Course Structure and Detailed Syllabus of Four Year Undergraduate Programme (FYUP) with Honours and Research in

Geology

(Under NEP 2020)

Effective from 2023-24

Rajiv Gandhi University

Rono Hills, Doimukh

Arunachal Pradesh - 791112

Programme Educational Objective (PEO)

Four Year Undergraduate Programme in Geology (NEP-2020)

PEOs	*PEO Descriptor*
PEO 1	To equip the students with critical thinking, problem solving, communication skills and teamwork through intense laboratory works, fieldworks, group discussions and seminar presentations.
PEO 2	To expose the student to the vast scope of geosciences as a theoretical and experimental science with applications in solving most of the geogenic problems in nature through internship, industrial visit etc.
PEO 3	Emphasize the need for integrating geosciences as one of the important branches of science for pursuing the interdisciplinary and multidisciplinary higher education and/or research.
PEO 4	To emphasize the importance of geology as a discipline for sustainable development of industries and earth's environment.

Programme Outcomes (PO)

Four Year Undergraduate Programme in Geology (NEP-2020)

	Type of Programme Outcome (PO)	*Programme Outcome (PO) Descriptor*
PO 1	**Problem-Solving**	A graduate student should be able to demonstrate the capability to: • solve problems of familiar and non-familiar contexts that are best approached with critical thinking and apply the learning to real-life situations**.**
PO 2	**Analytical Reasoning & Critical Thinking**	The graduates should be able to demonstrate the capability to: • apply analytical thought to a body of knowledge, including the analysis, evaluation and practices, as well as evidence, arguments, claims, beliefs, and the reliability and relevance of evidence, • identify relevant assumptions or implications; and formulate coherent arguments, • identify logical flaws in the arguments, • analyse and synthesise data from various sources, draw valid conclusions and support them with evidence and examples.
PO 3	**Creativity**	The graduates should be able to demonstrate the ability to: • create, perform, or think in different and diverse ways about the same objects or scenarios, • deal with problems and situations that do not have simple solutions, • innovate and perform tasks in a better manner, • view a problem or a situation from multiple perspectives, • think 'out of the box' and generate solutions to complex problems in unfamiliar contexts, • adopt innovative, imaginative, lateral thinking, interpersonal skills and emotional intelligence.

PO 4	**Communication Skills**	The graduates should be able to demonstrate the skills that enable them to: • listen carefully, read texts and research papers analytically, and present complex information clearly and concisely to peers and the public at large, • express thoughts and ideas effectively in writing and orally and communicate with others using appropriate media, • confidently share views and express herself/himself, • construct logical arguments using correct technical language related to a field of learning, work/vocation, or an area of professional practice, • convey ideas, thoughts, and arguments using respectful and sensitive language to gender and other minority groups.
PO 5	**Research-related Skills**	The graduates should be able to demonstrate: • a keen sense of observation, inquiry, and capability for asking relevant/ appropriate questions, • the ability to problematise, synthesize and articulate issues and design research proposals, • the ability to define problems, formulate appropriate and relevant research questions, formulate hypotheses, test hypotheses using quantitative and qualitative data, establish hypotheses, make inferences based on the analysis and interpretation of data, and predict cause-and-effect relationships, • the capacity to develop appropriate methodology and tools of data collection, • the appropriate use of statistical and other analytical tools and techniques, • the ability to plan, execute and report the results of an experiment or investigation, • the ability to understand basic research ethics and skills in practising/doing ethics in the field/ in personal research work, regardless of the funding authority or field of study.
PO 6	**Coordinating / Collaborating with others**	The graduates should be able to demonstrate the ability to: • work effectively and respectfully with diverse teams, • facilitate cooperative or coordinated effort on the part of a group, • act together as a group or a team in the interests of a common cause and work efficiently as a member of a team.

PO 7	**Leadership Development**	The graduates should be able to demonstrate the capability for: • mapping out the tasks of a team or an organization and setting direction. • formulating an inspiring vision and building a team that can help achieve the vision, motivating and inspiring team members to engage with that vision. • using management skills to guide people to the right destination.
PO 8	**Digital and technological skills**	The graduates should be able to demonstrate the capability to: • use ICT in a variety of learning and work situations, • access, evaluate, and use a variety of relevant information sources, • use appropriate software for analysis of data.
PO 9	**Environmental awareness and action**	The graduates should be able to demonstrate the acquisition of and ability to apply the knowledge, skills, attitudes, and values required to take appropriate actions for: • recognize environmental and sustainability issues and participate in actions to promote sustainable development. • mitigating the effects of environmental degradation, climate change, and pollution, • effective waste management, conservation of biological diversity, management of biological resources and biodiversity,

Programme Specific Outcomes (PSO)

Four Year Undergraduate Programme in Geology (NEP-2020)

	Type of PSO	*PSO Descriptor*
PSO 1	**Knowledge and understanding**	Graduates in geology should be able to demonstrate the acquisition of: • comprehensive knowledge and coherent understanding in theoretical knowledge in diverse branches of geology such as physical geology, historical geology, applied geology etc. and understanding of the relationship among these branches and recent developments. • procedural knowledge to carry out experimental studies and analyses towards understanding the complex earth materials and processes by applying broader knowledge in geology and other disciplines.
PSO 2	**Skills related to one's specialization**	• Imparting skills such as understanding diverse geological terrains through intense fieldwork and industrial visits towards the better knowledge on earth system and related disciplines.
PSO 3	**Application of knowledge and skills**	• learning to solve complex geological problems by applying knowledge on diverse branches of geology and to developing critical thinking.
PSO 4	**Quantitative, analytical and instrument-based skills**	• hands-on training in learning analytical techniques and understanding geological terrains in order to pursue higher education or grabbing job opportunities or developing self-employment.

Course Structure for Four Year Undergraduate Programme (FYUP) with Honours in Geology

NCrF Credit Level	Semester	Course Type	Course code	Course Name	Credit
4.5	B.Sc. I	Major Course (Core)	**GEL-CC-1110**	General Geology	4
		Minor Course	**GEL-MC-1110**	Introduction to Geology	4
		Multidisciplinary Course	**GEL-MD-1110**	Earth Materials	3
		Ability Enhancement Course	**ENG-AE-1110**	English Language & Communication Skills	4
		Skill Enhancement Course	**GEL-SE-1110**	Surveying and Levelling	3
		Value Added Course	**EVS-VA-1110**	Environmental Science - I	2
	B.Sc. II	Major Course (Core)	**GEL-CC-1210**	Mineralogy	4
		Minor Course	**GEL-MC-1210**	Mineral Science	4
		Multidisciplinary Course	**GEL-MD-1210**	Natural Hazards	3
		Ability Enhancement Course	**ENG-AE-1210**	Academic Writing and Professional Communication	4
		Skill Enhancement Course	**GEL-SE-1210**	Optics and Optical Mineralogy	3
		Value Added Course	**EVS-VA-1210**	Environmental Science - II	2
Students exiting the programme after securing 40 credits will be awarded UG Certificate in the relevant Discipline provided they secure 4 credits in work-based vocational courses offered during the summer term or internship / Apprenticeship in addition to 6 credits from skill-based courses earned during the first and second semester					
5.0	B.Sc. III	Major Course (Core)	**GEL-CC-2310**	Structural Geology	4
			GEL-CC-2320	Igneous and Metamorphic Petrology	4
		Minor Course	**GEL-MC-2310**	Earth Structure	4
		Multidisciplinary Course	**GEL-MD-2310**	Earth Resources	3
		Skill Enhancement Course	**GEL-SE-2310**	Basics of Geoinformatics	3
		Value Added Course	**GEL-VA-2310**	Gemology	2
	B.Sc. IV	Major Course (Core)	**GEL-CC-2410**	Sedimentology and Principles of Stratigraphy	4
			GEL-CC-2420	Palaeontology	4
			GEL-CC-2430	Geodynamics and Global Tectonics	4
			GEL-CC-2440	Geological Field Methods and Techniques	4
		Minor Course	**GEL-MC-2410**	Petrology	4
Students exiting the programme after securing 80 credits will be awarded UG Diploma in the relevant Discipline provided they secure additional 4 credits in skill-based vocational courses offered during the first year or second year summer term.					
5.5	B.Sc. V	Major Course (Core)	**GEL-CC-3510**	Indian Stratigraphy	4
			GEL-CC-3520	Economic Geology	4
			GEL-CC-3530	Fuel Geology	4
			GEL-CC-3540	Environmental Geology	2
		Internship	**GEL-IN-3510**	Internship	2
		Minor Course	**GEL-MC-3510**	Historical Geology	4
	B.Sc. VI	Major Course (Core)	**GEL-CC-3610**	Geochemistry	4
			GEL-CC-3620	Geomorphology and Quaternary Geology	4
			GEL-CC-3630	Geoexploration and Mining	4
			GEL-CC-3640	Engineering Geology and Hydrogeology	4
		Minor Course	**GEL-MC-3610**	Economic Geology	4
Students who want to undertake 3-year UG programme will be awarded UG Degree (B.Sc.) in Geology upon securing 124 credits.					
6.0	B.Sc. VII	Major Course (Core)	**GEL-CC-4710**	Advanced Mineralogy	4
			GEL-CC-4720	Advanced Structural Geology	4
			GEL-CC-4730	Advanced Petrology	4
			GEL-CC-4740	Advanced Sedimentology	4
		Research Course	**GEL-RC-4710**	Research Methodology	4
	B.Sc. VIII	Major Course (Core)	**GEL-CC-4810**	Geological Fieldwork	4
		Major Course (Department Specific Elective): Students should take *any three* courses	**GEL-DE-4810**	Remote Sensing and GIS for Geology	4
			GEL-DE-4820	Advanced Palaeontology	4
			GEL-DE-4830	Isotope Geology	4
			GEL-DE-4840	Geohazard and Disaster Management	4
			GEL-DE-4850	Marine Science	4
			GEL-DE-4860	Mineral Resources of India and World	4
			GEL-DE-4870	Statistics and Data Analysis in Geology	4
			GEL-DE-4880	Advanced Hydrogeology	4
			GEL-DE-4890	Geotechnical Engineering	4
		Research Course	**GEL-RC-4810**	Research and Publication Ethics	4
				Total Credit	**160**

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		Minor Course	**GEL-MC-1110**	Introduction to Geology	4
		Multidisciplinary Course	**GEL-MD-1110**	Earth Materials	3
		Ability Enhancement Course	**ENG-AE-1110**	English Language & Communication Skills	4
		Skill Enhancement Course	**GEL-SE-1110**	Surveying and Levelling	3
		Value Added Course	**EVS-VA-1110**	Environmental Science - I	2
	B.Sc. II	Major Course (Core)	**GEL-CC-1210**	Mineralogy	4
		Minor Course	**GEL-MC-1210**	Mineral Science	4
		Multidisciplinary Course	**GEL-MD-1210**	Natural Hazards	3
		Ability Enhancement Course	**ENG-AE-1210**	Academic Writing and Professional Communication	4
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			GEL-CC-2320	Igneous and Metamorphic Petrology	4
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		Multidisciplinary Course	**GEL-MD-2310**	Earth Resources	3
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		Value Added Course	**GEL-VA-2310**	Gemology	2
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			GEL-CC-2420	Palaeontology	4
			GEL-CC-2430	Geodynamics and Global Tectonics	4
			GEL-CC-2440	Geological Field Methods and Techniques	4
		Minor Course	**GEL-MC-2410**	Petrology	4
Students exiting the programme after securing 80 credits will be awarded UG Diploma in the relevant Discipline provided they secure additional 4 credits in skill-based vocational courses offered during the first year or second year summer term.					
5.5	B.Sc. V	Major Course (Core)	**GEL-CC-3510**	Indian Stratigraphy	4
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			GEL-CC-3530	Fuel Geology	4
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		Internship	**GEL-IN-3510**	Internship	2
		Minor Course	**GEL-MC-3510**	Historical Geology	4
	B.Sc. VI	Major Course (Core)	**GEL-CC-3610**	Geochemistry	4
			GEL-CC-3620	Geomorphology and Quaternary Geology	4
			GEL-CC-3630	Geoexploration and Mining	4
			GEL-CC-3640	Engineering Geology and Hydrogeology	4
		Minor Course	**GEL-MC-3610**	Economic Geology	4
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6.0	B.Sc. VII	Major Course (Core)	**GEL-CC-4710**	Advanced Mineralogy	4
			GEL-CC-4720	Advanced Structural Geology	4
			GEL-CC-4730	Advanced Petrology	4
			GEL-CC-4740	Advanced Sedimentology	4
		Research Course	**GEL-RC-4710**	Research Methodology	4
	B.Sc. VIII	Major Course (Core)	**GEL-CC-4810**	Geological Fieldwork	4
		Research Course	**GEL-RC-4810**	Research and Publication Ethics	4
		Research Project	**GEL-RP-4810**	Research Project	12
				Total Credit	**160**

FIRST SEMESTER

GEL-CC-1110

General Geology

Credit: 4 (L-3:T-0:P-1)

Course Objective

This course is designed to introduce the students to the subject geology. The main objectives of the course are to give the students an idea about the origin, the interior, the surface features and the evolution of the earth. Besides, it is also intended to give the students an idea about the earth's materials and various processes and their interaction which led to the development of different features on the earth.

Course Learning Outcome

CO 1: Understand the essential components of the earth.
CO 2: Understand the origin, evolution and various processes operating on the earth.
CO 3: Study and identify different types of topographic features, rocks, minerals, fossils etc. in the laboratory as well as in their natural settings.
CO 4: Understand different endogenic and exogenic processes that shape the Earth's surface.

Detailed Syllabus

Unit 1 ***10 Lectures***

Definition, scope and subdivisions of geology; characteristics of the earth; origin and age of the earth; internal structure of the earth.

Unit 2 ***12 Lectures***

Minerals and crystals; properties of minerals; basic characteristics of igneous, sedimentary and metamorphic rocks; rock cycle; fossils and fossilization; ore minerals and fossil fuels.

Unit 3 ***13 Lectures***

Introduction to historical geology; evolution of the earth's crust, oceans, atmosphere and life forms; introduction to the concept of geological time; principles of stratigraphy; mass extinction.

Unit 4 ***10 Lectures***

Basic concept of plate tectonics, earthquake and volcanism; rock deformation and geological structures; earth's surface processes and surface features.

Practical ***30 Hours***

1. Study of topographic maps, contour patterns, profiles etc.
2. Study different types of rocks.
3. Study of different properties of minerals.
4. Study of geological structures.
5. Study of fossils.
6. Practical records.
7. Viva-voce.

Recommended Books

Text Books:

1. **A Textbook of Geology** - P. K. Mukherjee, *World Press, Kolkata*
2. **Earth Materials: Components of a Diverse Planet** - Dexter Perkins, Kevin R. Henke, Adam C. Simon and Lance D. Yarbrough, *CRC Press*
3. **Earth: Portrait of a Planet** - Stephen Marshak, *W.W. Norton & Co.*
4. **Essentials of Geology** - Lutgens, Tarbuck and Tasa, *Pearson*

Reference Books:

1. **Earth Materials** - Kevin Hefferan and John O'Brien, *Wiley-Blackwell*
2. **Earth Materials: Introduction to Mineralogy and Petrology** - C. Klein and A. R. Philpotts, *Cambridge University Press*
3. **Earth Science: The Earth, The Atmosphere, and Space** - S. Marshak and R. Rauber, W.W. Norton & Co.
4. **Fundamentals of Physical Geology** - Sreepat Jain, *Springer*
5. **Introduction to Physical Geology**- Thompson and Turk, Brooks
6. **Introduction to Planetary Science**- Gunter Faure and Teresa M. Mensing, Springer
7. **Physical Geology**- Charles C. Plummer, Diane H. Carlson and Lisa Hammersley, *McGraw Hill*
8. **Principles of Physical Geology** - Arthor Holmes, *Champman and Hall, London*
9. **Understanding Earth** - John Grotzinger and Thomas H. Jordan, *Macmillan*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	1	2	1	0	1	0	0	2	2	3	2	1	3
CO2	1	2	1	0	1	0	0	2	2	3	2	2	2
CO3	3	3	2	1	2	2	1	2	1	3	3	3	3
CO4	1	2	1	0	1	0	0	2	2	3	2	2	2
Average	**1.50**	**2.25**	**1.25**	**0.25**	**1.25**	**0.50**	**0.25**	**2.00**	**1.75**	**3.00**	**2.25**	**2.00**	**2.50**

GEL-MC-1110

Introduction to Geology

Credit: 4 (L-3:T-0:P-1)

Course Objective

The main aim of this course is to introduce the subject geology to the learners. The course will provide the students an idea about the origin, evolution, basic characteristics and different processes operating on the earth.

Course Learning Outcome

CO 1: Knowledge on components of the earth.
CO 2: Understanding various earth materials such as minerals, rocks, fossils and ores.
CO 3: Learning the geologic history of the earth and its evolution through time.
CO 4: Knowledge on internal and external forces acting in the earth and its consequences.

Detailed Syllabus

Unit 1 ***15 Lectures***

Definition, scope and subdivisions of geology; characteristics of the earth; origin and age of the earth; internal structure of the earth.

Unit 2 ***10 Lectures***

Minerals and crystals; properties of minerals; basic characteristics of igneous, sedimentary and metamorphic rocks; rock cycle; fossils and fossilization; ore minerals and fossil fuels.

Unit 3 ***10 Lectures***

Introduction to historical geology; evolution of the earth's crust, oceans, atmosphere and life forms; introduction to the concept of geological time; mass extinction.

Unit 4 ***10 Lectures***

Basic concept of plate tectonics, earthquake and volcanism; rock deformation and geological structures; earth's surface processes and surface features.

Practical ***30 Hours***

1. Study of topographic maps, contour patterns, profiles etc.
2. Study different types of rocks.
3. Study of different properties of minerals.
4. Study of geological structures.
5. Study of fossils.
6. Practical records.
7. Viva-voce.

Recommended Books

Text Books:

1. **A Textbook of Geology** - P. K. Mukherjee, *World Press, Kolkata*
2. **Earth Materials: Components of a Diverse Planet** - Dexter Perkins, Kevin R. Henke, Adam C. Simon and Lance D. Yarbrough, *CRC Press*
3. **Earth: Portrait of a Planet** - Stephen Marshak, *W.W. Norton & Co.*
4. **Essentials of Geology** - Lutgens, Tarbuck and Tasa, *Pearson*

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8. **Principles of Physical Geology** - Arthor Holmes, *Champman and Hall, London*
9. **Understanding Earth** - John Grotzinger and Thomas H. Jordan, *Macmillan*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	2	1	1	0	1	1	0	1	1	3	1	1	1
CO2	1	2	1	0	1	1	0	1	2	3	2	2	2
CO3	2	1	1	0	1	1	0	1	1	3	1	1	1
CO4	2	1	1	0	1	1	0	1	2	3	1	1	1
Average	**1.75**	**1.25**	**1.00**	**0.00**	**1.00**	**1.00**	**0.00**	**1.00**	**1.50**	**3.00**	**1.25**	**1.25**	**1.25**

GEL-MD-1110

Earth Materials

Credit: 3 (L-3:T-0:P-0)

Course Objective

The important objectives of the course are to introduce the learners on the various types of earth materials such as minerals, rocks, ores and fuels.

Course Learning Outcome

CO 1: Learning components of the solid earth and its different materials.
CO 2: Understanding crystalline and non-crystalline matter, physical chemical, and optical characteristics of minerals.
CO 3: Knowledge about structure, classification and origin of igneous, metamorphic, and sedimentary rocks.
CO 4: Understanding the economic importance of earth materials, its various forms and origin.

Detailed Syllabus

Unit 1 ***15 Lectures***

Layers of the solid earth; crystalline and non-crystalline materials; mineral - definition, physical properties and classification; introduction to rock forming minerals.

Unit 2 ***15 Lectures***

Major types of rocks; rock cycle; igneous rocks - structure, mode of occurrence and origin; classification of igneous rocks; metamorphic rocks - structure, origin, and classification; sedimentary rocks - origin and classification; layering in sedimentary rocks.

Unit 3 ***15 Lectures***

Ore and gangue minerals; native elements; industrial minerals; uses of ore and industrial minerals to human society; introduction to gem minerals; construction materials; coal and petroleum; earth materials and human health.

Recommended Books

Text Books:

1. **Applied Mineralogy: Applications in Industry and Environment** - Swapna Mukherjee, Springer.
2. **Earth Materials: Introduction to Mineralogy and Petrology** - C. Klein and A. Philpotts, Cambridge University Press.
3. **Introduction to Mineralogy** - W. D. Nesse, Cambridge University Press.
4. **Introduction to Mineralogy and Petrology** - S. K. Haldar and J. Tisljar, Elsevier.
5. **Mineralogy** - Dexter Perkins, Prentice Hall India.
6. **Exploring Geology** - Stephen J. Reynolds and Julia K Johnson, *McGraw Hill*

Reference Books:

1. **An Introduction to Rock-Forming Minerals** - W. A. Deer, R. A. Howie and J. Zussman, *The Geological Society.*
2. **Introduction to Mineralogy, Crystallography and Petrology** - C.W. Correns, Springer-Verlag.
3. **Manual of Mineralogy** - C. Klein and C.S. Hurlbut Jr, John Wiley.
4. **Rutley's Elements of Mineralogy** - C.D. Gribble, CBC Publishers and Distributors

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	2	1	1	0	1	1	0	1	1	3	1	1	1
CO2	2	1	1	0	1	1	0	1	1	3	1	1	1
CO3	2	1	1	0	1	1	0	1	1	3	2	2	1
CO4	1	2	1	0	1	1	0	1	1	3	2	2	2
Average	**1.75**	**1.25**	**1.00**	**0.00**	**1.00**	**1.00**	**0.00**	**1.00**	**1.00**	**3.00**	**1.50**	**1.50**	**1.25**

GEL-SE-1110

Surveying and Levelling

Credit: 3 (L-2:T-0:P-1)

Course Objective

The objective of the course is to introduce the students to the basic principles and different methods involved in surveying and levelling.

Course Learning Outcome

CO 1: Learning the methods of plane and geodetic surveying.
CO 2: Understanding the methods of levelling.
CO 3: Understanding the theoretical aspects of diverse instruments employed in surveying and levelling.
CO 4: Learning to utilize various surveying and levelling instruments through hands-on training.

Detailed Syllabus

Unit 1 ***10 Lectures***

Definitions and objectives of surveying; measurement of angle; measurement of distance; open traverse and close traverse in surveying, closing errors and balancing traverse.

Unit 2 ***10 Lectures***

Definitions of terms used in levelling; principles of levelling: simple and differential; steps in levelling; bench marks and change points; reduction of levels.

Unit 3 ***10 Lectures***

Introduction to surveying and levelling instruments: plane table, prismatic compass, theodolite, total station, dumpy level and levelling staff.

Practical ***30 Hours***

1. Measurement of distance using various instruments and techniques.
2. Measurement of horizontal and vertical angles.
3. Balancing of closing errors.
4. Practical records.
5. Viva-voce.

Recommended Books

Text Books:

1. **A Textbook of Surveying and Levelling** - R. Agor, *Khanna Publishers*
2. **Elementary Surveying: An Introduction to Geomatics** - Charles D. Ghilani and Paul R. Wolf, *Pearson*
3. **Surveying (Vol. I & II)** - B. C. Punmia, *Standard Publishers*

Reference Books:

1. **Plane and Geodetic Surveying** - Aylmer Johnson, *CRC Press*
2. **Surveying (Vol. I & II)** - K. R. Arora, *Standard Book House*
3. **Surveying (Vol. I & II)** - S. K. Duggal, *Tata McGraw-Hill*
4. **Surveying and Levelling** – N. N. Basak, *Tata McGraw Hills*
5. **Surveying and Levelling (Part I)** - T. P. Kanetkar and S. V. Kulkarni, *Vidhyarthi Griha Prakashan*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	1	2	1	1	2	0	0	2	1	3	2	2	3
CO2	3	3	2	0	2	1	1	2	1	3	3	3	3
CO3	1	2	1	1	1	0	1	2	1	2	2	2	2
CO4	3	3	3	1	2	0	1	2	1	2	3	3	3
Average	**2.00**	**2.50**	**1.75**	**0.75**	**1.75**	**0.25**	**0.75**	**2.00**	**1.00**	**2.50**	**2.50**	**2.50**	**2.75**

SECOND SEMESTER

GEL-CC-1210

Mineralogy

Credit: 4 (L-3:T-0:P-1)

Course Objective

The course is intended to provide fundamental knowledge about crystals and minerals. Students would be expected to learn the internal and external attributes of crystals, physical, chemical, and optical characteristics of minerals and different techniques used study the minerals.

Course Learning Outcome

CO 1: Understand the external symmetry of crystals and its relationship with internal structures.
CO 2: Understand different laws and theories in the field of crystallography.
CO 3: Have knowledge on the physical, chemical and optical characteristics of minerals.
CO 4: Learn to study, identify and classify unknown minerals in hand specimen and in thin sections.

Detailed Syllabus

Unit 1 ***15 Lectures***

Minerals and mineraloids - definition and nomenclature; historical development of mineralogy; economic importance of minerals; crystallography - introduction; basic concepts of point symmetry and translational symmetry; point groups and crystal systems.

Unit 2 ***10 Lectures***

Crystal faces; Laws of Haüy and Bravais; crystal zones and forms; Steno's law; measurement of crystal angles; stereographic projections of crystal faces; crystal chemistry: abundance of elements; types of bonds in minerals; isostructuralism and polymorphism; pseudomorphism; twinning in crystals.

Unit 3 ***10 Lectures***

Classification and physical properties of minerals; silicate structure; minerals in igneous, metamorphic, and sedimentary rocks; systematic description of rock forming silicate minerals.

Unit 4 ***10 Lectures***

Optical mineralogy: introduction; polarization of light; reflection, refraction, and dispersion of light; isotropic and anisotropic materials; introduction to optical indicatrix; brief study of colour, pleochroism, extinction and interference figure; optical properties of important rock-forming minerals.

Practical ***30 Hours***

1. Study of important crystal models.
2. Stereographic projection of holohedral classes of selected crystal systems.
3. Study of twin crystals.
4. Megascopic identification of rock-forming minerals.
5. Microscopic identification of rock-forming minerals.
6. Practical records.
7. Viva-voce.

Recommended Books

Text Books:

1. **An Introduction to the Rock-Forming Minerals** - W.A. Deer, R.A. Howie and J. Zussman, *The Mineralogical Society London*.
2. **Crystallography and Mineralogy: Concepts and Methods** - R. S. Sharma and Anurag Sharma, *Geological Society of India.*
3. **Introduction to Mineralogy** - William D. Nesse, *Oxford University Press.*
4. **Introduction to Optical Mineralogy** - William D. Nesse*, Oxford University Press.*
5. **Mineralogy** - Dexter Perkins, *Pearson.*
6. **Mineralogy** - L.G. Berry, Brian Mason and R.V. Dietrich, *CBS Publishers and Distributors*.
7. **Optical Mineralogy** - B.F. Kerr, *McGraw Hill*.
8. **Practical Approach to Mineralogy and Crystallography** - R.N. Hota, *CBS Publishers and Distributors*.
9. **The Manual of Mineral Science** - Cornelis Klein and Barbara Dutrow, *Wiley*.

Reference Books:

1. **A Key for Identification of Rock-forming Minerals in Thin Section** - Andrew J. Barker, *CRC Press.*
2. **A Practical Introduction to Optical Mineralogy** - C. D. Gribble and A. J. Hall, *Springer.*
3. **Atlas of Rock-Forming Minerals in Thin Section** - W. S. MacKenzie and C. Guilford, *Routledge.*
4. **Dana's Textbook of Mineralogy** - William E. Ford, *CBS Publishers and Distributors*.
5. **Earth Materials: Introduction to Mineralogy and Petrology** - Cornelis Klein and Anothony Philpotts, *Cambridge.*
6. **Introduction to Mineralogy and Petrology** - S.K. Haldar and Josip Tisljar*, Elsevier.*
7. **Rock Forming Minerals, Volume 3A: Micas** - W. A. Deer, R. A. Howie and J. Zussman, *The Geological Society of London.*
8. **Rock Forming Minerals, Volume 4A: Framework Silicates (Feldspars)** - W. A. Deer, R. A. Howie and J. Zussman, *The Geological Society of London.*
9. **Rock Forming Minerals, Volume 4B: Framework Silicates (Silica Minerals, Feldspathoids and the Zeolites)** - W. A. Deer, R. A. Howie and J. Zussman, *The Geological Society of London*.
10. **Rock-Forming Minerals, Volume 3B: Layered Silicates (Excluding Micas and Clay Minerals)** - W. A. Deer, R. A. Howie and J. Zussman, *The Geological Society of London.*
11. **Rock-Forming Minerals, Volume 3C: Sheet Silicates (Clay Minerals)** - W. A. Deer, R. A. Howie and J. Zussman, *The Geological Society of London*.
12. **Rocks and Minerals in Thin Section** - W.S. MacKenzie, A.E. Adams and K.H. Brodie, *CRC Press.*
13. **Rutley's Elements of Mineralogy** - C.D. Gribble, *CBS Publishers and Distributors*.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	2	2	1	0	2	0	0	1	1	3	1	1	1
CO2	1	2	1	0	2	1	0	1	2	3	2	3	2
CO3	1	2	1	0	2	1	0	1	2	3	3	3	2
CO4	3	3	2	1	2	2	1	1	1	3	3	3	3
Average	**1.75**	**2.25**	**1.25**	**0.25**	**2.00**	**1.00**	**0.25**	**1.00**	**1.50**	**3.00**	**2.25**	**2.50**	**2.00**

GEL-MC-1210

Mineral Science

Credit: 4 (L-3:T-0:P-1)

Course Objective

The course is intended to introduce the learners to the geological study of crystals and minerals. Students would be expected to learn the internal and external attributes of crystals, physical, chemical, and optical attributes of minerals and different techniques used in identification of minerals.

Course Learning Outcome

CO 1: Understanding the external symmetry of crystals and its relationship with internal structures.
CO 2: Knowledge on different laws and theories of crystallography.
CO 3: Understanding the physical, chemical and optical characteristics of minerals.
CO 4: Learning to study, identify and classify unknown minerals in hand specimen and in thin sections.

Detailed Syllabus

Unit 1 ***15 Lectures***

Crystalline and amorphous substances; nomenclature of minerals; minerals and society; basic concepts of crystal symmetry; point groups and crystal systems; space group.

Unit 2 ***10 Lectures***

Crystal faces - Laws of Haüy and Bravais; Miller Indices; crystal zones and forms; Steno's law; measurement of crystal angles; crystal chemistry: abundance of elements; types of bonds in minerals; isostructuralism and polymorphism; pseudomorphism; twinning in crystals.

Unit 3 ***10 Lectures***

Physical properties of minerals; classification of minerals; silicate structure; minerals in igneous, metamorphic, and sedimentary rocks; systematic description of rock forming silicate minerals.

Unit 4 ***10 Lectures***

Optical mineralogy: introduction; properties of light; polarization of light; reflection, refraction, and dispersion of light; petrographic microscope - parts and assembly; isotropic and anisotropic materials; introduction to optical indicatrix; brief study of colour, pleochroism, extinction and interference figure; optical properties of important rock-forming minerals.

Practical ***30 Hours***

1. Study of crystal models.
2. Megascopic identification of rock-forming minerals.
3. Microscopic identification of rock-forming minerals.
4. Practical record.
5. Viva voce.

Recommended Books

Text Books:

1. **An Introduction to the Rock-Forming Minerals** - W.A. Deer, R.A. Howie and J. Zussman, *The Mineralogical Society London*.
2. **Crystallography and Mineralogy: Concepts and Methods** - R. S. Sharma and Anurag Sharma, *Geological Society of India.*
3. **Mineralogy** - Dexter Perkins, *Pearson.*
4. **Practical Approach to Mineralogy and Crystallography** - R.N. Hota, *CBS Publishers and Distributors*.
5. **The Manual of Mineral Science** - Cornelis Klein and Barbara Dutrow, *Wiley*.

Reference Books:

1. **A Key for Identification of Rock-forming Minerals in Thin Section** - Andrew J. Barker, *CRC Press.*
2. **Atlas of Rock-Forming Minerals in Thin Section** - W. S. MacKenzie and C. Guilford, *Routledge.*
3. **Dana's Textbook of Mineralogy** - William E. Ford, *CBS Publishers and Distributors*.
4. **Earth Materials: Introduction to Mineralogy and Petrology** - Cornelis Klein and Anothony Philpotts, *Cambridge.*
5. **Introduction to Mineralogy** - William D. Nesse, *Oxford University Press.*
6. **Introduction to Mineralogy and Petrology** - S.K. Haldar and Josip Tisljar*, Elsevier.*
7. **Introduction to Optical Mineralogy** - William D. Nesse*, Oxford University Press.*
8. **Mineralogy** - L.G. Berry, Brian Mason and R.V. Dietrich, *CBS Publishers and Distributors*.
9. **Optical Mineralogy** - B.F. Kerr, *McGraw Hill*.
10. **Rutley's Elements of Mineralogy** - C.D. Gribble, *CBS Publishers and Distributors*.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	2	1	1	0	1	1	0	1	2	3	2	1	2
CO2	2	2	1	0	2	1	0	2	1	3	2	2	2
CO3	3	3	2	1	2	1	0	2	2	3	3	2	1
CO4	3	3	3	3	2	2	2	2	1	3	3	3	2
Average	**2.50**	**2.25**	**1.75**	**1.00**	**1.75**	**1.25**	**0.50**	**1.75**	**1.50**	**3.00**	**2.50**	**2.00**	**1.75**

GEL-MD-1210

Natural Hazards

Credit: 3 (L-3:T-0:P-0)

Course Objective

The main objective of this course is to introduce the students to various natural hazards and disasters, their vulnerability, risk assessment, mitigation measures.

Course Learning Outcome

CO 1: Learning about different hazardous natural processes and associated risk.
CO 2: Understanding earthquake, volcanic eruptions and related processes as hazard and its mitigation measures.
CO 3: Understanding landslide, flooding and coastal process as natural hazard and its mitigation measures.
CO 4: Understanding the natural hazards resulting due to meteoritic impact.

Detailed Syllabus

Unit 1 ***15 Lectures***

Basic concepts of natural hazard, disaster and catastrophe; magnitude and frequency of hazardous events; understanding natural processes as hazards.

Unit 2 ***10 Lectures***

Earthquake and related hazards; magnitude and intensity of earthquake; earthquake predictions; minimizing earthquake damages; volcanic hazards; minimizing the volcanic hazard.

Unit 3 ***10 Lectures***

Introduction to landslides; types of landslides; prevention of landslides; river flooding as natural hazard; nature and extent of flood hazards; reducing flood damage.

Unit 4 ***10 Lectures***

Coastal hazard: perception and mitigation; hurricane and cyclone as natural hazards; hazards related to weather and climate; mitigation of climate change, impact hazards and risk.

Recommended Books

Text Books:

1. **Natural Hazards and Disasters -** Donald Hyndman and David Hyndman, *Brooks-Cole*
2. **Natural Hazards: Earthquakes, Volcanoes and Landslides -** Ramesh P. Singh and Darius Bartlett, *CRC Press*
3. **Natural Hazards: Earth's Processes as Hazards, Disasters, and Catastrophes -** Edward A. Keller, Duane E. DeVecchio and Robert H. Blodgett, *Pearson*

Reference Books:

1. **Disaster Education and Management: A Joyride for Students, Teachers and Disaster Managers -** Rajendra Kumar Bhandari, *Springer*
2. **Environmental Hazards and Disasters: Contexts, Perspectives and Management -** B. K. Paul, *Wiley-Blackwell*
3. **Environmental Hazards: Assessing Risk and Reducing Disaster** - Keith Smith and David N. Petley, *Routledge*
4. **Geological Hazards** - B. A. Bolt, W. L. Horn, G. A. Macdonald and R. F. Scott, *Springer-Verlag*
5. **Introduction to Emergency Management** - Michael K. Lindell, Carla Prater and Ronald W. Perry, *Wiley*
6. **Natural Disasters** - Patrick L. Abbott, *McGraw-Hill*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	1	1	1	1	1	1	1	1	3	3	1	2	2
CO2	3	2	1	1	2	1	1	1	3	3	1	2	1
CO3	3	3	3	1	2	1	1	2	3	3	1	3	2
CO4	1	2	1	1	1	1	0	1	3	2	1	2	1
Average	**2.00**	**2.00**	**1.50**	**1.00**	**1.50**	**1.00**	**0.75**	**1.25**	**3.00**	**2.75**	**1.00**	**2.25**	**1.50**

GEL-SE-1210

Optics and Optical Mineralogy

Credit: 3 (L-2:T-0:P-1)

Course Objective

The course is intended to introduce the students to the basic concepts of optics and optical mineralogy including the interaction of light with minerals.

Course Learning Outcome

CO 1: Understanding the concepts of optics.
CO 2: Learning the principles of interactions that take place with light and materials.
CO 3: Learning about petrographic microscope, its usage and preparation of samples for optical characterization.
CO 4: Acquainting hands-on training in studying minerals under petrographic microscope.

Detailed Syllabus

Unit 1 ***10 Lectures***

Wave theory of light; reflection; refraction; polarisation; double refraction; birefringence; refractive index and its determination.

Unit 2 ***10 Lectures***

Petrographic microscope - parts and assembly; accessory plates and their uses; photomicrographs; laboratory techniques for preparing thin section, grain mount and polished sections.

Unit 3 ***10 Lectures***

Optical properties of minerals: isotropic and anisotropic minerals; optical indicatrix; pleochroism and pleochroic scheme; sign of elongation; interference in crystals; conoscopy: interference figure and its use in determining optic sign; techniques for determining order of interference colour and 2V.

Practical ***30 Hours***

1. Study of optical properties of rock-forming minerals in thin section.
2. Determination of refractive index using Becke line test.
3. Determination of pleochroic schemes with reference to vibration direction.
4. Measurement of extinction angles and determination of sign of elongation.
5. Study of uniaxial and biaxial interference figure and determination of optic sign.
6. Practical record.
7. Viva-voce.

Recommended Books

Text Books:

1. **A Key Identification to Rock-Forming Minerals in Thin Section** - A.J. Barker, *CRC Press*.
2. **A Practical Introduction to Optical Mineralogy** - C. D. Gribble and A.J. Hall*, Springer*.
3. **Introduction to Optical Mineralogy** - W. D. Nesse, *Oxford University Press*.
4. **Optical Mineralogy** - P. K. Verma, *Ane Books Pvt. Ltd*.
5. **Petrography Laboratory Manual: Hand specimen and Thin Section Petrography** - L. A. Raymond, Tom Terranova, *Waveland Press Inc*.
6. **Rocks and Minerals in Thin Section: A Colour Atlas** - W. S. MacKenzie, A. E. Adams and K. H. Brondi, *CRC Press.*

Reference Books:

1. **An Introduction to Rock-Forming Minerals** - W. A. Deer, R. A. Howie and J. Zussman, *Mineralogical Society of Great Britain and Ireland.*
2. **Introduction to Mineralogy** - W. D. Nesse, *Oxford University Press.*
3. **Mineralogy** - Dexter Perkins, *Pearson*.
4. **Mineralogy for Petrologists: Optics, Chemistry and Occurrence of Rock-Forming Minerals** - M. Demanage, *CRC Press.*
5. **Minerals in Thin Section** - Dexter Perkins and Kevin Henke, *Pearson*.
6. **Optical Mineralogy: Principles and Practice** - C. D. Gribble and A. J. Hall, *Springer.*
7. **The Ore Minerals Under the Microscope: An Optical Guide** - Bernhard Pracejus, *Elsevier.*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	1	1	1	0	1	1	0	1	0	3	2	2	2
CO2	1	2	1	0	1	1	0	1	0	2	1	1	1
CO3	2	3	2	0	2	1	1	1	0	2	2	2	3
CO4	3	3	2	0	2	1	0	0	0	2	2	3	3
Average	**1.75**	**2.25**	**1.50**	**0.00**	**1.50**	**1.00**	**0.25**	**0.75**	**0.00**	**2.25**	**1.75**	**2.00**	**2.25**

THIRD SEMESTER

GEL-CC-2310

Structural Geology

Credit: 4 (L-3:T-0:P-1)

Course Objective

The course is intended for student to gain knowledge of the geometry of the rock structures, understand the mechanism of the evolution of geological structures that result through the deformation processes operative within the earth.

Course Learning Outcome

CO 1: Learning the earth structures and different structural elements.
CO 2: Understand the different forces responsible for deformation of rocks.
CO 3: Knowledge on different brittle and ductile structural features.
CO 4: Learning to interpret geological maps and solve structural problems through hands-on training.

Detailed Syllabus

Unit 1 ***15 Lectures***

Primary and secondary structures; planar and linear structures; concept of strike and dip of planar structures; pitch and plunge of linear structural elements; compass-clinometer; unconformities and their types; recognition of unconformities in the field.

Unit 2 ***10 Lectures***

Basic concept of stress and strain; ductile and brittle deformation; effects of temperature, pressure, time and pore fluids on rock strength.

Unit 3 ***10 Lectures***

Folds - geometry and classification; mechanism of folding; shear zones and their types; boudinage; foliation and lineation - types and relation with other structures.

Unit 4 ***10 Lectures***

Faults - geometry and classification; recognition of faults; joints and fractures - types and significance.

Practical ***30 Hours***

1. Study of geological maps involving horizontal and dipping beds, fold, fault, unconformity, dyke and sill.
2. Graphical solutions of simple structural problems: dip-strike, true dip-apparent dip.
3. Three-point problems and determination of dip and strike from borehole data.
4. Construction of vertical geological sections to illustrate different geological structures.
5. Practical records.
6. Viva-voce.

Recommended Books

Text Books:

1. **An Introduction to Structural Geology** - A. K. Jain, *Geological Society of India*
2. **Earth structure: An Introduction to Structural Geology and Tectonics** - B. A. van der Pluijm and S.Marshak, *W. W. Norton & Company*
3. **Structural Geology** - H. Fossen, *Cambridge University Press*
4. **Structural Geology** - R. J. Twiss and E. M. Moors, *W. H. Freeman & Co.*
5. **Structural Geology: Fundamentals and Modern Developments** - S. K. Ghosh, *Pergamon Press*

Reference Books:

1. **Folding and Fracturing of Rocks** - John G. Ramsay, *McGraw Hills Book Company*
2. **Structural Geology: The Mechanics of Deforming Metamorphic Rocks** - Bruce E. Hobbs and Alison Ord, *Elsevier*
3. **The Techniques of Modern Structural Geology Vol. 1: Strain Analysis** - J. G. Ramsay and M. I. Huber, *Elsevier*
4. **The Techniques of Modern Structural Geology Vol. 2: Folds and Fractures** - J. G. Ramsay and M. I. Huber, *Elsevier*
5. **The Techniques of Modern Structural Geology Vol. 3: Applications of Continuum Mechanics in Structural Geology** -J. G. Ramsay and Richard Lisle, *Elsevier.*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	2	3	2	0	2	0	0	1	1	3	2	2	1
CO2	2	3	2	0	2	1	0	1	2	3	2	1	1
CO3	1	2	1	0	2	1	0	1	2	3	1	2	1
CO4	3	3	2	1	2	2	1	1	1	3	2	3	3
Average	**2.00**	**2.75**	**1.75**	**0.25**	**2.00**	**1.00**	**0.25**	**1.00**	**1.50**	**3.00**	**1.75**	**2.00**	**1.50**

GEL-CC-2320

Igneous and Metamorphic Petrology

Credit: 4 (L-3:T-0:P-1)

Course Objective

The course is intended in providing fundamental knowledge of igneous and metamorphic rocks including occurrence, classification, and description. The learners are also expected to understand igneous and metamorphic processes and resulting products.

Course Learning Outcome

CO 1: Understanding the attributes of magma and magmatic bodies.
CO 2: Knowledge on the classification of igneous and metamorphic rocks and its usefulness in understanding subtle differences among them.
CO 3: Learning the principles of metamorphism and its products.
CO 4: Establishing relationships between mineral assemblage and intensity of metamorphism.
CO 5: Learning texture and mineral assemblage of different rocks.

Detailed Syllabus

Unit 1 ***15 Lectures***

Magma - nature and composition; forms of igneous bodies; structures and textures of igneous rocks; classification of igneous rocks; CIPW normative classification; IUGS classification for volcanic and plutonic rocks.

Unit 2 ***10 Lectures***

Introduction to phase equilibrium studies; magma generation within the earth; primary magma; magmatic differentiation; Bowen's reaction principle; systematic description of important igneous rocks.

Unit 3 ***10 Lectures***

Metamorphism - types and agents; structure and texture of metamorphic rocks; classification of metamorphic rocks; grade of metamorphism; index minerals and mineral zones; metamorphic facies.

Unit 4 ***10 Lectures***

Metamorphism of pelitic rocks and ultramafic rocks; systematic description of common metamorphic rocks.

Practical ***30 Hours***

1. Systematic study of igneous and metamorphic rocks in hand specimen.
2. Petrography of igneous and metamorphic rocks.
3. Plotting and interpretation of QAP and TAS classification diagrams.
4. Practical record.
5. Viva-voce.

Recommended Books

Text Books:

1. **Essentials of Igneous and Metamorphic Petrology** - B. R. Frost and C. D. Frost, *Cambridge University Press.*
2. **Igneous and Metamorphic Petrology** - Myron G. Best, Wiley-Blackwell.
3. **Petrology: The Study of Igneous, Sedimentary, and Metamorphic Rocks** - Loren A. Raymond, *Waveland Press Inc.*
4. **Principles of Igneous and Metamorphic Petrology** - A. R. Philpotts and J. J. Ague, *Cambridge University Press.*
5. **Principles of Igneous and Metamorphic Petrology** - John D. Winter, *Pearson India*.

Reference Books:

1. **An Introduction to Metamorphic Petrology** - Bruce W. D. Yardley, *Longman.*
2. **Earth Materials** - Cornelis Klein and Anthony R. Philpotts, *Cambridge University Press.*
3. **Igneous Petrogenesis: A Global Tectonic Approach** - Marjorie Wilson, *Springer.*
4. **Igneous Rocks and Processes: A Practical Guide** - Robin Gill, *Wiley-Blackwell.*
5. **Igneous Rocks: A Classification and Glossary of Terms** - R. W. Le Maitre, *Cambridge University Press.*
6. **Petrogenesis of Metamorphic Rocks** - Kurt Bucher and Rodney Grapes, *Springer-Verlag.*
7. **Petrography of Igneous and Metamorphic Rocks** - Anthony R. Philpotts, *CBS Publishers and Distributors.*
8. **Petrography: An Introduction to the Study of Rocks in Thin Section** - H. Williams, F. C. Turner and C. M. Gilbert, *CBS Publishers and Distributors.*
9. **Petrology: Principles and Practice** - Gautam Sen, *Springer.*
10. **Principles of Metamorphic Petrology** - Ron H. Vernon and Geoffrey L. Clarke, *Cambridge University Press.*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	1	2	1	1	1	1	0	0	1	2	1	1	1
CO2	1	2	1	0	1	1	0	0	1	3	1	2	2
CO3	1	2	1	0	1	1	0	0	1	2	1	1	1
CO4	2	3	2	0	2	1	1	1	0	2	2	2	3
CO5	2	3	2	0	2	1	0	1	0	2	2	2	3
Average	**1.40**	**2.40**	**1.40**	**0.20**	**1.40**	**1.00**	**0.20**	**0.40**	**0.60**	**2.20**	**1.40**	**1.60**	**2.00**

GEL-MC-2310

Earth Structure

Credit: 4 (L-3:T-0:P-1)

Course Objective

The course is intended to introduce the learners to the different earth structures and its systematic study and measurements. The course will also discuss the diverse forces acting within the earth and resulting earth structures.

Course Learning Outcome

CO 1: Learning the fundamentals of primary and secondary geological structures.
CO 2: Knowledge on the forces responsible for rock deformation.
CO 3: Understanding planar and linear geological structures.
CO 4: Learning to collect structural data using different instruments.

Detailed Syllabus

Unit 1 ***10 Lectures***

Introduction to geological structures; primary and secondary structures; planar and linear structures; penetrative and non-penetrative structures; strike and dip of planar structures; pitch and plunge of linear structure; clinometer-compass.

Unit 2 ***10 Lectures***

Basic concept of stress and strain; behaviour of rock under stress; elastic and plastic deformation; ductile and brittle deformation.

Unit 3 ***15 Lectures***

Folds - geometry and classification; fault - geometry and classification; joints - types and significance; foliation and lineation; shear zones; unconformities and their types.

Unit 4 ***10 Lectures***

Plate tectonics: types of plate boundaries; plate motions; continental drift; seafloor spreading; hot spot and mantle plume; theories of isostasy.

Practical ***30 Hours***

1. Study of geological maps.
2. Graphical and mathematical solution of simple structural problems.
3. Measuring attitude of planar structures.
4. Identification of structures in hand specimen.
5. Practical records.
6. Viva-voce.

Recommended Books

Text Books:

1. **An Introduction to Structural Geology** - A. K. Jain, *Geological Society of India*
2. **Earth structure: An Introduction to Structural Geology and Tectonics** - B. A. van der Pluijm and S. Marshak, *W. W. Norton & Company*
3. **Structural Geology** - H. Fossen, *Cambridge University Press*

Reference Books:

1. **Structural Geology** - M. P. Billings, *Pearson*
2. **Structural Geology** - R. J. Twiss and E. M. Moors, *W. H. Freeman & Co.*
3. **Structural Geology of Rocks and Regions** - G. H. Davis, S. J. Reynolds and C. Kluth, *Wiley*
4. **Structural Geology: Fundamentals and Modern Developments** - S. K. Ghosh, *Pergamon Press*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	2	1	1	0	1	1	0	1	1	3	2	1	1
CO2	1	2	1	0	1	1	0	1	1	3	2	2	2
CO3	2	1	1	0	1	1	0	1	1	3	1	2	1
CO4	3	3	3	2	3	2	2	1	1	3	2	2	3
Average	**2.00**	**1.75**	**1.50**	**0.50**	**1.50**	**1.25**	**0.50**	**1.00**	**1.00**	**3.00**	**1.75**	**1.75**	**1.75**

GEL-MD-2310

Earth Resources

Credit: 3 (L-3:T-0:P-0)

Course Objective

The objective of the present course is to introduce the students with the natural resources present within the earth including their classification and uses.

Course Learning Outcome

CO 1: Understanding the different types of earth resources and their attributes.
CO 2: Learning diverse metallic and non-metallic resources
CO 3: Knowing different types of energy resources that are necessary for various purposes where geologists are commonly engaged.
CO 4: Understanding the precious water and soil resources of the earth for the sustainable development.

Detailed Syllabus

Unit 1 ***15 Lectures***

Introduction to natural resources; classification of natural resources; biotic and abiotic resources; renewable and non-renewable resources; conventional and non-conventional resources.

Unit 2 ***10 Lectures***

Mineral resources: metallic and non-metallic resources; introduction to some common ore minerals; natural resources as construction materials.

Unit 3 ***10 Lectures***

Energy resources; fossils fuels: coal, petroleum and natural gas; nuclear fuels; non-conventional energy sources: solar energy, geothermal energy, biomass energy and wind energy.

Unit 4 ***10 Lectures***

Water resources: marine, lacustrine and fluvial and ground water; water scarcity index and its remedy; soil resources; conservation of resources; sustainable development.

Recommended Books

Text Books:

1. **Resources of the Earth: Origin, Use and Environmental Impact** - James R. Craig, David J. Vaughan and Brian J. Skinner, *Pearson Education.*
2. **Earth's Natural Resources** - John V. Walther, *Jones and Bartlett Publishers*
3. **Fuel Geology** - Manabendra Nath, *Vishal Publishing Co.*

Reference Books:

1. **Introducing Natural Resources** - Graham Park, *Dunedin*
2. **India's Mineral Resources** - S. Krishnaswamy, *Oxford and IBH.*
3. **Non-Conventional Energy Resources** - B. H. Khan, *Tata McGraw-Hill*
4. **World Petroleum Resources and Reserves** - Joseph Riva, *Routledge*
5. **Mineral Resources of India** - D. K. Banerjee, *World Press Pvt. Ltd*.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	1	1	0	1	1	0	0	1	1	3	1	2	1
CO2	2	1	1	0	1	0	0	1	1	3	1	1	1
CO3	3	3	1	1	2	1	1	1	1	2	1	2	2
CO4	2	2	1	1	2	1	1	1	2	3	1	3	2
Average	**2.00**	**1.75**	**0.75**	**0.75**	**1.50**	**0.50**	**0.50**	**1.00**	**1.25**	**2.75**	**1.00**	**2.00**	**1.50**

GEL-SE-2310

Basics of Geoinformatics

Credit: 3 (L-2:T-0:P-1)

Course Objective

This course aims to introduce students to the fundamental principles and techniques of remote sensing, basic properties of EMR and its interaction with atmosphere, fundamentals of digital image processing and image interpretation. The course also intends to introduce the students to the basics of geographical information system.

Course Learning Outcome

CO 1: Learning the principles of remote sensing and electromagnetic spectrum and its interaction with atmosphere and surface features.
CO 2: Understanding different types of remote sensing and its applications.
CO 3: Developing knowledge on GIS and its applications in geosciences.
CO 4: Understanding various aspects of geodesy.

Detailed Syllabus

Unit 1 ***15 Lectures***

Fundamentals of remote sensing; electromagnetic spectrum; interaction of EMR with Earth's atmosphere and surface features; atmospheric window; sensors and platforms; advantages and limitations of remote sensing.

Unit 2 ***10 Lectures***

Types of remote sensing: optical, thermal, microwave and hyper-spectral; geosynchronous and sun synchronous orbit; concept of digital image; sensor resolution; principles of digital image processing; elements of image interpretation.

Unit 3 ***10 Lectures***

Fundamentals of GIS: vector and raster data; spatial and attribute data; GIS data analysis and visualization; map projection and coordinate system; concept of global positioning system (GPS).

Practical ***30 Hours***

1. Digital image processing.
2. Georeferencing of maps.
3. Interpretation of satellite data.
4. Extraction of spatial features through digitization.
5. Map composition.
6. Practical records.
7. Viva-voce.

Recommended Books

Text Books:

1. **An Introduction to Geographical Information Systems -** I. Heywood, S. Cornelius and S. Carver, *Pearson*
2. **Global Positioning System: Concept, Technique and Application** - A. Rahman and S. Fazal, *New Age International*
3. **Remote Sensing and GIS** - Basudeb Bhatta, *Oxford University Press*
4. **Remote Sensing and Image Interpretation** - T. M. Lillesand, R. W. Kiefer and J. W. Chipman, *John Wiley and Sons*

Reference Books:

1. **Concepts and Techniques of Geographic Information Systems** - C. P. Lo and A. K. W. Yeung, *Pearson*
2. **Fundamentals of Remote Sensing** - George Joseph and C. Jeganathan, *Universities Press*
3. **Global Positioning System: Signals, Measurements, and Performance** - P. Misra and P. Enge, *Ganga-Jamuna Press*
4. **Principles and Applications of Photogeology** - S. N. Pandey, *New Age International, Delhi*
5. **Principles of Geographical Information Systems** - P. A. Burrough, R. A. McDonnell and C. D. Lloyd, *Oxford University Press*
6. **Remote Sensing of the Environment** - J. R. Jensen, *Pearson Education*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	2	1	1	0	1	1	0	1	0	3	2	1	1
CO2	2	1	1	0	1	1	0	1	0	2	1	1	1
CO3	2	3	2	1	2	1	1	3	1	2	3	3	2
CO4	1	1	0	0	1	0	0	0	1	3	1	1	1
Average	**1.75**	**1.50**	**1.00**	**0.25**	**1.25**	**0.75**	**0.25**	**1.25**	**0.50**	**2.50**	**1.75**	**1.50**	**1.25**

GEL-VA-2310

Gemology

Credit: 2 (L-2:T-0:P-0)

Course Objective

This course will introduce the principles and topics of gemology including the chemistry, structure, and properties.

Course Learning Outcome

CO 1: Learning attributes of gem minerals and their occurrence.
CO 2: Learning the physical and optical characteristics of gem minerals.
CO 3: Knowledge on the identification of gem minerals using different physical characteristics.
CO 4: Knowledge on the testing of gem minerals using different techniques.

Detailed Syllabus

Unit 1 ***10 Lectures***

Gemology: introduction to gems; basic properties of gems; formation of gem stones; causes of colours in gemstones; factors that influence the value of gemstones: beauty, durability, rarity and acceptability.

Unit 2 ***10 Lectures***

Introduction to special optical properties like chatoyancy, asterism, luminescence, play of colours, labradorescence, inclusions; distinction between synthetic and natural gem stones; use of refractometers, polariscope, and dichroscope.

Unit 3 ***10 Lectures***

Use of gem testing instruments: hand lens, dichroscope, polariscope; study of the fluorescent colours exhibited by various gemstones under ultraviolet light; measurement of refractive indices and birefringence tests using a gem-testing refractometer.

Recommended Books

Text Books:

1. **Gemmology** - P. G. Read, *Butterworth-Heinemann Ltd.*
2. **Gem Testing** - B. Anderson, *Read Books Pvt. Ltd.*
3. **Gems and Gem Industry in India** - R.V. Karanth, *Geological society of India*
4. **Diamonds and Their Source Rocks in India** - Fareeduddin and R. H. Mitchell, *Geological Society of India*

Reference Books:

1. **Diamonds in India** - T.M. Babu, *Geological Society of India*
2. **Gems: Their Sources, Descriptions and Identification**- B.W. Anderson (Ed.), *Butterworth- Heinemann Ltd.*
3. **Gemstones: Enchanting Gifts of Nature** - R.V. Karanth, *Geological Society of India*
4. **Mineralogy: A First Course** - J. Sinkankas, *Van Nostrand Reinhold Company*
5. **Beginner's Guide to Gemmology** - Peter G. Read, *Heinemann Professional Publishing*
6. **Color Encylopedia of Gemstones** - Joel Arem, *Springer*
7. **Dictionary of Gems and Gemology** - M. Manutchehr-Danai, *Springer*
8. **Gem Identification Made Easy: A Hands-on Guide to More Confident Buying & Selling** - A. Matlins and A. C. Bonnano, *Gemstone Press*
9. **Popular Gemology** - Richard M. Pearl, *Read Books Pvt. Ltd.*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	2	2	1	0	1	0	1	1	0	3	1	2	1
CO2	2	2	1	0	2	0	1	1	0	3	1	2	3
CO3	3	3	2	0	2	1	1	2	0	2	2	2	2
CO4	3	3	1	0	1	0	0	1	0	2	3	3	3
Average	**2.50**	**2.50**	**1.25**	**0.00**	**1.50**	**0.25**	**0.75**	**1.25**	**0.00**	**2.50**	**1.75**	**2.25**	**2.25**

FOURTH SEMESTER

GEL-CC-2410

Sedimentology and Principles of Stratigraphy

Credit: 4 (L-3:T-0:P-1)

Course Objective

The important objective of this course is to introduce the students about different sedimentary processes and sedimentary rocks, structures and textures of sedimentary rocks, sedimentary facies analysis, and principles of stratigraphy.

Course Learning Outcome

CO 1: Understand the origin of different types of sediments and sedimentary rocks.
CO 2: Study and identify different sedimentary rocks, sedimentary structure and texture.
CO 3: Interpret depositional sedimentary environment, sedimentary facies and tectonic setting.
CO 4: Understand the principles of stratigraphy, stratigraphic correlation and classification.

Detailed Syllabus

Unit 1 ***15 Lectures***

Origin of sedimentary rocks: weathering processes, sediment generation, transportation, deposition, lithification and diagenesis; types of sedimentary rocks.

Unit 2 ***10 Lectures***

Structures of sedimentary rocks: syngenetic and diagenetic; textures of sedimentary rocks: clastic and non-clastic.

Unit 3 ***10 Lectures***

Concepts of sedimentary environments and facies; interpretation and reconstruction of sedimentary facies and depositional environment; sedimentation and tectonics.

Unit 4 ***10 Lectures***

Principles of stratigraphy; stratigraphic classification and correlation; types of stratigraphic units; concepts of stratotypes; GSSA and GSSP; Geological time scale.

Practical ***30 Hours***

1. Identification of sedimentary rocks in hand specimen.
2. Petrography of sedimentary rocks - texture and mineralogy.
3. Interpretation of geological maps and sections to identify geological events.
4. Practical records.
5. Viva-voce.

Recommended Books

Text Books:

1. **Applied Sedimentology** - Richard C. Selley, *Academic Press*
2. **Introduction to Sedimentology**- S. M. Sengupta, *CBS Publishers*
3. **Principles of Sedimentology and Stratigraphy**- S. Boggs Jr, *Pearson Education India*
4. **Sedimentary Geology: An Introduction to Sedimentary Rocks and Stratigraphy -** D. R. Prothero, *W. H. Freeman and Co.*
5. **Sedimentary Structure** - J. D. Collinson, N. P. Mountney and D. B. Thompson, *Terra Publishing*
6. **Sedimentology and Stratigraphy** - G. Nichols, *CBS Publishers*

Reference Books:

1. **Applied Sedimentology**- R. K. Sukhtankar, *CBS Publishers*
2. **Depositional Sedimentary Environments** - H. E. Reineck and I. B. Singh, *Springer-Verlag*
3. **International Stratigraphic Guide: A Guide to Stratigraphic Classification, Terminology and Procedure** - Amos Salvador, *The International Union of Geological Sciences & Geological Society of America*
4. **Petrology of Sedimentary Rocks** - Sam Boggs Jr., *Cambridge University Press*
5. **Petrology: The study of Igneous, Sedimentary, and Metamorphic Rocks** - Loren A. Raymond, *Waveland Press Inc*
6. **Sedimentary Petrology**- M. E. Tucker, *CBS Publishers*
7. **Sedimentary Rocks**- F. J. Pettijohn, *CBS Publishers*
8. **Stratigraphy: A Modern Synthesis** - Andrew D. Miall, *Springer*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	1	2	1	0	1	0	0	1	1	2	2	1	2
CO2	3	2	2	1	2	0	0	1	1	2	3	2	2
CO3	3	3	3	1	3	0	0	1	2	3	2	3	2
CO4	2	1	1	0	1	0	0	1	1	2	1	2	1
Average	**2.25**	**2.00**	**1.75**	**0.50**	**1.75**	**0.00**	**0.00**	**1.00**	**1.25**	**2.25**	**2.00**	**2.00**	**1.75**

GEL-CC-2420

Palaeontology

Credit: 4 (L-3:T-0:P-1)

Course Objective

This course is intended to introduce the students to the basic knowledge of fossils, their classification, preservation, morphology, evolution through geological time and their geological applications.

Course Learning Outcome

CO 1: Knowledge about different types of fossils, their mode of preservation, taxonomy, and applications.

CO 2: Understanding the physical and environmental changes that occurred in geologic past and relate them to evolution of life.

CO 3: Learning morphology of important invertebrate and vertebrate fossils.

CO 4: Learning the morphology, and application of different plant fossils and micro fossils.

Detailed Syllabus

Unit 1 ***10 Lectures***

Fossils - definition and types; fossilization and modes of preservation of fossil; applications of fossils; evidences of early life in rock records; taxonomy.

Unit 2 ***15 Lectures***

Morphology, classification, geological evolution and applications of important invertebrate fossils.

Unit 3 ***10 Lectures***

Origin and evolution of vertebrates; brief introduction to the study of origin and evolution of mammals with special reference to horses and human in geologic history.

Unit 4 ***10 Lectures***

Classification of plant kingdom and general morphology of plants; preservation of early plants in rocks; morphology and classification of Gondwana flora; introduction to palynology; micropalaeontology - introduction to different microfossil groups; uses of microfossils in exploration.

Practical ***30 Hours***

1. Megascopic identification of invertebrate fossils.
2. Megascopic identification of plant fossils.
3. Study of microfossils under microscope.
4. Stratigraphic position of important index fossils in Indian context.
5. Practical record.
6. Viva-voce.

Recommended Books

Text Books:

1. **Introduction to Palaeontology –** Amal Dasgupta*, World press*
2. **Micropaleontology: Principles and Applications** - Pratul K. Saraswati and M.S. Srinivasan, *Springer*
3. **Palaeontology (Palaeobiology): Evolution and Animal Distribution** - P. C. Jain and M. S. Anantharaman, *Vishal Publishing Co.*
4. **Paleobotany: The Biology and Evolution of Fossil Plants** - E. Taylor, T. Taylor and M. Krings, *Elsevier*
5. **Principles of Paleontology** - David M. Raup and Steven M. Stanley, *CBS Publishers & Distributors*

Reference Books:

1. **Bringing Fossils to Life: An Introduction to Paleobiology** - Donald Prothero, *Columbia University Press*
2. **Fundamentals of Invertebrate Palaeontology: Macrofossils** - Sreepat Jain, *Springer*
3. **Fundamentals of Invertebrate Palaeontology: Microfossils** - Sreepat Jain, *Springer*
4. **Introduction to Paleobiology and the Fossil Record** - Michael J. Benton, David A. T. Harper, *Wiley-Blackwell*
5. **Invertebrate Fossils** - Raymond C. Moore, Cecil G. Lalicker and Alfred G. Fischer, *CBS Publishers & Distributors*
6. **Invertebrate Palaeontology and Evolution –** E. N. K. Clarkson, *ALBS, Allen and Unwin*
7. **Organic Evolution** - Veer Bala Rastogi, *Medtech*
8. **Principles of Invertebrate Paleontology** - Robert R. Shrock and William H. Twenhofel, *CBS Publishers*
9. **Understanding Fossils: An introduction to Invertebrate Palaeontology** - Peter Doyle, *John Wiley & Sons*
10. **Vertebrate Paleontology** - Michael Benton, *Wiley Blackwell*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	1	1	0	0	1	0	0	1	2	2	2	1	1
CO2	2	2	1	0	2	0	0	1	3	2	2	3	2
CO3	1	1	0	0	1	0	0	0	1	2	1	1	0
CO4	2	2	1	0	2	0	0	1	2	3	2	3	2
Average	**1.50**	**1.50**	**0.50**	**0.00**	**1.50**	**0.00**	**0.00**	**0.75**	**2.00**	**2.25**	**1.75**	**2.00**	**1.25**

GEL-CC-2430

Geodynamics and Global Tectonics

Credit: 4 (L-3:T-0:P-1)

Course Objective

The student will be taught about the internal structure and mechanisms of the earth and resulting geodynamic changes. This course also is expected develops the concepts of plate tectonics on a global scale and analyses the physical processes responsible for the formation and destruction of the plates. Students will also be introduced to the concepts of seismology and palaeoseismology.

Course Learning Outcome

CO 1: Understand the nature and characteristics of different compositional and physical layers of the earth.
CO 2: Understand the theory of plate tectonics, continental drift, sea floor spreading.
CO 3: Understand the earth's magnetism, plate motion, hotspot, supercontinent and Wilson cycle.
CO 4: Appraise basic seismological theory and its application in earth science.

Detailed Syllabus

Unit 1 ***10 Lectures***

Interior of the earth: the crust, the mantle and the core; discontinuities; lithosphere and asthenosphere; concept of isostasy; continental drift; sea floor spreading.

Unit 2 ***10 Lectures***

Plates and plate margins; mid-oceanic ridge; ocean floor topography; continental rift and rift margin; subduction zones; ocean trenches; island arcs; collision zones; triple junction.

Unit 3 ***10 Lectures***

Relative and absolute plate motion; mantle plume and hotspot; Euler poles; geomagnetism and palaeomagnetism; Wilson cycle; supercontinent assembly and breakup.

Unit 4 ***15 Lectures***

Basic seismological theory; seismic waves; focal mechanism; seismicity and seismotectonics; seismographs and seismograms; earthquake kinematics and dynamics; velocity structure of the earth; palaeoseismology and palaeoseismic evidence.

Practical ***30 Hours***

1. Identification of plate boundaries.
2. Determination of plate motion.
3. Study of sea floor spreading from map.
4. Determination of focus and magnitude of an earthquake.
5. Practical records.
6. Viva voce.

Recommended Books

Text Books:

1. **Geodynamics** - Donald Turcotte and Gerald Schubert, *Cambridge University Press*
2. **Geodynamics of the Lithosphere: An Introduction** - Kurt Stuwe, *Springer*
3. **Global Tectonics** - P. Kearey, K. A. Klepeis and F. J. Vine, *Wiley-Blackwell*
4. **Plate Tectonics and Crustal Evolution** - Kent C. Condie, *Butterworth-Heinemann*
5. **Plate Tectonics: Continental Drift and Mountain Building** - W. Frisch, M. Meschede and R. Blakey, *Springer*

Reference Books:

1. **Dynamic Earth: Plates, Plumes and Mantle Convection** – G. F. Davies, *Cambridge University Press*
2. **Making of India: Geodynamic Evolution** - K. S. Valdiya, *Springer*
3. **Plate Tectonics and Great Earthquakes** - Lynn R. Sykes, *Columbia University Press*
4. **Plate Tectonics: A Comprehensive Introduction** - F. Morrison, *Larsen and Keller Education*
5. **Plate Tectonics: A Very Short Introduction** - Peter Molnar, *Oxford*
6. **Plates vs Plumes: A Geological Controversy** - Gillian R. Foulger, Wiley-Blackwell
7. **Seismology and Plate Tectonics** - David Gubbins, *Cambridge*
8. **Supercontinent** - Ted Nield, *Harvard University Pres*
9. **The Dynamics of the Earth System** - A.M. Patwardhan, *Prentice Hall of India*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	1	2	1	0	1	0	0	1	1	3	1	1	1
CO2	1	1	0	0	1	0	0	0	0	2	1	2	2
CO3	2	1	1	0	0	0	0	1	1	2	1	1	1
CO4	2	2	1	1	2	1	1	2	3	2	2	3	2
Average	**1.50**	**1.50**	**0.75**	**0.25**	**1.00**	**0.25**	**0.25**	**1.00**	**1.25**	**2.25**	**1.25**	**1.75**	**1.50**

GEL-CC-2440

Geological Field Methods and Techniques

Credit: 4 (L-0:T-0:P-4)

Course Objective

The main objective of the course is to teach geological field techniques such as mapping techniques in different geological terrains, recording, presenting and interpretation of field data. The course is also aimed to develop field skills of students.

Course Learning Outcome

CO 1: Learning the techniques of data collection and interpretation in the field.
CO 2: Carrying out geological mapping in different types of terrains.
CO 3: Identification of different types of rocks and structures in the field.
CO 4: Learning different geological field techniques.
CO 5: Developing skills in preparing geological maps, field reports and presentation.

Detailed Syllabus

Practical ***120 Hours***

In this course, students will be carrying out geological fieldwork for a period of ten days in which, they will be taught about techniques of mapping in igneous, sedimentary and metamorphic terrains. They will also be taught on lithological, structural, palaeontological and geomorphological data collection methods and preparation of lithologs. Field training will also focus on recording geological features in notebook and photographic techniques. Seminar presentation by students in the field will be evaluated by the concerned teacher in-charge. Report on the fieldwork shall be submitted by the students individually or in groups, as decided by the teacher in-charge, before the commencement of semester examinations, which will be followed by viva-voce.

Marks Distribution:

1. Field Performance : 40%
2. Field Report : 40%
3. Viva-voce : 20%

Recommended Books

Text Books:

1. **A Guide to Field Geology** - N. W. Gokhale, *CBS Publishers*
2. **Basic Geological Mapping** - J. W. Barnes and R.J. Lisle*, Wiley-Blackwell*
3. **Field Geology** - F. H. Lahee, *CBS Publishers*
4. **Geological Field Techniques** - Angela L. Coe, *Wiley-Blackwell*
5. **Geology in The Field** - R. R. Compton*, Earthspun Books*

Reference Books:

1. **Sedimentary Rocks in the Field** - M. E. Tucker, *Wiley-Blackwell*
2. **Sedimentary Rocks in the Field: A Colour Guide** - D. A. V. Stow, *Manson Publishing*
3. **The Field Description of Igneous Rocks** - D. Jerram and N. Petford, *Wiley-Blackwell*
4. **The Field Description of Metamorphic Rocks** - N. Fry, *Wiley-Blackwell*
5. **The Mapping of Geological Structures** - K. R. McClay, *Wiley-Blackwell*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	2	3	2	2	3	2	1	1	2	2	1	2	2
CO2	1	2	3	2	3	2	1	1	1	1	2	3	2
CO3	1	2	1	0	2	1	1	2	1	2	2	2	1
CO4	3	3	2	0	1	2	0	1	1	3	3	3	2
CO5	1	2	3	1	3	1	0	2	0	2	3	3	2
Average	**1.60**	**2.40**	**2.20**	**1.00**	**2.40**	**1.60**	**0.60**	**1.40**	**1.00**	**2.00**	**2.20**	**2.60**	**1.80**

GEL-MC-2410

Petrology

Credit: 4 (L-3:T-0:P-1)

Course Objective

Important objectives of the course are to introduce the three major categories of rocks, their structure, mineral assemblage, classification and origin.

Course Learning Outcome

CO 1: Learning structure and P/T changes within the earth.
CO 2: Understanding the physical and chemical characteristics of magma, structure, texture, classification, and origin of igneous rocks.
CO 3: Knowledge on structure, texture, classification and origin of metamorphic rocks.
CO 4: Developing knowledge about sedimentary rocks, classification, structure, texture and origin.
CO 5: Acquainting with the study of structure, texture and mineral assemblage of different rocks in hand specimen and under microscope through the hands-on training.

Detailed Syllabus

Unit 1 ***10 Lectures***

Origin of earth's internal layering; pressure distribution and thermal gradient within the earth; rock cycle; recent advances in petrology.

Unit 2 ***12 Lectures***

Magma - physical properties and composition; forms of igneous bodies; structure, texture, and classification of igneous rocks; mode and norm; magma generation within the earth; primary magma; Bowen's reaction principle; systematic description of common igneous rocks.

Unit 3 ***12 Lectures***

Metamorphism - definition, types and agents; structure and texture of metamorphic rocks; zones and grades of metamorphism; facies and facies series; classification of metamorphic rocks; systematic description of metamorphic rocks.

Unit 4 ***11 Lectures***

Sedimentary rocks - origin and classification; sedimentary structures and textures; sedimentary environment; systematic description of sedimentary rocks.

Practical ***30 Hours***

1. Systematic study of igneous, metamorphic, and sedimentary rocks in hand specimen and in thin sections.
2. Plotting mineral and chemical composition of rocks in classification diagrams.
3. Determination of metamorphic grade from mineral assemblages.
4. Granulometric analysis.
5. Practical record.
6. Viva-voce.

Recommended Books

Text Books:

1. **An Introduction to Igneous and Metamorphic Petrology** - J.D. Winter, *Pearson.*
2. **Essentials of Igneous and Metamorphic Petrology** - B.R. Frost and C.D. Frost, *Cambridge University Press.*
3. **Petrography of Igneous and Metamorphic Rocks** - A. R. Philpotts, *Prentice Hall.*
4. **Petrology of Sedimentary rocks** - Sam Boggs Jr., Cambridge University Press.
5. **Principles of Igneous and Metamorphic Petrology** - A. R. Philpotts and J. J. Ague, *Cambridge University Press.*
6. **Sedimentary Petrology** - M. E. Tucker, *Blackwell Publishing.*

Reference Books:

1. **Igneous Rocks: A Classification and Glossary of Terms** - R.W. Le Maitre, *Cambridge.*
2. **Introduction to Petrology** - E. Johnson and J. C. Liu, *Virtual Library of Virgina (VIVA).*
3. **Metamorphic Rocks: A Classification and Glossary of Terms** - D. Fettes and J. Desmons, *Cambridge University Press.*
4. **Principles of Metamorphic Petrology** - R. H. Vernon and G.L. Clarke, *Cambridge University Press*.
5. **Principles of Sedimentology and Stratigraphy** - Sam Boggs Jr., *Pearson.*
6. **Petrology: Principles and Practice** - Gautam Sen, *Springer.*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	2	1	1	0	1	1	0	1	2	3	1	1	1
CO2	2	2	1	1	2	1	0	1	1	3	2	2	2
CO3	2	1	1	0	1	1	0	1	2	3	1	1	1
CO4	2	2	1	1	2	1	0	1	1	3	2	1	2
CO5	3	3	2	3	2	2	1	1	1	3	2	3	2
Average	2.20	1.80	1.20	1.00	1.60	1.20	0.20	1.00	1.40	3.00	1.60	1.60	1.60

FIFTH SEMESTER

GEL-CC-3510

Indian Stratigraphy

Credit: 4 (L-4:T-0:P-0)

Course Objective

The course intends to introduce students to different geological formations of India, from Precambrian to Recent times. It is also aimed to acquaint the students the detailed study of the geological sequence and structural disposition NE Indian and Himalayan region.

Course Learning Outcome

CO 1: Understanding tectonic framework of Indian subcontinent.
CO 2: Geology of Archean cratons, Proterozoic basins, and Phanerozoic formations.
CO 3: Evolution and economic significances of the geological formations of different ages.
CO 4: Understanding the complex geological architecture of NE India and the Himalaya.

Detailed Syllabus

Unit 1 ***20 Lectures***

Major physiographic divisions of the Indian subcontinent; tectonic terrains of India; brief study of origin and evolution of cratons; stratigraphic succession, lithology, structure and tectonic evolution of Archaean cratons and Proterozoic basins of India; Eparchaean unconformity.

Unit 2 ***15 Lectures***

Palaeozoic succession of India with special reference to Kashmir; Gondwana basins - stratigraphy, structure, and economic importance; Mesozoic succession of India with special references to Triassic of Spiti, Jurassic of Kutch and Cretaceous of Trichinopoly; brief study of Deccan Volcanic Province.

Unit 3 ***10 Lectures***

Cretaceous-Palaeogene boundary; Cenozoic Stratigraphy: Kutch basin and Siwalik successions.

Unit 4 ***15 Lectures***

Geology of NE India: lithostratigraphy, tectonic setting and evolution of Shillong Plateau; Shylhet Traps and Abor volcanics; Assam-Arakan basin; introduction to Himalayan geology; outline of tectonic divisions and evolution of the Himalayas.

Recommended Books

Text Books:

1. **Fundamentals of Historical Geology and Stratigraphy of India** - Ravindra Kumar, *New Age International*
2. **Geodynamics of Northeastern India and the Adjoining Region** - D. R. Nandy, *Scientific Book Centre*
3. **Geology of Arunachal Pradesh** - G. Kumar, *Geological Society of India*
4. **Geology of Assam** - A. B. Das Gupta and A. K. Biswas, *Geological Society* of *India*
5. **Geology of India (Vol. 1 & 2)** - R. Vaidyanandhan and M. Ramakrishnan, *Geological Society of India*
6. **Historical Geology of India** - S. K. Shah, *Scientific Publishers (India)*
7. **The Making of India: Geodynamic Evolution** - K. S. Valdiya, *Springer*

Reference Books:

1. **Geology and Evolution of the Indian Plate (From Hadean to Holocene 4 Ga to 4 Ka) -** S. M. Naqvi, *Capital Publishing Company*
2. **Geology and Mineral Resources of Arunachal Pradesh -** *Geological Survey of India*
3. **Geology and Mineral Resources of Assam -** *Geological Survey of India*
4. **Geology of India and Burma -** M. S. Krishnan, *CBS Publishers*
5. **Geology of the Himalayan Belt: Deformation, Metamorphism, Stratigraphy -** B. K. Chakrabarti, *Elsevier*
6. **Understanding an Orogenic Belt: Structural Evolution of the Himalaya -** A. K. Dubey, *Springer*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	1	1	1	0	1	0	0	1	0	2	1	1	1
CO2	1	0	0	0	1	0	0	0	1	2	1	1	1
CO3	0	1	1	0	1	0	0	1	1	3	1	2	2
CO4	1	1	0	0	2	1	0	1	1	3	2	2	2
Average	**0.75**	**0.75**	**0.50**	**0.00**	**1.25**	**0.25**	**0.00**	**0.75**	**0.75**	**2.50**	**1.25**	**1.50**	**1.50**

GEL-CC-3520

Economic Geology

Credit: 4 (L-3:T-0:P-1)

Course Objective

This course is designed to provide the basic knowledge about the economic aspects of geology. It aimed at understanding the genesis, mode of occurrences and also uses of the economically important minerals.

Course Learning Outcome

CO 1: Understanding of ore and associated minerals and their structural and textural relationship.
CO 2: Knowledge on mode of occurrence and distribution of ore minerals.
CO 3: Understanding different ore forming processes and types of deposits.
CO 4: Learning important ore deposits of India.

Detailed Syllabus

Unit 1 ***15 Lectures***

Ore and gangue; grade and tenor; forms of ore bodies - concordant and discordant; classification of ore deposits; ore-gangue textures; spatial and temporal distribution of ore deposits.

Unit 2 ***10 Lectures***

Magmatic processes - early magmatic, late magmatic and residual liquid processes; hydrothermal processes; metamorphic ore forming processes; contact metamorphic processes.

Unit 3 ***10 Lectures***

Sedimentary processes - allochthonous deposits; autochthonous deposits - chemical precipitates, organic deposits and residual deposits.

Unit 4 ***10 Lectures***

Types, origin and metallogeny of selected metallic and non-metallic deposits: diamond, chromite, nickel, copper, platinum group elements, lead-zinc, uranium, iron, gold and industrial minerals; world class deposits in India.

Practical ***30 Hours***

1. Identification and description of ore and industrial minerals.
2. Study of optical characters of ore minerals under microscope.
3. Practical records.
4. Viva voce.

Recommended Books

Text Books:

1. **Economic Geology** - Umeshwar Prasad, *CBS Publishers & Distributors*
2. **Economic Geology Principles and Practice** - Walter L. Pohl, *Wiley-Blackwell*
3. **Economic Mineral Deposits** - Mead L. Jensen and Alan M. Bateman, *Book Selection Centre*
4. **Introduction to Ore Forming Processes** - Laurence Robb, *Blackwell Publishing Company*
5. **Understanding Mineral Deposits** - Kula C. Misra, *Springer Netherlands*

Reference Books:

1. **Hydrothermal Processes and Mineral Systems -** Franco Pirajno, *Springer Netherlands*
2. **Ore Deposit Geology -** John Ridley, Cambridge University Press
3. **Ore Deposit Geology and Its Influence on Mineral Exploration -** R. Edwards and K. Atkinson, *Chapman and Hall*
4. **Ore Deposits in an Evolving Earth -** G.R.T. Jenkin, P.A.J. Lusty, I. McDonald, M.P. Smith, A.J. Boyce, and J.J. Wilkinson, *The Geological Society London*
5. **Ore Deposits: Origin, Exploration, and Exploitation -** Sophie Decree and Laurence Robb, *Wiley*
6. **Ore Geology and Industrial Minerals: An Introduction -** Anthony M. Evans, *Wiley India Pvt. Ltd*
7. **The World of Mineral Deposits -** Florian Neukirchen and Gunnar Ries, *Springer*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	1	2	1	1	2	0	0	1	2	3	2	3	1
CO2	2	1	1	0	0	0	0	1	1	2	1	1	1
CO3	1	2	2	0	1	0	0	0	1	2	0	1	2
CO4	1	1	0	0	0	0	0	1	0	2	0	1	0
Average	**1.25**	**1.50**	**1.00**	**0.25**	**0.75**	**0.00**	**0.00**	**0.75**	**1.00**	**2.25**	**0.75**	**1.50**	**1.00**

GEL-CC-3530

Fuel Geology

Credit: 4 (L-3:T-0:P-1)

Course Objective

The main objectives of this course are to introduce the students to different types of fossil fuels, their characteristics, origin, classification, distribution and exploitation. The course is also intended to introduce basic concepts of radioactive minerals as fuel, their occurrences, and uses.

Course Learning Outcome

CO 1: Knowledge on description, classification, origin, and occurrence of coal in India and in the world.
CO 2: Gaining geological knowledge on CBM and natural gas resources.
CO 3: Knowledge on description, classification, origin, and occurrence of petroleum in India.
CO 4: Understanding of radioactive minerals as fuel and their occurrences, uses and nuclear waste management.

Detailed Syllabus

Unit 1 ***15 Lectures***

Coal Geology: origin, age and occurrence of coal; types of coal; macroscopic and microscopic description of coal; quality of coal - physical, chemical and combustion properties; spatial and temporal distribution of Indian coal deposits.

Unit 2 ***10 Lectures***

Petroleum system: introduction to reservoir rock, source rock and cap rock; physical and chemical properties of hydrocarbon; origin, migration and entrapment of petroleum; different reservoir traps; characteristics of reservoir; hydrocarbon source rocks and cap rocks; onshore and offshore petroliferous basins of India; oil and gas fields of Northeast India.

Unit 3 ***10 Lectures***

Unconventional fuel resources: Coal bed Methane (CBM) - introduction and early development; conventional natural gas resource; CBM resource; coal rank significance in natural gas reservoirs; gas flow in coal deposits; problems in CBM mining; important natural gas resources in India; shale gas; oil shale; bituminous shale.

Unit 4 ***10 Lectures***

Nuclear Geology: radioactive minerals as source of energy; nuclear fuel cycle; mineralogy, geochemistry and mode of occurrence of radioactive minerals; productive geologic horizons of atomic minerals in India; nuclear waste disposal.

Practical ***30 Hours***

1. Megascopic identification of coal types.
2. Identification of macerals in coal.
3. Preparation of polished mounts of coal.
4. Hydrocarbon source rock analysis.
5. Study of uranium and thorium bearing minerals and rocks.
6. Practical Records.
7. Viva-voce.

Recommended Books

Text Books:

1. **Coal Geology -** Larry Thomas, *Wiley Blackwell*
2. **Elements of Petroleum Geology**- Richard C. Selley and Stephen A. Sonnenberg, *Academic Press*
3. **Principles of Nuclear Geology** - U. Aswathanarayana, *Oxford University Press*
4. **Geology of Petroleum** - A. L. Leverson, *CBS Publishers*
5. **Textbook of Coal** - D. Chandra, R. M. Singh and M. P. Singh, *Tara Book Agency, Varanasi*

Reference Books:

1. **Coalbed Methane: Principles and Practice** - Rudy Rogers, Kumar Ramurthy, Gary Rodvelt and Mike Mullen, *Oktibbeha Publishing*
2. **Petroleum Geoscience** - Jon Gluyas and Richard Swarbrick, *Blackwell Publishing*
3. **Petroleum Geoscience: From Sedimentary Environments to Rock Physics** - Knut Bjorlykke, *Springer*
4. **Petroleum Geosciences: Indian Contexts** - Soumyajit Mukherjee, *Springer*
5. **Coal Geology and Coal Technology** - Colin R. Ward, *Blackwell Scientific Publications*
6. **Coal and Organic Petrology** - M. P. Singh, *Hindustan Publishing Corp*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	1	1	0	0	1	0	0	1	1	3	1	2	1
CO2	1	1	0	0	1	0	0	1	2	2	2	1	0
CO3	2	1	0	0	1	0	0	1	1	3	1	2	1
CO4	2	2	0	0	2	1	1	1	2	2	2	2	1
Average	**1.50**	**1.25**	**0.00**	**0.00**	**1.25**	**0.25**	**0.25**	**1.00**	**1.50**	**2.50**	**1.50**	**1.75**	**0.75**

GEL-CC-3540

Environmental Geology

Credit: 2 (L-2:T-0:P-0)

Course Objective

The course primarily deals with the natural resources and their degeneration and geogenic hazards and disasters.

Course Learning Outcome

CO 1: Aware of important geological factors responsible for earth's environments.
CO 2: Learning the interaction between human activity and the natural environment in terms of earth resources and earth processes.
CO 3: Developing idea about the different energy resources and their usage.
CO 4: Learning the effective methods of managing wastes.

Detailed Syllabus

Unit 1 ***10 Lectures***

Environmental geology: introduction, and fundamental concepts; natural hazards - earthquakes, volcanic activity, floods, landslides, and coastal hazards.

Unit 2 ***10 Lectures***

Earth resources - water, mineral and energy resources; pollution of water and air; global climate change and human activities; geologists' role in environmental health and environmental planning.

Unit 3 ***10 Lectures***

Waste management: characteristics, collection, disposal of wastes; handling and disposal of hazardous wastes; industrial hygiene; occupational health; environmental toxicology; engineering and safety measures.

Recommended Books

Text Books:

1. **A Concise Textbook of Environmental Geology** – B. S. Rathore*, Notion Press*
2. **Environmental Geology: Ecology, Resource and Hazard Management** - K. S. Validya, *Tata McGraw-Hill*
3. **Introduction to Environmental Geology** - Edward A. Keller, *Prentice Hall*

Reference Books:

1. **Environmental Geology** - C. W. Montgomery, *McGraw Hill*
2. **Environmental Geology** - James W. LaMoreaux, *Springer New York*
3. **Environmental Geology: Geology and The Human Environment** - M. R. Bennett and P. Doyle*, Wiley India*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	2	2	1	2	1	0	0	2	3	2	2	3	2
CO2	2	1	0	1	2	2	1	2	3	2	1	2	1
CO3	1	1	3	0	1	1	1	1	3	3	2	3	1
CO4	2	1	2	2	1	1	1	2	3	2	2	3	1
Average	**1.75**	**1.25**	**1.50**	**1.25**	**1.25**	**1.00**	**0.75**	**1.75**	**3.00**	**2.25**	**1.75**	**2.75**	**1.25**

GEL-IN-3510

Internship

Credit: 2

Course Objective

The main objective of the course is to give the students industrial/institutional exposure for preliminary research, develop professional skills, gain hands-on experience, evaluate career opportunities and begin building a professional network.

Course Learning Outcome

CO 1: Exposure to different kinds of organizations and gaining experience through carrying out research activities.
CO 2: Develop their skills and knowledge by working with professionals in their field of interest.
CO 3: Explore career opportunities prior to graduation.
CO 4: Acquire mindset and skills to work with diverse people and in diverse geological fields necessary for successful career.

Detailed Syllabus

Upon completion of fourth semester examination the students shall undergo institutional or industrial training for a period of at least four weeks during summer vacation with prior approval from the department. Report shall be submitted to the department within 60 days from the date of completion of the internship. The report should be duly certified by the supervisor under whom the student carried out the internship. The students shall be evaluated based on the report, seminar presentation and viva-voce in front of the duly constituted committee by the department.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	3	2	3	3	3	3	2	2	1	2	3	2	3
CO2	2	2	2	3	3	3	3	2	1	3	3	3	2
CO3	1	1	2	3	3	3	3	2	1	2	3	2	2
CO4	3	3	2	2	3	2	2	2	1	3	3	3	3
Average	**2.25**	**2.00**	**2.25**	**2.75**	**3.00**	**2.75**	**2.50**	**2.00**	**1.00**	**2.50**	**3.00**	**2.50**	**2.50**

GEL-MC-3510

Historical Geology

Credit: 4 (L-3:T-0:P-1)

Course Objective

The course is intended to introduce the students to the basic knowledge of historical geology including the history of the origin and evolution of the different geological terrain along with the history and evolution of the life on earth.

Course Learning Outcome

CO 1: Learning fundamental principles of stratigraphy and concept of geologic time scale.
CO 2: Develop knowledge on stratigraphy of different geological terrains in India.
CO 3: Understanding the basic concepts of palaeontology and knowledge on important fossils.
CO 4: Understanding the applications of fossils in stratigraphy and other economic aspects.

Detailed Syllabus

Unit 1 ***10 Lectures***

Introduction to historical geology; principles of stratigraphy; uniformitarianism and catastrophism; concept of geological time scale and stratigraphic units.

Unit 2 ***13 Lectures***

Geological terrains of Indian continent; introduction to the Archean cratons, Proterozoic mobile belts and Proterozoic sedimentary basins of India; Phanerozoic rocks and their type areas; introduction to geology of NE India.

Unit 3 ***10 Lectures***

Introduction to palaeontology; definition and types of fossils; fossilization and modes of preservation; application of fossils in geological studies; evidence of early life in rock records.

Unit 4 ***12 Lectures***

Systematic description of important vertebrate, invertebrate and plant fossils.

Practical ***30 Hours***

1. Identification of stratigraphic sequence from maps and sections.
2. Systematic study of megafossils.
3. Practical record.
4. Viva-voce.

Recommended Books

Text Books:

1. **Fundamentals of Historical Geology and Stratigraphy of India** - Ravindra Kumar, *New Age International*
2. **Historical Geology: Evolution of Earth & Life Through Time** - Reed Wicander and James S. Monroe, *Cengage*
3. **Historical geology Lan Manual** - Pamela J. W. Gore, *Wiley*
4. **Palaeontology (Palaeobiology): Evolution and Animal Distribution** - P. C. Jain and M. S. Anantharaman, *Vishal Publishing Co.*

Reference Books:

1. **Bringing Fossils to Life: An Introduction to Paleobiology** - Donald Prothero, *Columbia University Press.*
2. **Historical Geology of India** - S. K. Shah, *Scientific Publishers (India)*
3. **The Making of India: Geodynamic Evolution** - K. S. Vadiya, *Springer*
4. **Historical Geology: Understanding Our Planet's Past** - Jon Erickson, *Facts On File, Inc.*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	2	1	1	0	1	1	0	1	1	2	1	1	1
CO2	2	2	1	1	2	1	1	1	1	3	1	2	2
CO3	1	2	1	1	1	1	0	1	1	3	2	1	1
CO4	3	3	2	1	2	1	1	1	1	3	2	2	3
Average	**2.00**	**2.00**	**1.25**	**0.75**	**1.50**	**1.00**	**0.50**	**1.00**	**1.00**	**2.75**	**1.50**	**1.50**	**1.75**

SIXTH SEMESTER

GEL-CC-3610

Geochemistry

Credit: 4 (L-3:T-0:P-1)

Course Objective

The main objectives of this course are to introduce the students about fundamentals and principles of geochemistry, analytical techniques useful in geochemical studies, and study various geochemical reservoirs of the Earth. The course also aims to enlighten the basic principles of isotope geology and their applications in earth sciences.

Course Learning Outcome

CO 1: Understanding origin and evolution of Solar System and distribution of elements in that.
CO 2: Fundamental atomic properties and geochemical characteristics of elements.
CO 3: Understanding of different reservoirs of the earth system, its chemical entity and relationship and interactions among the reservoirs.
CO 4: Principles of radioactivity, isotopic systematics and its applications in geosciences.

Detailed Syllabus

Unit 1 ***10 Lectures***

Geochemistry - introduction and applications; The Big Bang and nucleosynthesis; solar system abundance of elements; atoms and molecules; internal structure of atoms; ionization energy; electronegativity; geochemical classification of elements.

Unit 2 ***10 Lectures***

Bonding in minerals; ionic crystals; ionic substitution and solid solution; distribution coefficients; law of mass action; concept of mass-balance and mixing theory.

Unit 3 ***13 Lectures***

Geochemical reservoir of the earth and their compositions: the atmosphere, the ocean, the crust, mantle and core; biogeochemical cycles.

Unit 4 ***12 Lectures***

Principles of radioactivity; radioactive isotopes; decay mechanisms and applications; stable isotopic systematics and applications.

Practical ***30 Hours***

1. Plotting of major element data in Harker diagrams.
2. Plotting of trace element data in multi-element diagrams.
3. Isochron plotting and determination of age using isotope ratios.
4. Practical record.
5. Viva-voce.

Recommended Books

Text Books:

1. **Geochemistry: An Introduction -** Francis Albarede, *Cambridge University Press*
2. **Principles and Applications of Geochemistry: A Comprehensive Textbook for Geology Students** - Gunter Faure, *Prentice Hall*
3. **Introduction to Geochemistry: Principles and Applications** - Kula C. Misra, *Wiley-Blackwell*
4. **Geochemistry** - William M. White, *Wiley-Blackwell*
5. **Isotope Geochemistry** - William M. White, *Wiley-Blackwell*
6. **Isotopes: Principles and Applications** - Gunter Faure and Teresa M. Mensing, *John Wiley*

Reference Books:

1. **Treatise on Geochemistry (Vol-I): Meteorites, Comets and Planets** - H. D. Holland and K. K. Turekian, *Elsevier*
2. **Radiogenic Isotope Geology** - Alan P. Dickin, *Cambridge University Press*
3. **Essentials of Geochemistry** - John V. Walther, *Jones and Bartlett Publishers*
4. **Geochemistry: Pathways and Processes** - Harry Mcsween, Sterven M Ricardson and Maria Uhle, *Columbia University Press*
5. **Inorganic Geochemistry** - Paul Henderson, *Pergamon Press*
6. **Radiogenic Isotope Geochemistry: A Guide for Industry Professionals** - Bruce F. Schaefer, *Cambridge University Press*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	1	0	0	0	1	0	0	1	1	2	2	2	3
CO2	1	2	0	0	2	0	0	1	1	3	1	2	1
CO3	1	1	1	0	1	0	0	1	1	2	12	1	0
CO4	2	2	1	0	2	0	0	1	2	3		3	2
Average	**1.25**	**1.25**	**0.50**	**0.00**	**1.50**	**0.00**	**0.00**	**1.00**	**1.25**	**2.50**	**3.75**	**2.00**	**1.50**

GEL-CC-3620

Geomorphology and Quaternary Geology

Credit: 4 (L-3:T-0:P-1)

Course Objective

The main objective of this course is to introduce students to the basic concepts of landforms and the processes that produce and modify them. The course is aimed to enable the students to understand different geomorphic processes and the landforms produced as a result of their interaction with the existing earth surface features. It is also aimed to introduce the students about basic concepts of Quaternary Geology.

Course Learning Outcome

CO 1: Learning about the basic geomorphic principles and landform development.
CO 2: Understand different geomorphic processes and learn about the associated landforms.
CO 3: Understanding the active tectonics through geomorphic analysis.
CO 4: Learning of the Quaternary geology and various methods of Quaternary study

Detailed Syllabus

Unit 1 ***10 Lectures***

Principles of geomorphology; landscape development and modification; scale of landscape analysis; energy flow in geomorphic system; weathering and soil formation; hillslopes and hillslope processes.

Unit 2 ***10 Lectures***

Fluvial geomorphic system; fluvial processes; drainage basin development and morphometry; channel pattern; floodplain, alluvial fan and delta; fluvial response to active tectonics.

Unit 3 ***10 Lectures***

Aeolian processes and landforms; glaciers and glacial landforms; coastal geomorphology: waves, coastal processes and landforms; tectonic geomorphology and geomorphic markers; geomorphic indices of active tectonics.

Unit 4 ***15 Lectures***

Introduction to Quaternary Geology; significance of Quaternary studies; Quaternary period and subdivisions; Quaternary climate change and sea level fluctuation; basic principles of morphostratigraphy, oxygen isotope stratigraphy and magnetostratigraphy; Quaternary dating techniques.

Practical ***30 Hours***

1. Study of geomorphic models and topographic maps.
2. Drainage basin morphometry.
3. Longitudinal profile of rivers and SL index.
4. Study of active tectonics from geomorphic indices.
5. Practical Records.
6. Viva-voce.

Recommended Books

Text Books:

1. **Active Tectonics: Earthquakes, Uplift and Landscape -** Edward A. Keller and Nicholas Pinter, *Prentice Hall*
2. **Fundamentals of Geomorphology** - Richard John Huggett, *Routledge*
3. **Geomorphology** - Mateo Gutiérrez, *CRC Press*
4. **Geomorphology: A systematic Analysis of Late Cenozoic Landforms** - A. L. Bloom, *Pearson*
5. **Geomorphology: The Mechanics and Chemistry of Landscapes** - R. S. Anderson and S. P. Anderson, *Cambridge University Press*
6. **Principles of Quaternary Geology and Environmental Study** - A. B. Goswami, *Books Way, Kolkata*
7. **Tectonic Geomorphology** - D. W. Burbank and R. S. Anderson**,** *Wiley-Blackwell*

Reference Books:

1. **Aeolian Geomorphology: A New Introduction** - Ian Livingstone and Andrew Warren, *Wiley-Blackwell*
2. **An Introduction to Coastal Processes and Geomorphology -** Robin Davidson-Arnott, *Cambridge University Press*
3. **Arid and Semi-Arid Geomorphology** - Andrew S. Goudie, *Cambridge University Press*
4. **Coastal Geomorphology: An Introduction**- Eric Bird, *John Wiley & Sons Ltd*
5. **Earth's Climate: Past and Future** - William F. Ruddiman, *W. H. Freeman and Company*
6. **Encyclopedia of Geomorphology -** A. S. Goudie, *Routledge*
7. **Fundamentals of Fluvial Geomorphology -** Ro Charlton, *Routledge*
8. **Introduction to Process Geomorphology** - Vijay K. Sharma, *CRC Press*
9. **Key Concepts in Geomorphology** - Paul R. Bierman and David R. Montgomery, *W. H. Freeman & Co.*
10. **Quaternary Dating Methods -** Mike Walker, *Wiley*
11. **Quaternary Geology: Indian Perspective** - U. B. Mathur, *Geological Society of India*
12. **River Dynamics: Geomorphology to Support Management** - Bruce L. Rhoads, *Cambridge University Press*
13. **River Morphology** - R. J. Garde, *New Age International (P) Limited, Publishers*
14. **River Processes: An Introduction to Fluvial Dynamics** - André Robert, *Arnold*
15. **River Variability and Complexity** - Stanley A. Schumm, *Cambridge University Press*
16. **Rivers in the Landscape** - Ellen Wohl, *Wiley-Blackwell*
17. **Tectonically Active Landscapes** - William B. Bull, *Wiley-Blackwell*
18. **The SAGE Handbook of Geomorphology** - Kenneth J. Gregory and Andrew S Goudie, *SAGE Publications*
19. **Treatise on Geomorphology -** John F. Shroder, Vols. 1- 14, *Academic Press*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	1	2	1	0	2	0	0	2	1	3	2	3	3
CO2	2	2	1	0	2	0	0	1	2	3	2	1	1
CO3	2	1	0	0	2	0	1	1	1	3	2	3	2
CO4	2	1	1	0	1	0	0	1	1	2	1	2	1
Average	**1.75**	**1.50**	**0.75**	**0.00**	**1.75**	**0.00**	**0.25**	**1.25**	**1.25**	**2.75**	**1.75**	**2.25**	**1.75**

GEL-CC-3630

Geoexploration and Mining

Credit: 4 (L-3:T-0:P-1)

Course Objective

The course is intended to provide the student basic concepts of mineral exploration techniques, sampling methods, ore reserve estimation and mining methods.

Course Learning Outcome

CO 1: Learning the fundamentals of prospecting for mineral deposits.
CO 2: Learning basic scientific techniques involved in the exploration and estimation of reserve.
CO 3: Students will learn various surface and underground mining methods.
CO 4: Knowledge about policies related to mining activities and conservation of mineral deposits.

Detailed Syllabus

Unit 1 ***10 Lectures***

Introduction to geological prospecting and exploration; principles of geological prospecting; basic concepts of geophysical, geochemical and geobotanical prospecting.

Unit 2 ***10 Lectures***

Sampling methods; pitting, trenching and drilling; categories of reserves; estimation of reserves: cross-sectional method, area of influence method, triangulation method and weighted volume estimate method.

Unit 3 ***10 Lectures***

Elements of mining; stages in the life of a mine; unit operations in mining. classification of mining methods; factors influencing choice of mining method.

Unit 4 ***15 Lectures***

Surface mining methods; underground mining methods; mineral processing; conservation of mineral resources; mine safety.

Practical ***30 Hours***

1. Identification of anomaly.
2. Reserve estimation of mineral deposits with regular geometry.
3. Reserve estimation of mineral deposits with irregular geometry.
4. Estimation of coal reserve.
5. Practical record.
6. Viva-voce.

Recommended Books

Text Books:

1. **Courses in Mining Geology** - R. P. N. Arogyaswamy, *Oxford and IBH Publishing*
2. **Introductory Mining Engineering** - Howard L. Hartman, *John Wiley and Sons*
3. **Mineral Exploration: Principles and Applications** - Swapan K. Haldar, *Elsevier*
4. **Introduction to Mineral Exploration** - C. J. Moon, M. K. G. Whateley and A. M. Evans, *Blackwell Publishing*
5. **Essentials of Mineral Exploration and Evaluation** - S. M. Gandhi and B. C. Sarkar, *Elsevier*

Reference Books:

1. **Environmental Geology** - C. W. Montgomery, *McGraw Hill*
2. **Environmental Geology: Geology and The Human Environment** - M. R. Bennett and P. Doyle, *Wiley India*
3. **Exploration Geophysics** - Mamdouh R. Gadallah and Ray Fisher, *Springer*
4. **Geological Methods in Mineral Exploration and Mining** - Roger Marjoribanks, *Springer*
5. **Mineral Exploration: Practical Application** - G. S. Roonwal, *Springer*
6. **Surface Mining** - Bruce A Kennedy, *Society for Mining, Metallurgy, and Exploration*
7. **Underground Mining Methods** - W. A. Hustrulid and R. L. Bullock, *Society for Mining, Metallurgy, and Exploration*
8. **Mineral Resources: From Exploration to Sustainability Assessment** - M.B. Revuelta, *Springer*
9. **Statistical Evaluations in Exploration for Mineral Deposits** - F.W. Wellmer, *Springer*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	3	1	1	0	0	0	0	1	1	3	2	3	1
CO2	3	2	1	1	2	0	0	2	1	3	3	2	3
CO3	3	1	1	2	2	1	0	2	2	3	1	2	2
CO4	2	1	1	1	0	0	0	0	3	2	0	1	0
Average	**2.75**	**1.25**	**1.00**	**1.00**	**1.00**	**0.25**	**0.00**	**1.25**	**1.75**	**2.75**	**1.50**	**2.00**	**1.50**

GEL-CC-3640

Engineering Geology and Hydrogeology

Credit: 4 (L-3:T-0:P-1)

Course Objective

The course is designed to impart knowledge of engineering geology along with technical problems related to various engineering sites and remedial measures. The course is also intended to impart knowledge about groundwater, its occurrence, and movement.

Course Learning Outcome

CO 1: Learning the geological investigation techniques for the engineering construction sites.
CO 2: Develop the knowledge on the engineering properties of soil and rock.
CO 3: Understanding the water cycle and basic concepts of hydrogeology.
CO 4: Learning physical and chemical criteria of groundwater and different causes for its pollution.

Detailed Syllabus

Unit 1 ***15 Lectures***

Role of engineering geologists; site investigation and characterization in construction of dam and reservoir, tunnel, highways and bridges.

Unit 2 ***10 Lectures***

Engineering properties of soil - unit weight, specific gravity, bulk density, porosity, void ratio, degree of saturation; shear strength of soil; concept of Atterberg limit; engineering properties of rocks - strength, elasticity, porosity, and specific gravity; concept of rock quality designation (RQD) and tunnelling quality index (Q).

Unit 3 ***10 Lectures***

Hydrologic cycle; surface water-groundwater interaction; rock properties affecting groundwater; vertical distribution and classification of subsurface water; water table and piezometric surface; utilization of groundwater.

Unit 4 ***10 Lectures***

Types of aquifers; springs; Darcy's law and its validity; intrinsic permeability; hydraulic conductivity; transmissivity; confined and unconfined aquifers; types of wells; groundwater flow rates and flow directions.

Practical ***30 Hours***

1. Study of engineering properties of soil and rocks.
2. Computation of RQD and Tunnelling Quality Index (Q).
3. Preparation and interpretation of water table maps.
4. Study, preparation and analysis of hydrographs for differing groundwater conditions.
5. Practical Records.
6. Viva-voce.

Recommended Books

Text Books:

1. **Applied Hydrogeology** - C. W. Fetter, *Pearson Education India*
2. **Groundwater Hydrology** - David Keith Todd and Larry W. Mays, *John Wiley & Sons Inc*
3. **Hydrogeology: Principles and Practice** - Kevin M. Hiscock and Victor F. Bense, *Wiley Blackwell*
4. **Engineering Geology** - S. Gangopadhyay, *Oxford University Press*
5. **Engineering Properties of Soils and Rocks** - F. G. Bell, *Wiley-Blackwell*
6. **Principles of Engineering Geology and Geotectonics** - D. K. Krynine and W. R. Judd, *CBS Publishers*

Reference Books:

1. **Groundwater Hydrology: Conceptual and Computational Models** - K. R. Rushton, *Wiley India*
2. **Engineering Geology** - F. G. Bell, *CBS Publishers*
3. **Hydrology: Principles-Analysis-Design** - H. M. Raghunath, *New Age International Publishers*
4. **Geotechnical Engineering (Soil Mechanics) -** T. G. Sitharam and T. N. Ramamurthy**,** *S. Chand*
5. **Hydrogeology: Problems with Solutions** - Nandipati Subba Rao, *Prentice Hall India*
6. **Practical and Applied Hydrogeology** - Zekai Sen, *Elsevier*
7. **Ground Water Assessment, Development and Management** - K. R. Karanth, *McGraw Hill Education*
8. **Ground Water** - H. M. Raghunath, *New Age International Publishers*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	0	1	0	0	1	1	3	2	2	1
CO2	2	1	1	0	1	0	0	1	1	2	1	2	2
CO3	2	1	0	0	2	0	0	2	2	3	1	2	1
CO4	2	2	1	0	1	1	0	2	3	2	1	2	1
Average	2.25	1.50	0.75	0.00	1.25	0.25	0.00	1.50	1.75	2.50	1.25	2.00	1.25

GEL-MC-3610

Economic Geology

Credit: 4 (L-3:T-0:P-1)

Course Objective

This course is aimed to teach systematic study of economic mineral deposits, their origin and distribution. The learners will also be taught about geological aspects of different types of energy resources.

Course Learning Outcome

CO 1: Understanding of ore and associated minerals and their structural and textural relationship.
CO 2: Understanding different ore forming processes and types of deposits.
CO 3: Knowledge on mode of occurrence and distribution of ore minerals in India.
CO 4: Geological knowledge on energy resources and their occurrences.

Detailed Syllabus

Unit 1 ***15 Lectures***

Ore forming processes: magmatic process - early magmatic, late magmatic and residual liquid processes; hydrothermal processes; metamorphic processes; sedimentary processes - allochthonous deposits; autochthonous deposits - chemical precipitates, organic deposits and residual deposits.

Unit 2 ***10 Lectures***

Ore and gangue; grade and tenor; forms of ore bodies - concordant and discordant forms; classification of ore deposits; spatial and temporal distribution of ore deposits; ore-gangue textures.

Unit 3 ***10 Lectures***

Study of important metallic and non-metallic deposits in India.

Unit 4 ***10 Lectures***

Coal - physical and chemical constituents, classification, mode of occurrence, origin, and uses; petroleum and natural gas - constituents, properties, origin, and uses; introduction to radioactive minerals.

Practical ***30 Hours***

1. Megascopic study of ore and industrial minerals.
2. Study of optical characters of ore minerals under microscope.
3. Systematic description of coal types.
4. Practical records.
5. Viva-voce.

Recommended Books

Text Books:

1. **Economic Geology** - Umeshwar Prasad, *CBS Publishers & Distributors*
2. **Economic Geology Principles and Practice** - Walter L. Pohl, *Wiley-Blackwell*
3. **Fuel Geology** - Manabendra Nath, *Vishal Publishing Co.*

Reference Books:

1. **Economic Mineral Deposits** - Mead L. Jensen and Alan M. Bateman, *Book Selection Centre*
2. **Geology of Petroleum** - A. L. Leverson, *CBS Publishers*
3. **Mineral Deposits of India** - R. M. Umathay, *Dattsons Publishers*
4. **Textbook of Coal** - D. Chandra, R. M. Singh and M. P. Singh, *Tara Book Agency, Varanasi*
5. **Understanding Mineral Deposits** - Kula C. Misra, *Springer Netherlands*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	2	1	1	0	1	1	1	2	1	3	1	1	2
CO2	1	1	1	0	1	1	1	1	1	2	2	1	2
CO3	2	1	1	0	1	1	0	1	1	2	1	1	1
CO4	1	1	1	0	1	1	1	1	1	2	1	2	2
Average	**1.50**	**1.00**	**1.00**	**0.00**	**1.00**	**1.00**	**0.75**	**1.25**	**1.00**	**2.25**	**1.25**	**1.25**	**1.75**

SEVENTH SEMESTER

GEL-CC-4710

Advanced Mineralogy

Credit: 4 (L-3:T-0:P-1)

Course Objective

The important objectives of the course are to provide in depth knowledge in the field of crystallography and mineralogy. Learners will be taught external symmetry, internal symmetry in atomic structure and resulting physical properties of crystals. The course will introduce advanced analytical techniques in analysing minerals and its geological inference. The course is also intended to teach physical and optical characteristics, and chemistry of mineral groups.

Course Learning Outcome

CO 1: Detailed knowledge about principles of crystallography.
CO 2: Understanding of influence of elements in crystal structure, its chemical composition, diversification and stability in different geological environments.
CO 3: Detailed knowledge on the physical and optical characteristics, composition, origin and economic importance of silicate and non-silicate minerals.
CO 4: Knowledge on the optical properties of minerals.

Detailed Syllabus

Unit 1 ***15 Lectures***

Crystallography: elements of point symmetry - rotation, reflection, inversion and rotoinversion; combination of symmetry operations; 32 point groups; Hermann-Mauguin notation; Miller Indices; translational symmetry - plane lattice, space lattice, and unit cell; Bravais lattice; screw axis and glide planes; space group.

Unit 2 ***10 Lectures***

Atomic structure: ionic packing in two dimensions and three dimensions; Pauling's rules; compositional variation in minerals - element substitution and solid solution; crystal growth and crystal defects; principles and applications of different analytical techniques for studying mineral morphology, crystal structure and composition.

Unit 3 ***10 Lectures***

Silicate and non-silicate structures; systematic study of important silicates, carbonates, oxides, and sulphides.

Unit 4 ***10 Lectures***

Optical mineralogy: interaction of light and matter; optics of isotropic and anisotropic minerals; determination of sample thickness and birefringence; uniaxial optics - uniaxial indicatrix, uniaxial interference figure, and determining indices of refraction; biaxial optics - biaxial indicatrix, biaxial interference figure and determining optic sign and 2V; optical properties of important silicate and non-silicate minerals.

Practical ***30 Hours***

1. Stereographic projection of holohedral classes of different crystal systems.
2. Calculation of cell parameters using XRD data.
3. Systematic description of minerals in hand specimen and under polarizing microscope.
4. Determination of refractive index, sign of elongation, order of interference colour and optic sign.

5. Determination of plagioclase composition using Michel-Levy method.
6. Recalculation of mineral formula from chemical analysis.
7. Practical Record.
8. Viva-voce.

Recommended Books

Text Books:

1. **An Introduction to the Rock-Forming Minerals** - W.A. Deer, R.A. Howie and J. Zussman, The Mineralogical Society London.
2. **Crystallography and Mineralogy: Concepts and Methods** - R. S. Sharma and Anurag Sharma, Geological Society of India.
3. **Introduction to Mineralogy** - William D. Nesse, Oxford University Press.
4. **Introduction to Optical Mineralogy** - William D. Nesse, Oxford University Press.
5. **Mineralogy** - Dexter Perkins, Pearson.
6. **Mineralogy** - L.G. Berry, Brian Mason and R.V. Dietrich, CBS Publishers and Distributors.
7. **Optical Mineralogy** - P. F. Kerr, McGraw Hill.
8. **Practical Approach to Mineralogy and Crystallography** - R.N. Hota, CBS Publishers and Distributors.
9. **The Manual of Mineral Science** - Cornelis Klein and Barbara Dutrow, Wiley.

Reference Books:

1. **A Key for Identification of Rock-forming Minerals in Thin Section** - Andrew J. Barker, CRC Press.
2. **A Practical Introduction to Optical Mineralogy** - C. D. Gribble and A. J. Hall, Springer.
3. **Atlas of Rock-Forming Minerals in Thin Section** - W. S. MacKenzie and C. Guilford, Routledge.
4. **Dana's Textbook of Mineralogy** - William E. Ford, CBS Publishers and Distributors.
5. **Earth Materials: Introduction to Mineralogy and Petrology** - Cornelis Klein and Anothony Philpotts, Cambridge.
6. **Introduction to Mineralogy and Petrology** - S.K. Haldar and Josip Tisljar, Elsevier.
7. **Rock Forming Minerals, Volume 3A: Micas** - W. A. Deer, R. A. Howie and J. Zussman, The Geological Society of London.
8. **Rock Forming Minerals, Volume 4A: Framework Silicates (Feldspars)** - W. A. Deer, R. A. Howie and J. Zussman, The Geological Society of London.
9. **Rock Forming Minerals, Volume 4B: Framework Silicates (Silica Minerals, Feldspathoids and the Zeolites)** - W. A. Deer, R. A. Howie and J. Zussman, The Geological Society of London.
10. **Rock-Forming Minerals, Volume 3B: Layered Silicates (Excluding Micas and Clay Minerals)** - W. A. Deer, R. A. Howie and J. Zussman, The Geological Society of London.
11. **Rock-Forming Minerals, Volume 3C: Sheet Silicates (Clay Minerals)** - W. A. Deer, R. A. Howie and J. Zussman, The Geological Society of London.
12. **Rocks and Minerals in Thin Section** - W.S. MacKenzie, A.E. Adams and K.H. Brodie, CRC Press.
13. **Rutley's Elements of Mineralogy** - C.D. Gribble, CBS Publishers and Distributors.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	3	2	2	0	2	1	1	2	1	3	2	3	1
CO2	2	2	1	0	1	1	0	1	1	2	2	1	1
CO3	2	2	1	1	2	0	0	1	2	3	2	3	1
CO4	3	1	1	1	1	0	0	1	0	3	3	2	3
Average	**2.50**	**1.75**	**1.25**	**0.50**	**1.50**	**0.50**	**0.25**	**1.25**	**1.00**	**2.75**	**2.25**	**2.25**	**1.50**

GEL-CC-4720

Advanced Structural Geology

Credit: 4 (L-3:T-0:P-1)

Course Objective

The main objective of this course is to introduce the students to rock deformation mechanisms and their interpretation. Also, this course will introduce the students to the plate tectonics and the tectonic setup of different types of plate boundaries.

Course Learning Outcome

CO 1: After completing this course, the students will have the basic understanding of stress and strain and behaviour of rocks under stress.
CO 2: Learning the geometry and morphology of different brittle and ductile structures.
CO 3: Understanding the significance of rock structures and interpret the deformation history.
CO 4: Inferring tectonic history through structural analysis.

Detailed Syllabus

Unit 1 ***15 Lectures***

Force and stress: two-dimensional stress and three-dimensional stress; principal planes and principal stresses; Mohr diagram for stress; mean and deviatoric stress; stress tensor.

Unit 2 ***10 Lectures***

Deformation and strain; finite homogeneous deformation; progressive deformation; measurement of strain; behaviour of rocks under stress; rheology: strain rate, the creep curve; deformation mechanisms.

Unit 3 ***10 Lectures***

Joints: surface morphology and arrays; origin and interpretation of joints; veins and vein arrays; lineaments; faults and faulting: fault geometry and displacement; mechanism of faulting, relation of faulting to stress; fault systems: geometrical classification.

Unit 4 ***10 Lectures***

Folds and folding: anatomy of a folded surface, classification of fold, superposed folding, mechanics of folding; foliations: geometry and relationship with folds and fault zones; lineation: categories and tectonic interpretation; shear zones: nature and types; shear zone rocks; shear-sense indicators; strain in shear zones; shear zone development; boudinage.

Practical ***30 Hours***

1. Interpretation of structure from hand specimen, photograph and map.
2. Preparation of cross sections representing different structural settings.
3. Completion of outcrop in a map.
4. Stereographic analysis of structural data.
5. Construction and study of dip isogon from fold profile.
6. Strain analysis of rocks using deformed objects.
7. Practical Records.
8. Viva-voce.

Recommended Books

Text Books:

1. **An Introduction to Structural Geology -** A. K. Jain, *Geological Society of India*
2. **Earth structure: An Introduction to Structural Geology and Tectonics** - B. A. van derPluijm and S. Marshak, *W. W. Norton & Company*
3. **Structural Geology** - H. Fossen, *Cambridge University Press*
4. **Structural Geology** - R. J. Twiss and E. M. Moors, *W. H. Freeman & Co.*
5. **Structural Geology of Rocks and Regions** - G. H. Davis, S. J. Reynolds and C. Kluth, *Wiley*
6. **Structural Geology: Fundamentals and Modern Developments -** S. K. Ghosh, *Pergamon Press*

Reference Books:

1. **Atlas of Structural Geology** - Soumyajit Mukherjee, *Elsevier*.
2. **Basic methods of structural geology** - S. Marshak and G. Mitra, *Prentice Hall*
3. **Evolution of Geological Structures in Micro- to Macro-scales** - Sudipta Sengupta, *Springer*
4. **Folding and Fracturing of Rocks** - John G. Ramsay, *McGraw Hills Book Company*
5. **Structural Geology: An Introduction to Geometrical Techniques** - D. M. Ragan, *Cambridge University Press*
6. **Structural Geology: The Mechanics of Deforming Metamorphic Rocks** - Bruce E. Hobbs and Alison Ord, *Elsevier*
7. **Tectonics and Structural Geology: Indian Context** - Soumyajit Mukherjee, *Springer*
8. **The Techniques of Modern Structural Geology Vol. 1: Strain Analysis** - J. G. Ramsay and M. I. Huber, *Elsevier.*
9. **The Techniques of Modern Structural Geology Vol. 2: Folds and Fractures** - J. G. Ramsay and M. I. Huber, *Elsevier*.
10. **The Techniques of Modern Structural Geology Vol. 3: Applications of Continuum Mechanics in Structural Geology** -J. G. Ramsay and Richard Lisle, *Elsevier.*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	3	2	2	1	0	0	1	1	1	3	3	2	3
CO2	2	1	2	0	1	0	1	2	1	3	1	2	1
CO3	2	1	1	1	0	0	1	1	1	2	1	2	1
CO4	1	3	2	0	3	0	1	2	1	3	1	3	3
Average	**2.00**	**1.75**	**1.75**	**0.50**	**1.00**	**0.00**	**1.00**	**1.50**	**1.00**	**2.75**	**1.50**	**2.25**	**2.00**

GEL-CC-4730

Advanced Petrology

Credit: 4 (L-3:T-0:P-1)

Course Objective

The course is designed to provide in depth knowledge on the magmatic processes, use of thermodynamics in petrology and magmatism in different tectonic regimes on the earth. This course will also teach metamorphic processes taking place within the earth. The learners will be provided hands-on training on studying igneous and metamorphic rock textures and mineral assemblages and interpreting them to identify the responsible geologic processes.

Course Learning Outcome

CO 1: knowledge on diverse types of magma and their nature, origin and diverse magmatic processes.
CO 2: learnt the concepts of thermodynamics and its applications in understanding magmatic systems to predict texture, mineral assemblages and rocks by using phase diagrams.
CO 3: understanding on the metamorphic processes and on the study of metamorphic terrain.
CO 4: learnt to apply the knowledge of thermodynamics in solving problems on the origin of metamorphic rocks.
CO 5: Sound knowledge on the texture and mineral assemblage of diverse igneous and metamorphic rocks by studying in hand specimen and under microscope.

Detailed Syllabus

Unit 1 ***15 Lectures***

Magma - physical properties and chemical composition; magma generation, intrusion and cooling; introduction to thermodynamics; laws of thermodynamics; concept of Gibbs phase rule; phase equilibrium studies of unary, binary, and ternary systems and their petrogenetic implications.

Unit 2 ***10 Lectures***

Magmatic processes - crystal nucleation, crystal settling, magma convection, diffusion, magma mixing, and magma assimilation and fractional crystallization (AFC); role of volatiles in magmatic systems; applications of trace elements and radiogenic isotopes in understanding igneous processes; magmatism in mid-oceanic ridges and subduction zones; continental flood basalts; large layered igneous complexes; granitoid rocks.

Unit 3 ***10 Lectures***

Basic concepts of metamorphism; paired metamorphic belts; metamorphic reactions; phase rule and phase equilibrium studies in metamorphic rocks; petrogenetic grid and Schirenmaker's rule; construction and projection of ACF, AKF and AFM diagrams; geothermometric and geobarometric studies; P-T-time path.

Unit 4 ***10 Lectures***

Anatexis and origin of migmatites; charnockites; metamorphism of carbonate rocks, pelitic rocks, mafic and ultramafic rocks and granitoid rocks.

Practical ***30 Hours***

1. Study of structure, texture, and mineral assemblages of igneous and metamorphic rocks in hand specimen and in thin sections.
2. Calculation of mode and CIPW norm.

3. Nomenclature of igneous rocks using classification diagrams.
4. Interpreting petrogenetic process using trace element composition.
5. Construction and interpretation of ACF, AKF and AFM diagrams.
6. Practical records.
7. Viva-voce.

Recommended Books

Text Books:

1. **Essentials of igneous and metamorphic petrology** - B. R. Frost and C. D. Frost, Cambridge University Press.
2. **Igneous and metamorphic petrology** - Myron G. Best, Wiley-Blackwell.
3. **Petrology: The study of igneous, sedimentary, and metamorphic rocks** - Loren A. Raymond, Waveland Press Inc.
4. **Principles of igneous and metamorphic petrology** - Anthony R. Philpotts and Jay J. Ague, Cambridge University Press.
5. **Principles of igneous and metamorphic petrology** - John D. Winter, Pearson India.

Reference Books:

1. **An Introduction to Metamorphic Petrology** - Bruce W. D. Yardley, Longman.
2. **Earth Materials** - Cornelis Klein and Anthony R. Philpotts, Cambridge University Press.
3. **Igneous Petrogenesis: A Global Tectonic Approach** - Marjorie Wilson, Springer.
4. **Igneous Rocks and Processes: A Practical Guide** - Robin Gill, Wiley-Blackwell.
5. **Igneous Rocks: A Classification and Glossary of Terms** - R. W. Le Maitre, Cambridge University Press.
6. **Petrogenesis of Metamorphic Rocks** - Kurt Bucher and Rodney Grapes, Springer-Verlag.
7. **Petrography of Igneous and Metamorphic Rocks** - Anthony R. Philpotts, CBS Publishers and Distributors.
8. **Petrography: An Introduction to the Study of Rocks in Thin Section** - H. Williams, F. C. Turner and C. M. Gilbert, CBS Publishers and Distributors.
9. **Petrology: Principles and Practice** - Gautam Sen, Springer.
10. **Principles of Metamorphic Petrology** - Ron H. Vernon and Geoffrey L. Clarke, Cambridge University Press.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	1	2	1	1	1	1	0	0	1	2	1	1	1
CO2	1	2	1	0	1	1	0	0	1	3	1	2	2
CO3	1	2	1	0	1	1	0	0	1	2	1	1	1
CO4	2	3	2	0	2	1	1	1	0	2	2	2	3
CO5	2	3	2	0	2	1	0	1	0	2	2	2	3
Average	**1.40**	**2.40**	**1.40**	**0.20**	**1.40**	**1.00**	**0.20**	**0.40**	**0.60**	**2.20**	**1.40**	**1.60**	**2.00**

GEL-CC-4740

Advanced Sedimentology

Credit: 4 (L-3:T-0:P-1)

Course Objective

The main objective of this course is to learn sedimentary rock forming processes, types of sedimentary rocks, sedimentary environment and facies. They will also be taught principles of stratigraphy and types of stratigraphic units.

Course Learning Outcome

CO 1: Learning the formation of sediments and sedimentary rocks, its structures and textures.
CO 2: Learning the classification schemes, composition and characteristics of different types of sedimentary rocks.
CO 3: Analysis of sediments and sedimentary rocks for facies modelling.
CO 4: Learning different stratigraphic units and their correlation.

Detailed Syllabus

Unit 1 ***15 Lectures***

Formation of sedimentary rock: weathering processes; generation of sediment; fluid flow mechanics, entrainment and sediment transport; flow regime and bedforms; lithification and diagenesis; sedimentary structures; sedimentary textures.

Unit 2 ***10 Lectures***

Sandstones: composition and classification; conglomerates and breccias; mudstones and shales; provenance of siliciclastic sedimentary rocks; limestones: composition, classification and texture; other chemical and biochemical sedimentary rocks.

Unit 3 ***10 Lectures***

Sedimentation and tectonics; sedimentary basins and basin analysis; grain size analysis; heavy mineral assemblage; palaeocurrent analysis, sedimentary environment and facies; facies analysis and facies models.

Unit 4 ***10 Lectures***

Evolution of stratigraphic concept; code of stratigraphic nomenclature; principles and methods of correlation of stratigraphic units; lithostratigraphy; chronostratigraphy; biostratigraphy; sequence stratigraphy; event stratigraphy; magnetostratigraphy; chemostratigraphy; Applications of sequence stratigraphy, magnetotratigraphy, and chemostratigraphy.

Practical ***30 Hours***

1. Study of sedimentary rocks in hand specimen.
2. Study of sedimentary structures.
3. Petrography of clastics and non-clastics.
4. Preparation of lithologs from field data.
5. Granulometry - plotting of grain size data and statistical analysis.
6. Separation of heavy minerals and their study under microscope.
7. Paleocurrent analysis.
8. Practical Records.
9. Viva-voce.

Recommended Books

Text Books:

1. **Applied Sedimentology** - Richard C. Selley, *Academic Press*
2. **Introduction to Sedimentology**- S. M. Sengupta, *CBS Publishers*
3. **Principles of Sedimentology and Stratigraphy**- S. Boggs Jr, *Pearson Education India*
4. **Sedimentary Geology: An Introduction to Sedimentary Rocks and Stratigraphy -** D. R. Prothero, *W. H. Freeman and Co.*
5. **Sedimentary Structure** - J. D. Collinson, N. P. Mountney and D. B. Thompson, *Terra Publishing*
6. **Sedimentology and Stratigraphy** - G. Nichols, *CBS Publishers*

Reference Books:

1. **Applied Sedimentology**- R. K. Sukhtankar, *CBS Publishers*
2. **Depositional Sedimentary Environments** - H. E. Reineck and I. B. Singh, *Springer-Verlag*
3. **International Stratigraphic Guide: A Guide to Stratigraphic Classification, Terminology and Procedure** - Amos Salvador, *The International Union of Geological Sciences & Geological Society of America*
4. **Petrology of Sedimentary Rocks** - Sam Boggs Jr., *Cambridge University Press*
5. **Petrology: The study of Igneous, Sedimentary, and Metamorphic Rocks** - Loren A. Raymond, *Waveland Press Inc*
6. **Sedimentary Petrology** - M. E. Tucker, *CBS Publishers*
7. **Sedimentary Rocks** - F. J. Pettijohn, *CBS Publishers*
8. **Stratigraphy: A Modern Synthesis** - Andrew D. Miall, *Springer*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	1	2	1	0	1	0	0	1	1	2	2	1	2
CO2	3	2	2	1	2	0	0	1	1	2	3	2	2
CO3	3	3	3	1	3	0	0	1	2	3	2	3	2
CO4	2	1	1	0	1	0	0	1	1	2	1	2	1
Average	**2.25**	**2.00**	**1.75**	**0.50**	**1.75**	**0.00**	**0.00**	**1.00**	**1.25**	**2.25**	**2.00**	**2.00**	**1.75**

GEL-RC-4710

Research Methodology

Credit: 4 (L-4:T-0:P-0)

Course Objective

The main objective of the course is to introduce the students to the fundamentals of scientific research including identification of research problem, research planning, research design, use of statistical tools and computer application in geoscientific research.

Course Learning Outcome

CO 1: Understanding the techniques of geoscientific research.
CO 2: Learning different methods of data collection and interpreting of geologic data.
CO 3: Developing skills on scientific writing.
CO 4: Learning to utilize computers and statistical tools for efficient handling of geologic data.

Detailed Syllabus

Unit 1 ***10 Lectures***

Fundamentals of scientific research; identification and definition of research problem; basic concepts of research design; review of literature; significance and status of research in geology.

Unit 2 ***18 Lectures***

Methods of data collection; processing and analysis of data; data display and interpretation; basic mathematical and statistical methods; trend surface analysis; cluster analysis; principal component analysis (PCA), Markov chain analysis; test of significance.

Unit 3 ***15 Lectures***

Developing a research proposal in geology; writing research report and scientific paper; peer review process for journals; writing a thesis/dissertation; abstract and summary writing.

Unit 4 ***17 Lectures***

Fundamentals of computer; operating system; common application software; open-source software; application software used in geology.

Recommended Books

Text Books:

1. **Research Methodologies for Beginners** - Kitsakorn Locharoenrat, *CRC Press*
2. **Research Methodology: A Step-by-Step Guide for Beginners** - Ranjit Kumar, *Sage Publications*
3. **Research Methodology: Methods and Techniques** - C. R. Kothari, *New Age Publications*
4. **Statistics and Data Analysis in Geology** - J. C. Davis, *Wiley India*

Reference Books:

1. **A Concise Guide to Writing a Thesis of Dissertation: Educational research and Beyond** - Halyna M. Kornuta and Ron W. Germaine, *Routledge*
2. **Authoring a PhD: How to Plan, Draft, Write and Finish a Doctoral Thesis or Dissertation** - Patrick Dunleavy, *Palgrave Macmillan*
3. **Fundamental of Research Methodology and Statistics** - Yogesh Kumar Singh, *New Age Publications*
4. **McGraw-Hill's Concise Guide to Writing Research Papers** - Carol Ellison, *McGraw-Hill*
5. **Research Design: Qualitative, Quantitative, and Mixed Method Approaches** - John W. Creswell, *Sage Publications*
6. **Research Methodology: The Aims, Practice and Ethics of Science** - Peter Pruzan, *Springer*
7. **Thesis Writing for Master's and Ph.D. Program** - Subhash Chandra Parija and Vikram Kate, *Springer*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	3	3	3	2	3	2	2	3	1	3	3	3	3
CO2	2	3	3	2	3	2	2	3	1	3	3	3	3
CO3	3	3	3	3	3	1	1	3	2	3	3	3	3
CO4	2	3	2	2	3	2	1	3	1	3	3	3	3
Average	**2.50**	**3.00**	**2.75**	**2.25**	**3.00**	**1.75**	**1.50**	**3.00**	**1.25**	**3.00**	**3.00**	**3.00**	**3.00**

EIGHTH SEMESTER

GEL-CC-4810

Geological Fieldwork

Credit: 4 (L-3:T-0:P-1)

Course Objective

The main objective of the course is visit and study diverse geological terrain within India, visit to exploration sites, mines, construction sites and oil fields to study the methods and activities.

Course Learning Outcome

CO 1: Carrying out geological mapping in different types of terrains.
CO 2: Learning advanced geological field techniques.
CO 3: Visiting different mines, construction and exploration sites to develop field knowledge.
CO 4: Developing skills in preparing geological maps, field reports and presentation.

Detailed Syllabus

Practical ***120 Hours***

In this course, students shall carryout geological field work for period of ten days in diverse geological terrains of India, visit to geologically important areas where exploration and mining activities are going on as well as to engineering construction sites and to oil fields. Seminar presentation by students in the field will be evaluated by the concerned teacher in-charge. Report on the fieldwork shall be submitted by the students individually or in groups, as decided by the teacher in-charge, before the commencement of semester examinations, which will be followed by viva-voce.

Marks Distribution:

1. Field Performance: 40%
2. Field Report : 40%
3. Viva-voce : 20%

Recommended Books

Text Books:

1. **A Guide to Field Geology** - N. W. Gokhale, *CBS Publishers*
2. **Field Geology** - F. H. Lahee, *CBS Publishers*
3. **Geological Field Techniques** - A. L. Coe, *Wiley-Blackwell*
4. **Geology in The Field** - R. R. Compton, *Earthspun Books*

Reference Books:

1. **Geology of India (Vol. 1 & 2)** - R. Vaidyanandhan and M. Ramakrishnan, *Geological Society of India*
2. **Sedimentary Rocks in the Field** - M. E. Tucker, *Wiley-Blackwell*
3. **Sedimentary Rocks in the Field: A Colour Guide** - D. A. V. Stow, *Manson Publishing*
4. **The Field Description of Igneous Rocks** - D. Jerram and N.Petford, *Wiley-Blackwell*
5. **The Field Description of Metamorphic Rocks** - N. Fry, *Wiley-Blackwell*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	2	2	3	2	3	2	2	3	1	3	3	3	3
CO2	2	2	2	1	3	1	1	3	0	3	3	2	3
CO3	1	1	2	2	1	2	2	1	1	3	1	0	0
CO4	2	3	3	1	3	2	1	2	1	3	3	3	3
Average	**1.75**	**2.00**	**2.50**	**1.50**	**2.50**	**1.75**	**1.50**	**2.25**	**0.75**	**3.00**	**2.50**	**2.00**	**2.25**

GEL-DE-4810

Remote Sensing and GIS for Geology

Credit: 4 (L-3:T-0:P-1)

Course Objective

The main objective of this course is to introduce students to the principles of remote sensing and digital image processing, and their application in geology for mapping and analysis.

Course Learning Outcome

CO 1: Understand principles of remote sensing, processing and interpretation of multispectral images for geological application.
CO 2: Understand the principles of microwave, thermal, hyperspectral and LiDAR remote sensing.
CO 3: Interpret radar, thermal, hyperspectral and LiDAR data and their application in geology.
CO 4: Learning about the spatial data acquisition, management and analysis for different applications using GIS techniques.

Detailed Syllabus

Unit 1 ***15 Lectures***

Principles of remote sensing; sensors and platforms; digital image data formats; visual image interpretation; digital image processing: image pre-processing, image enhancement, multi-image manipulation, image classification and accuracy assessment.

Unit 2 ***10 Lectures***

Microwave remote sensing; transmission characteristics of microwave signals; characteristics of radar image; geometric distortions in radar images; synthetic aperture radar (SAR); processing and interpretation of radar data; SAR interferometry; application of radar data in geology.

Unit 3 ***10 Lectures***

Principles of thermal radiation; thermal properties of materials; thermal image characteristics; interpretation of thermal images for application in geology; imaging spectrometers; hyperspectral image analysis; application of hyperspectral data in geology; principles of LiDAR remote sensing; processing and application of LiDAR data.

Unit 4 ***10 Lectures***

Spatial data and spatial data models; GIS data acquisition, spatial data accuracy and quality; data editing and management; vector data analysis; raster data analysis; terrain mapping and analysis; watershed analysis; spatial interpolation; GIS applications.

Practical ***30 Hours***

1. Digital image processing using various software.
2. Satellite image interpretation.
3. Georeferencing of satellite images and maps.
4. Creation and editing of GIS database.
5. Spatial data analysis and terrain analysis.
6. Map composition in GIS.
7. Practical Record.
8. Viva-voce.

Recommended Books

Text Books:

1. **An Introduction to Geographical Information Systems** - I. Heywood, S. Cornelius and S. Carver, *Pearson*
2. **Fundamentals of Remote Sensing** - George Joseph and C. Jeganathan, *Universities Press*
3. **Image Interpretation in Geology** - S. A. Drury, *Nelson Thornes*
4. **Remote Sensing and GIS** - Basudeb Bhatta, *Oxford University Press*
5. **Remote Sensing and Image Interpretation** - T. M. Lillesand, R. W. Kiefer and J. W. Chipman, *John Wiley and Sons*

Reference Books:

1. **Concepts and Techniques of Geographic Information Systems** - C. P. Lo and A. K. W. Yeung, *Pearson*
2. **ERDAS IMAGINE Tour Guides** - *ERDAS Inc.*
3. **Getting to Know ArcGIS Desktop** - Michael Law, *ESRI Press*
4. **Introducing Geographic Information Systems with ArcGIS: A Workbook Approach to Learning GIS** - Michael D. Kennedy, Michael F. Goodchild and Jack Dangermond, *Wiley*
5. **Introduction to Geographic Information Systems** - Kang-tsung Chang, *McGraw-Hill*
6. **Introduction to Microwave Remote Sensing** - Iain H. Woodhouse, *CRC Press*
7. **Introductory Digital Image Processing: A Remote Sensing Perspective** - John R. Jensen, *Pearson Education, Inc.*
8. **Learning QGIS** - Anita Graser, *Packt Publishing Limited*
9. **Principles of Geographical Information Systems** - P. A. Burrough, R. A. McDonnell and C. D. Lloyd, *Oxford University Press*
10. **Remote Sensing Geology** - R. P. Gupta, *Springer-Verlag*
11. **Remote Sensing Handbook (Vols. 1-3)** - Prasad S. Thenkabali, *CRC Press*
12. **Remote Sensing of the Environment** - J. R. Jensen, *Pearson Education*
13. **Textbook of Remote Sensing and Geographical Information Systems** – M. Anji Reddy, *B. S. Publications*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	2	3	1	0	2	0	0	2	0	3	2	1	1
CO2	1	3	1	0	2	0	0	2	0	3	2	1	1
CO3	1	3	2	1	3	0	0	3	0	3	3	2	3
CO4	2	3	2	1	3	1	0	3	1	3	2	1	2
Average	**1.50**	**3.00**	**1.50**	**0.50**	**2.50**	**0.25**	**0.00**	**2.50**	**0.25**	**3.00**	**2.25**	**1.25**	**1.75**

GEL-DE-4820

Advanced Palaeontology

Credit: 4 (L-3:T-0:P-1)

Course Objective

The main objective of the course is to introduce the students to different types of vertebrate and invertebrate fossils, microfossils and plant fossils, their geological significance, and applications.

Course Learning Outcome

CO 1: Understanding evolution of life through time and geological events that influenced the evolution.
CO 2: Understanding the geologic evolution of vertebrates through time.
CO 3: Knowledge on the study of microfossils and its applications.
CO 4: Learning the preservation methods, morphology and significance of plant fossils.

Detailed Syllabus

Unit 1 ***15 Lectures***

Mechanism of evolution and speciation; adaptation and functional morphology; exaptation and its causes; bio-stratigraphic correlation; palaeo-biogeography and the relation of fossil diversity with plate tectonics; mass extinction with special reference to the Permian-Triassic and Cretaceous-Palaeogene boundary.

Unit 2 ***10 Lectures***

Evolution and geological significance of vertebrates; study of fossil vertebrates; origin and evolution of dinosaur, horse, elephant, and human; vertebrate fossil records of Siwaliks; Mesozoic reptiles of India.

Unit 3 ***10 Lectures***

Classification, sampling methods and sample processing of microfossils; morphology, classification, composition, ecology, and geologic history of foraminifera, ostracoda, radiolaria, diatoms, conodonts, and dinoflagellates; applications of microfossils with special reference to hydrocarbon exploration.

Unit 4 ***10 Lectures***

Sample processing of plant fossils; morphology, classification and geological significance of spores and pollens; Gondwana plant fossils and their significances.

Practical ***30 Hours***

1. Ecological interpretation from molluscs, brachiopods, echinoids, and trilobites.
2. Study of microfossils.
3. Megascopic study of important plant fossils of Gondwana.
4. Microscopic study of spores, pollens, and dinoflagellate.
5. Practical Records.
6. Viva-voce.

Recommended Books

Text Books:

1. **Introduction to Palaeontology –** Amal Dasgupta*, World press*
2. **Micropaleontology: Principles and Applications** - Pratul K. Saraswati and M.S. Srinivasan, *Springer*
3. **Palaeontology (Palaeobiology): Evolution and Animal Distribution** - P. C. Jain and M. S. Anantharaman, *Vishal Publishing Co.*
4. **Paleobotany: The Biology and Evolution of Fossil Plants** - E. Taylor, T. Taylor and M. Krings, *Elsevier*
5. **Principles of Paleontology** - David M. Raup and Steven M. Stanley, *CBS Publishers & Distributors*

Reference Books:

1. **Bringing Fossils to Life: An Introduction to Paleobiology** - Donald Prothero, *Columbia University Press*
2. **Fundamentals of Invertebrate Palaeontology: Macrofossils** - Sreepat Jain, *Springer*
3. **Fundamentals of Invertebrate Palaeontology: Microfossils** - Sreepat Jain, *Springer*
4. **Introduction to Paleobiology and the Fossil Record** - Michael J. Benton, David A. T. Harper, *Wiley-Blackwell*
5. **Invertebrate Fossils** - Raymond C. Moore, Cecil G. Lalicker and Alfred G. Fischer, *CBS Publishers & Distributors*
6. **Invertebrate Palaeontology and Evolution –** E. N. K. Clarkson, *ALBS, Allen and Unwin*
7. **Organic Evolution** - Veer Bala Rastogi, *Medtech*
8. **Principles of Invertebrate Paleontology** - Robert R. Shrock and William H. Twenhofel, *CBS Publishers*
9. **Understanding Fossils: An introduction to Invertebrate Palaeontology** - Peter Doyle, *John Wiley & Sons*
10. **Vertebrate Paleontology** - Michael Benton, *Wiley Blackwell*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	0	2	0	0	1	0	0	1	0	3	1	2	1
CO2	0	2	0	0	1	0	0	0	0	3	1	2	1
CO3	1	1	1	0	1	0	0	2	0	3	1	2	1
CO4	1	1	2	0	3	1	0	3	1	3	2	2	3
Average	**0.50**	**1.50**	**0.75**	**0.00**	**1.50**	**0.25**	**0.00**	**1.50**	**0.25**	**3.00**	**1.25**	**2.00**	**1.50**

GEL-DE-4830

Isotope Geology

Credit: 4 (L-4:T-0:P-0)

Course Objective

The main objective of the course is to introduce the students to basic principles of radioactivity and isotopes, their applications in geosciences, instruments that is used to carry out isotopic studies, and various isotopic systematics and their applications in geology. The course is also aimed to introduce basic principles of stable and cosmogenic isotopes, and their applications in geosciences.

Course Learning Outcome

CO 1: Understanding of historical development of isotope geology and concepts of radioactive decay mechanisms.

CO 2: Theoretical knowledge about the laboratory techniques and mass spectrometers employed in precise measurements of isotopic composition of earth materials.

CO 3: Knowledge about the principles of different radiogenic isotope systematics and its applications in earth sciences.

CO 4: Understanding the stable isotope composition of earth's reservoirs and its applications to understand geological processes.

Detailed Syllabus

Unit 1 ***16 Lectures***

Discovery of radioactivity; historical development of radioactive studies and its impact on geology; nucleosynthesis and nuclear stability; stable and radiogenic isotopes; decay mechanisms of radioactive atoms; radioactive decay and growth.

Unit 2 ***15 Lectures***

Mass spectrometer - principles and instrumentation; chemical separation and isotope dilution technique; isochron.

Unit 3 ***12 Lectures***

Principles and applications of K-Ar, Rb-Sr, Sm-Nd, Lu-Hf and U-Th-Pb isotopic systematics in earth sciences.

Unit 4 ***17 Lectures***

Stable isotopes: the δ notation and fractionation factor; theory of mass dependent isotope fractionation; stable isotopes of hydrogen, carbon, oxygen, nitrogen, and sulphur; fractionation of stable isotopes in biosphere, lithosphere, and hydrosphere; stable isotope composition of mantle; cosmogenic nuclides and their applications in geology.

Recommended Books

Text Books:

1. **Geochemistry: An introduction** - Francis Albarede, Cambridge University Press.
2. **Isotope geochemistry** - W.M. White, Wiley.
3. **Isotope geology** - Claude J. Allegre, Cambridge University Press.
4. **Isotopes: principles and applications** - Gunter Faure and Teresa M. Mensing, Wiley.
5. **Radiogenic isotope geology** - A.P. Dickin, Cambridge University Press.
6. **Stable isotope geochemistry** - Hoefs, Springer.

Reference Books:

1. **Chemical fundamentals of geology and environmental geoscience** - Robin Gill, Wiley-Blackwell.
2. **Geochemistry** - W.M. White, Wiley-Blackwell.
3. **Introduction to geochemistry: Principles and applications** - K.C. Misra, Wiley-Blackwell.
4. **Treatise on geochemistry (Volume-1): Meteorites, comets and planets** - A.M. Davis, H.D. Holland and K.K. Turekian, Elsevier.
5. **Using geochemical data to understand geological processes** - Hugh Rollinson and Victoria Pease, Cambridge University Press.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	1	1	1	0	2	0	0	0	1	3	2	2	1
CO2	2	1	2	0	3	0	0	1	1	3	1	2	3
CO3	1	1	2	0	3	0	0	1	2	3	2	2	3
CO4	1	2	2	1	3	0	0	0	2	3	1	2	3
Average	**1.25**	**1.25**	**1.75**	**0.25**	**2.75**	**0.00**	**0.00**	**0.50**	**1.50**	**3.00**	**1.50**	**2.00**	**2.50**

GEL-DE-4840

Geohazard and Disaster Management

Credit: 4 (L-4:T-0:P-0)

Course Objective

The main objective of this course is to introduce the students to various geological hazards and disasters, their causes, vulnerability, risk assessment, mitigation measures and their management at different stages to reduce the loss of life and property.

Course Learning Outcome

CO 1: Learning about different hazardous natural processes and associated risk.
CO 2: Understanding earthquake, volcanic eruptions and related processes as hazard and its mitigation measures.
CO 3: Understanding landslide, flooding and coastal process as natural hazard and its mitigation measures.
CO 4: Understanding the natural hazards resulting due to meteoritic impact and mining activities.

Detailed Syllabus

Unit 1 ***15 Lectures***

Hazardous natural processes and energy sources; hazard, risk, disaster, and catastrophe; fundamental concepts for understanding natural processes as hazards; man-made hazards and disasters; risk assessment.

Unit 2 ***15 Lectures***

Earthquake: magnitude and intensity; seismicity of the world; reduction of earthquake hazard; introduction to tsunamis; tsunami risk and its minimization; volcanic hazards; distribution of active volcanoes; minimizing the volcanic hazard.

Unit 3 ***15 Lectures***

Introduction to landslides; types of landslides; identification of potential landslides; prevention of landslides; landslide warning systems; hazards from ground subsidence and snow avalanche. river flooding as natural hazard; magnitude and frequency of floods; nature and extent of flood hazards; adjustments to flood hazards.

Unit 4 ***15 Lectures***

Coastal hazards; coastal processes; sea-level change; perception and mitigation of coastal hazards; meteoritic impact and impact hazard; mass extinction; hazards and disaster related to mining activities; management of mining related hazards and disasters.

Recommended Books

Text Books:

1. **Disaster Education and Management: A Joyride for Students, Teachers and Disaster Managers -** Rajendra Kumar Bhandari, *Springer*
2. **Geological Hazards** - B. A. Bolt, W. L. Horn, G. A. Macdonald and R. F. Scott, *Springer-Verlag*
3. **Natural Hazards: Earth's Processes as Hazards, Disasters, and Catastrophes -** Edward A. Keller, Duane E. DeVecchio and Robert H. Blodgett, *Pearson*

Reference Books:

1. **Environmental Hazards and Disasters: Contexts, Perspectives and Management -** B. K. Paul, *Wiley-Blackwell*
2. **Environmental Hazards: Assessing Risk and Reducing Disaster** - Keith Smith and David N. Petley, *Routledge*
3. **Introduction to Emergency Management** - Michael K. Lindell, Carla Prater and Ronald W. Perry, *Wiley*
4. **Natural Disasters** - Patrick L. Abbott, *McGraw-Hill*
5. **Natural Hazards and Disasters -** Donald Hyndman and David Hyndman, *Brooks-Cole*
6. **Natural Hazards: Earthquakes, Volcanoes and Landslides -** Ramesh P. Singh and Darius Bartlett, *CRC Press*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	0	2	0	0	2	0	0	2	3	3	1	2	2
CO2	1	2	1	1	3	2	0	3	3	3	2	3	3
CO3	1	2	1	1	3	2	0	3	3	3	2	3	3
CO4	1	2	1	1	3	2	0	3	3	3	2	3	3
Average	**0.75**	**2.00**	**0.75**	**0.75**	**2.75**	**1.50**	**0.00**	**2.75**	**3.00**	**3.00**	**1.75**	**2.75**	**2.75**

GEL-DE-4850

Marine Science

Credit: 4 (L-4:T-0:P-0)

Course Objective

The main objectives of the course are to introduce the students to basic concepts of marine science and associated geological phenomena. The course is also aimed to introduce morphological features, sediment nature, interactions of ocean water with various spheres of the Earth and life in marine environment.

Course Learning Outcome

CO 1: Learning the concepts of marine science and physical and chemical nature of seawater.
CO 2: Understanding the characteristics of marine sediments and its significance.
CO 3: Knowledge on the interactions between ocean and atmosphere and resulting effects on climate.
CO 4: Understanding on the resources of ocean.

Detailed Syllabus

Unit 1 ***15 Lectures***

Introduction, history and development of marine science;; origin and dimensions of the ocean; bathymetry; turbidity currents; physical and chemical properties of sea water.; Deep-Ocean Drilling Programmes.

Unit 2 ***15 Lectures***

Ocean sediments: classification, composition and source; geochronology of oceanic sediments; proxy indicators for palaeoceanographic interpretation; reconstruction of monsoon variability using marine proxy records.

Unit 3 ***15 Lectures***

Atmosphere-ocean interaction; Coriolis effect and Ekman spiral; ocean water circulation; El Nino and La Nina; Indian Ocean Dipole (IOD) and Indian monsoon; global oceanic conveyor belt and its control on earth's climate; cyclones and anticyclones; waves and tides.

Unit 4 ***15 Lectures***

Productivity of the ocean; thermocline and its implications; life in the ocean; resources of the ocean; abuses of the ocean, ocean in changing world: the Keeling curve; ocean circulation in a warming climate.

Recommended Books

Text Books:

1. **Climatology and Oceanography** - D. S. Lal, *Sharda Pustak Bhawan*
2. **Essentials of oceanography** - Tom Garrison, *Cengage Learning*
3. **Oceanography: A Brief Introduction** - K. Siddhartha, *Kitab mahal*
4. **Oceanography: An Invitation to Marine Science** - Tom Garrison and Robert Ellis, *Cengage Learning*
5. **The Sea Floor: An Introduction to Marine Geology** - Eugen Seibold and Wolfgang Berger, *Springer*

Reference Books:

1. **Essentials of Oceanography** - Alan P. Trujillo and Harold V. Thurman, *Pearson*
2. **Introduction to Physical Oceanography** - Robert H. Stewart, *Prentice Hall*
3. **Invitation to Oceanography** - Paul R. Pinet, *Jones and Bartlett Publishers*
4. **Marine Geology: Exploring the New Frontiers of the Ocean** - Jon Erickson, *Facts On File, Inc.*
5. **Oceanography** - Savindra Singh, *Pravalika Publications*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	1	1	0	1	2	0	0	2	1	3	2	0	3
CO2	1	1	0	1	2	0	0	1	1	3	2	0	3
CO3	2	3	3	2	3	1	0	2	3	3	2	1	3
CO4	1	1	1	1	1	1	0	1	1	3	1	0	1
Average	**1.25**	**1.50**	**1.00**	**1.25**	**2.00**	**0.50**	**0.00**	**1.50**	**1.50**	**3.00**	**1.75**	**0.25**	**2.50**

GEL-DE-4860

Mineral Resources of India and World

Credit: 4 (L-4:T-0:P-0)

Course Objective

The course is designed to provide knowledge about the important acts and policies of the Government of India to the students. The course is also intended to teach the geological aspects and distribution of different metallic, non-metallic deposits and energy resources of the country. The learners will also be introduced about the major metallic deposits of the world, for providing understanding of the global mineral deposits.

Course Learning Outcome

CO 1: Learning acts and policies of the government which will help them during their profession as geologists.
CO 2: Knowledge on recent activities by government agencies.
CO 3: Geology and distribution of economic mineral and energy resources of the nation.
CO 4: Knowledge about important world class mineral deposits.

Detailed Syllabus

Unit 1 ***10 Lectures***

Brief outline of distribution of mineral resources in India; Mines and Mineral (Development and Regulations) Act; The Offshore Area Mineral Act; Act on Illegal Mining; National Mineral Policy; national and international mineral scenario; recent report on exploration activities by GSI.

Unit 2 ***15 Lectures***

Study on physical characteristics, mode of occurrence, uses and distribution of important non-metallic deposits of India; study on physical characteristics, mineralogy, mode of occurrence, uses and distribution of important metallic deposits in India.

Unit 3 ***17 Lectures***

Geological and geographical distribution of coal in India; geology of large coal fields of the world; geology and distribution of petroleum resources and natural gas in India; strategy of non-conventional energy resources such as atomic minerals, geothermal energy, and solar energy in India.

Unit 4 ***18 Lectures***

Geology and global distribution of the following world class deposits: chromite, copper, platinum group elements, volcanic massive sulphide deposits, sediment-hosted massive Pb-Zn deposits, uranium, iron, and gold.

Recommended Books

Text Books:

1. **Economic Geology: Economic Mineral Deposits** - U. Prasad, *CBS Publishers and Distributors*.
2. **India's Mineral Resources** - S. Krishnaswamy, *Oxford and IBH.*
3. **Mineral Resources and Policy in India** - K. N. Jetli, *Ingram.*
4. **Minerals and Allied Natural Resources and Their Sustainable Development: Principles, Perspective with Emphasis on the India Scenario** - Mihir Deb and S. C. Sarkar, *Springer.*
5. **Non-Conventional Energy Resources** - B. H. Khan, *Tata McGraw-Hill.*
6. **Non-conventional Energy Resources** - N. K. Bansal, *Vikas.*
7. **Understanding mineral deposits** - Kula C. Misra, *Springer.*
8. **World Petroleum Resources and Reserves** - Joseph Riva, *Routledge.*

Reference Books:

1. **Hydrocarbon Exploration and Production (V-46)** - Frank Jahn, *Elsevier.*
2. **Mineral Economics: An Indian Perspective** - K. Randive and S. Jawadand, *Nova Scientific Series.*
3. **Mineral Resources of India** - D. K. Banerjee, *World Press Pvt. Ltd*.
4. **Non-conventional Energy Resources** - S. N. Singh, *Pearson.*
5. **The Indian Ocean: Exploitable Mineral and Petroleum Resources** - G.S. Roonwal, *Springer.*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	0	1	0	0	2	1	0	2	1	2	1	2	1
CO2	0	1	0	0	2	0	0	1	1	2	1	1	2
CO3	1	2	1	0	1	0	0	1	0	1	2	1	3
CO4	2	1	0	0	2	0	0	2	0	3	3	3	3
Average	**0.75**	**1.25**	**0.25**	**0.00**	**1.75**	**0.25**	**0.00**	**1.50**	**0.50**	**2.00**	**1.75**	**1.75**	**2.25**

GEL-DE-4870

Statistics and Data Analysis in Geology

Credit: 4 (L-4:T-0:P-0)

Course Objective

The main objective of this course is to introduce students to the fundamentals of statistical methods and its application in analysing various geological data.

Course Learning Outcome

CO 1: Learning the use of different statistical tools for geology.
CO 2: Understanding the concepts of probability and its applications in geology.
CO 3: Learning the techniques of statistical data analysis in geology.
CO 4: Understanding the distribution of geological data and test of significance.

Detailed Syllabus

Unit 1 ***10 Lectures***

Collection, tabulation and display of geological data; measure of central tendency and dispersion; measurement of moments, skewness and kurtosis.

Unit 2 ***10 Lectures***

Probability concept; elements of set theory; statistical independence and conditional probability; Bayes' theorem; mathematical expectation.

Unit 3 ***20 Lectures***

Correlation and regression; trend surface analysis; kriging; cluster analysis; principal component analysis; Markov chain analysis; analysis of directional data, analytical hierarchy process.

Unit 4 ***20 Lectures***

Binomial distribution, Gaussian distribution and Poisson distribution; sampling distribution of mean; confidence interval and test of significance; z-test, t-test, F-test, chi-square ($\chi 2$) test.

Recommended Books

Text Books:

1. **Applied Geostatistics** - Edward H. Isaaks and R. Mohan Srivastava, *Oxford University Press*
2. **Geostatistics Explained: An Introductory Guide for Earth Scientists** - Steve McKillup and Melinda Darby Dyar, *Cambridge University Press*
3. **Statistical Methods**- S. P. Gupta, *Sultan Chand*
4. **Statistics and Data Analysis in Geology**- J. C. Davis, *Wiley India*

Reference Books:

1. **Fundamentals of Mathematical Statistics** - S. C. Gupta and V. K. Kapoor, *Sultan Chand*
2. **Geostatistics with Applications in Earth Sciences -** D. D. Sarma, *Springer*
3. **Statistics and Analysis of Scientific Data** - Massimiliano Bonamente, *Springer*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	0	3	0	0	2	0	3	2	3	3
CO2	3	3	3	1	3	0	0	2	1	3	2	3	3
CO3	3	3	2	1	3	0	0	3	0	3	3	3	3
CO4	3	3	3	1	3	0	0	1	0	3	2	3	3
Average	**3.00**	**3.00**	**2.50**	**0.75**	**3.00**	**0.00**	**0.00**	**2.00**	**0.25**	**3.00**	**2.25**	**3.00**	**3.00**

GEL-DE-4880

Advanced Hydrogeology

Credit: 4 (L-4:T-0:P-0)

Course Objective

The objectives of the course are to master the knowledge in hydrogeology and solve related problems. The course is aimed to teach principles of hydrogeology and their applicability in real world. The course is also aimed to teach construction of different types of wells, and effective management of groundwater.

Course Learning Outcome

CO 1: Understanding concepts of hydrogeology, properties of aquifer and groundwater flow.
CO 2: Knowledge about groundwater occurrence in natural environments, its interactions with rocks and sea water and methods of constructing wells.
CO 3: Knowledge about physical, chemical, and biological characteristics of groundwater and different causes for contamination of groundwater.
CO 4: Knowledge about management of groundwater.

Detailed Syllabus

Unit 1 ***15 Lectures***

Hydrogeology: aquifer properties; hydraulic conductivity; groundwater flow; transmissivity and storativity; aquifer test; sources of information, ethical and business aspects; hydrographs; hydrologic budget.

Unit 2 ***15 Lectures***

Occurrence of groundwater in different rock types and in unconsolidated sediments; water wells: test holes and well logs; methods of constructing shallow and deep wells; well completion and well development; well protection and rehabilitation.

Unit 3 ***15 Lectures***

Types of chemical reactions in groundwater; carbonate equilibrium; ion exchange; isotope hydrology; major ion chemistry; piper diagram; physical, chemical and biological properties of groundwater; water quality standards; groundwater monitoring; groundwater contamination and restoration.

Unit 4 ***15 Lectures***

Groundwater management: groundwater budget; management of potential aquifers; water law; water quality protection in aquifers; global water issues; groundwater models and its applications; MODFLOW.

Recommended Books

Text Books:

1. **Applied Hydrogeology** - C.W. Fetter Jr, *Pearson*
2. **Groundwater Hydrology** - David Keith Todd and Larry W. Mays, *John Wiley*.
3. **Hydrogeology: Principles and Practice** - Kevin M. Hiscock and Victor F. Bense, *Wiley Blackwell*.

Reference Books:

1. **Ground Water Assessment Development and Management** - K. R. Karanth, *Tata McGraw Hills*
2. **Hydrogeology Problems with Solutions** - Nandipati Subba Rao, *Prentice Hall India Learning Pvt. Limited*
3. **Hydrogeology: Objectives, Methods and Applications** - Eric Gilli, Christian Mangan and Jacques Mudry, *CRC Press.*
4. **Hydrology: Principles, Analysis, Design** - H.M. Raghunath, *New Age International Publishers.*
5. **Principles of Hydrogeology** - Paul F. Hudak, *CRC Press*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	0	2	0	0	2	0	0	1	1	2	1	1	1
CO2	1	1	1	0	3	0	0	1	1	3	1	1	1
CO3	1	1	1	0	2	0	0	1	2	3	1	2	2
CO4	1	2	1	0	1	0	0	1	1	3	2	1	1
Average	**0.75**	**1.50**	**0.75**	**0.00**	**2.00**	**0.00**	**0.00**	**1.00**	**1.25**	**2.75**	**1.25**	**1.25**	**1.25**

GEL-DE-4890

Geotechnical Engineering

Credit: 4 (L-3:T-0:P-1)

Course Objective

The main objective of the course is to introduce the students to the application of geology in civil engineering and construction purposes. The course should also train the geology students to apply geological knowledge in solving engineering problems.

Course Learning Outcome

CO 1: Learning the concepts of geotechnical engineering and soil mechanics.
CO 2: Understanding the basic characteristics and classification of engineering soil.
CO 3: Learning the behaviour of soils to different stress conditions.
CO 4: Understanding slope stability, bearing capacity and subsoil exploration.

Detailed Syllabus

Unit 1 ***15 Lectures***

Origin and type of soil; soil phases; soil mechanics; rock mechanics; weight-volume relationships; plasticity and structure of soil.

Unit 2 ***10 Lectures***

Classification of soil - textural classification, classification by engineering behaviour, AASHTO classification system, unified soil classification system, Indian standard soil classification system.

Unit 3 ***10 Lectures***

Soil compaction and compaction test; permeability and seepage; in-situ stress; stress in soil mass; compressibility of soil; shear strength of soil.

Unit 4 ***10 Lectures***

Lateral earth pressure; slope stability; soil bearing capacity for shallow foundations; determination of bearing capacity of soil.

Practical ***30 Hours***

1. Determination of index properties of soil.
2. Determination of strength of soil.
3. Determination of consistency limit of soil.
4. Calculation of shear strength parameters of soil by direct shear test and triaxial test.
5. Numerical and graphical solution of slope stability problems.
6. Practical Record.
7. Viva-voce.

Recommended Books

Text Books:

1. **Engineering Geology** - S. Gangopadhyay, *Oxford University Press*
2. **Engineering Properties of Soils and Rocks** - F. G. Bell, *Wiley-Blackwell*
3. **Principles of Engineering Geology and Geotectonics** - D. K. Krynine and W. R. Judd, *CBS Publishers*
4. **Principles of Geotechnical Engineering** - Braja M. Das, Khaled Sobhan*, Cengage*

Reference Books:

1. **Engineering Geology** - F. G. Bell, *CBS Publishers*
2. **Geotechnical Engineering (Soil Mechanics) -** T. G. Sitharam and T. N. Ramamurthy**,** *S. Chand*
3. **Engineering and General Geology** - P. Singh, *S. K. Kataria & Sons*
4. **Soil Mechanics in Engineering Practice** - Karl Terzaghi, Ralph B. Peck and Gholamreza Mesri*, John Wiley & Sons*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	1	1	0	0	2	0	0	2	1	2	1	1	2
CO2	1	1	0	0	2	0	0	2	0	1	1	1	2
CO3	2	2	1	0	3	0	0	3	1	3	3	1	2
CO4	2	1	1	0	3	0	0	2	3	3	3	1	3
Average	**1.50**	**1.25**	**0.50**	**0.00**	**2.50**	**0.00**	**0.00**	**2.25**	**1.25**	**2.25**	**2.00**	**1.00**	**2.25**

GEL-RC-4810

Research and Publication Ethics

Credit: 4 (L-4:T-0:P-0)

Course Objective

The main objective of the course is to introduce the students to research and publication ethics and misconducts.

Course Learning Outcome

CO 1: Learning the objectives of philosophy and ethics in scientific research.
CO 2: Understanding the intellectual honesty and research integrity to orient themselves into carrying out genuine research activities.
CO 3: Understanding the nitty-gritty in publishing research works.
CO 4: Identifying research misconduct and predatory publications.

Detailed Syllabus

Unit 1 ***15 Lectures***

Philosophy - definition, nature and scope, concept, and branches; ethics: definition, moral philosophy, nature of moral judgements and reactions.

Unit 2 ***15 Lectures***

Ethics with respect to science and research; intellectual honesty and research integrity; scientific misconducts; redundant publications.

Unit 3 ***15 Lectures***

Publication ethics - definition, introduction and importance; best practices/standards setting initiatives and guidelines - COPE, WAME, etc.; conflicts of interest.

Unit 4 ***30 Hours***

Publication misconduct - definition, concept, problems that lead to unethical behaviour and vice versa, types; violation of publication ethics, authorship and contributorship; predatory publishers and journals.

Recommended Books

Text Books:

1. **Handbook of Research and Publication Ethics** - Nimit Chowdhary and Sarah Hussain, *Bharti Publications*
2. **Research and Publication Ethics** - Santosh Kymar Yadav, *Springer*
3. **Text Book of Research and Publication Ethics** - Yogita Sharma and Aarti Sharma, Kalyani Publishers
4. **The Student's Guide to Research Ethics** - Paul Oliver, *Open University Press*

Reference Books:

1. **Ethics in Science: Ethical Misconduct in Scientific Research** - John D'Angelo, *CRC Press*
2. **McGraw-Hill's Concise Guide to Writing Research Papers** - Carol Ellison, *McGraw-Hill*
3. **Philosophy in Educational Research: Epistemology, Ethics, Politics and Quality** - David Bridges, *Springer*
4. **Research Methodology: The Aims, Practice and Ethics of Science** - Peter Pruzan, *Springer*
5. **Scientific Integrity and Research Ethics: An Approach from the Ethos of Science** - David Koepsell, *Springer*
6. **Textbook of Research Ethics**: Theory and Practice - Sana Loue, *Springer*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	2	2	2	2	3	2	2	2	2	2	3	3	2
CO2	2	2	1	2	3	2	2	2	2	2	1	2	2
CO3	2	3	2	3	3	3	2	3	1	3	2	2	2
CO4	2	3	2	3	3	3	2	2	1	3	2	2	2
Average	2.00	2.50	1.75	2.50	3.00	2.50	2.00	2.25	1.50	2.50	2.00	2.25	2.00

GEL-RP-4810

Research Project

Credit: 12

Course Objective

The basic aim of this course is to introduce the students to the early stages of research where students can learn to choose geological problems and solve with appropriate methods.

Course Learning Outcome

CO 1: Understanding the methods of carrying out geological research work.
CO 2: Learning the skills to identify research problems and writing research proposals with appropriate research methods.
CO 3: Acquiring experience in field and laboratory techniques.
CO 4: Developing the ability to demonstrate the research works.

Detailed Syllabus

Students who desire to obtain B.Sc. Honours with research and fulfil the requirement as per the university guidelines on NEP 2020, have to carry out a research project during eighth semester. Supervisor will be assigned to the student during seventh semester. Progress of the research work will be evaluated periodically through power point presentation in front of duly constituted committee by the department and submission of report attested by the concerned supervisor. The final research project report must be submitted to the department for evaluation before the commencement of the eighth semester examination. The students must present their work in the form of seminar followed by viva-voce.

Distribution of Marks:

1. **Internal Assessment : 20%**
2. **Report : 50%**
3. **Presentation : 20%**
4. **Viva-voce : 10%**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	3	3	3	1	3	2	2	3	2	3	3	3	2
CO2	3	3	3	1	3	2	2	2	1	2	3	3	2
CO3	3	3	3	2	3	1	3	3	1	3	3	2	3
CO4	2	3	2	2	3	2	2	2	1	2	2	2	3
Average	2.75	3.00	2.75	1.50	3.00	1.75	2.25	2.50	1.25	2.50	2.75	2.50	2.50