance. Grain-scale deformation mechanism in mylonites: dislocation and diffusion creep, strain hardening and softening mechanisms lattice Preferred orientation. **Crustal deformation** Deformation behaviour of quartzo-feldspathic rocks. Brittle-plastic transition and seismic behaviour of the lithosphere. Plate convergence and continental deformation: transpressional and transtensional tectonics: Indian and other examples. Tectonics of Eastern Himalaya. Evolution of the Upper Assam Basin.				
4 **(Marks:15)**	**Practical** Problems related to practical strain measurement (Rf -φ method, Fry method etc.) Analysis and interpretation of geological maps of various complexities. Stereographic techniques: contour diagrams and orientation analyses of foliation and lineation data for regional structural geometry Palaeostress analysis			15	30
					75

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- **Two Internal Examination - 20 + 10**
- **Others (Any one) - 5**
- **Group Discussion**
- **Seminar presentation on any of the relevant topics**
- **Debate**
- **Home Assignment**
- **One practical In-sem- 5**

COURSE OUTCOMES (COs)

Student will be able to

CO1: Understand the principles of deformation, stress, strain, and rheological behavior of rocks, and their geological significance.

- **LO 1**: Define and describe the concepts of stress, strain, deformation, and their representation using tensors and Mohr diagrams.
- **LO 2**: Interpret the behavior of rocks under different rheological conditions (elastic, plastic, viscous).
- **LO 3**: Evaluate the mechanics of rock fracturing using Coulomb's criterion and Griffith's theory.

CO2: Analyze complex structural geometries such as superposed folds, faults, and joints to interpret tectonic histories.

- **LO 1**: Analyze fold interference patterns and understand strain distribution in folded layers.
- **LO 2**: Describe fault geometries and mechanics using Anderson's theory and assess its limitations.
- **LO 3**: Perform paleostress analysis using fault-slip data and joint fracture analysis.

CO3: Explain the mechanics and kinematics of brittle and ductile shear zones and their role in crustal evolution as well as investigate the deformation mechanisms and seismic behavior of lithospheric rocks, with a focus on regional tectonics like the Eastern Himalayas and Assam Basin.

- **LO 1**: Explain the formation and significance of shear zones in crustal deformation and evolution.
- **LO 2**: Identify and classify shear zone rocks such as mylonites, cataclasites, and pseudotachylytes.
- **LO 3**: Understand grain-scale deformation mechanisms, including dislocation and diffusion creep.
- **LO 4**: Assess deformation at brittle-plastic transitions and relate seismic behavior to lithospheric dynamics.
- **LO 5**: Discuss regional tectonic processes, including transpression/transtension and the tectonics of the Eastern Himalayas and Upper Assam Basin.

CO4: Apply structural geology concepts in practical contexts such as strain analysis, geological mapping, and paleostress analysis to solve real-world geological problems as well as to develop skills in using advanced tools like stereographic projection and fault-slip analysis for structural interpretation.

- **LO 1**: Conduct strain measurement using techniques such as Rf/φ and Fry methods.
- **LO 2**: Interpret and analyze geological maps of varying complexities.
- **LO 3**: Use stereographic projection for regional structural analyses of foliation, lineation, and paleostress.
- **LO 4**: Apply structural geology concepts to practical challenges in engineering geology and resource exploration.

Suggested readings

Structural Geology

8. Fossen, H. 2010. Structural Geology, Cambridge University Press, ISBN: 978-0-521-51664-8,
9. Pluijm, B. A. V.D., and Marshak, S, 2003. Earth Structure. Second Edition. W.W. Norton and Company. ISBN 0-393-92467-X.
10. Ramsay, J. G., 1967. Folding and fracturing of rocks. McGraw-Hill, New York
11. Ramsay, J.G., and Huber, M.I., 1983. The techniques of modern structural geology, Vol.1, Strain Analysis. Academic Press, pp.1-308.
12. Ghosh, S.K., 1993. Structural Geology: Fundamentals and Modern Developments, Pergamon Press, Oxford, p 598.

13. Passchier, C. W., and Trouw, R. A. J., 2005. Microtectonics, 2nd Edn., Springer Verlag, Berlin.
14. Pollard, D. D. (2005) Fundamental of Structural Geology. Cambridge University Press.

Course Title : **Metamorphic Petrology**
Course Code : **AGC 6.2**
Nature of Course : **Major (Core)**
Total Credits : 04 credits
Distribution of Marks :60 (End-Sem.) +40 (In-Sem.)

COURSE OBJECTIVES: *The primary objective of learning metamorphic petrology is to understand the process of formation of metamorphic rocks. This subject deals with the dynamic processes of the earth that has affected the pre existing rocks. This subject also helps us to understand ore localization and genesis*.

UNITS	CONTENTS	L	T	P	Total Hours
I (12 Marks)	Metamorphism: definition, controlling factors, types of metamorphism - contact, regional, fault zone metamorphism, impact metamorphism. Regional metamorphism of argillaceous, calcareous and basic rocks. Occurrence of metamorphic rocks. Classification of metamorphic rocks: pelitic, basic, calcic and calc-silicates.	**08**	**02**		**10**
II (16 marks)	**Concept of zones and facies** Index minerals, Metamorphic zones and isograde. Concept of metamorphic facies and grade. Metamorphism in relation to plate tectonic settings. **Thermodynamic Considerations in Metamorphism** General idea about the thermodynamic consideration in metamorphic rock. Equilibrium in metamorphism. Mineralogical phase rule of closed and open systems.	**10**	**03**		**13**
III (17 Marks)	**Metamorphic structures and textures** Structure and textures of metamorphic rocks Relationship between metamorphism and deformation. **Metasomatism and Migmatites** Metasomatism and role of fluids in metamorphism. Migmatites and their origin. **Descriptive Metamorphic Petrology** Descriptive petrography of the following rocks: Slate, Phyllite, Schist, Blue Schists, Gneiss, Quartzite, Marble, Amphibolite, Granulite, Hornfels, Eclogites, Khasi Greenstone.	**20**	**02**		**22**
IV Practical (15 marks)	➢ Study of metamorphic rocks in hand specimens. ➢ Study of metamorphic rocks in thin section (mineralogy, textures, structures and petrogenesis) ➢ Note Book and Viva Voce			**15**	**30**
Total					**75**

Where, L: Lectures T: Tutorials P: Practical

MODES OF IN-SEMESTER ASSESSMENT: **(40 Marks)**

- **Two Internal Examination -** **15 + 15**
- **Others (Any one) -** **10**
  - **Group Discussion**
  - **Seminar presentation on any of the relevant topics**
  - **Debate**
  - **Home Assignment**

- **COURSE DESCRITION:** The course is design to deliver the knowledge of metamorphic processes, mineral transformations, and rock textures; to identify and classify metamorphic rocks, interpret pressure-temperature conditions, and apply petrological methods to geological problems, equipping them for careers in geosciences and advanced research in metamorphic geology.

COURSE OUTCOES (COs)

Student will be able to

CO1:Develop a comprehensive understanding of metamorphism and the classification of metamorphic rocks.

LO1.1: Define metamorphism and identify the controlling factors.
LO1.2: Describe the different types of metamorphism, including contact, regional, fault zone, and impact metamorphism.
LO1.3: Explain regional metamorphism of argillaceous, calcareous, and basic rocks.
LO1.4: Understand the occurrence and distribution of metamorphic rocks.
LO1.5: Classify metamorphic rocks into groups such as politic, basic, calcic, and calc-silicates.

CO2: Achieve a deep understanding of the concepts of metamorphic zones and facies, thermodynamic considerations in metamorphism

LO2.1: Understand and explain the concept of metamorphic zones, isograds, and index minerals.
LO2.2: Describe the concept of metamorphic facies and grade.
LO2.3: Analyze the relationship between metamorphism and plate tectonic settings.
LO2.4: Explain the thermodynamic considerations in metamorphism, including equilibrium and mineralogical phase rule.

CO3: Gain comprehensive knowledge of the structures, textures, and mineral reactions in metamorphic rocks and develop the ability to describe and identify various metamorphic rock types.

LO3.1: Identify and describe the structures and textures of metamorphic rocks.
LO3.2: Explain the relationship between metamorphism and deformation, and differentiate between prograde and retrograde metamorphic reactions.
LO3.3: Understand the process of metasomatism and the role of fluids in metamorphism.
LO3.4: Describe the origin and characteristics of migmatites.
LO3.5: Develop descriptive petrographic skills for various metamorphic rocks.

CO4: Develop practical skills in the study and analysis of metamorphic rocks through hands-on examination of hand specimens and thin sections

LO4.1: Identify and describe metamorphic rocks in hand specimens.

LO4.2: Analyze the mineralogy, textures, structures, and petrogenesis of metamorphic rocks in thin sections.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	**CO1, CO2**	**CO3**				
Conceptual Knowledge		**CO1, CO2, CO3**		**CO1, CO2**		
Procedural Knowledge			**CO4**	**CO3, CO4**		
Metacognitive Knowledge						

Mapping of Course Outcomes to Program Outcomes

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	S	S	M	S	S	M
CO2	S	S	M	S	S	M
CO3	S	S	S	S	S	M
CO4	S	S	S	S	S	S

Suggested Readings:

1. Philpotts, A., & Ague, J. (2009). *Principles of igneous and metamorphic petrology*.CambridgeUniversityPress.
2. Winter,J.D.(2014). *Principlesofigneousandmetamorphicpetrology*.Pearson.
3. Rollinson, H. R. (2014). *Using geochemical data: evaluation, presentation,interpretation*.
4. Raymond, L. A. (2002). *Petrology: the study of igneous, sedimentary, and metamorphicrocks*.McGraw-Hill ScienceEngineering.
5. Yardley, B. W., & Yardley, B. W. D. (1989). An introduction to metamorphicpetrology.LongmanEarthScienceSeries.
6. Bucher K. and Martin F. 2002. Petrogenesis of Metamorphic rocks. Springer-Verlag Publication.
7. Vernon R. H. and Clarke G. L. 2008. Principles of Metamorphic Petrology. Cambridge publication.
8. Spears F. 1993. Metamorphic Phase Equilibria and Pressure-Temperature-Time Paths. AGU publication
9. Manickavasagam R.M. 2023. Basics of Metamorphic Petrology. Atlantic Publication.

Course Title : **Geophysical Exploration**
Course Code : **AGC-6.3**
Nature of Course : **Major (Core)**
Total Credits : 4 credits
Distribution of Marks : 60 (End-Sem.) + 40 (In-Sem.)

COURSE OBJECTIVES: This course aims to provide students a comprehensive understanding of seismic, gravity, magnetic, electrical and electromagnetic methods, as well as well logging techniques in geophysical exploration. It also seeks to equip students with practical experience in interpreting different types of geophysical data for subsurface analysis useful for various applications.

UNITS	CONTENTS	L	T	P	Total Hours
I (14 Marks)	**Seismic Methods:** Seismic refraction and reflection surveying; acoustic impedance; ray path seismology for two layered earth – horizontal and dipping; geophones and hydrophones; overview of seismic data acquisition, processing and interpretation; vertical seismic profiling.	**12**	**2**		**14**
II (13 Marks)	**Gravity and Magnetic Methods:** Introduction; factors affecting gravity; measurement of gravity; gravimeter and its principles; gravity anomaly; corrections to gravity observations; gravity field survey procedure; satellite gravimetry. Magnetic properties of minerals and rocks; Earth's geomagnetic field; magnetometers and their principles; magnetic anomaly; interpretation of magnetic data; magnetic field survey procedures.	**11**	**2**		**13**
III (18 Marks)	**Electrical and Electromagnetic Methods:** Introduction; electrical methods: resistivity, self-potential, and induced polarization; electrical resistivity surveying: sounding and profiling; interpretation of data. The principle of electromagnetic (EM) surveying; Transient Electromagnetic (TEM) method; Frequency Domain Electromagnetic (FDEM) method; Airborne EM surveying; magneto telluric surveying. **Well Logging:** Introduction to well logging; wireline logs: Resistivity, Spontaneous Potential, Gamma, Density, Sonic and Neutron logs; Recent	**15**	**3**		**18**

	advances in well logging; application of logs in petrophysical analysis and facies analysis.				
IV Practical (15 Marks)	Interpretation of gravity and magnetic data, electrical resistivity data, self-potential data and seismic data; analysis of seismic sections; interpretation of well log data.			**15**	**30**
	Total				**75**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- **Two Internal Examination - 15 + 15**
- **Others (Any one) - 10**
  - **Project**
  - **Seminar presentation on any of the relevant topics**
  - **Home Assignment**
  - **Group Discussion**

COURSE OUTCOMES (COs):

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

CO 01: Demonstrate knowledge of seismic methods for subsurface exploration

LO 1.1: Explain the principles and applications of seismic refraction and reflection surveying.
LO 1.2: Explain the concept of acoustic impedance and its role in seismic interpretation.
LO 1.3: Apply ray path seismology techniques for two-layered earth models, including horizontal and dipping layers.
LO 1.4: Describe the functioning of geophones and hydrophones in seismic data acquisition.
LO 1.5: Demonstrate knowledge of the overview and techniques involved in seismic data acquisition, processing, and interpretation.
LO 1.6: Develop the ability to interpret vertical seismic profiling (VSP) data and its applications in subsurface analysis.

CO 02: Develop proficiency in gravity and magnetic methods for geophysical exploration

LO 2.1: Explain the key factors affecting gravity and describe how gravity is measured using a gravimeter.
LO 2.2: Identify and interpret gravity anomalies and apply corrections to gravity observations for accurate analysis.
LO 2.3: Explain the principles and methods involved in gravity field survey procedures, including satellite gravimetry.
LO 2.4: Describe the magnetic properties of minerals and rocks and the Earth's geomagnetic field.
LO 2.5: Analyze magnetic anomalies and use magnetometers to conduct magnetic surveys and interpret their results.

CO 03: Demonstrate comprehensive understanding of electrical and electromagnetic methods

LO 3.1: Explain the fundamental principles of electrical methods, including resistivity, self-potential, and induced polarization techniques.

LO 3.2: Conduct electrical resistivity surveys, both in sounding and profiling modes, and interpret the collected data for subsurface analysis.

LO 3.3: Explain the principles and applications of electromagnetic (EM) methods, including Transient Electromagnetic (TEM) and Frequency Domain Electromagnetic (FDEM) methods.

LO 3.4: Describe the process and benefits of airborne EM surveying and magnetotelluric surveying in geophysical exploration.

LO 3.5: Apply well logging techniques, including wireline logs (Resistivity, Spontaneous Potential, Gamma, Density, Sonic, and Neutron logs), to analyze subsurface conditions.

LO 3.6: Get acquainted with the recent advances in well logging and their applications in petrophysical and facies analysis.

CO 04: Conduct practical application and interpretation of geophysical data

LO 4.1: Conduct practical exercises in the interpretation of gravity and magnetic data, identifying key geological features.

LO 4.2: Demonstrate competence in the interpretation of electrical resistivity data and self-potential data through hands-on case studies.

LO 4.3: Analyze and interpret seismic sections to determine subsurface structures and geological formations.

LO 4.4: Interpret well log data to assess petrophysical properties and geological facies in subsurface formations.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	CO1, CO2, CO3					
Conceptual Knowledge		CO1, CO2, CO3	CO1, CO2, CO3	CO1, CO2, CO3		
Procedural Knowledge			CO1, CO2, CO3	CO1, CO2, CO3, CO4	CO1, CO2, CO3, CO4	
Metacognitive Knowledge					CO4	

Mapping of Course Outcomes to Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	S	M	S	S	M
CO2	M	S	M	S	S	M
CO3	S	S	M	S	S	M
CO4	S	S	S	S	M	S

Where, S = Strong Correlation and M = Medium Correlation.

SUGGESTED READINGS:

1. Dobrin, M.B., Savit, C.H. Introduction to Geophysical Prospecting, 4th Ed. McGraw Hill, 1988.
2. Lowrie, W., Fundamentals of Geophysics, 2nd edition, Cambridge University Press, 2007.
3. Mussett, A. E., Khan, M.A., Looking into the earth: An introduction to geological geophysics, 1st Published, Cambridge University Press, 2000.
4. Robinson, E.S., Coruh, C., Basic Exploration Geophysics, 1st ed., Wiley, 1988.
5. Sheriff, R.E., Encyclopedic Dictionary of Applied Geophysics, Fourth edition, Society of Exploration Geophysics, 2001.
6. Sheriff, R.E., & Geldart, L.P., Exploration Seismology Vol. 1 & 2, Reprint ed. Cambridge, 1986, 1987.
7. Telford, M., Geldart, L.P., Sheriff, R.E. and Keys, D.A., Applied Geophysics, 1st Indian ed. Oxford & IBH, 1988.
8. Yilmaz öz, Seismic Data Analysis: Processing, Inversion and Interpretation of Seismic Data, Society of Exploration Geophysics, 2000.
9. Dewan, J. T., Essentials of Modern Open-hole Log Interpretation, PennWell Books, 1983.
10. Serra, O., Serra, L., Well Logging and Geology, Technip Editions, 2004.
11. Serra, O., Fundamentals of Well-Log Interpretation, Elsevier, 1984.

Course Title : **Remote sensing and GIS**
Course Code : **AGC- 6.4**
Nature of Course : **Major**
Total Credits : 04 credits
Distribution of Marks : 60 (End-Sem.) + 40 (In-Sem.)

COURSE OBJECTIVES: The main objective of the course is to introduce the student to attain foundation knowledge and understanding of principles of remote sensing, its capabilities and limitations, a sense of the diversity of applications, and the relationship between these and a variety of sensors, platforms, and systems. Also to gain basic hands on experience of application of remote sensing data through visual interpretation and photogrammetory exercises. The course is also designed to provide a basic knowledge of GIS, concepts, terminology, methods of Geographic Information System technology, practical understanding, techniques and real world applications of GIS.

Unit	Topic	L	T	P	Total Hours
I (15 marks)	Concepts and fundamentals of aerial photography and remote sensing. Electromagnetic Radiation (EMR) and Spectrum. Physics of remote sensing, Spectral reflectance curve. Aerial photography: Photographic flight planning, Geometric characteristics of Aerial photographs, Terminology. Tilt and image displacement. Stereoscopic parallax, stereoscopy and vertical exaggeration Aerial photographs in field mapping and preparation of photogeological maps. Working principles and use of simple photogrammetric instruments.	13	02		15
II (15 marks)	Remote sensing sensors and platforms. Active and Passive Remote sensing, Concept of Digital Image Processing (DIP) - Geometric and radiometric corrections. Principles of photo interpretation. Elements of photo interpretation : Scale, tone, colour, texture, pattern, shape, size.	13	02		15

	Drainage patterns, Drainage anomaly and its significance Applications: Photogeological Techniques in lithological and structural interpretation. Application of photogeological interpretation in mineral exploration, engineering geology and ground waters studies. Geological features identification from Remote Sensing Techniques. Space Missions: Global and Indian space mission LANDSAT, METEOSAT, SEASAT. SPOT, IRS.				
III **(15 marks)**	Introduction to Geographic Information System (GIS) – Concepts, Components, Data formats, Data structure, Raster data model and vector data model, Raster versus vector, Advantages and disadvantages of raster and vector Application areas of GIS, advantages and disadvantages of GIS Coordinate systems: Cartesian Coordinate System, Geographic Coordinate system Definition, Classification and types of maps projection, Polyconic projection, UTM projection, Latitude/Longitude geographic coordinates General idea about of Global Positioning System (GPS) of America, Indian Regional Navigation Satellite System (IRNSS) and Indian Navigation System NAVIC	13	2		15
IV **(Practical)** **(15 marks)**	Pocket Stereoscope- stereo-test and study of different types of aerial photos. Mirror Stereoscope: Orientation of stereo-model under mirror stereoscope. Tracing of details from stereopairs. Determination of photo scale. Determination of Height: Using single photograph and with mirror stereoscope from stereopairs. Study of multispectral data Working with ArcGIS software: Image Processing, Creating vector files, digitization, attribute generation, labeling, symbolizing and preparation of map. DEM analysis: contours extraction, slope map, aspect map			**15**	**30**

					75

Where, L: Lectures T: Tutorials P: Practicals

MODE OF IN-SEMESTER ASSESSMENT: (40 Marks)

- **Two Internal Examination - 15 + 15**
- **Others (Any one) - 10**
  - **Group Discussion**
  - **Seminar presentation on any of the relevant topics**
  - **Debate**
  - **Home Assignment**

COURSE OUTCOMES: Students will be able to:

CO 01: Understand the Concepts and Fundamentals of Aerial Photography and Remote Sensing

LO 1.1: Explain the basics of aerial photography and the fundamentals of remote sensing, including the electromagnetic spectrum and the physics behind remote sensing.

LO 1.2: Interpret spectral reflectance curves and understand their significance in remote sensing applications.

LO 1.3: Plan photographic flights and understand the geometric characteristics of aerial photographs, including the geometry of vertical aerial photographs and related terminology.

LO 1.4: Describe concepts such as tilt, image displacement, vertical exaggeration, stereoscopic parallax, and stereoscopy.

LO 1.5: Use aerial photographs in field mapping and preparation of photogeological maps.

CO 02: Apply Remote Sensing Techniques for Geological and Environmental Studies

LO 2.1: Operate simple photogrammetric instruments and understand their working principles and uses.

LO 2.2: Identify and describe different remote sensing sensors and platforms, and understand remote sensing data products.

LO 2.3: Apply the principles of photo interpretation, including elements such as scale, tone, color, texture, pattern, shape, and size.

LO 2.4: Recognize and analyze drainage patterns and drainage anomalies using aerial

photographs and remote sensing data.

LO 2.5: Use photogeological techniques in lithological and structural interpretation, mineral exploration, engineering geology, and groundwater studies.

CO 03: Conduct Digital Image Processing and Photo Interpretation

LO 3.1: Explain the concept of digital image processing and perform geometric and radiometric corrections on remote sensing data.

LO 3.2: Apply principles of photo interpretation to extract meaningful information from aerial and satellite images.

LO 3.3: Analyze elements of photo interpretation, such as scale, tone, color, texture, pattern, shape, and size, to identify geological features.

LO 3.4: Utilize remote sensing techniques for the identification of geological features and for environmental monitoring.

LO 3.5: Integrate photogeological interpretation in various applications, including lithological and structural analysis.

CO 04: Understand Space Missions and Remote Sensing Technologies

LO 4.1: Describe global and Indian space missions such as IRS, LANDSAT, METEOSAT, SEASAT, and SPOT, and understand their significance in remote sensing.

LO 4.2: Identify the contributions of different space missions to remote sensing technology and data availability.

LO 4.3: Compare the capabilities and applications of various remote sensing satellites.

LO 4.4: Evaluate the impact of space missions on the advancement of remote sensing techniques and applications.

CO 05: Grasp the Basics of Geographic Information Systems (GIS)

LO 5.1: Define GIS and understand its components, application areas, and the advantages and disadvantages of using GIS.

LO 5.2: Explain different coordinate systems, including the Cartesian Coordinate System and the Geographic Coordinate System.

LO 5.3: Understand map projections, including their definitions, classifications,

and types, with a focus on Polyconic and UTM projections.

LO 5.4: Utilize GIS for spatial data analysis and integration with remote sensing data.

LO 5.5: Apply GIS techniques in various fields such as urban planning, environmental management, and disaster response.

LO 5.6: Understand Global Positioning System, Indian Regional Navigation Satellite System and Indian Navigation System NAVIC

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	**CO3**	**CO1, CO2**	**CO2, CO3**			
Conceptual Knowledge		**CO1, CO2, CO5**	**CO5**	**CO3**	**CO1, CO4**	
Procedural Knowledge		**CO3, CO5**				
Metacognitive Knowledge						

Mapping of Course Outcomes to Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	S	S	M	S	S	M
CO2	M	S	S	S	S	S
CO3	M	M	S	M	M	S
CO4	S	S	M	S	S	M
CO5	S	S	M	S	S	M

Where, S= Strong Correlation and M= Medium Correlation

Suggested Books

- Lillesand, T.M. and Kieffer, R.W.,1987, Remote sensing and Image interpretation-Jhon wiley
- Campbell, J.B. and Wynne, R.H., 1944, Introduction to remote sensing-the Guilford press
- Pandey, S.N., 2001, Principles and applications of photogeology- New age international publishers
- Miller, V.C.,1961, Photogeology- McGraw-Hill

- Allum, J.A.E, 1978, Photogeology and Regional Mapping, Pergamon Press
- Gupta, R.P., 2003, Remote sensing geology – Springer
- Sahu, K.C., 2008, A textbook of remote sensing and geographical information system- Atlantic publishers and Distributors (p) Ltd
- Bhatta, B, 2011, Remote sensing and GIS – Oxford University Press.
- Demers, M.N,1997, Fundamentals of Geographic Information systems, John Willey &sons.Inc.

Course Title **: Economic Geology**
Course Code **: AGM 6.1**
Nature of Course **: Minor**
Total Credits **:** 04 credits
Distribution of Marks **:** 60 (End-Sem.) + 40 (In-Sem.)

COURSE OBJECTIVES:

The subject Economic geology provides an intimate knowledge of the country's mineral wealth in relation to its industrial applicability. The main objective of this paper is to introduce the students with the mode of formation and occurrence of deposits of useful minerals and rocks having an economic value and importance. It also helps to conveniently explore the deposits and make their economic use. The paper also details with the National Mineral policy of India.

UNITS	CONTENTS	L	T	P	Total Hours
I (15 Marks)	**Principles of Economic geology**: Definition of ore, ore minerals, gangue and tenor. Morphology of mineral deposit, Global Tectonics and metallogeny, Processes of formation of Mineral deposits. **Mineral Deposits:** Classification of mineral deposits. Introduction to various types of ore deposits in specific rock associations.	**13**	**02**		**15**
II (18 Marks)	**Mineral Deposits of India :** Origin, occurrence and distribution in India and uses of the economic minerals/ores of Aluminium, chromium, copper, gold, lead, zinc, iron, manganese and atomic minerals. Deposits of minerals used as abrasives, refractories and in ceramics, cement, fertilizer, glass industries and their occurrences.	**15**	**03**		**18**
III (12 Marks)	**National Mineral Policy:** Strategic, Essential and Critical minerals of India. Conservation and Utilization of mineral resources.	**10**	**02**		**12**
IV Practical (15 Marks)	Identification of Economic Mineral Industrial Mineral assemblage Ore Reserve Estimation Note book and Viva-voce			**15**	**30**
	Total				**75**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: **(40 Marks)**

- **Two Internal Examination -** **15 + 15**
- **Others (Any one)** **-** **10**
    - **Group Discussion**

- **Seminar presentation on any of the relevant topics**
- **Debate**
- **Home Assignment**

COURSE OUTCOME:

Student will be able to

CO 01: Understand the fundamental concepts of economic geology, including the formation, classification, and distribution of mineral deposits.

LO 1.1: Define and Explain Key Concepts – Describe the terms ore, ore minerals, gangue, and tenor, along with their economic significance.

LO 1.2: Analyze the Morphology of Mineral Deposits – Understand how global tectonics influence metallogeny and the formation of mineral deposits.

LO 1.3: Classify and Interpret Mineral Deposits – Identify and classify different types of ore deposits based on their rock associations and formation processes.

CO 02: Gain comprehensive knowledge about the origin, occurrence, distribution, and economic significance of major mineral deposits in India.

LO 2.1: Understand the Genesis and Distribution – Explain the origin, geological settings, and spatial distribution of economically significant minerals in India.

LO 2.2: Identify and Describe Economic Minerals – Discuss the occurrence, mineralogy, and uses of aluminium, chromium, copper, gold, lead, zinc, iron, manganese, and atomic minerals.

LO 2.3: Evaluate Industrial Applications – Analyze the significance of mineral deposits used in abrasives, refractories, ceramics, cement, fertilizers, and glass industries, along with their occurrences in India.

CO 03: Understand India's National Mineral Policy, its strategic importance, and the principles of conservation and sustainable utilization of mineral resources.

LO 3.1: Explain National Mineral Policy – Understand the objectives, framework, and significance of India’s National Mineral Policy in mineral resource management.

LO 3.2: Identify Strategic, Essential, and Critical Minerals – Analyze the classification and importance of strategic, essential, and critical minerals for India’s economic and industrial growth.

LO 3.3: Discuss Conservation and Utilization Strategies – Evaluate sustainable practices for mineral conservation, efficient utilization, and resource management for long-term economic benefits.

CO 04: Develop an understanding of economic mineral identification, industrial mineral assemblages, and ore reserve estimation techniques.

LO 4.1: Identify Economic Minerals – Recognize and describe key economic minerals based on their physical, chemical, and optical properties.

LO 4.2: Understand Industrial Mineral Assemblages – Analyze the assemblages of industrial minerals and their significance in various industries.

LO 4.3: Apply Ore Reserve Estimation Techniques – Learn and apply different methods of ore reserve estimation for evaluating mineral deposits.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	**CO 01, CO 02, CO 03**	**CO 01, CO 02**	**CO 03**			
Conceptual Knowledge	**CO 04**	**CO1, CO2, CO3**	**CO 04**	**CO 02, CO 04**	**CO 04**	
Procedural Knowledge	**CO 04**	**CO 04**	**CO 04**			
Metacognitive Knowledge						

Mapping of Course Outcomes to Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	S	S	M	S	S	M
CO2	S	S	S	S	S	M
CO3	M	M	M	S	S	M
CO4	S	S	M	S	S	M
CO5	S	M	M	S	S	S

Where, S= Strong Correlation and M= Medium Correlation

SUGGESTED READINGS

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

Course Title **:Engineering Geology**
Course Code **:AGC-7.1**
Nature of Course **:Major (Core)**
Total Credits **:**4 credits
Distribution of Marks **:**60 (End-Sem.) + 40(In-Sem.)

COURSE OBJECTIVES: To develop students' skills for using knowledge of geology for economic construction of civil engineering project.

UNITS	CONTENTS	L	T	P	Total Hours
I (16Marks)	The role of Engineering Geology in civil construction. Stages of engineering geological investigation for civil engineering projects. Engineering properties of intact rock and rock mass. Engineering properties considered for rock classifications. Engineering classification of rocks– Intact rock classification and rock mass classification. Engineering properties for soil. Universal Soil Classification System (USCS). VS 30.	**13**	**03**		**16**
II (17Marks)	Geological considerations for selection of sites for construction of dams, reservoirs, tunnels, roads and bridges. Mass movements with special emphasis on landslides and causes of hill-slope instability. Geological considerations for evaluation of foundation of buildings.	**14**	**03**		**17**
III (12Marks)	Earthquakes and seismicity, seismic risk zones of India. Aseismic design of buildings	**10**	**02**		**12**
IV Practical (15Marks)	Study of site-maps of important engineering structures such as dams and tunnels. Exercises on engineering-geological site problems.			**15**	**30**
	Total				**75**

Where, L: Lectures T: Tutorials P:Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examination – 15 + 15
- Others (Anyone) – 10
    - o Group Discussion
    - o Seminar presentation on any of the relevant topics
    - o Debate
    - o Home Assignment

COURSE OUTCOME:

Student will be able to:

CO 01: Understand the role of engineering geology in civil construction and apply geological investigations to assess rock and soil properties for effective civil engineering design and construction**.**

LO1.1: Explain the significance of engineering geology in civil engineering projects and describe the stages of geological investigation.

LO1.2: Analyze the engineering properties of intact rock, rock mass, and soil for classification and construction suitability.

LO1.3: Understand and apply the Universal Soil Classification System (USCS) and the concept of VS_{30} in site characterization.

CO 02: Assess geological factors for site selection and stability in civil engineering projects, including dams, reservoirs, tunnels, roads, bridges, and building foundations, with emphasis on mass movements and hill-slope stability.

LO2.1: Identify key geological considerations for selecting construction sites for dams, reservoirs, tunnels, roads, and bridges.

LO2.2: Analyze mass movements, particularly landslides, and determine the causes of hill-slope instability.

LO2.3: Evaluate geological factors influencing the foundation stability of buildings to ensure safe and sustainable construction.

CO 03: Understand earthquakes, seismicity, and seismic risk zones in India, and apply principles of aseismic design for earthquake-resistant buildings.

LO3.1: Explain the causes of earthquakes, seismicity, and their impact on structures.

LO3.2: Identify and analyze the seismic risk zones of India based on geological data.

LO3.3: Understand and apply aseismic design principles to enhance the earthquake resistance of buildings.

CO 04: Develop skills in analyzing site maps of major engineering structures and solving engineering-geological site problems for practical applications.

LO4.1: Interpret and analyze site maps of important engineering structures such as dams and tunnels.

LO4.2: Identify geological challenges and propose solutions for engineering site problems.

LO4.3: Apply engineering geology principles in real-world construction and infrastructure projects.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	**CO 01**	**CO01,CO 02, CO 03**	**CO01, CO02, CO 03**			
Conceptual Knowledge		**CO1,CO2, CO4**	**CO 04**	**CO02, CO 03**	**CO3, CO4**	
Procedural Knowledge		**CO02,CO 03, CO 04**	**CO02, CO03, CO 04**	**CO02, CO 03**	**CO3, CO4**	
Metacognitive Knowledge						

Mapping of Course Outcomes to Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	S	S	M	M	S	M
CO2	S	S	S	S	S	S
CO3	S	S	S	S	S	M
CO4	S	S	M	S	S	S

Where, S=Strong Correlation and M=Medium Correlation

SUGGESTED READINGS:

1. Krynine, D.P. & Judd, W.R. "Principles of Engineering Geology and Geotectonics" CBS Publications & Distributors, 2001.
2. Bell, F.G. "Fundamentals of Engineering Geology" Elsevier, 2007.
3. Singh, B. & Goel, R.K. "Rock Mass Classification: A Practical Approach in Civil Engineering" Elsevier, 1999.
4. Gokhale, K.V.G.K. "Principles of Engineering Geology" B.S. Publications.
5. Johnson, R.B. & DeGraff, J.V. "Principles of Engineering Geology" Wiley

Course Title **:Petroleum Geology**
Course Code **:AGC- 7.2**
Nature of Course **: Major (Core)**
Total Credits **:**04 credits
Distribution of Marks **:**60 (End-Sem.)+40 (In-Sem.)

COURSE OBJECTIVES: Petroleum Geology plays an important role in geological sciences, providing detailed knowledge of occurrence, origin, source, reservoir, trap, petroliferous basins, and important oil and gas fields of India, especially Northeast India. The course is designed to provide students with detailed coverage of topics related to petroleum and petroleum exploration.

UNITS	CONTENTS	L	T	P	Total Hours
I (20 Marks)	Introduction to Petroleum Geology. Origin, migration, and accumulation of petroleum. Physical and chemical properties of petroleum. Mode of occurrences of petroleum. Source rocks, kerogen and its types, source rock characterization.	**18**	**02**		**20**
II (25 Marks)	Reservoir rock: Clastic reservoir, non-clastic reservoir. Reservoir petrophysics: Porosity and permeability. Reservoir fluids: Gas, oil, and water. Seal rock, traps, and different trapping mechanisms for oil and gas. Petroliferous basins of India. Geology of major oil and gas fields of India. Geology of oil and gas fields of Northeast India in detail. A brief review of the important oil and gas fields of the world. Future trends of oil exploration. Unconventional hydrocarbon sources.	**22**	**03**		**25**
III (Practical 15 Marks)	Identification of trap in the subsurface. Measurement of porosity and permeability. Source rock characterization.			**15**	**30**
Total					**75**

Where, **L: Lectures** **T: Tutorials** **P: Practicals**

MODES OF IN-SEMESTER ASSESSMENT: **(40Marks)**

- **Two Internal Examination-** **15 + 15**
- Others (Anyone) - 10

- Group Discussion
- Seminar presentation on any of the relevant topics
- Debate
- HomeAssignment

COURSEOUTCOMES(COs):
Students will be able to:-

CO1: Understand the Fundamentals of Petroleum Geology

LO1.1: Explain the origin of petroleum, including organic and inorganic sources.

LO1.2: Describe the primary and secondary migration of petroleum.

LO1.3: Discuss the physical and chemical properties of petroleum.

LO1.4: Identify the different modes of occurrence of petroleum (surface, subsurface, and miscellaneous).

CO2: Analyze Source Rocks and Reservoir Petrophysics

LO2.1: Explain the concept of source rocks and their evaluation methods, including Rock-Eval Pyrolysis.

LO2.2: Describe the conversion of organic matter into petroleum.

LO2.3: Discuss the characteristics of reservoir rocks, including clastic and non-clastic reservoirs.

LO2.4: Analyze porosity and permeability measurements in reservoir petrophysics.

CO3: Understand Reservoir Fluids, Seal Rocks, and Trapping Mechanisms

LO3.1: Describe the characteristics of reservoir fluids, including gas, oil, and water.

LO3.2: Explain the concept of seal rocks and their role in trapping petroleum.

LO3.3: Discuss the different trapping mechanisms for oil and gas, including structural, stratigraphic, hydrodynamic, and combination traps.

LO3.4: Identify the importance of trap identification in the subsurface.

CO4: Apply Knowledge of Petroleum Geology to Real-World Scenarios

LO4.1: Describe the geology of major oil and gas fields in India and around the world.

LO4.2: Analyze the future trends of oil exploration and production.

LO4.3: Apply source rock characterization techniques to real-world scenarios.

LO4.4: Integrate knowledge of petroleum geology to identify potential hydrocarbon-bearing basins and fields.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge	**CO01, CO 02, CO04**	**CO02, CO 03**	**CO03**			
Conceptual Knowledge		**CO02, CO 03, CO04**	**CO04**	**CO 03, CO 04**	**CO03**	
Procedural Knowledge		**CO04**	**CO03**	**CO04**		
Metacognitive Knowledge						

Mapping of Course Outcomes to Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	S	M	M	S	M	M
CO2	S	M	M	S	M	M
CO3	S	M	M	S	M	M
CO4	S	M	M	S	M	M

Where, S=Strong Correlation and M=Medium Correlation

SUGGESTED READINGS:

- Geology of Petroleum: A.I. Levorsen, CBS Publishers and Distributors, New Delhi, 1985.
- Petroleum Geology: F.K. North, Unwin Hyman Inc., Boston, USA.
- Petroleum Exploration and Exploration Practices: Bhagwan Sahay, Allied Publishers Limited, 1994.
- Geology for Petroleum Exploration, Drilling and Production: Norman J. Hyne, 1983.
- Elements of Petroleum Geology: Richard Selley and Stephen Sonnenberg, Elsevier.
- Sedimentology and Petroleum Geology: Knut Bjorlykke, Springer, 1989.
- Petroleum Geosciences: Indian Context: Soumyajit Mukherjee (Editor), Springer, 2015.
- Petroleum (Indian Context): D. Chandra and R.M. Singh, Tara Book Agency, 2003.
- Petroleum Geochemistry: D. Satyanarayana, Daya Publishing House, New Delhi, 2011.
- Sedimentation of Organic Particles: Alfred Traverse, Cambridge University Press, 1994.
- Oil and Gas Fields of India: Lakshman Singh, Indian Petroleum Publisher.

Course Title **:Geoscientific Data Analysis with Matlab**
Course Code **:AGC-7.3**
Nature of Course **: Major (Core)**
Total Credits **:**4 credits
Distribution of Marks **:**60 (End-Sem.) + 40 (In-Sem.)

COURSE OBJECTIVES: This course aims to provide students with a basic knowledge of computing in Matlab, as well as hands-on training in using Matlab for various types of geoscientific data analysis such as image processing, signal processing, simulation, regression, classification, and optimization. This course also equips students with various techniques for geoscientific data visualization including line plots, scatter plots, polar plots, rose plots, compass plots, contour plots, surface plots, histograms, and images.

UNITS	CONTENTS	L	T	P	Total Hours
I (10 Marks)	**Introduction to Matlab:** Common functions and operations; Arrays: vectors and matrices; Array indexing: subscript indexing, linear indexing, and logical indexing; Visualizing data: line plots, scatter plots, polar plots, rose plots, compass plots, contour plots, surface plots, histograms, and images; Matrix operations and manipulations; Vectorization; Scripts and functions.	**10**	**3**		**13**
II (10 Marks)	**Image processing and signal processing:** Transforms: Fourier transform, discrete cosine transform, radon transform, wavelet transform; Filters: Gaussian filter, Laplacian filter, moving average filter, median filter; Frequency responses; Speckle noise removal; Image reconstruction; Edge detection; Image thresholding; Properties of image regions. Fast Fourier transform; Sampling and aliasing; Spectral analysis; Power spectral density; Cross correlation and auto correlation; Time-frequency spectrogram; High pass and low-pass filters; Down sampling and removing trends in data; Principal component analysis	**10**	**3**		**13**
III (10 Marks)	**Simulation, regression, classification and optimization:** 2D random walk; Monte Carlo simulation; Bootstrapping; Kernel density estimate; Probability density functions; Empirical cumulative distribution; Linear least squares regression; Eigenvectors and eigenvalues; Polynomial fitting; Non-linear least squares regression; Optimization; Objective functions.	**10**	**3**		**13**

	Numerical solution of ODEs; Numerical integration and discretization.				
IV Practical (30 Marks)	Hands-on exercises on Matlab array operations, data manipulation, visualization, writing script files and function files, vectorization, image processing using different transforms and filters, signal processing using Fourier transform, spectral analysis, correlation between signals, time-frequency spectrogram, down sampling and removing trends in data, Monte Carlo simulation, linear and non-linear regression, polynomial fitting, eigen values and eigen vectors, optimization, numerical solution of ODEs, numerical integration and discretization.			**18**	**36**
	Total				**75**

Where, L: Lectures T: Tutorials P:Practicals

MODESOFIN-SEMESTERASSESSMENT: (40 Marks)

- **Two Internal Examination - 15 + 15**
- **Others(Any one) - 10**
  - **Project**
  - **Seminar presentation on any of the relevant topics**
  - **Home Assignment**

COURSEOUTCOMES(COs):

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

CO01: Apply Matlab's core functions and operations for array manipulation and visualization.

LO1.1: Demonstrate proficiency in basic Matlab operations, including arithmetic and logical operations.

LO1.2: Create, manipulate, and index arrays (vectors and matrices) using subscript indexing, linear indexing, and logical indexing.

LO1.3: Visualize data using Matlab's plotting functions such as line plots, scatter plots, polar plots, and surface plots.

LO1.4: Write and execute Matlab scripts and functions to automate tasks and simplify repeated operations.

LO1.5: Apply vectorization techniques to enhance code efficiency and performance.

CO02: Apply Matlab for image and signal processing techniques.

LO2.1: Use different image processing transforms like Fourier transform, discrete cosine transform, and wavelet transform for analyzing images and signals.

LO2.2: Apply various image filters (Gaussian, Laplacian, moving average, and median) to process and enhance images.

LO2.3: Implement edge detection, image thresholding, and noise removal (e.g., speckle noise) techniques in Matlab.

LO2.4: Perform spectral analysis and cross-correlation on signals and images.

LO2.5: Utilize Fast Fourier Transform (FFT) for signal processing tasks and understand the impact

of sampling and aliasing on data.

CO03: Analyze and interpret signal data using advanced mathematical techniques and visualizations.

LO3.1: Perform and interpret time-frequency spectrograms to analyze signals.

LO3.2: Use principal component analysis (PCA) to reduce the dimensionality of large datasets and extract meaningful patterns.

LO3.3: Apply high-pass and low-pass filters to remove noise and analyze signal characteristics in the frequency domain.

LO3.4: Implement downsampling techniques and trends removal from data for clearer analysis.

LO3.5: Perform auto-correlation and cross-correlation to analyze relationships between signals.

CO04: Implement computational techniques for simulation, regression, and optimization problems.

LO4.1: Simulate random processes such as 2D random walks and Monte Carlo simulation to model and solve real-world problems.

LO4.2: Apply regression techniques, including linear and nonlinear least squares regression, to fit data and make predictions.

LO4.3: Use polynomial fitting to model complex relationships between variables.

LO4.4: Implement optimization techniques to solve problems with objective functions.

LO4.5: Solve ordinary differential equations (ODEs) and perform numerical integration for physical modeling and simulations.

CO05: Gain hands-on experience with Matlab through practical exercises and projects.

LO5.1: Develop and execute Matlab scripts and functions for array manipulation, data visualization, and basic signal processing tasks.

LO5.2: Implement image processing techniques such as filtering, edge detection, and noise removal in Matlab.

LO5.3: Solve simulation-based problems (e.g., Monte Carlo, random walk) and apply regression methods to analyze datasets.

LO5.4: Apply optimization techniques and numerical solutions to real-world problems, including ODEs and integration.

LO5.5: Analyze and interpret data using Matlab's various built-in functions and tools for signal processing, regression, and optimization.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	CO1, CO2	CO1, CO2, CO3				
Conceptual Knowledge		CO1, CO2, CO3				
Procedural Knowledge			CO2, CO3, CO4, CO5	CO2, CO3, CO4, CO5	CO4, CO5	CO5
Metacognitive Knowledge						CO5

Mapping of Course Outcomes to Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	M	S	S	M	M
CO2	M	S	S	S	M	M
CO3	M	S	S	S	M	M
CO4	M	S	S	S	M	M
CO5	M	S	S	S	M	S

Where, S=Strong Correlation and M=Medium Correlation.

SUGGESTED READINGS:

1. Menke, W. and Menke, J. (2016). *Environmental Data Analysis with Matlab*. Academic Press.
2. Hanselman, D. and Littlefield, B. (2011). *Mastering Matlab*. Prentice Hall.
3. Moler, C. (2004). *Numerical Computing with Matlab*. SIAM.
4. Van Loan, C.F. and Fan, K.Y.D. (2010). *Insight Through Computing: A Matlab Introduction to Computational Science & Engineering*. SIAM.
5. Middleton, G.V. (2000). *Data Analysis in the Earth Sciences using Matlab*. Prentice-Hall.
6. Johnson, R.K. (2011). *The Elements of Matlab Style*. Cambridge University Press.

Course Title : **Geomorphology and Remote sensing**
Course Code : **AGM- 7.1**
Nature of Course : **Minor**
Total Credits : **04 credits**
Distribution of Marks :**60 (End-Sem.)+40 (In-Sem.)**

COURSE OBJECTIVE: The main objective of the course is to introduce students to the basic concepts of landforms and the processes that produce and modify them. The main aim of the course is the understanding of natural processes, the mechanics of geomorphic processes, and the relationships between properties of earth materials and the forces applied to them by gravity, wind, ice, water, waves, and humans. The objective of remote sensing is to train students to utilize remote sensing techniques for geological mapping, mineral exploration, terrain analysis, and monitoring geological hazards, thereby enhancing the understanding and management of Earth's geological resources

Unit	Topic	L	T	P	Total Hours
I (12marks)	Basic concept of Geomorphology, Endogenic and Exogenic processes, Geomorphic cycle. Rock weathering, Soil formation, Soil profiles and soil types. Mass movement and classification of mass movements.	10	2		12
II (12marks)	Fluvial system, drainage pattern, types of river. Fluvial processes and related landforms. Glacial processes and landforms, Aeolian processes and landforms, Coastal processes and landforms. Geomorphological subdivisions of the Indian subcontinent, Geomorphology of the Indo-Gangetic Plain, Peninsula, and Brahmaputra Valley.	10	2		12

III **(21 marks)**	Remote sensing: Definition and fundamentals of remote sensing. Electromagnetic Radiation (EMR) and spectrum. Physics of remote sensing, spectral reflectance curve. Active and passive remote sensing, sensors and sensor resolutions. Concept of Digital Image Processing (DIP). Principles of photo interpretation. Elements of photo interpretation: Scale, tone, colour, texture, pattern, shape, size. Photogeology, aerial photography, geometric characteristics of aerial photographs, terminology. Tilt and image displacement. Space missions: Global and Indian space missions — LANDSAT, METEOSAT, SEASAT, SPOT, IRS.	**17**	**4**		**21**
III (Practical) (15marks)	Study of geomorphic models and topographic maps. Measurement of morphometric parameters for drainage basins. Pocket stereoscope: Stereo-text and study of different types of aerial photos. Mirror stereoscope: Orientation of stereo model under mirror stereoscope. Tracing of details from stereopairs. Study of multispectral data.			**15**	**30**
					75

Where, L: Lectures T: Tutorials P: Practicals

MODEOFIN-SEMESTER ASSESSMENT: (40 Marks)

- **Two Internal Examination- 15 + 15**
- **Others(Any one) - 10**
  - **Group Discussion**
  - **Seminar presentation on any of the relevant topics**
  - **Debate**
  - **Home Assignment**

COURSE OUTCOMES:

At the end of the semester, students will be able to:

CO01: Understand the Basic Concepts of Geomorphology

LO1.1: Define geomorphology and explain its significance in understanding Earth's surface processes and landforms.

LO1.2: Describe the geomorphic cycle and the principle of uniformitarianism in shaping Earth's landscapes.

LO1.3: Differentiate between endogenic and exogenic processes and their role in landform development.

LO1.4: Analyze the control of geological structure, lithology, and climate on geomorphological features.

CO02: Explore Weathering Processes and Mass Movement

LO2.1: Identify and describe the physical, chemical, and biological processes involved in weathering.

LO2.2: Explain the formation of soil profiles and classify soil horizons according to their characteristics.

LO2.3: Classify mass movements based on their mechanism and analyze their impact on landscape evolution.

CO03: Study Fluvial, Glacial, Aeolian, and Coastal Processes

LO3.1: Describe the components of a fluvial system and analyze the characteristics of drainage basins and networks.

LO3.2: Explain fluvial erosion, transportation, and depositional processes and their associated landforms.

LO3.3: Identify different types of glaciers, describe their movement, and analyze the formation of glacial landforms.

LO3.4: Understand the formation and characteristics of deserts, Aeolian processes, and landforms.

LO3.5: Describe coastal processes and landforms, including erosion, deposition, and coastal features.

CO04: Analyze Geomorphological Subdivisions of the Indian Subcontinent

LO4.1: Describe the geomorphological subdivisions of the Indian subcontinent, including the Indo-Gangetic Plain, Peninsula, and Brahmaputra Valley.

LO4.2: Analyze the geological and climatic factors influencing the geomorphology of different regions in India.

CO05: Apply Remote Sensing Techniques in Geomorphological Studies

LO5.1: Understand the concepts and fundamentals of aerial photography and remote sensing.

LO5.2: Explain the electromagnetic spectrum and the physics of remote sensing, including spectral reflectance curves.

LO5.3: Identify different remote sensing sensors and platforms used in geomorphological studies.

LO5.4: Apply principles of digital image processing, including geometric and radiometric corrections.

LO5.5: Utilize photo interpretation techniques to analyze geomorphological features based on scale, tone, color, texture, pattern, shape, and size.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	**CO2, CO3**	**CO1, CO3**				
Conceptual Knowledge	**CO4**	**CO1, CO3, CO5**	**CO5**	**CO1, CO4**	**CO5**	
Procedural Knowledge						
Metacognitive Knowledge						

Mapping of Course Outcomes to Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	S	S	M	M	S	M
CO2	S	S	M	S	S	S
CO3	S	S	S	M	S	S
CO4	M	M	M	M	S	M
CO5	S	S	S	S	S	M

Where, S=Strong Correlation and M=Medium Correlation

Suggested Books

- Bloom, A.L., 2003, *Geomorphology – A Systematic Analysis of Late Cenozoic Landforms* – Pearson Education.
- Singh, S., 2016, *Geomorphology* – Pravalika Publication, Allahabad.
- Thornbury, W.D., 2002, *Principles of Geomorphology* – CBS Publishers & Distributors Pvt. Ltd.
- Spark, B.W., 1986, *Geomorphology* – Longman Scientific & Technical.
- Dayal, P., 2001, *A Textbook of Geomorphology* – Shukla Book Depot.
- Lillesand, T.M. and Kieffer, R.W., 1987, *Remote Sensing and Image Interpretation* – John Wiley.
- Campbell, J.B. and Wynne, R.H., 1994, *Introduction to Remote Sensing* – The Guilford Press.
- Pandey, S.N., 2001, *Principles and Applications of Photogeology* – New Age International Publishers.
- Miller, V.C., 1961, *Photogeology* – McGraw-Hill.
- Allum, J.A.E., 1978, *Photogeology and Regional Mapping* – Pergamon Press.
- Sahu, K.C., 2008, *A Textbook of Remote Sensing and Geographical Information System* – Atlantic Publishers and Distributors (P) Ltd.
- Bhatta, B., 2011, *Remote Sensing and GIS* – Oxford University Press.

Course Title **: Hydrogeology**
Course Code **:AGC 8.1**
Nature of Course **:Major (Core)**
Total Credits :4 credits
Distribution of Marks :60 (End-Sem.) + 40 (In-Sem.)

COURSE OBJECTIVES: The course aims to provide students with a comprehensive understanding of the principles and processes governing the occurrence, movement, and quality of groundwater. Topics include aquifer characterization, groundwater flow, contaminant transport etc. enabling students to address real-world challenges in water resource management, environmental protection, and drinking water sustainability.

UNITS	CONTENTS	L	T	P	Total Hours
I (12Marks)	Concepts of Hydrogeology, Hydrologic cycle, Hydrologic equation, Groundwater in the hydrologic cycle. Groundwater as a resource. Water-bearing properties of rocks: porosity, permeability, specific yield, and specific retention. Vertical distribution of water, zone of aeration and zone of saturation, classification of rocks according to hydrogeological characters.	**10**			**10**
II **(18Marks)**	**Physical Hydrogeology:** Types and origin of ground water; aquifers, classification of aquifers, concepts of groundwater basins. Aquifer parameters: transmissivity and storage coefficient, water table and piezometric surface, anisotropy and heterogeneity of aquifers. Darcy's law and its applications, validity of Darcy's law, intrinsic permeability and hydraulic conductivity, sea water intrusion and groundwater discharge in coastal aquifers. The Steady-state Groundwater Flow Equation Surface and sub-surface techniques used in ground water exploration. Use of AI/ML in hydrogeological studies.	**20**			**20**
III (15 Marks)	**Chemical Hydrogeology:** Groundwater composition, quality criteria for different uses. Chemical reactions: acid-base reactions, oxidation-reduction reactions, hydrolysis. Isotopic processes and uses. Contamination of groundwater. Sources of groundwater contamination. Geogenic contamination in the Brahmaputra River Basin. Emerging groundwater contaminants. Groundwater management: Surface and subsurface water interaction, groundwater level fluctuation, water balance, groundwater resource development and management, rainwater harvesting methods, sustainable use of groundwater.	**15**			**15**

IV **Practical** (15Marks)	• Preparation of depth to water level contour map. • Preparation and interpretation of water table contour map. • Study, preparation, and analysis of well hydrographs. • Graphical representation of groundwater quality data. • Numerical problems related to aquifer parameters. • Note Book and Viva Voce.			15	30
	Total				75

Where, L:***Lectures*** ***T:Tutorials*** ***P:Practicals***

MODES OF IN-SEMESTER ASSESSMENT: (40Marks)

- **Two Internal Examination 15+15**
- **Others (Anyone) 10**
  - **Group Discussion**
  - **Seminar presentation on any of the relevant topics**
  - **Debate**
  - **HomeAssignment**

Course Outcomes (COs):

Students will be able to —

CO01: Understand the fundamental concepts of hydrogeology

LO1.1: Define hydrogeology and explain its applications.

LO1.2: Describe the hydrologic cycle, including processes like infiltration and evapotranspiration.

LO1.3: Understand the concept of groundwater and its uses.

LO1.4: Explain water-bearing properties of rocks, including porosity, permeability, specific yield, and specific retention.

LO1.5: Identify the vertical distribution of water in zones of aeration and saturation.

LO1.6: Classify rocks based on their hydrogeological characteristics.

CO02: Gain knowledge on the physical aspects of groundwater

LO2.1: Understand various types of groundwater and aquifers.

LO2.2: Explain the concepts of groundwater basins and aquifer parameters such as transmissivity and storage coefficient.

LO2.3: Describe the water table, piezometric surface, and the concepts of anisotropy and heterogeneity in aquifers.

LO2.4: Apply Darcy's law to groundwater flow problems and understand its validity, along with concepts like intrinsic permeability and hydraulic conductivity.

LO2.5: Explain seawater intrusion in coastal aquifers and the steady-state groundwater flow equation.

CO03: Gain proficiency in groundwater exploration techniques

LO3.1: Utilize surface and sub-surface exploration techniques for groundwater detection.

LO3.2: Use emerging tools like AI/ML for hydrogeological studies.

LO3.3: Analyze and interpret data from groundwater exploration methods.

CO04: Understand groundwater quality and management

LO4.1: Evaluate the physical and chemical properties of groundwater and establish quality criteria for various uses.

LO4.2: Describe different chemical reactions governing groundwater composition.

LO4.3: Describe the isotopic processes and appreciate their uses in understanding the hydrological system.

LO4.4: Explain the concepts of groundwater contamination and its sources.

LO4.5: Discuss the geogenic contaminants in the Brahmaputra River Basin and the emerging groundwater contaminants.

LO4.6: Discuss groundwater management strategies, including surface and subsurface water interaction, groundwater level fluctuation, water balance, resource development, and sustainable usage.

CO05: Gain practical skills in hydrogeology

LO5.1: Prepare and interpret depth to water level contour maps.

LO5.2: Create and analyze water table contour maps.

LO5.3: Study and interpret well hydrographs.

LO5.4: Prepare and interpret various water quality graphs and charts.

LO5.5: Solve numerical problems related to aquifer parameters.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	CO1	CO2				
Conceptual Knowledge	CO3	CO1,CO2, CO4	CO1, CO3, CO4, CO5	CO2, CO2		CO5

Procedural Knowledge		CO3	CO1, CO2 CO4 CO2	CO4		
Metacognitive Knowledge			CO5			

Mapping of Course Outcomes to Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**S**	**S**	**M**	**S**	**S**	**M**
CO2	**S**	**S**	**M**	**S**	**S**	**M**
CO3	**M**	**S**	**M**	**S**	**S**	**S**
CO4	**S**	**S**	**S**	**S**	**M**	**M**
CO5	**M**	**M**	**S**	**M**	**M**	**S**

Where S: Strong Correlation & M: Medium Correlation

SUGGESTED READINGS

1. Todd, D.K., 2006. *Groundwater Hydrology*, 2nd Ed., John Wiley & Sons, New York.
2. Davis, S.N. and De Weist, R.J.M., 1966. *Hydrogeology*, John Wiley & Sons Inc., New York.
3. Karanth, K.R., 1987. *Groundwater: Assessment, Development and Management*, Tata McGraw-Hill Publishing Co. Ltd.
4. Gross, M.G., 1977. *Oceanography: A View of the Earth*, Prentice Hall.
5. Fetters, C.W., 2001. *Applied Hydrogeology*, Fourth Ed., Prentice Hall, New Jersey.
6. Domenico, P.A. and Schwartz, F.W., 1998. *Physical and Chemical Hydrogeology*, 2nd Ed., John Wiley & Sons Inc., New York

Course Title **:Coal Geology**
Course Code **:AGC8.2**
Nature of Course **:Major (core)**
Total Credits **:**4 credits
Distribution of Marks **:**60 (End-Sem.) + 40(In-Sem.)

COURSE OBJECTIVES:

It is intended to provide the students with knowledge on the geology and nature of coal, varying properties together with the practices and techniques required in order to evaluate coal in terms of its utilization. In addition, the alternative uses of coal as a source of energy are also addressed.

UNITS	CONTENTS	L	T	P	Total Hours
I (12 Marks)	**Coal** ➢ Coal forming epochs. ➢ Origin and mode of occurrence of coal. ➢ Physical properties of coal. ➢ Chemical characteristics: Composition, proximate and ultimate analysis. ➢ Rank, grade, and type of coal.	**10**	**02**		**12**
II (13 Marks)	**Coal Classification and Petrography** ➢ Indian and International Classifications of Coal. ➢ Coal Petrology - Introduction to macrolithotypes, microlithotypes, and macerals in coal.	**10**	**03**		**13**
III (20 Marks)	**Coal as Fuel and Resource** ➢ Coal bed methane: A new energy resource, maturation of coal and generation of methane in coal beds. ➢ Underground coal gasification. ➢ Coal liquefaction. ➢ Coalfields of Northeast India. ➢ Geological and geographical distribution of major coalfields in India. ➢ Methods of coal prospecting and production in India.	**16**	**04**		**20**
IV (15Marks)	**Practical** ➢ Study of different ranks of coal in hand specimens - Megascopic characteristics. ➢ Proximate and ultimate analysis of coal.			**15**	**30**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40Marks)

- **Two Internal Examination- 15 + 15**
- **Others (Anyone) - 10**
  - **Group Discussion**
  - **Seminar presentation on any of the relevant topics**
  - **Debate**

- **HomeAssignment**

COURSE OUTCOMES:

Students will be able to:

CO01: Understand the formation, occurrence, classification, and properties of coal along with its chemical characteristics and analysis methods.

LO1.1: Explain the coal-forming epochs, origin, and mode of occurrence of coal.

LO1.2: Describe the physical properties and chemical characteristics of coal, including proximate and ultimate analysis.

LO1.3: Classify coal based on rank, grade, and type, and explain their significance in industrial applications.

CO02: Gain knowledge of coal classification systems and the fundamentals of coal petrology, including macrolithotypes, microlithotypes, and macerals.

LO2.1: Compare and contrast Indian and international coal classification systems.

LO2.2: Explain the fundamentals of coal petrology and the significance of macrolithotypes and microlithotypes.

LO2.3: Identify and describe different macerals in coal and their impact on coal properties and utilization.

CO03: Understand the role of coal as a fuel and resource, including coal bed methane, coal gasification, liquefaction, coal distribution, and methods of coal prospecting and production in India.

LO3.1: Explain the formation, maturation, and extraction of coal bed methane as an alternative energy resource.

LO3.2: Describe underground coal gasification and coal liquefaction processes and their significance in energy production.

LO3.3: Analyze the geological and geographical distribution of major coalfields in India, with a focus on Gondwana and Tertiary coalfields, and explain methods of coal prospecting and production in India.

CO04: Develop practical skills in identifying different ranks of coal, analyzing its chemical composition, and studying macerals under a microscope.

LO4.1: Identify and describe the megascopic characteristics of different ranks of coal through hand specimen examination.

LO4.2: Perform and interpret proximate and ultimate analyses to determine the chemical composition and quality of coal.

LO4.3: Identify and classify macerals in coal using microscopic techniques and understand their significance in coal utilization.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	**CO01,CO 02,CO04**	**CO01,CO 02**	**CO01, CO02**			
Conceptual Knowledge		**CO02,CO 03,CO 04**	**CO03, CO04**	**CO 02, CO 04**		
Procedural Knowledge		**CO03,CO 04**	**CO03, CO04**	**CO04**		
Metacognitive Knowledge						

Mapping of Course Outcomes to Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	S	M	M	S	S	M
CO2	S	M	M	S	S	M
CO3	S	M	M	S	S	M
CO4	S	M	M	S	S	M

Where, S=Strong Correlation and M=Medium Correlation

Suggested Books:

1. Wagner, N.J., 2020. *Geology of Coal*. In *Encyclopedia of Geology: Volume 1–6, Second Edition* (pp. 745–761). Elsevier.
2. Suarez-Ruiz et al., 2008. *Applied Coal Petrology*. Elsevier.
3. Thomas, L., 2002. *Coal Geology*. John Wiley and Sons Inc.
4. Ross, C.A. and Ross, June R.P., 1984. *Geology of Coal*. Hutchinson Ross Publishing Co.
5. Singh, R.M., Chandra, D. and Singh, M.P., 2000. *Textbook of Coal (Indian Context)*, 1st Ed., Tara Book Agency, Kamacha, Varanasi, 402 p.
6. Francis, W., 1961. *Coal, Its Formation and Composition*. Edward Arnold Publications, London, 806 p.
7. Raja Rao, C.S. (Ed.), 1981. *Coal Fields of India*. Bulletin Series A, No. 45, Vol. I, Coal Fields of North Eastern India, GSI.
8. Ward, Colin R., 1984. *Coal Geology and Coal Technology*. Blackwell Scientific Publication, 345 p.
9. Van Krevelen, D.W., 1961. *Coal Typology-Chemistry-Physics-Constitution*. Elsevier Publication, Amsterdam, 514 p.
10. Stach, E., Mackowsky, M.Th., Teichmuller, M., Taylor, G.H., Chandra, D., and Teichmuller, R., 1982. *Stach's Textbook of Coal Petrology*, 3rd revised and enlarged edition, Gebruder Borntraeger, Berlin and Stuttgart, 535 p.

Course Title : **Essentials of Exploration Geology**
Course Code : **AGM-8.1**
Nature of Course : **Minor**
Total Credits : 4 credits
Distribution of Marks : 60(End-Sem.) + 40 (In-Sem.)

COURSE OBJECTIVES: The aim and objective of this course is to enable the students to systematically master the basic principles and methods of exploration geochemistry so that they can apply the effectiveness of this method and know the techniques of data processing, geochemical mapping, detecting geochemical anomalies, and their interpretation.

UNITS	CONTENTS	L	T	P	Total Hours
I (16Marks)	➢ Introduction to Mineral Exploration. ➢ Common economic minerals and their mode of occurrence. ➢ Stages of exploration. ➢ Surface guide to mineral exploration. ➢ Geological mapping: Surface and underground. ➢ UNFC classification scheme. ➢ Sampling methods.	**12**	**02**		**14**
II (15Marks)	➢ Exploration geochemistry. ➢ Elemental dispersion, pathfinder elements, background and threshold values. ➢ Orientation survey. ➢ Scales of exploration geochemistry. ➢ Analytical techniques. ➢ Geochemical methods of exploration.	**16**	**02**		**18**
III (14Marks)	➢ Electrical and Electromagnetic methods. ➢ Gravity and Magnetic methods. ➢ Seismic methods. ➢ Brief idea about geophysical logging methods.	**10**	**03**		**13**
IV (15Marks)	**Practical** ➢ Preparation and interpretation of geological maps and cross-sections. ➢ Map exercises based on geological exploration methods. ➢ Interpretation of seismic refraction data to find the depth to bedrock.			**15**	**30**
	Total				**75**

Where, L: Lectures T: Tutorials P: Practicals

MODESOFIN-SEMESTERASSESSMENT: (40 Marks)

- **Two Internal Examination- (15 + 15)**

Others (Anyone) - 10

- Group Discussion
- Seminar presentation on any of the relevant topics
- Debate
- HomeAssignment

LEARNING OUTCOMES

Students will develop a comprehensive understanding of mineral exploration techniques, including geological, geochemical, and geophysical methodologies. They will acquire expertise in identifying economic minerals, assessing their occurrence, and implementing exploration strategies using mapping, sampling, and classification systems.

Through hands-on exercises in geological mapping, cross-section interpretation, and seismic data analysis, students will develop essential skills for real-world mineral exploration, preparing them for research and industry careers in the field of geosciences.

COURSE OUTCOMES:

CO1: Develop an in-depth understanding of mineral exploration, including economic mineral occurrences, exploration stages, geological mapping, and classification systems.

- **LO1.1:** Explain the principles and significance of mineral exploration in resource identification.
- **LO1.2:** Identify economically important minerals and analyze their modes of occurrence.
- **LO1.3:** Describe the various stages of exploration, from reconnaissance to detailed survey.
- **LO1.4:** Recognize different surface guides used for mineral exploration.
- **LO1.5:** Conduct geological mapping for both surface and underground exploration projects.
- **LO1.6:** Interpret the UNFC classification scheme for resource estimation and management.
- **LO1.7:** Apply appropriate sampling methods to ensure accurate mineral assessment.

CO2: Apply advanced geochemical exploration techniques, including elemental dispersion analysis, pathfinder elements, and geochemical survey methodologies.

- **LO2.1:** Define and analyze elemental dispersion patterns in different geological settings.
- **LO2.2:** Identify pathfinder elements and distinguish between background and threshold values.
- **LO2.3:** Design and implement orientation surveys for geochemical exploration.
- **LO2.4:** Differentiate between various scales of geochemical exploration and their applications.
- **LO2.5:** Apply advanced analytical techniques for geochemical data interpretation.
- **LO2.6:** Utilize geochemical exploration methods in mineral resource evaluation.

CO3: Evaluate geophysical exploration methods such as electrical, electromagnetic, gravity, magnetic, seismic, and geophysical logging techniques.

- **LO3.1:** Explain the principles and applications of electrical and electromagnetic methods in mineral exploration.
- **LO3.2:** Analyze gravity and magnetic exploration techniques for subsurface mineral detection.
- **LO3.3:** Understand and apply seismic methods for resource exploration and subsurface imaging.
- **LO3.4:** Gain an overview of geophysical logging techniques used in mineral exploration.

CO4: Develop hands-on skills in geological mapping, seismic data interpretation, and map-based exercises for mineral exploration applications.

- **LO4.1:** Prepare and interpret geological maps and cross-sections for mineral exploration.
- **LO4.2:** Conduct map-based exercises utilizing geological exploration techniques.
- **LO4.3:** Analyze seismic refraction data to determine the depth to bedrock and assess subsurface conditions.

Mapping of Course Outcomes to Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	S	M	M	S	S	M
CO2	S	M	M	S	S	M
CO3	S	M	M	S	S	M
CO4	S	M	M	S	S	M

Where, S=Strong Correlation and M=Medium Correlation

Suggested Reading:

1. Haldar, S.K., 2018. *Mineral Exploration: Principles and Applications*. Elsevier.
2. Dobrin, M.B. and Savit, C.H., 1960. *Introduction to Geophysical Prospecting* (Vol. 4). New York: McGraw-Hill.
3. Gandhi, S.M. and Sarkar, B.C., 2016. *Essentials of Mineral Exploration and Evaluation*. Elsevier.
4. White, W.M., 2020. *Geochemistry*. John Wiley & Sons.
5. Mason, B. and Moore, C.B., 1985. *Principles of Geochemistry*.
6. Rollinson, H.R., 2014. *Using Geochemical Data: Evaluation, Presentation, Interpretation*. Routledge.

Course Title **:Analytical Techniques in geology**
Course Code **:AGDSE-8.1**
Nature of Course **:Discipline Specific Elective**
Total Credits **:** 4 credits
Distribution of Marks **:** 60(End-Sem.) + 40 (In-Sem.)

COURSE OBJECTIVES: The course is intended to develop concepts of analytical skills and techniques required for solving complex geological problems. Addressing problems using sophisticated instrumentation is the key highlight of the course. The students will learn about the basic principles as well as develop an in-depth understanding of the working mechanisms of different analytical instruments.

UNITS	CONTENTS	L	T	P	Total Hours
I (12Marks)	➢ Characterization methods for geological samples. ➢ Sample, specimen, precision, accuracy, sample standards. ➢ Important features of analytical techniques.	**10**	**02**		**12**
II (13Marks)	➢ Principles of microscopic and spectroscopic techniques. ➢ Principle, instrumentation, and uses of XRD. ➢ XRF. ➢ TGA, DTA. ➢ IR-Spectroscopy.	**12**	**02**		**14**
III (20Marks)	➢ Principle, instrumentation, and uses of: ➢ SEM. ➢ EPMA. ➢ ICP-MS. ➢ IRMS. ➢ SHRIMP. ➢ AMS. ➢ Point load test. ➢ Triaxial compression test.	**16**	**03**		**19**
IV (15Marks)	**Practical** ➢ Acquisition and interpretation of analytical data.			**15**	**30**
	Total				**75**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: **(40 Marks)**

- **Two Internal Examination-** **(15 + 15)**

Others (Anyone) - **10**

- Group Discussion
- Seminar presentation on any of the relevant topics
- HomeAssignment

LEARNING OUTCOME:

Students will develop a comprehensive understanding of geological sample characterization methods and their applications in mineralogical and geochemical studies. They will gain expertise in using advanced microscopic and spectroscopic techniques, including XRD, XRF, TGA, DTA, and IR-Spectroscopy, to analyze mineral compositions and thermal properties. The course will provide hands-on experience in state-of-the-art analytical techniques such as SEM, EPMA, ICP-MS, IRMS, SHRIMP, and AMS for high-

resolution geochemical and isotopic analysis. The practical component of the course will equip students with skills in acquiring, processing, and interpreting analytical data, preparing them for research and industry roles in geological sciences.

CO1: Understand the fundamental principles of geological sample characterization, including precision, accuracy, and analytical sample standards.

LO1.1: Define and differentiate between sample, specimen, precision, accuracy, and sample standards.

LO1.2: Explain the significance and key features of analytical techniques in geological studies.

LO1.3: Assess various characterization methods for geological samples to ensure reliable data interpretation.

CO2: Apply advanced microscopic and spectroscopic techniques such as XRD, XRF, TGA, DTA, and IR-Spectroscopy for geological material analysis.

LO2.1: Explain the principles and applications of microscopic and spectroscopic techniques in geological research.

LO2.2: Describe the principles, instrumentation, and uses of X-ray Diffraction (XRD) and X-ray Fluorescence (XRF) in mineral analysis.

LO2.3: Analyze the thermal properties of geological samples using Thermogravimetric Analysis (TGA) and Differential Thermal Analysis (DTA).

LO2.4: Interpret geological sample compositions using Infrared Spectroscopy (IR-Spectroscopy).

CO3: Evaluate the principles, instrumentation, and applications of high-resolution analytical techniques, including SEM, EPMA, ICP-MS, IRMS, SHRIMP, AMS, and mechanical testing methods.

LO3.1: Explain the working principles, instrumentation, and applications of Scanning Electron Microscopy (SEM) and Electron Probe Microanalysis (EPMA).

LO3.2: Evaluate the use of Inductively Coupled Plasma Mass Spectrometry (ICP-MS) and Isotope Ratio Mass Spectrometry (IRMS) in geochemical analysis.

LO3.3: Describe high-resolution dating and elemental analysis techniques such as Sensitive High-Resolution Ion Microprobe (SHRIMP) and Accelerator Mass Spectrometry (AMS).

LO3.4: Understand the mechanical properties of geological samples through Point Load and Triaxial Compression Tests.

CO4: Develop proficiency in acquiring, processing, and interpreting analytical data through hands-on practical applications.

LO4.1: Acquire and analyze analytical data from different geological sample characterization techniques.

LO4.2: Interpret experimental results from microscopic, spectroscopic, and mechanical testing methods.

LO4.3: Apply data processing techniques for accurate mineralogical and geochemical analysis.

Mapping of Course Outcomes to Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	S	M	M	S	S	M
CO2	S	M	M	S	S	M
CO3	S	M	M	S	S	M
CO4	S	M	M	S	S	M

Where, S=Strong Correlation and M=Medium Correlation

Suggested Reading:

1. Potts, P.J., 2012. *A Handbook of Silicate Rock Analysis*. Springer Science & Business Media.
2. Hudson, J.A. and Harrison, J.P., 2000. *Engineering Rock Mechanics: An Introduction to the Principles*. Elsevier.
3. Goodman, R.E., 1991. *Introduction to Rock Mechanics*. John Wiley & Sons

Course Title **:Fluvial Geomorphology and Seismology**
Course Code **:**AGDSE8.2
Nature of Course **: DSE**
Total Credits **:**04 credits
Distribution of Marks **:**60 (End-Sem.) + 40 (In-Sem.)

172 – 189

Unit	Topic	L	T	P	Total Hours
I (12marks)	Meaning, scope, and evolution of fluvial geomorphology. Fluvial system, fluvial regime. Modern methods and techniques in fluvial geomorphological studies: Remote sensing, GIS, and computer applications. Drainage basin as a fluvial system: Inputs and outputs in the basin, drainage basin as a fundamental geomorphic unit. Channel processes: Forces acting in channels, flow types, velocity distribution, water and sediment discharge, channel erosion, and deposition.	10	2		12
II (18 marks)	Channel patterns: Straight, meandering, anabranching, and braided. Geometry of meanders, development and causes of meandering, mechanics and causes of braiding. River channel changes, channel metamorphosis, misfit stream. Flood geomorphology: Flood as a geomorphic agent, flood frequency analysis, recurrence interval. Paleoflood analysis. Floodplain morphology of the Brahmaputra River and its tributaries. Fluvial geomorphology of the Brahmaputra Valley. Channel morphology of the Brahmaputra River. Active tectonics and alluvial rivers.	15	3		18
III (15 marks)	Introduction to seismology; Earthquake and its effects; Elastic rebound theory; Classification of earthquakes; Seismicity and seismo-tectonics of India; Magnitude scales; Intensity scales; Theory of elasticity; Generalized Hooke's law; Different types of elastic waves; Seismometers; Analysis of seismograms; Seismic networks and arrays; Earthquake prediction.	13	2		15

IV (Practical) (15marks)	Preparation of hydrographs, rating curves, flow duration curve; Flood frequency analysis; Determination of recurrence interval; Identification of different geomorphic units from satellite imagery; Morphometric and morphotectonic analysis.			**15**	**30**
					75

where, L: Lectures T: Tutorials P: Practicals

Mapping of Course Outcomes to Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	S	M	M	S	S	M
CO2	S	M	M	S	S	M
CO3	S	M	M	S	S	M
CO4	S	M	M	S	S	M

Where, S=Strong Correlation and M=Medium Correlation

Course Title : Geological and Geochemical Exploration
Course Code : AGDSC9.1
Nature of Course : Discipline Specific Core
Total Credits : 04 credits
Distribution of Marks : 60 (End-Sem.) + 40 (In-Sem.)

COURSE OBJECTIVES: The aim and objective of this course is to enable the students to systematically know the basic principles and methods of geological exploration, exploration geochemistry and exploration geophysics so that they can apply the effectiveness of this method and know the techniques of data processing, geochemical mapping, detecting geochemical anomaly and also their interpretation.

UNITS	CONTENTS	L	T	P	Total Hours
I (12 Marks)	➢ Principles of mineral exploration and Exploration Geology ➢ Stages and norms of exploration. Geological techniques and procedures of exploration. ➢ Geological criteria and guides to mineral search. ➢ Sampling methods and ore reserve estimation.	**10**	**02**		**12**
II (12 Marks)	➢ Exploration of important economic mineral deposits. ➢ Study of geological maps and sections, stratigraphic columns, structure contour maps, isopach maps. ➢ Exploratory drilling – brief reviews of different drilling methods, planning and selection of sites.	**10**	**02**		**12**
III (21 Marks)	➢ The earth in relation to the Universe. Earth as Physicochemical system. ➢ Geochemical cycle. The Geochemical classification of elements. ➢ Special properties of trace and REE elements. ➢ Isotopes and their application. ➢ Geochemistry in Mineral exploration. Geochemical dispersion, mobility, association of elements. ➢ Various prospecting methods for geochemical rock sampling, soil, water, drainage. ➢ Biogeochemical and geobotanical surveys and a brief description of geochemical anomalies developed in it.	**16**	**05**		**21**
IV (15 Marks)	**Practical** ➢ Identification of anomaly ➢ Concept of weighted average in anomaly				

	detection ➢ Geological cross-section ➢ Models of reserve estimation ➢ Viva Voce			**15**	**30**
	Total				**75**

Where, L:Lectures T:Tutorials P:Practicals

MODESOFIN-SEMESTERASSESSMENT: (40Marks)

- Two Internal Examination - 20(T) +10 (P)
- Others (Anyone) - 10
  - Group Discussion
  - Seminar presentation on any of the relevant topics
  - HomeAssignment

LEARNINGOUTCOMES:

Thecourseismainlydesignedastomakethestudentsdeeplyunderstandtheuseofgeology and geochemistry in exploration purpose and also to make the students really be able to use it in practice.

COURSEOUTCOMES:

CO1: Advanced Principles of Mineral Exploration

LO1.1: Analyze the theoretical and applied principles of mineral exploration in diverse geological settings.

LO1.2: Evaluate the stages, norms, and evolving trends in exploration geology and their economic significance.

LO1.3: Develop strategic models for mineral exploration based on geological criteria and prospecting guides.

LO1.4: Apply sophisticated sampling methodologies and statistical techniques for precise ore reserve estimation.

CO2: Exploration of Economic Mineral Deposits & Geological Data Interpretation

LO2.1: Assess the distribution and genesis of economic mineral deposits with a focus on their exploration potential.

LO2.2: Critically interpret geological and structural maps, stratigraphic columns, and isopach maps for resource evaluation.

LO2.3: Compare and contrast different exploratory drilling methods, incorporating data acquisition and decision-making strategies.

LO2.4: Integrate multi-scale geological and geochemical datasets for site selection and feasibility analysis in drilling operations.

CO3: Assess the physicochemical properties of Earth, geochemical processes, and isotopic applications in mineral exploration.

LO3.1: Examine Earth's physicochemical systems and their implications for mineral exploration and environmental sustainability.

LO3.2: Investigate geochemical cycles, element behaviour, and classification in ore-forming processes.

LO3.3: Apply isotopic geochemistry in mineral exploration, including stable and radiogenic isotope applications.

LO3.4: Design geochemical prospecting models for mineral exploration using element dispersion, mobility, and association patterns.

LO3.5: Conduct high-resolution geochemical surveys and analyze multi-element geochemical data for anomaly detection.

LO3.6: Implement innovative techniques in geobotanical and biogeochemical exploration, evaluating their role in mineral deposit discovery.

LO3.7: Utilize computational and statistical tools for predictive geochemical modeling in mineral exploration.

CO4: Practical Applications & Research in Mineral Exploration

LO4.1: Apply sophisticated geospatial techniques for anomaly detection and mineral exploration targeting.

LO4.2: Utilize weighted averaging and geostatistical approaches in mineral anomaly interpretation.

LO4.3: Construct 3D geological cross-sections and integrate geophysical, geochemical, and structural data for mineral exploration.

LO4.4: Evaluate and apply ore reserve estimation models, including geostatistical and computational techniques.

LO4.5: Develop independent research projects in mineral exploration, demonstrating expertise through scientific writing, presentations, and viva voce examinations.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	**CO1, CO2**	**CO1**				
Conceptual Knowledge		**CO2, CO3**		**CO2, CO3**		
Procedural Knowledge			**CO4**			
Metacognitive Knowledge				**CO4**		

Mapping of Course Outcomes to Program Outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	S	S	M	S	S	M
CO2	S	S	M	S	S	M
CO3	S	S	M	S	S	M
CO4	S	S	S	S	S	S

Where, S=Strong Correlation and M=Medium Correlation

Suggested Readings:

1. Clark, G. B., 1967. Elements of Mining. 3rd Ed. John Wiley & Sons.

2. Arogyaswami, R. P. N., 1996. Courses in Mining Geology. 4th Ed. Oxford-IBH.

3. Moon, C. J., Whateley, M. K. G., Evans, A. M., 2006. Introduction to Mineral Exploration. Blackwell Publishing.

4. Mason, B. & Moore, C. Principles of Geochemistry.

5. Hawkes, H. E. and Webb, J. S. Geochemistry in Mineral Exploration.

Course Title : Sequence Stratigraphy and Hydrocarbon Exploration
Course Code : AGDSC-9.2
Nature of Course : Discipline Specific Core
Total Credits : 4 Credits
Distribution of Marks : 60 (End-Semester) + 40 (In-Semester)

COURSE OBJECTIVES: It is intended to provide the students the knowledge on the basic concepts of sequence stratigraphy together with practice and techniques required in order to evaluate a hydrocarbon reservoir.

UNITS	CONTENTS	L	T	P	Total Hours
I (15Marks)	➢ Sequence stratigraphy – basic concepts and principles ➢ Allostratigraphy; Seismic stratigraphy – standard methodology ➢ Cyclicity and correlation in stratigraphic successions ➢ Base level and accommodation ➢ Eustasy and sea level changes – concept and controls ➢ Stratal stacking patterns – upstream and downstream controls ➢ Concepts of Depositional System ➢ Facies and Facies Models	**12**	**02**		**14**
II (18Marks)	➢ Sequence elements and their implications ➢ Concept of parasequences, systems tracts, boundaries ➢ Sequence stratigraphic surfaces ➢ Hierarchy of sequence and sequence boundaries ➢ Types of stratigraphic sequences – depositional sequence, genetic stratigraphic sequence, transgressive-regressive (T-R) sequence	**16**	**02**		**18**
III (12Marks)	➢ Sequence stratigraphic models of common sedimentary environments: shallow marine, deep marine, and continental ➢ Application of sequence stratigraphy to coal and petroleum exploration ➢ Application of sequence stratigraphy to Carbon Capture, Utilization and Storage (CCUS) studies	**10**	**03**		**13**
IV (15Marks)	**Practical** ➢ Litholog-based facies analysis ➢ Identification of sequence stratigraphic elements ➢ Application of sequence stratigraphy in hydrocarbon exploration ➢ Viva Voce			**15**	**30**
	Total				**75**

Where, L:Lectures T:Tutorials P:Practicals

MODESOFIN-SEMESTERASSESSMENT: (40Marks)

- Two Internal Examination - 20(T) +10 (P)

- Others(Anyone) - 10
    - Group Discussion
    - Seminar presentation on any of the relevant topics
    - HomeAssignment

LEARNINGOUTCOMES

Students will develop an advanced understanding of sequence stratigraphy, including seismic stratigraphy, depositional systems, and stratigraphic correlation. They will be able to critically analyze sequence elements, boundaries, and their hierarchical significance in reconstructing basin evolution and geological history. Additionally, students will apply sequence stratigraphic models to various sedimentary environments and integrate these concepts into resource exploration, including petroleum, coal, and carbon storage projects.

CO1: Critically evaluate the principles and advanced methodologies of sequence stratigraphy for interpreting complex stratigraphic successions in geological research and industry applications.

LO1.1: Demonstrate a critical understanding of sequence stratigraphy concepts and their significance in basin analysis.
LO1.2: Evaluate allostratigraphy and seismic stratigraphy methodologies for subsurface interpretation.
LO1.3: Analyze cyclicity and correlation in stratigraphic successions to infer depositional dynamics.
LO1.4: Assess the role of base level and accommodation in sequence development and sedimentary infill.
LO1.5: Investigate eustatic sea level changes, their driving mechanisms, and their impact on stratigraphic architecture.
LO1.6: Interpret stratal stacking patterns and their control mechanisms, including upstream and downstream influences.
LO1.7: Synthesize depositional system concepts with facies models to predict reservoir distribution and quality.

• CO2: Analyze sequence elements, stratigraphic boundaries, and their hierarchical significance to reconstruct basin evolution and depositional history.

LO2.1: Identify and classify sequence elements based on their geological significance and implications for basin evolution.
LO2.2: Critically analyze the formation of parasequences, systems tracts, and sequence stratigraphic surfaces.
LO2.3: Evaluate the hierarchy of sequence boundaries and their role in sequence development and stratigraphic correlation.
LO2.4: Compare and contrast different types of stratigraphic sequences, including depositional, genetic stratigraphic, and transgressive-regressive (T-R) sequences, in applied geological studies.

• CO3: Apply sequence stratigraphic models to different sedimentary environments and assess their role in natural resource exploration and carbon storage.

LO3.1: Develop and implement sequence stratigraphic models for interpreting shallow marine, deep marine, and continental sedimentary environments.
LO3.2: Apply sequence stratigraphic techniques in petroleum and coal exploration, integrating seismic, well-log, and core data.
LO3.3: Assess the significance of sequence stratigraphy in Carbon Capture, Utilization, and Storage (CCUS) and evaluate its potential for sustainable resource

management.

• CO4: Conduct high-level stratigraphic interpretation through practical applications, including facies analysis, hydrocarbon prospecting, and geoscientific research.

LO4.1: Perform litholog-based facies analysis to infer depositional environments and stratigraphic trends.
LO4.2: Identify and interpret sequence stratigraphic elements from geological and geophysical datasets.
LO4.3: Utilize sequence stratigraphy principles in hydrocarbon exploration, reservoir characterization, and resource evaluation.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	**CO1, CO2**	**CO1**				
Conceptual Knowledge		**CO2, CO3**		**CO2, CO3**		
Procedural Knowledge			**CO4**			
Metacognitive Knowledge				**CO4**		

Mapping of Course Outcomes to Program Outcomes

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	S	S	M	S	S	M
CO2	S	S	M	S	S	M
CO3	S	S	M	S	S	M
CO4	S	S	S	S	S	S

Where, S=Strong Correlation and M=Medium Correlation

Suggested reading:

Suggested Readings:

1. Catuneanu, O., 2006. Principles of Sequence Stratigraphy. Elsevier.

2. Catuneanu, O., 2022. Principles of Sequence Stratigraphy. Newnes.

3. Catuneanu, O., 2017. Sequence Stratigraphy: Guidelines for a Standard Methodology. In Stratigraphy & Timescales (Vol. 2, pp. 1–57). Academic Press.

4. Embry, A. F., 2009. Practical Sequence Stratigraphy. Canadian Society of Petroleum Geologists, 81, p. 79.

5. Montenari, M., 2017. Advances in Sequence Stratigraphy, Vol. 2, 1st Ed. Elsevier.

6. Posamentier, H. W. and James, D. P., 1993. An Overview of Sequence-Stratigraphic Concepts: Uses and Abuses. Sequence Stratigraphy and Facies Associations, pp. 1–18.

7. Van Wagoner, J. C., Posamentier, H. W., Mitchum, R. M., Vail, P. R., Sarg, J. F., Loutit, T. S. and Hardenbol, J., 1988. An Overview of the Fundamentals of Sequence Stratigraphy and Key Definitions.

Course Title : Geological Field Work and Mapping
Course Code : AGDSC9.3
Nature of Course : Major (Core)
Total Credits : 4 credits
Distribution of Marks : 60 (End-Sem.) + 40 (In-Sem.)

COURSE OBJECTIVES : This course aims to provide fundamental knowledge of surveying techniques, geological mapping, and field data collection. It covers EDM, TS, GPS, coordinate systems, contouring methods, and the use of compasses. Students will learn field project planning, data documentation, stratigraphic measurements, and geological report preparation, including map plotting and cross-section interpretation.

UNITS	CONTENTS	L	T	P	Total Hours
I (12Marks)	Basics of surveying History of development of surveying Working principles of EDM, TS, and GPS Coordinate systems mainly used for plotting of field data Different types of contouring used in geological maps Uses of different types of compass	**09**	**03**		**12**
II (18Marks)	Purpose of field geology Planning of field project Documentation of field data Collection of field data for igneous, sedimentary, and metamorphic rocks Hydrogeological data and palaeontological data collection Measuring of stratigraphic thickness	**14**	**04**		**18**
III (15Marks)	Plotting of geological features in map using symbols and colours Preparation of geological map and cross-section Preparation of geological report	**12**	**03**		**15**
IV Practical (15Marks)	Plotting of field data on map Methods of contouring used for different disciplines of geology Preparation of geological maps and cross-sections			**15**	**30**
	Total				**75**

Where, L:Lectures T:Tutorials P:Practicals

MODESOFIN-SEMESTERASSESSMENT: (40Marks)

- **Two Internal Examination- 15+ 15**
- **Others (Anyone) - 10**
  - **Group Discussion**
  - **Seminar presentation on any of the relevant topics**
  - **Debate**
  - **HomeAssignment**

COURSEOUTCOME:

Student will be able to:

CO 01 : Develop an understanding of surveying fundamentals, modern techniques like EDM, TS, and GPS, coordinate systems, contouring methods in geological mapping, and the applications of different types of compasses.

LO1.1 : Explain the basics and historical development of surveying, along with the working principles of EDM, TS, and GPS.

LO1.2 : Understand coordinate systems used for plotting field data and different types of contouring in geological maps.

LO1.3 : Identify and describe the uses of various types of compasses in geological and engineering surveys.

CO 02 : Understand the purpose, planning, and documentation of field geology projects, along with techniques for collecting geological, hydrogeological, and palaeontological data, including stratigraphic thickness measurements.

LO2.1 : Explain the purpose and importance of field geology and the steps involved in planning a field project.

LO2.2 : Learn proper methods for documenting and collecting geological data related to igneous, sedimentary, and metamorphic rocks.

LO2.3 : Understand techniques for gathering hydrogeological and palaeontological data and measuring stratigraphic thickness in the field.

CO 03 : Develop skills in geological mapping, including plotting geological features using symbols and colors, preparing geological maps and cross-sections, and compiling geological reports.

LO3.1 : Learn the methods of plotting geological features on maps using standard symbols and colors.

LO3.2 : Understand the process of preparing geological maps and cross-sections for interpretation.

LO3.3 : Develop skills in writing geological reports based on field observations and mapping data.

CO 04 : Gain proficiency in plotting field data, applying contouring methods for geological disciplines, and preparing geological maps and cross-sections for analysis and interpretation.

LO4.1 : Understand techniques for accurately plotting field data on geological maps.

LO4.2 : Learn different contouring methods used in various geological disciplines.

LO4.3 : Develop skills in preparing geological maps and cross-sections for geological interpretation and analysis.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	**CO01**	**CO01, CO 02, CO 03**	**CO01, CO02, CO03**		**CO02, CO 03, CO 04**	
Conceptual Knowledge	**CO01**	**CO1, CO2, CO4**	**CO04**	**CO02, CO03**	**CO3, CO4**	
Procedural Knowledge	**CO02, CO 03, CO 04**	**CO02, CO 03, CO 04**	**CO02, CO03, CO04**	**CO02, CO03**	**CO3, CO4**	
Metacognitive Knowledge						

Mapping of Course Outcomes to Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	S	S	S	S	S	M
CO2	S	S	S	S	S	S
CO3	S	S	S	S	S	M
CO4	S	S	S	S	S	S

Where, S=Strong Correlation and M=Medium Correlation

SUGGESTEDREADINGS:

1. Goodman, R. E. Introduction to Rock Mechanics. John Wiley & Sons.
2. Ramamurthy, T. (Ed.). Engineering in Rocks for Slopes, Foundations and Tunnels. Prentice Hall India Pvt. Ltd.
3. Jaeger, J. C., Cook, N. G. W., and Zimmerman, R. W. Fundamentals of Rock Mechanics, Fourth Edition. Blackwell Publishing.
4. Obert, L. and Duvall, W. I. Rock Mechanics and the Design of Structures in Rock. John Wiley & Sons, Inc.

Course Title **:Non-conventional energy**
Course Code **:AGDSE-9.1a**
Nature of Course **:Discipline Specific Elective**
Total Credits **:** 04 credits
Distribution of Marks **:**60(End-Sem.)+40 (In-Sem.)

Course objective: As conventional fossil fuel energy sources are depleting at a faster rate and the world's environmental concern about acid deposition and global warming increases, renewable energy sources (solar, wind, tidal, biomass and geothermal etc.) are attracting more attention as alternative energy sources. These are all pollution free, cost effective and eco-friendly. The course introduces the processes and scope of the alternative energy sources- their working principles and use in different countries and a glimpse on the economics etc. The course should enable the students to: a) Understand the various forms of conventional energy resources. b) Learn the present energy scenario and the need for energy conservation c) Explain the concept of various forms of renewable energy. d) Outline division aspects and utilization of renewable energy sources for both domestics and industrial application e) Analyze the environmental aspects of renewable energy resources.

UNITS	CONTENTS	L	T	P	Total Hours
I (22 Marks)	Components of Energy: Non-Renewable and Renewable Production of Thermal energy using fossil fuels and solar energy Conversion of solar energy into various forms of energy (heat, electricity, mechanical etc.) Geothermal and Tidal Energy: Basic principles, Systems used in practice and applications Resource assessment.	**15**	**5**		**20**
II (22 Marks)	Wind Energy: Wind resource assessment, various models to predict wind pattern and their analysis concept of wind farms, Classification of wind mills. Concept of Bioenergy: Photosynthesis process, Biofuels, Biomass resources Bio based chemicals and materials Biofuels-Biomass : Importance, Production and applications Hydrogen as a renewable energy source, Sources of Hydrogen, Fuel for Vehicles	**18**	**4**		**22**
III (16 Marks)	Utilization of Hydrogen: Fuel cell-principle of working, construction and applications Environmental degradation due to energy production and utilization	**12**	**6**		**18**
Total					**60**

Where, **L: Lectures** **T: Tutorials** **P: Practicals**

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examination - 15 + 15
- Others (Any one) - 10
  - Group Discussion
  - Seminar presentation on any of the relevant topics
  - Debate
  - Home Assignment

COURSE OUTCOMES (COs):
Students will be able to: -

CO 01: Understand the components of energy resources and the basic principles of thermal and renewable energy generation systems.

LO 1.1: Explain the concepts of renewable and non-renewable energy resources and their importance in modern energy systems.

LO 1.2: Describe the production of thermal energy using fossil fuels and solar energy and the processes involved in energy generation.

LO 1.3: Discuss the basic principles, systems, applications, and resource assessment of geothermal and tidal energy.

CO 02: Understand the principles and technologies of wind energy, bioenergy, and hydrogen as renewable energy resources and their applications in sustainable energy systems.

LO 2.1: Explain the concept of wind energy, including wind resource assessment, models for predicting wind patterns, the concept of wind farms, and classification of windmills.

LO 2.2: Describe the concept of bioenergy, including the process of photosynthesis, biomass resources, biofuels, and the production and applications of biomass-based chemicals and materials.

LO 2.3: Discuss hydrogen as a renewable energy source, including its sources, production methods, and its use as fuel for vehicles.

CO 03: Understand the utilization of hydrogen as a clean energy source and evaluate the environmental impacts associated with energy production and utilization.

LO 3.1: Explain the principle, construction, and working of fuel cells used for hydrogen energy utilization.

LO 3.2: Describe the applications of hydrogen fuel cells in transportation, power generation, and other energy systems.

LO 3.3: Discuss the environmental degradation caused by energy production and utilization and the need for sustainable energy practices.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	CO 01, CO 02	CO 01, CO02,CO 03				
Conceptual Knowledge		CO 01, CO02,CO 03	CO02	CO 02, CO 03		
Procedural Knowledge		CO01	CO 01, CO 02	CO02	CO 03	
Metacognitive Knowledge				CO 03	CO 03	

Mapping of Course Outcomes to Program Outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	S	S	M	S	S	S
CO2	S	S	M	S	S	S
CO3	S	S	M	S	S	S

Where, S=Strong Correlation and M=Medium Correlation

Suggested Reading:

- Non-Conventional Energy Sources, BH Khan, Tata McGraw Hill Publisher, 2006.
- Non-Conventional Energy Sources and Utilisation, Er. R.K. Rajput, S. Chand Publisher, 2012.
- Non-Conventional Energy Resources, G.S. Sawhney, PHI Learning Pvt. Ltd. Publisher, 2012.
- Non-Conventional Energy Resources, Dr. J.P. Navani and Er. Sonal Sapra, S. Chand & Company Pvt. Ltd. Publisher, 2015.
- Non-Conventional Energy Resources, Shobh Nath Singh, Pearson Publisher, 2015.

Course Title **:Himalayan Geology**
Course Code **:AGDSE-9.1b**
Nature of Course **:Discipline Specific Elective**
Total Credits **:** 04 credits
Distribution of Marks **:**60(End-Sem.) + 40 (In-Sem.)

Course objective: Himalayan geology describes the structural evolution of Himalaya, pre- Himalayan tectonics, evolution of the fold and thrust belt, sedimentation and evolution of the Himalayan arc magmatism. It also describes the active tectonics in the Himalayan mountain front and the morphotectonics in the Himalayan frontal foothills.The objective of this course is to expose the students to the geological processes in the immediate neighbourhood of Himalayas. This course offers an unique opportunity for the students to understand the thrust tectonics and deformational history related to plate motions. Students can also get an opportunity to understand the natural hazards

UNITS	CONTENTS	L	T	P	Total Hours
I (12 Marks)	Introduction, importance and significance of Himalayas, their morphology, Regional, physical and geological subdivision of Himalayas	**10**	**2**		**12**
II (18 Marks)	Formation of Himalayas, Indian plate margin, plate movement and rise of Himalayas, Himalayan foredeep. Brahmaputra plain and its relation with Shillong and Mikir massif . Major litho-tectonic boundaries Concept of exhumation in the Himalayas	**14**	**4**		**18**
III (18 Marks)	Geology of Lesser Himalayas and Sub-Himalayas, geological history and structures, sedimentary basins, igneous and metamorphic belts with special reference to Eastern Himalayas Geology of Higher Himalayas, structural framework, inverted metamorphism, Magmatism and its geological history. Tethys Himalaya: geology, structure, and relationship with Higher Himalayas and trans-Himalayan belts.	**14**	**4**		**18**
IV (12 Marks)	Himalayan seismicity, its characteristics, major earthquakes, in relation to the structure of Himalayas. Mineral deposits and metallogeny of Himalayas	**10**	**2**		**12**
Total					**60**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Two Internal Examination - 15 + 15
- Others (Any one) - 10
  - Group Discussion
  - Seminar presentation on any of the relevant topics
  - Debate
  - Home Assignment

COURSE OUTCOMES (COs):
Students will be able to:

CO 01: Understand the origin, importance, morphology, and regional as well as geological subdivisions of the Himalayas.

LO 1.1: Explain the introduction, importance, and significance of the Himalayas in terms of geography, geology, and environment.

LO 1.2: Describe the morphological features and physical divisions of the Himalayan mountain system.

LO 1.3: Identify and explain the regional and geological subdivisions of the Himalayas and their characteristics.

CO 02: Understand the tectonic evolution of the Himalayas and the relationship between plate movement, major structural features, and adjacent geological regions.

LO 2.1: Explain the formation of the Himalayas, the role of the Indian plate margin, plate movements, and the development of the Himalayan foredeep.

LO 2.2: Describe the Brahmaputra plain and its geological relationship with the Shillong Plateau and Mikir Massif.

LO 2.3: Discuss the major litho-tectonic boundaries of the Himalayas and the concept of exhumation in the Himalayan mountain belt.

CO 03: Understand the geological framework and evolution of the Himalayan regions, including the Lesser, Sub-Himalaya, Higher Himalaya, and Tethys Himalaya.

LO 3.1: Describe the geology of the Lesser Himalayas and Sub-Himalayas, including their geological history, structural features, sedimentary basins, and igneous and metamorphic belts with special reference to the Eastern Himalayas.

LO 3.2: Explain the geology of the Higher Himalayas, including the structural framework, inverted metamorphism, magmatism, and their geological evolution.

LO 3.3: Discuss the geology and structural characteristics of the Tethys Himalaya and its relationship with the Higher Himalayas and Trans-Himalayan belts.

CO 04: Understand the seismic characteristics and mineral resources of the Himalayas and their relationship with the regional geological structure.

LO 4.1: Explain the nature and characteristics of Himalayan seismicity in relation to the tectonic framework of the Himalayas.

LO 4.2: Describe the major Himalayan earthquakes and their relationship with the structural features of the Himalayan mountain belt.

LO 4.3: Discuss the mineral deposits and metallogeny of the Himalayas and their geological significance.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	**CO 01, CO 02**	**CO 01, CO02,CO 03**				
Conceptual Knowledge		**CO 01, CO02,CO 03, CO 04**	**CO02, CO03**	**CO 03, CO 04**		
Procedural Knowledge		**CO02**	**CO 01, CO 03**	**CO03, CO 04**	**CO 04**	
Metacognitive Knowledge				**CO 04**	**CO 04**	

Mapping of Course Outcomes to Program Outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	S	S	M	S	S	S
CO2	S	S	M	S	S	S
CO3	S	S	M	S	S	S
CO4	S	S	M	S	S	S

Where, S=Strong Correlation and M=Medium Correlation

Suggested reading:

- The Making of India-Geodynamic Evolution 2nd Edition, K S Valdiya, Springer, Society of Earth Scientist Series ISBN: 978-3-319-25029-8
- Himalayan Collsion Tectonics, A K Jain & Sandeep Singh, Gondwana Research Group, Memoir No.7, 2002
- Dimensions Of Himalayan Geology, A.K. Biyani, Satish Serial Publishing House (2006), ISBN-10: 8189304151
- Kumar, G., 1997: Geology of Arunachal Pradesh. Geol. Soc. Ind. Publ., Bangalore, 217.
- Geodynamics of NW Himalaya, Eds. A.K. Jain, & R M Manickavasgam, Gondwana Research Group, Memoir No.6, 1999.
- Geology of the Himalayan Belt, B . K. Chakrabarti, ISBN: 9780128020210**, Elsevier 2016.**

Course Title **:Petroleum Micropalaeontology**
Course Code **:AGDSE-9.1c**
Nature of Course **:Discipline Specific Elective**
Total Credits **:** 04 credits
Distribution of Marks **:**60(End-Sem.)+40 (In-Sem.)

COURSE OBJECTIVES: Petroleum is rock oil found primarily in sedimentary rocks. Generation of oil occurs from organisms through various organic processes in source rocks under appropriate temperature and pressure conditions, and it is then stored in porous and permeable reservoir rocks in commercial quantities for exploitation. Micropalaeontology deals with the study of microfossils, which play an important role in petroleum exploration and in understanding major changes in global climate. Dating of geological sequences during petroleum exploration is largely supported by microfossil data. This course is designed to provide detailed coverage of key microfossil groups responsible for hydrocarbon generation, combined with major components of petroleum geosciences. It also focuses on the role of microfossils in understanding major changes in global climate.

UNITS	CONTENTS	L	T	P	Total Hours
I **(20 Marks)**	Introduction to micropalaeontology Classification of microfossils Micropalaeontological techniques for extraction of microfossils Introduction to different microfossils such as foraminifera, radiolaria, ostracoda, acritarchs, diatoms, calcareous algae, spores and pollen, calcareous nannoplankton, and dinoflagellates, and their geological distribution Application of these microfossils for palaeoenvironment interpretation and petroleum exploration Petroleum Geosciences: Introduction to petroleum geology and petroleum systems Source rocks and their evaluation: Rock-Eval Pyrolysis, Vitrinite Reflectance, Thermal Alteration Index (TAI), Total Organic Carbon (TOC), and Carbon Ratio Method Kerogen and thermal maturity of microfossils and their applications in source rock assessment Colour Index (CI), Spore Colouration Index (SCI), Foraminifera Colouration Index (FCI) Stable isotope analysis Reservoir rocks and petrophysics Seal rocks Various trapping mechanisms for oil and gas	**18**	**02**		**20**

II (25 Marks)	**Applied micropalaeontology in petroleum exploration and global climate change** Biostratigraphy and Sequence Biostratigraphy and their applications in petroleum exploration and depositional environment interpretation, with examples from industrial case studies Understanding major global climate changes using microfossils as a proxy Introduction to biomarkers and application of biomarkers for petroleum exploration **Geology of Petroliferous Sedimentary Basins** Petroliferous sedimentary basin geology Classification of petroliferous sedimentary basins of India Major oil and gas fields of India	**23**	**02**		**25**
III (Practical 15Marks)	Microscopic identification of different microfossils and their systematic palaeontology			**15**	**30**
Total					**75**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

Two Internal Examination - 15 + 15

Others (Any one) - 10

Group Discussion
Seminar presentation on any of the relevant topics
Debate

COURSEOUTCOMES(COs):

Students will be able to:

CO1 : Understand the Fundamentals of Micropalaeontology

LO1.1 : Define micropalaeontology and explain its significance in geological sciences.
LO1.2 : Describe the classification of microfossils and their characteristics.
LO1.3 : Explain the techniques used for extraction and identification of microfossils.
LO1.4 : Identify different types of microfossils, including foraminifera, radiolaria, and ostracoda.

CO2 : Apply Micropalaeontology in Petroleum Exploration and Palaeoenvironment Interpretation

LO2.1 : Explain the application of microfossils in petroleum exploration and palaeoenvironment interpretation.
LO2.2 : Describe the use of microfossils in source rock assessment and thermal maturity analysis.
LO2.3 : Discuss the role of microfossils in reservoir rock characterization and seal

rock identification.
LO2.4 : Apply micropalaeontological techniques to interpret palaeoenvironments and depositional settings.

CO3 : Understand Petroleum Geosciences and Applied Micropalaeontology

LO3.1 : Explain the concept of petroleum geology and petroleum systems.
LO3.2 : Describe the evaluation of source rocks using Rock-Eval Pyrolysis, Vitrinite Reflectance, and other techniques.
LO3.3 : Discuss the application of micropalaeontology in petroleum exploration, including biostratigraphy and sequence biostratigraphy.
LO3.4 : Explain the use of biomarkers in petroleum exploration and their significance in understanding petroleum systems.

CO4 : Apply Micropalaeontology in Global Climate Change and Sedimentary Basin Analysis

LO4.1 : Explain the use of microfossils as a proxy for understanding global climate change.
LO4.2 : Describe the geology of petroliferous sedimentary basins and their classification.
LO4.3 : Discuss the major oil and gas fields of India and their geological characteristics.
LO4.4 : Apply micropalaeontological techniques to analyze sedimentary basin evolution and petroleum potential.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	**CO01,CO 02,CO04**	**CO02,CO 03**	**CO04**			
Conceptual Knowledge		**CO02,CO 03,CO04**	**CO04**	**CO 03, CO 04**	**CO04**	
Procedural Knowledge		**CO04**	**CO04**	**CO03**		
Metacognitive Knowledge						

Mapping of Course Outcomes to Program Outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	S	M	M	S	M	M
CO2	S	M	M	S	M	M
CO3	S	M	M	S	M	M
CO4	S	M	M	S	M	M

Where, S=Strong Correlation and M=Medium Correlation

SUGGESTEDREADINGS:

- Wynn-Jones, R. Micropalaeontology in Petroleum Exploration. Oxford Science Publication.
- Kathal, P. K. Applied Geological Micropalaeontology. Scientific Publishers, India.
- Jenkins, D. G. (Ed.). Applied Micropalaeontology. Kluwer Academic Publishers.

• Nield, E. W. and Tucker, V. C. T. Palaeontology – An Introduction. Pergamon Press.

• Traverse, A. (Ed.). Sedimentation of Organic Particles. Cambridge University Press.

• Levorsen, A. I. Geology of Petroleum. CBS Publishers and Distributors, New Delhi.

• North, F. K. Petroleum Geology. Boston: Unwin Hyman Inc., USA.

• Sahay, Bhagwan. Petroleum Exploration and Exploration Practices. Allied Publishers Limited.

• Hyne, N. J. (1983). Geology for Petroleum Exploration, Drilling and Production.

• Selley, R. C. and Sonnenberg, S. A. Elements of Petroleum Geology. Elsevier.

• Bjorlykke, K. Sedimentology and Petroleum Geology. Springer.

• Mukherjee, S. (Ed.). Petroleum Geosciences: Indian Context. Springer.

• Chandra, D. and Singh, R. M. Petroleum (Indian Context). Tara Book Agency.

• Satyanarayana, D. Petroleum Geochemistry. Daya Publishing House, Delhi.

Course Title :**Critical Minerals & Strategic Resources: Foundations, Technologies & Policy**
Course Code :AGDSE9.1d
Nature of Course : **DSE**
Total Credits :04 credits
Distribution of Marks :60(End-Sem.)+40 (In-Sem.)

Course Objectives:

- Provide an integrated understanding of critical minerals in global and Indian context.
- Familiarize students with geology, exploration, extraction, and processing methods.
- Explore their strategic role in clean energy, defense, electronics, and advanced technologies.
- Introduce students to policy frameworks, sustainability issues, and supply chain risks.

Unit	Topic	L	T	P	Total Hours
I (12 marks)	**Fundamentals of Critical Minerals** Definition and classification of critical minerals, Indian & global lists of critical/strategic minerals (India CMMP, USGS, EU CRM Act, IEA), Geological distribution and tectonic controls, Strategic importance in defense, energy transition, and high-tech sectors.	16	02		18
II (18 marks)	**Extraction and Beneficiation** Principles of mineral processing, Beneficiation techniques, Hydrometallurgical and pyrometallurgical extraction, Processing of critical minerals such as lithium, REE and vanadium **Non-conventional Sources of Critical Minerals (with emphasis on India)** Recovery of critical minerals from mine tailings and industrial wastes, Deep-sea polymetallic nodules, Extraction from coal ash and brines, Urban mining and e-waste recycling, Recent discoveries and initiatives related to critical minerals in India	18	04		22
III (18 marks)	**Sustainability, Policy & Supply Chains** Basics of Geopolitics and critical minerals, Global supply chain risks and mineral economics, ESG, sustainable mining, and environmental impact assessment, Life cycle analysis (LCA) of critical minerals, Circular economy & urban mining approaches, National and global policies: India CMMP, US IRA, EU CRM Act, China's strategy	18	02		20
IV (marks)	**Technology Integration & Case Studies** Role of critical minerals in EVs, batteries, solar, wind, defense electronics, Industry case studies: Vanadium and graphite deposits of Arunachal Pradesh, lithium deposits of Jammu and Kashmir, and rare earth element (REE) deposits in in India, Lithium in South America, Cobalt in Africa,	13	02		15
					75

Where, L: Lectures T: Tutorials P:Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- **Two Internal Examination - 15 + 15**
- **Others (Any one) - 10**
  - **Group Discussion**
  - **Seminar presentation on any of the relevant topics**
  - **Debate**
  - **Home Assignment**

COURSEOUTCOMES(COs):

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

CO 01: Understand the concept, classification, geological distribution, and strategic importance of critical minerals at national and global levels.

LO 1.1: Define and classify critical and strategic minerals and explain the criteria used for their identification.

LO 1.2: Describe the Indian and global lists of critical minerals with reference to India's Critical Minerals Policy (CMMP), USGS, the EU Critical Raw Materials Act, and IEA reports.

LO 1.3: Explain the geological distribution, tectonic controls, and strategic importance of critical minerals in defense, energy transition, and high-technology sectors.

CO 02:Understand the principles of extraction, beneficiation, and non-conventional sources for the recovery of critical minerals with emphasis on processing techniques and recent initiatives in India.

LO 2.1: Explain the principles of mineral processing and beneficiation techniques used for the concentration of critical minerals.

LO 2.2: Describe hydrometallurgical and pyrometallurgical extraction methods and the processing of important critical minerals such as lithium, rare earth elements (REE), and vanadium.

LO 2.3: Discuss non-conventional sources of critical minerals including mine tailings, industrial wastes, deep-sea polymetallic nodules, coal ash, brines, urban mining, e-waste recycling, and recent discoveries and initiatives in India.

CO 03:Understand the sustainability, policy framework, geopolitics, and supply chain dynamics associated with critical minerals at national and global levels.

LO 3.1: Explain the basics of geopolitics, mineral economics, and global supply chain risks related to critical minerals.

LO 3.2: Describe the principles of ESG, sustainable mining practices, environmental impact assessment (EIA), and life cycle analysis (LCA) of critical minerals.

LO 3.3: Discuss circular economy and urban mining approaches along with national and global policies such as India's CMMP, the US Inflation Reduction Act (IRA), the EU Critical Raw Materials Act, and China's critical minerals strategy.

CO 04:Understand the role of critical minerals in modern technologies and analyze important

global and Indian case studies of critical mineral deposits.

LO 4.1: Explain the role of critical minerals in emerging technologies such as electric vehicles, batteries, solar and wind energy systems, and defense electronics.

LO 4.2: Describe important Indian case studies including vanadium and graphite deposits of Arunachal Pradesh, lithium deposits of Jammu and Kashmir, and rare earth element (REE) deposits in India.

LO 4.3: Discuss global case studies of critical mineral resources such as lithium deposits in South America and cobalt deposits in Africa.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	CO 01	CO 01				
Conceptual Knowledge		CO 01, CO 02, CO 03	CO 01, CO 02, CO 03	CO 02, CO 03, CO 04		
Procedural Knowledge			CO 02, CO 03	CO 02, CO 03, CO 04	CO 04	CO 04
Metacognitive Knowledge					CO 04	CO 04

Mapping of Course Outcomes to Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	S	M	M	M	S	S
CO2	S	M	M	S	S	S
CO3	S	S	M	S	S	S
CO4	S	S	S	S	S	S
CO5	S	S	S	S	S	S

Where, S=Strong Correlation and M=Medium Correlation.

Suggested Readings

1. National Critical Minerals Strategy (India, Ministry of Mines)
2. USGS Critical Minerals Report (Annual)
3. European Commission – Critical Raw Materials Act
4. IEA: Role of Critical Minerals in Energy Transitions
5. Gupta, C.K. & Krishnamurthy, N. – Extractive Metallurgy of Rare Earths
6. Kesler, S.E. & Simon, A.C. – Mineral Resources, Economics and the Environment

Course Title **:Principles and Applications of Geostatistics**
Course Code **:AGDSC-10.1**
Nature of Course **:Discipline Specific Core**
Total Credits **:**4 credits
Distribution of Marks **:**60(End-Sem.)+40(In-Sem.)

COURSE OBJECTIVES : This course aims to provide students a comprehensive understanding of the core concepts in geostatistics as applied to spatial interpolation and geostatistical simulation. It also seeks to equip students with practical experience in implementing various geostatistical techniques such as variogram modeling, kriging, two-point geostatistical simulation algorithms, and multi-point geostatistical simulation algorithms through software-based exercises.

UNITS	CONTENTS	L	T	P	Total Hours
I (13 Marks)	**Introduction to Geostatistics:** Concepts in probability and statistics: univariate distribution, Monte Carlo simulation, measures of distribution center, measures of spread, concept of stationarity, prior and posterior distribution, standard normal distribution, lognormal distribution, histogram transformation, data transformation, bivariate distribution, conditional probability, Bayes rule, indicator statistics, and uncertainty quantification.	**11**	**2**		**13**
II (17 Marks)	**Spatial Interpolation:** Spatial continuity and correlation; Experimental correlogram; Experimental variogram; Variogram modeling; Simple kriging; Universal kriging.	**15**	**2**		**17**
III (15 Marks)	**GeostatisticalSimulation:** Gaussian theory and sequential simulation; Multiple secondary variables: co-kriging and simulation; Two-point geostatistical simulation algorithms; Multi-point geostatistical simulation algorithms; Non-stationary modeling.	**13**	**2**		**15**
IV Practical (15 Marks)	Hands-on exercises using the Stanford Geostatistical Modeling Software (SGEMS) on variogram modeling, kriging, two-point geostatistical simulation and multi-point geostatistical simulation. Reservoir modeling exercises using real field datasets.			**15**	**30**
	Total				**75**

Where, L:Lectures T:Tutorials P:Practicals

MODESOFIN-SEMESTERASSESSMENT: **(40Marks)**

- **Two Internal Examination - 15 + 15**
- **Others (Anyone) - 10**
  - **Project**
  - **Seminar presentation on any of the relevant topics**
  - **Home Assignment**

COURSE OUTCOMES (COs):

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

CO01 : Apply the foundational concepts of probability and statistics with regard to geostatistics.

LO1.1 : Define and describe key concepts in probability and statistics, including univariate and bivariate distributions, conditional probability, and Bayes' rule.
LO1.2 : Apply Monte Carlo simulations to model random processes in geostatistics.
LO1.3 : Compute measures of central tendency (mean, median) and measures of spread (variance, standard deviation) for datasets.
LO1.4 : Apply the concepts of stationarity and isotropy in geostatistical analysis.
LO1.5 : Apply histogram transformations in order to adjust the distributions of data.
LO1.6 : Distinguish between prior and posterior distributions in Bayesian inference.

CO02 : Develop proficiency in spatial interpolation methods and spatial continuity analysis.

LO2.1 : Analyze spatial data to determine spatial continuity and correlation.
LO2.2 : Construct and interpret experimental correlograms and variograms to assess spatial dependence.
LO2.3 : Fit and model experimental variograms to theoretical models.
LO2.4 : Apply simple kriging to interpolate spatial data based on known locations.
LO2.5 : Implement universal kriging methods for spatial interpolation considering non-stationarity in the data.

CO03 : Gain knowledge and skills in geostatistical simulation techniques.

LO3.1 : Explain the theory of Gaussian random fields and their role in geostatistical simulations.
LO3.2 : Implement sequential simulation methods and interpret their results in the context of geostatistical analysis.
LO3.3 : Use co-kriging to handle multiple secondary variables and demonstrate its application in spatial modeling.
LO3.4 : Apply two-point geostatistical simulation algorithms to generate spatial realizations from variogram models.
LO3.5 : Implement multi-point geostatistical simulation algorithms for more complex spatial patterns.

CO04 : Develop practical skills in geostatistical modeling using the Stanford Geostatistical Modeling Software (SGEMS).

LO4.1 : Gain proficiency in using SGEMS for variogram modeling and interpretation.
LO4.2 : Perform kriging and other geostatistical interpolation techniques within SGEMS to estimate spatial variables.
LO4.3 : Conduct two-point and multi-point geostatistical simulations in SGEMS and interpret the results for spatial modeling.
LO4.4 : Apply geostatistical techniques to real field datasets, performing reservoir modeling and spatial analysis for resource estimation.

CO05 : Quantify and manage uncertainty in geostatistical models and simulations.

LO5.1 : Identify sources of uncertainty in geostatistical models and data.
LO5.2 : Quantify uncertainty through probabilistic methods and simulation techniques.
LO5.3 : Apply uncertainty quantification methods to assess the reliability of geostatistical predictions and simulations.
LO5.4 : Incorporate uncertainty into decision-making processes in geostatistical applications.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	CO1	CO1				
Conceptual Knowledge		CO1,CO2, CO3	CO1, CO2, CO3	CO2, CO3, CO4		
Procedural Knowledge			CO1, CO2, CO3	CO2, CO3, CO4, CO5	CO4, CO5	CO4
Metacognitive Knowledge					CO5	CO4

Mapping of Course Outcomes to Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	M	M	M	M	M
CO2	M	M	M	S	M	M
CO3	M	S	M	S	M	M
CO4	M	S	S	S	M	S
CO5	M	S	S	S	M	S

Where, S=Strong Correlation and M=Medium Correlation. SUGGESTED

Suggested Readings:

1. Caers, J. (2011). Modeling Uncertainty in the Earth Sciences. Wiley.

2. Remy, N., Boucher, A., and Wu, J. (2009). Applied Geostatistics with SGeMS.

Cambridge University Press.

3. Mariethoz, G. and Caers, J. (2015). Multiple-Point Geostatistics: Stochastic Modeling with Training Images. Wiley.

4. Dubrule, O. (2003). Geostatistics for Seismic Data Integration in Earth Models. SEG.

5. Caers, J. (2005). Petroleum Geostatistics. SPE.

6. Deutsch, C. V. (2002). Geostatistical Reservoir Modeling. Oxford University Press.

7. Goovaerts, P. (1997). Geostatistics for Natural Resources Evaluation. Oxford University Press.

Course Title :**Mineral Optics and Advanced Petrology**
Course Code :**AGDSC-10.2**
Nature of Course :**Discipline Specific Core**
Total Credits :4 credits
Distribution of Marks :60(End-Sem.)+40(In-Sem.)

Course Objectives: This advanced course will help students understand the intricacies of optical mineralogy and some advanced concepts of petrology.

UNITS	CONTENTS	L	T	P	Total Hours
I (13Marks)	➢ Petrographic microscope – Parts of microscope ➢ Becke line test; Extinction angle; Interference colours ➢ Nature of light, ordinary and plane polarized light ➢ Interference of two rays ➢ Birefringence, uniaxial and biaxial minerals ➢ Interference figures ➢ Types of interference figures in uniaxial and biaxial minerals ➢ Optical accessories ➢ Optic sign and indicatrix figures	**12**	**02**		**14**
II (20Marks)	➢ Igneous rocks associated with plate margins ➢ Rock associations ➢ Large igneous plutons ➢ Kimberlites, Carbonatites, and Charnockites ➢ Igneous petrogenesis ➢ Metamorphic facies ➢ Metamorphic reactions and their types ➢ Geothermobarometry ➢ P–T–t paths ➢ Metamorphism of pelitic sediments, calcareous, mafic, and ultramafic rocks ➢ Metamorphic petrogenesis	**18**	**02**		**20**
III (12Marks)	➢ Depositional environments ➢ Energy transition ➢ Sedimentary basins and tectonism ➢ Use of sophisticated analytical techniques in clay mineralogy and diagenetic study	**10**	**01**		**11**
IV (15Marks)	**Practical** ➢ Determination of optic sign and indicatrix figures ➢ Identification of diagenetic features in siliciclastic and carbonate rocks under microscope ➢ Interpretation of paleodepositional environment ➢ Identification and interpretation of igneous and metamorphic textures and structures			**15**	**30**
	Total				**75**

Where, L: Lectures T: Tutorials P: Practicals

MODESOFIN-SEMESTERASSESSMENT: (40Marks)

- **TwoInternalExamination - (15 + 15)**

  Others(Anyone)- 10

- Group Discussion
- Seminar presentation on any of the relevant topics
- HomeAssignment

COURSE OUTCOMES:

CO1: Develop an advanced understanding of petrographic microscope principles, including optical mineralogy concepts such as birefringence, interference figures, and optic sign determination.

LO1.1: Explain the principles and components of the petrographic microscope and their applications in mineral identification.
LO1.2: Differentiate between ordinary light and plane-polarized light, including their behavior in mineral sections.
LO1.3: Demonstrate the use of the Becke line test, interference colors, and extinction angles in mineral identification.
LO1.4: Interpret birefringence, interference figures, and optic sign in uniaxial and biaxial minerals.
LO1.5: Utilize optical accessories for mineralogical studies and explain the significance of indicatrix figures in optical mineralogy.

CO2: Analyze the petrogenesis of igneous and metamorphic rocks, their plate tectonic associations, and the application of geothermobarometry in understanding metamorphic evolution.

LO2.1: Assess the role of plate tectonics in the formation of different igneous rock associations, including large igneous plutons and specialized rock types such as kimberlites, carbonatites, and charnockites.
LO2.2: Explain the processes governing igneous petrogenesis and the significance of rock associations in different tectonic settings.
LO2.3: Differentiate between various metamorphic facies and evaluate metamorphic reactions controlling mineral stability.
LO2.4: Apply geothermobarometry techniques to estimate metamorphic conditions and analyze pressure–temperature–time (P–T–t) paths.
LO2.5: Interpret metamorphic petrogenesis, including the transformation of pelitic, calcareous, mafic, and ultramafic rocks under varying metamorphic conditions.

CO3: Evaluate the relationship between sedimentary processes, depositional environments, and tectonism, with emphasis on analytical techniques in clay mineralogy and diagenesis.

LO3.1: Identify different depositional environments and explain their influence on sedimentary rock formation.
LO3.2: Analyze transitions in energy conditions within sedimentary systems and their impact on sediment deposition.
LO3.3: Correlate sedimentary basins with tectonism to understand basin evolution and sediment dynamics.
LO3.4: Apply advanced analytical techniques in clay mineralogy and diagenetic studies to interpret sedimentary rock transformations.

CO4: Apply advanced microscopic techniques to identify mineralogical, textural, and diagenetic features in igneous, metamorphic, and sedimentary rocks for geological interpretation.

LO4.1: Determine optic sign and indicatrix figures for mineral identification using a petrographic microscope.
LO4.2: Identify diagenetic features in siliciclastic and carbonate rocks and interpret their geological significance.
LO4.3: Analyze sedimentary rock textures and structures to reconstruct paleodepositional environments.
LO4.4: Identify and interpret igneous and metamorphic rock textures and structures using thin-section analysis.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	CO1	CO1				
Conceptual Knowledge		CO1, CO2, CO3	CO1, CO2, CO3, CO4	CO2, CO3, CO4	CO4	
Procedural Knowledge		CO2,CO3	CO2, CO3, CO4	CO2, CO3, CO4	CO4	
Metacognitive Knowledge						CO4

Mapping of Course Outcomes to Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	S	M	S	M	M
CO2	M	S	S	S	M	M
CO3	M	S	S	S	M	M
CO4	S	S	S	S	M	S

Where, S=Strong Correlation and M=Medium Correlation.

Course Title **:Isotope Geochemistry**
Course Code **:AGDSE-10.1**
Nature of Course **:Discipline Specific Elective**
Total Credits **:** 04 credits
Distribution of Marks **:**60(End-Sem.)+40 (In-Sem.)

COURSE OBJECTIVES: Isotope Geochemistry deals with the study of the characteristics of both radioactive and stable isotopes and their ratios. The course is essentially framed to understand geochronology and the geochemistry of the Earth's crust and mantle, as well as meteorites-their compositions and their relationship to the Earth. The course is designed to familiarize students with isotopes, isotopic ratios, and isotopic dating techniques applied to rocks and minerals. Isotope Geochemistry is found to be particularly useful in understanding the petrogenesis of igneous and metamorphic rocks.

UNITS	CONTENTS	L	T	P	Total Hours
I (20 Marks)	The origin of isotope geology Isotopes and their impacts in geology; cosmic abundance of elements and their characteristics Stable isotopes and their fractionation Radioactive decay and growth Decay of radioactive parent to a stable daughter; decay series Nuclear fission Units of radioactivity and dosage Neutron activation Mass spectrometry: types and isotope dilution analysis	18	02		**20**
II (25 Marks)	Principles and procedures of the following radioactive dating methods: K–Ar dating Rb–Sr dating Sm–Nd dating U–Pb dating Fission track dating Isotope geology of Ar, Sr, and Nd Oxygen and Hydrogen isotopes and their applications Isotope geochemistry related to petrology Evolution of isotopic reservoirs in the mantle and crust	20	05		**25**
III Practicals (15 Marks)	Calculation and determination of the age of mineral and whole-rock samples using Rb–Sr and Sm–Nd dating methods. Identification of fission tracks and dating of rocks containing suitable minerals using the fission track dating method. Interpretation of fission track ages, and estimation of cooling rates and exhumation rates using the fission track dating method.			15	**30**
Total					**75**

Where, **L:Lectures** **T:Tutorials** **P:Practicals**

MODESOFIN-SEMESTERASSESSMENT: **(40Marks)**

- **Two Internal Examination-** **15 + 15**
- Others (Any one) - 10
  - Group Discussion
  - Seminar presentation on any of the relevant topics
  - Debate
  - HomeAssignment

COURSEOUTCOMES(COs):

Students will be able to:

CO1: Understand the Fundamental Principles of Geochemistry

LO1.1: Explain the structure of the periodic table and its relevance to geochemistry.
LO1.2: Describe the different types of chemical bonding and their significance in geochemical processes.
LO1.3: Define and explain geochemical classifications and their application in understanding Earth's composition.
LO1.4: Discuss the concept of isotopes and their importance in geochemistry.

CO2: Apply Major and Minor Element Geochemistry

LO2.1: Explain the basics of major and minor element geochemistry and their methods of analysis.
LO2.2: Describe the distribution of major and minor elements in the Earth's crust.
LO2.3: Apply normative mineral calculations to understand the composition of rocks.
LO2.4: Interpret variation diagrams to understand geochemical processes and trends.

CO3: Analyze Trace Element Geochemistry

LO3.1: Explain the basics of trace element geochemistry and their distribution in different geological environments.
LO3.2: Describe the unique characteristics of rare earth elements and their significance in geochemistry.
LO3.3: Discuss the principles of radioactive and stable isotopes and their applications in geochemistry.
LO3.4: Apply trace element geochemistry to understand geological processes and solve related problems.

CO4: Apply Geochemical Principles to Petrology and Petroleum Geochemistry

LO4.1: Explain the chemical composition of magmas and igneous rocks using variation diagrams.
LO4.2: Describe the geochemical processes involved in sedimentation and the composition of sedimentary rocks.
LO4.3: Discuss the principles of petroleum geochemistry, including the carbon cycle and origin of organic matter.
LO4.4: Apply geochemical methods to characterize source rocks and assess their maturation.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	**CO01,CO 02,CO04**	**CO02,CO 03**	**CO04**			
Conceptual Knowledge		**CO02,CO 03**	**CO04**	**CO 03, CO 04**	**CO04**	
Procedural Knowledge		**CO04**	**CO02**	**CO03**		
Metacognitive Knowledge						

Mapping of Course Outcomes to Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	S	M	M	S	M	M
CO2	S	M	M	S	M	M
CO3	S	M	M	S	M	M
CO4	S	M	M	S	M	M

Where,S=StrongCorrelationandM=Medium Correlation

SUGGESTED READINGS

1. Mason, B., & Moore, C. B. (1982). Principles of Geochemistry (4th ed.).
2. Konrad, B. K. (1979). Introduction to Geochemistry (2nd ed.). McGraw-Hill.
3. White, W. M. (2009). Geochemistry.
4. White, W. M. (2023). Isotope Geochemistry (2nd ed.). Wiley-Blackwell.
5. Sharp, Z. (2017). Principles of Stable Isotope Geochemistry.

Course Title **:Machine Learning and Artificial Intelligence for Geoscientific Applications**
Course Code **:AGDSE-10.1**
Nature of Course **:Department Specific Elective**
Total Credits **:** 4 credits
DistributionofMarks:60 (End-Sem.)+40 (In-Sem.)

COURSE OBJECTIVES: This course aims to provide students with the fundamental concepts of supervised, unsupervised, and reinforcement learning, along with parametric and non-parametric methods. It also seeks to provide practical experience to students in implementing various machine learning techniques such as regression, classification, and dimensionality reduction for geoscience problems.

UNITS	CONTENTS	L	T	P	Total Hours
I (10 Marks)	**Introduction:** Basic concepts of supervised learning, unsupervised learning and reinforcement learning, Parametric and non-parametric methods, Bias-Variance tradeoff.	**9**	**1**		**10**
II (20 Marks)	**Supervised learning:** Linear regression, Variable selection, Regularization, Ridge regression, Lasso, Elastic net, Regression trees, Bagging, Boosting, Random forests, Support vector machines, Cross validation, Bootstrapping, Principal Components Regression, Partial Least Squares Regression, Basis functions, Splines, Generalized Additive Models, Bayes classifier, k nearest neighbors, Logistic regression, Linear discriminant analysis, Quadratic discriminant analysis, Perceptron, Artificial neural networks.	**17**	**3**		**20**
III (15 Marks)	**Unsupervised learning:** Clustering, K-means clustering, Hierarchical clustering, Dimensionality reduction, Multidimensional scaling, Principal component analysis, Kernel methods.	**13**	**2**		**15**
IV Practical (15 Marks)	Hands-on exercises in machine learning applications in petroleum reservoir characterization, subsurface carbon storage, decision-making related to the geosciences, and value of information analysis for subsurface applications.			**15**	**30**
	Total				**75**

Where, L: Lectures T: Tutorials P: Practicals

MODESOFIN-SEMESTERASSESSMENT: **(40Marks)**

- **Two Internal Examination - 15 + 15**
- **Others(Anyone) - 10**
  - **Project**
  - **Seminar presentation on any of the relevant topics**
  - **Home Assignment**

COURSEOUTCOMES(COs):

CO01: Explain and apply fundamental machine learning concepts

LO1.1: Explain the key differences between supervised, unsupervised, and reinforcement learning techniques.
LO1.2: Identify and describe parametric and non-parametric methods in machine learning.
LO1.3: Analyze the Bias–Variance trade-off and its implications on model performance.
LO1.4: Discuss the importance of model evaluation, including cross-validation and bootstrapping techniques.
LO1.5: Describe the role of regularization techniques (Ridge, Lasso, Elastic Net) in improving model performance and avoiding overfitting.

CO02: Demonstrate proficiency in implementing supervised learning algorithms for regression and classification

LO2.1: Apply linear regression techniques for solving real-world regression problems, including variable selection and regularization.
LO2.2: Implement Ridge regression, Lasso, and Elastic Net methods to improve prediction accuracy.
LO2.3: Demonstrate the use of decision trees, bagging, boosting, and random forests for both regression and classification tasks.
LO2.4: Evaluate the performance of support vector machines (SVM) and logistic regression for binary and multiclass classification problems.
LO2.5: Implement the Perceptron algorithm and artificial neural networks in supervised learning.
LO2.6: Apply cross-validation and bootstrapping techniques to assess model performance and avoid overfitting.

CO03: Apply unsupervised learning techniques to identify patterns and reduce dimensionality in complex datasets

LO3.1: Implement clustering techniques such as K-means and hierarchical clustering to identify patterns and structure in unlabeled data.
LO3.2: Apply dimensionality reduction techniques like Principal Component Analysis (PCA) and Multidimensional Scaling (MDS).
LO3.3: Use kernel methods for advanced clustering and data transformation tasks.
LO3.4: Interpret the results of unsupervised learning algorithms and assess their effectiveness in extracting meaningful insights from data.

CO04: Develop hands-on skills to apply machine learning methods to subsurface applications

LO4.1: Integrate machine learning techniques into petroleum reservoir characterization to

predict reservoir properties.

LO4.2: Use machine learning models to assist in subsurface carbon storage predictions and analysis.

LO4.3: Use machine learning for decision-making in geoscience applications, including exploration and production.

LO4.4: Implement value of information analysis for subsurface applications to optimize resource allocation and decision-making.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	CO1	CO1				
Conceptual Knowledge		CO1, CO2, CO3	CO1, CO2, CO3, CO4	CO2, CO3, CO4	CO4	
Procedural Knowledge		CO2,CO3	CO2, CO3, CO4	CO2, CO3, CO4	CO4	
Metacognitive Knowledge						CO4

Mapping of Course Outcomes to Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	S	M	S	M	M
CO2	M	S	S	S	M	M
CO3	M	S	S	S	M	M
CO4	S	S	S	S	M	S

Where, S=Strong Correlation and M=Medium Correlation.

SUGGESTED READINGS:

1. James, G., Witten, D., Hastie, T. and Tibshirani, R. (2013). An Introduction to Statistical Learning: with Application in R. Springer.

2. Hastie, T., Tibshirani, R. and Friedman, J. (2009). The Elements of Statistical Learning. Springer.

3. Bishop, C. (2006). Pattern Recognition and Machine Learning. Springer.

4. Goodfellow, I., Bengio, Y. and Courville, A. (2016). Deep Learning. The MIT Press.

5. Eidsvik, J., Mukerji, T. and Bhattacharjya, D. (2015). Value of Information in the Earth Sciences. Cambridge University Press.

Course Title **:GIS**
Course Code **:**AGDSE10.2b
Nature of Course **: DSE**
Total Credits **:**04 credits
Distribution of Marks **:**60(End-Sem.)+40(In-Sem.)

Unit	Topic	L	T	P	Total Hours
I (12 marks)	Introduction and definitions of GIS, components, application areas of GIS, advantages and disadvantages of GIS Data formats, data structure, raster data model and vector data model, raster versus vector, advantages and disadvantages of raster and vector	12	2		12
II (12 marks)	Functional elements of GIS: Data acquisition, data input and data processing, data management system, product and report generation Concept of database and DBMS	10	2		12
III (21 marks)	Coordinate systems: Cartesian Coordinate System, Geographic Coordinate System Map Projection: Definition, classification and types of map projection, Polyconic projection, UTM projection, Latitude/Longitude geographic coordinates Digital image processing and GIS software (ArcGIS, ERDAS)	16	5		21
IV (15 marks)	Geometric registration: Georeferencing of topographic sheet of the area, satellite image with a topographic sheet, image-to-image referencing, re-projection, creating FCC image from raw data (layer stacking/band combination), image clipping, masking Working with ArcGIS software: Creating vector files, digitization, attribute generation, labeling, symbolizing and preparation of map DEM analysis: contour extraction, slope map, aspect map			**15**	**30**
					75

Where, L: Lectures T: Tutorials P:Practicals

MODESOFIN-SEMESTERASSESSMENT: **(40Marks)**

- **One Internal Examination-** **20(T)+10**
  (P)

- **Others(Anyone) - 10**
    - **Group Discussion**
    - **Seminar presentation on any of the relevant topics**
    - **Debate**
    - **HomeAssignment**

Course Outcome (CO):

CO1: Understand the fundamentals of Geographic Information Systems (GIS) and database management systems (DBMS) and apply them in spatial analysis

LO1.1: Define GIS, its components, application areas, and evaluate its advantages and disadvantages.
LO1.2: Differentiate between raster and vector data models, including their structures, formats, and comparative advantages.
LO1.3: Explain the functional elements of GIS such as data acquisition, input, processing, management, and output generation.
LO1.4: Understand the concept of databases and database management systems (DBMS) in GIS.

CO2: Understand and apply coordinate systems, map projections, and digital image processing techniques using GIS software for spatial analysis

LO2.1: Explain the concepts of coordinate systems, including Cartesian and Geographic Coordinate Systems.
LO2.2: Describe different types of map projections, their classifications, and specific projections such as Polyconic and UTM.
LO2.3: Interpret latitude/longitude geographic coordinates and their significance in spatial mapping.
LO2.4: Understand the basics of digital image processing and explore GIS software applications like ArcGIS and ERDAS.

CO3: Perform geometric registration and georeferencing of spatial datasets using ArcGIS software to create accurate spatial maps

LO3.1: Perform georeferencing of topographic sheets and satellite images by aligning them with real-world coordinate systems.
LO3.2: Apply image-to-image referencing and re-projection techniques to integrate spatial datasets.
LO3.3: Create False Colour Composite (FCC) images from raw satellite data using band combinations and layer stacking.
LO3.4: Use GIS tools to clip, mask, and manage spatial data for further analysis and map preparation.

CO4: Analyze digital elevation models (DEMs) and perform raster-based analysis to extract topographic features using GIS tools

LO4.1: Generate vector files in ArcGIS and perform digitization of spatial features for mapping and analysis.
LO4.2: Develop attribute data for spatial features and apply labeling and symbolization techniques in ArcGIS.
LO4.3: Extract contour lines from DEMs and generate slope and aspect maps for terrain analysis.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	CO1	CO1				
Conceptual Knowledge		CO1,	CO2, CO3	CO1, CO2, CO3, CO4	CO2, CO3, CO4	CO4
Procedural Knowledge		CO2,CO3	CO2, CO3, CO4	CO2, CO3, CO4	CO4	
Metacognitive Knowledge						CO4

Mapping of Course Outcomes to Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	S	S	S	M	S
CO2	M	S	S	S	M	S
CO3	M	S	S	S	M	S
CO4	M	S	S	S	M	S

Where, S=Strong Correlation and M=Medium Correlation

Suggested Books:

- Sahu, K. C. (2008). A Textbook of Remote Sensing and Geographical Information System. Atlantic Publishers and Distributors (P) Ltd.
- Bhatta, B. (2011). Remote Sensing and GIS. Oxford University Press.
- Demers, M. N. (1997). Fundamentals of Geographic Information Systems. John Wiley & Sons Inc.

Course Title **:Coal Resources of India**
Course Code **:AGDSE10.3a**
Nature of Course **:Major(core)**
Total Credits **:**4 credits
Distribution of Marks **:**60(End-Sem.)+40(In-Sem.)

COURSE OBJECTIVES: It is intended to provide students with knowledge of the geology and nature of coal, its varying properties, together with the practices and techniques required to evaluate coal in terms of its utilization. In addition, the alternative uses of coal as a source of energy are also addressed.

UNITS	CONTENTS	L	T	P	Total Hours
I (12 Marks)	**Introduction** ➢ Coal: Historical review, mining in India ➢ Classification of coal – Indian and International	**4**	**1**		**5**
II (13 Marks)	**Exploration and Mining of coal** ➢ Coal reserves of India, production and demand ➢ Stages of exploration, modern techniques of exploration ➢ Assessment and calculation of coal reserves, Indian standard procedure for coal reserve estimation ➢ Methods of coal mining, mining hazards ➢ Compositional differences of Gondwana and Tertiary coals of India	**12**	**3**		**15**
III (20 Marks)	**Coal as Fuel and resource** ➢ Beneficiation of coal: Coal washing method ➢ Utilization of coal: combustion, carbonization, gasification, liquefaction and other uses of coal ➢ Coal bed methane: a new energy resource; maturation of coal and generation of methane in coal beds; methods of extraction of CBM; current scenario and future prospects ➢ Clean Coal Initiatives ➢ Geological and geographical distribution of major coalfields in India	**20**	**5**		**25**
IV (15 Marks)	**Practical** ➢ Completion of outcrops in the given maps and calculation of coal reserves			**15**	**30**

	Total				**75**

Where, L:Lectures T:Tutorials P:Practicals

MODESOFIN-SEMESTERASSESSMENT: (40Marks)

- **Two Internal Examination- 15 + 15**
- **Others (Anyone) - 10**
  - **Group Discussion**
  - **Seminar presentation on any of the relevant topics**
  - **Debate**
  - **HomeAssignment**

COURSE OUTCOMES:

CO01: Understand the significance of coal as a fossil fuel, its historical impact, and its role in industrial development

LO1.1: Describe the historical development of coal usage and its impact on industrial growth.

LO1.2: Explain coal mining practices in India, including major coal-producing regions and government regulations.

LO1.3: Differentiate between Indian coal grading and international classification systems, highlighting their significance in energy production.

CO02: Analyze coal exploration and mining processes, including reserve estimation, modern exploration techniques, and mining hazards in the Indian context

LO2.1: Explain the coal reserves, production, and demand scenario in India.

LO2.2: Describe the stages of coal exploration and modern techniques used for reserve assessment.

LO2.3: Identify various methods of coal mining and assess the associated hazards in the Indian mining industry.

CO03: Understand the various uses of coal as a fuel and resource, its preparation and beneficiation, coal bed methane, clean coal initiatives, and geological distribution of coalfields

LO3.1: Explain the different processes involved in coal utilization, including combustion, carbonization, gasification, and liquefaction.

LO3.2: Describe coal bed methane (CBM) as an emerging energy resource, its formation, and future potential.

LO3.3: Identify and analyze the geological and geographical distribution of major coalfields in India, focusing on Gondwana, Tertiary, and Northeastern coalfields.

CO04: Interpret geological maps and apply standard methods for coal reserve estimation

LO4.1: Analyze and interpret outcrop patterns on geological maps to understand coal deposit distribution.

LO4.2: Apply standard methods and procedures for estimating coal reserves using geological and mathematical techniques.

LO4.3: Evaluate the accuracy of coal reserve calculations based on Indian standard procedures and international best practices.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	**CO01,CO 02,CO03**	**CO02,CO 03**	**CO02, CO03, CO04**		**CO02**	
Conceptual Knowledge		**CO02,CO 03,CO04**	**CO02, CO04**	**CO 02, CO 04**		
Procedural Knowledge		**CO03,CO 04**	**CO03, CO04**	**CO04**		
Metacognitive Knowledge						

Mapping of Course Outcomes to Program Outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	S	M	M	S	S	M
CO2	S	M	M	S	S	M
CO3	S	M	M	S	S	M
CO4	S	M	M	S	S	M

Where, S=Strong Correlation and M=Medium Correlation

Suggested Books

1. Chandra, D., Singh, R. M., Singh, M. P. (2000). Textbook of Coal (Indian Context). Tara Book Agency, Varanasi.
2. Scott, A. C. (1987). Coal and Coal-bearing Strata: Recent Advances. Blackwell Scientific Publications.
3. Singh, M. P. (1998). Coal and Organic Petrology. Hindustan Publishing Corporation, New Delhi.
4. Stach, E., Mackowsky, M.-Th., Taylor, G. H., Chandra, D., Teichmüller, M., & Teichmüller, R. (1982). Stach's Textbook of Coal Petrology. Gebrüder Borntraeger, Stuttgart.
5. Thomas, L. (2002). Coal Geology. John Wiley and Sons Ltd., England.
6. Van Krevelen, D. W. (1993). Coal: Typology–Physics–Chemistry–Constitution. Elsevier Science, Netherlands.
7. Ward, C. R. (1984). Coal Geology and Coal Technology. Blackwell Scientific Publication.
8. Raja Rao, C. S. (Ed.) (1981). Coalfields of India. Bull. Series A, No. 45, Vol. I, Geological Survey of India.
9. Francis, W. (1961). Coal: Its Formation and Composition. Edward Arnold Publications, London.
10. Sharma, N. L. & Ram, K. S. V. (1983). Introduction to Geology of Coal and Indian Coalfields. Dhanbad Publications, Dhanbad.

Course Title **:Brahmaputra Studies**
Course Code **:AGDSE10.3b**
Nature of Course **:Major(Core)**
Total Credits **:**4credits
Distribution of Marks **:**60(End-Sem.)+40(In-Sem.)

COURSE OBJECTIVES: This course is aimed to acquaint the students with the multi-dimensional perspectives associated with the Brahmaputra basin. The inter-disciplinary approach will equip the students with an understanding of the formation of the Brahmaputra Basin, the drainage system associated with this region, issues of flood, erosion, development, flood control measures and the technologies, issue of dams and related debates, geopolitics associated with the Brahmaputra as a transboundary river, the riverine communities, cultures and economy.

UNITS	CONTENTS	L	T	P	Total Hours
I (12Marks)	Geology of the Brahmaputra Basin Drainage system and landforms of the Brahmaputra Basin Origin of the Brahmaputra Basin	**09**	**03**		**12**
II (18Marks)	Flood, Erosion and Displacement across the valley: Dams and Debates Hydrology and sediment dynamics of the Brahmaputra River Siltation and drainage congestion, Role of anthropogenic activities in drainage modification, Role of tectonics in shaping the channel morphology	**14**	**04**		**18**
III (15Marks)	Technologies of Flood Control: Technology of Embankments Porquipines, Diversion structure, Dams & reservoirs, Channel alteration and geotubes	**12**	**03**		**15**
IV (15Marks)	Impact and Issues related with Flood Control technologies Embankments and channel congestion Structural failures Impacts on the ecosystem Changing risks perspective due to over settlement in the floodplains			**15**	**30**

	Total				**75**

Where, L:Lectures T:Tutorials P:Practicals

MODESOFIN-SEMESTERASSESSMENT: (40Marks)

- **Two Internal Examination- 15+ 15**
- **Others(Anyone) - 10**
  - **Group Discussion**
  - **Seminar presentation on any of the relevant topics**
  - **Debate**
  - **HomeAssignment**

COURSEOUTCOME:
Student will be able to:

CO 01: Understand the geological setting, drainage characteristics, and historical development of the Brahmaputra Basin.

LO 1.1: Explain the geological background and evolution of the Brahmaputra Basin.

LO 1.2: Describe the drainage system and major landforms associated with the Brahmaputra Basin.

LO 1.3: Discuss the historical exploration and theories regarding the origin of the Brahmaputra Basin.

CO 02: Understand the causes and impacts of floods, riverbank erosion, and displacement in the Brahmaputra Valley and evaluate the role of dams in flood management.

LO 2.1: Explain the causes and characteristics of floods and riverbank erosion in the Brahmaputra Valley.

LO 2.2: Describe the social and environmental impacts of floods and erosion, including displacement of populations across the valley.

LO 2.3: Discuss the role of dams in flood control and the debates surrounding their environmental and socio-economic impacts.

CO 03: Understand the technologies used for flood control and riverbank protection in the Brahmaputra Valley.

LO 3.1: Explain the principles and functions of flood control technologies used in river management.

LO 3.2: Describe the technology and role of embankments in controlling floods and protecting riverbanks.

LO 3.3: Discuss the use of porcupines and geotubes as engineering measures for erosion control

and riverbank stabilization.

CO 04: Understand the impacts and challenges associated with flood control technologies in river basin management.

LO 4.1: Explain the environmental and geomorphological impacts of flood control technologies.

LO 4.2: Describe the social and economic issues related to the implementation of flood control measures.

LO 4.3: Evaluate the effectiveness and limitations of different flood control technologies in managing floods and erosion.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	**CO 01, CO 02**	**CO 01, CO 02, CO 03**				
Conceptual Knowledge		**CO 01, CO 02, CO 03, CO 04**	**CO 03**	**CO 02, CO 04**		
Procedural Knowledge		**CO 03**	**CO 03, CO 04**	**CO 02, CO 04**	**CO 04**	
Metacognitive Knowledge				**CO 04**	**CO 04**	

Mapping of Course Outcomes to Program Outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	S	S	M	S	S	S
CO2	S	S	M	S	S	S
CO3	S	S	M	S	S	S
CO4	S	S	M	S	S	S

Where, S=Strong Correlation and M=Medium Correlation

SUGGESTEDREADINGS:

References:

1. André Robert (2003). *River Processes-An Introduction to Fluvial Dynamics.* Published by Arnold, London (http://www.arnoldpublishers.com) Distributed in the USA by Oxford University press.
2. Arup Kumar Dutta (2001). *The Brahmaputra*. Published by National Book Trust, India, 2001. (p.237)[[**ISBN-13:** 978-8123735443]
3. Arupjyoti Saikia (2019). The Unquiet River – a biography of the Brahmaputra. Oxford University Press. (p.620)[**ISBN-13:** 978-0199468119]
4. John S. Bridge (2003). *Rivers and Floodplains – Forms, Processes, and Sedimentary record*, Blackwell Publishing
5. *Large Rivers-Geomorphology and Management*, Edited by Avijit Gupta (2007), John Wiley & Sons, Ltd.
6. 'The Brahmaputra Basin Water Resources' Editors: Singh, Vijay., Sharma, Nayan., Ojha, C. Shekhar P., Springer, 2004 (p. 613) [**ISBN-13:** 978-1402017377]
7. 'Neo-Thinking on Ganges-Brahmaputra Basin Geomorphology' by Editors: Balai Chandra Das, Sandipan Ghosh, Aznarul Islam, Md. Ismail, Springer, 2016 (p.177)**[ASIN:** B01ACZ6U7E]