CURRICULUM AND CREDIT FRAMEWORK FOR FOUR-YEAR UNDERGRADUATE PROGRAMMES OF GEOLOGY WITH A SINGLE MAJOR

(*w.e.f. A.Y. 2023-2024*)

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Content

1. Introduction 1
2. Semester-wise credit distribution in different UG programmes of Geology with a single major 2
3. Semester-wise detailed course curriculum 3
4. Major and Minor Courses 4
   4.1 Department Specific Core Courses (DSC) 4
      4.1.1 Palaeontology [SGEL-501MJC-9 & SGEL-505MN-5] 4
      4.1.2 Petrology Lab [SGEL-502MJC-10] 5
      4.1.3 Geodynamics [SGEL-502MJC-11] 7
      4.1.4 Geomorphology, Remote Sensing and GIS [SGEL-502MJC-12] 8
      4.1.5 Principles of Stratigraphy and Precambrian Stratigraphy of India [SGEL-601MJC-13 & SGEL-605MN-6] 10
      4.1.6 Phanerozoic Stratigraphy of India [SGEL-601MJC-14] 12
      4.1.7 Fuel Geology [SGEL-601MJC-14] 13
      4.1.8 Oceanography [SGEL/601/MJC-14] 14
5. Internship/Apprenticeship [ACS506-INT-3] 16
6. Programme Outcome 16
7. Programme Specific Outcome 17

1. Introduction

One of the major initiatives of University Grants Commission (UGC) for quality improvement in higher education system is the curriculum revision. National Education Policy (NEP) 2020 recognizes the important role of higher education in promoting human as well as societal well-being and in developing India. NEP recommends that the undergraduate (UG) programmes will be of either 3 or 4-year duration with multiple entry and exit options within this period. The recommended programme certifications are: UG certificate after completing 01 (one) year, or a UG diploma after 02 (two) years of study; or a bachelor degree after 03 (three) years and a bachelor degree (with honours/ honours with research) after 04 (four) years.

In accordance with the NEP 2020, the UGC has formulated a new student-centric Curriculum and Credit Framework for Undergraduate Programmes (CCFUP) incorporating a flexible choice-based credit system, multidisciplinary approach, and multiple entry and exit options. This will facilitate students to pursue their career path by choosing the subject/field of their own interest.

Geology as a discipline falls within the special category of science with a multidisciplinary approach. The present syllabus for geology at undergraduate level under the CBCS has been framed in compliance with curriculum and credit framework given by the UGC following NEP. The goal of the syllabus is to equip students with the fundamental knowledge of the diverse fields of earth science. The geology programmes integrate field trips with classroom learning to give the hands-on experience, which is often required to succeed. These opportunities develop the technical skills using measuring instruments and laboratory equipment. Thus, more emphasis has been given on skill enhancement courses.

The ultimate goal of the syllabus is to equip students with knowledge, skills, values, attitudes, leadership readiness/qualities and learning. Hence, at the end, the students will be able to secure very good opportunities as per their own choices.

Abbreviations used:

AEC- Ability Enhancement Courses (e.g., English language, MIL etc.); DSC - Department Specific Core Course; DSE – Department Specific Electives; ESE – End Semester Examination; IA – Internal Assessment; L – Lecture, P/Pr.- Practical; SEC – Skill Enhancement Course; T – Tutorial Th. – Theoretical; VAC – Value-Added Course (e.g., Environmental study, Understanding India, Health and Wellness etc.).

2. Semester-wise credit distribution in different UG programmes of Geology with a single major (as on 28.02.2024)

Year	Semester	Category of Courses (Credit of each course** x No. of courses)									Semester-wise total credits (No. of courses)
		Major		Minor Discipline	Multi-disciplinary	SEC	AEC	VAC	Internship/ Apprenticeship	Research Project/ Dissertation	
		DSC	DSE								
1st	**I**	(4x1) = 4	-	(4x1) = 4	(3x1) = 3	(3x1) = 3	(2x1) = 2	(4x1) = 4	(2x1) = 2##	--	**20**(6)
	II	(4x1) = 4	-	(4x1) = 4	(3x1) = 3	(3x1) = 3	(2x1) = 2	(4x1) = 4	(2x1) = 2##	-	**20**(6)
	Total credits (courses) up to 2nd Semester	**8**(2)		**8**(2)	**6**(2)	**6**(2)	**4**(2)	**8** (2)	**4** (2)##		**40** (12)
2nd	**III**	(4x2) = 8	-	(4x1) = 4	(3x1) = 3	(3x1) = 3	(2x1) = 2	-	(2x1) = 2##	-	**20**(6)
	IV	(4x4) = 16	-	(4x1) = 4	-		(2x1) = 2	-	(2x1) = 2##	-	**22**(6)
	Total credits (courses) up to 4th Semester	**32** (8)		**16** (4)	**9**(3)	**9**(3)	**8**(4)	**8**(2)	**4**##	-	**82** (24)
3rd	**V**	(4x4) = 16		(4x1) = 4	-	-	-	-	(2x1) = 2	-	**22** (6)
	VI	(4x4) = 16		(4x1) = 4	-	-	-	-	-		**20** (5)
	Total credits (courses)up to 6th Semester	**64**(16)		**24** (6)	**9**(3)	**9**(3)	**8**(4)	**8**(2)	**2** (1)	-	**124** ((35)
4th	**VII**	(4x4) = 16		(4x1) = 4	-	-	-	-	-	-	**20** (5)
	VIII	(4x4) =16@@		(4x1) = 4	-	-	-	-	-	12$$	**20** (5/3)
	Total credits (courses) up to 8th Semester	**96** (24)		**32** (8)	**9**(3)	**9**(3)	**8**(4)	**8**(2)	**2** (1)	-	**164** (45)
	Total credits (courses)up to 8th Semester	**84** (21)		**32** (8)	**9**(3)	**9**(3)	**8**(4)	**8**(2)	**2** (1)	**12**$$	**164** (43)

** ***Credit of each course***: Major courses (DSC & DSE) – 4; Minor discipline – 4; Multidisciplinary – 3; AEC – 2; SEC – 3; VAC – 4; Internship/Apprenticeship – 2 and Research Project//Dissertation – 12.

Additional requirement (to be acquired during first year and/or second year summer term), if a student wants to get UG Certificate or UG Diploma programme certifications.

@@ Honours students not undertaking research will do 3 courses for 12 credits for Major in lieu of a research project / Dissertation and total four courses in Major in VIII semester.

$$ Required only for students who opt for B. Sc. (Honours with Research), instead of 03 (three) DSE courses with a total of 12 credits

3. Semester-wise detailed course curriculum

SEMESTER-V

COURSE CODE	COURSE TITLE	CREDIT			MARKS				NO. OF HOURS PER WEEK		
		Th	Pr.	Total	IA	ESE		Total	L	T	P
						Th.	Pr				
S/GEL/501/MJC-9	Palaeontology	3	1	4	10	25	15	50	3	0	2
S/GEL/502/MJC-10	Petrology Lab	0	4	4	10	0	40	50	0	0	8
S/GEL/503/MJC-11	Geodynamics	4	0	4	10	40	0	50	4	0	0
S/GEL/504/MJC-12	Geomorphology, Remote Sensing and GIS	3	1	4	10	25	15	50	3	0	2
S/GEL/505/MN-5*	Palaeontology	3	1	4	10	25	15	50	3	0	2
ACS/506/INT-3	Internship/Apprenticeship	0	2	2	10	0	40	50			
	Total in Semester- V	**13**	**9**	**22**	**60**	**115**	**125**	**300**			

***** To be opted by the students having major course of other discipline

SEMESTER-VI

COURSE CODE	COURSE TITLE	CREDIT			MARKS				NO. OF HOURS PER WEEK		
		Th	Pr.	Total	IA	ESE		Total	L	T	P
						Th.	Pr.				
S/GEL/601/MJC-13	Principles of Stratigraphy and Precambrian Stratigraphy of India	4	0	4	10	40	0	50	4	0	0
S/GEL/602/MJC-14	Phanerozoic Stratigraphy of India	4	0	4	10	40	0	50	4	0	0
S/GEL/603/MJC-15	Fuel Geology	4	0	4	10	40	0	50	4	0	0
S/GEL/604/MJC-16	Oceanography	4	0	4	10	40	0	50	4	0	0
S/GEL/605/MN-6*	Principles of Stratigraphy and Precambrian Stratigraphy of India	4	0	4	10	40	0	50	4	0	0
	Total in Semester- VI	**20**	**0**	**20**	**50**	**200**	**0**	**250**	20	0	0

***** To be opted by the students having major course of other discipline

4. Major and Minor Courses

4.1 Department Specific Cores (DSC)

4.1.1 PALAEONTOLOGY [SGEL-501MJC-9 & SGEL-505MN-5]

[4 Credits: Th.-3; Pr.-1]

(i) Course objectives:

This course aims to focus on:

(a) importance of studying palaeontology, concept of fossils and fossilization processes,
(b) the study of fossilized ancient invertebrate, vertebrate and micro-organisms in the light of their morphology, adaptation, ecology, and evolution,
(c) the evidences and records of the earliest life on the earth, and
(d) major events in the course of evolution of life through the geological time**.**

(ii) Course learning outcomes:

The study of this course enables to understand:
(a) older life-forms with their external and internal features,
(b) deduction of ecology with the application of morphological modifications,
(c) mass extinction and their causes, and
(d) application of principles of speciation and evolution.

(iii) Course Content:

THEORY
[*45 Hours*]

Unit 1: Fossilization and fossil record [05 Hours]

Fossilization: definition of fossil, fossilization processes and modes of preservation, nature and importance of fossil record; Taphonomy: definition, different types of taphonomic filters.

Unit 2: Taxonomy and systematics [05 Hours]

Taxonomy: concept of taxonomy and taxonomic hierarchy; Species concept with special reference to palaeontology.

Unit 3: Evolution and history of life [10 Hours]

Organic evolution interpreted from fossil record: theories, concepts of adaptation and variation, natural selection; Doubtful organic traces of life during the Precambrian; Ediacaran fauna; Palaeozoic-Cambrian explosion of life; Plants: appearance of angiosperm and gymnosperm; and appearance of fish, amphibia, reptiles, birds, mammals and humans; Mass extinction: five major extinction episodes and their causes, effect of extinction.

Unit 4: Invertebrates and vertebrates [10 Hours]

Introduction to important invertebrate groups: bivalvia, gastropoda, cephalopoda, brachiopoda, and their functional aspects; Brief introduction to trilobites and echinodermata; Origin of vertebrates and major steps in vertebrate evolution; Evolution of horse; human evolution.

Unit 4: Palaeobotany and ichnology. [05 Hours]

Gondwana flora; Introduction to ichnology.

Unit 5: Application of fossils in stratigraphy [10 Hours]

Biostratigraphy: biozones, index fossils, stratigraphic correlation; Significance of ammonites in Mesozoic biostratigraphy and their paleobiogeographic implications; Role of fossils in paleoenvironmental analysis, palaeoclimatology and sequence stratigraphy; Paleoecology: biotic interactions, abiotic controlling factors; Application of trace fossils in palaeoecology.

PRACTICAL
[*30 Hours*]

Hard part morphology and identification of common invertebrates (bivalvia, gastropoda, cephalopoda); Study of Gondwana flora.

Suggested Readings

- Benton, M. (2009). Vertebrate Paleontology. John Wiley & Sons.
- Benton, M. J. and Harper, D. A. T. (2010). Introduction to Paleobiology and the Fossil Record. Wiley-Blackwell.
- Clarkson, E. N. K. (2012). Invertebrate Paleontology and evolution. 4th Edition. Blackwell Publishing Company.
- Raup, D. M., Stanley and S. M., Freeman, W. H. (1971). Principles of Paleontology.
- Shukla, A. C. and Misra, S. P. (1975). Essentials of Paleobotany. Vikas Publisher.

4.1.2 PETROLOGY LAB [SGEL-502MJC-10] [4 Credits: Th.-0; Pr.-4]

(i) Course objectives:

This course focusses on:

(a) mesoscopic and microscopic petrography (mineral composition and texture/structure) and identifications of igneous, sedimentary and metamorphic rocks,
(b) CIPW norm calculation, and
(c) different graphical plots commonly used for understanding the classification and genesis of different igneous, sedimentary and metamorphic rocks.

(ii) Course learning outcomes:

After studying the course, the students will be able to:

(a) identify mineral composition and texture/structure of igneous, sedimentary and metamorphic rocks mesoscopically and microscopically, and

(a) solve different petrological problems using standard graphical plots commonly used for interpretation igneous, sedimentary and metamorphic rocks.

(iii) Course Content:

PRACTICAL

[*120 Hours*]

Unit 1: Igneous petrology lab [40 Hours]

Study of important igneous rocks in hand specimen and thin section: granite, granodiorite, diorite, syenite, nepheline syenite, gabbro, dolerite, anorthosites, dunite, peridotite, basalt and andesite; CIPW norm calculation; Plotting of mode in IUGS classification of plutonic rocks (Streckeisen's diagram).

Unit 2: Metamorphic petrology lab [40 Hours]

Study of important metamorphic rocks in hand specimen and thin section: slate, phyllite, schist, gneiss, amphibolite, charnockite, khondalite, mafic granulite, eclogite and marble; Graphical plots of metamorphic mineral assemblages using chemographic diagrams.

Unit 3: Sedimentology lab [40 Hours]

Identification of sedimentary structures in hand specimen; Identification of diagenetic features; Particle size distribution and statistical analysis; Paleocurrent analysis: data acquisition, methodology and interpretation; Petrographic study of sedimentary rocks in hand specimens and in thin sections: sandstone (quartz arenite, arkose, lithic arenite and greywacke) and limestone.

Suggested Readings

- Pettijohn, F. J. (2019). Sedimentary Rocks. 3rd e-book Edition. CBS Publishers and Distributers, New Delhi.
- Sengupta, S. M. (1994). Introduction to Sedimentology. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, 314 pp.
- Tucker, M. E. (2006). Sedimentary Petrology. Blackwell Publishing Company.
- William, H., Turner, F. J. and Gilbert, C., M. (1954). Petrography: An Introduction to the study of rocks in thin section. 2nd Edition. W. H. Freeman and Company, 416 pp.
- Winter, J. D. (2015). Principles of Igneous and Metamorphic Petrology. Pearson India Education Services Pvt. Ltd., 739 pp.

4.1.3 GEODYNAMICS [SGEL-503MJC-11] [4 Credits: Th.-4; Pr.-0]

(i) Course objective:

To impart knowledge on
(a) geodynamic processes of the Earth, and
(b) the crustal evolution

(ii) Course learning Outcome:

Upon successful completion of course, the students will be able to understand:
(a) the origin and evolution of early earth systems,
(b) continental drift, sea floor spreading and plate tectonics, and
(c) origin and evolution of continental crust.

THEORY
[*60 Hours*]

(iii) Content of the course:

Unit 1: Introduction [15 Hours]

Definition: continents and oceans, continental and oceanic crust, lithosphere and asthenosphere; Petrologic and seismic Moho; Earth's internal processes; Heat flow and geothermal gradient; Concept of plate; Hot spot, hot spot traces and mantle plume; Ophiolites.

Unit 2: Continental drift [10 Hours]

Wegner's hypothesis on continental drift and its evidences in favour and against the hypothesis. Continental positions in the past.

Unit 3: Sea floor spreading [05 Hours]

Palaeomagnetism; Palaeomagnetic time scale; Sea-floor spreading process and its evidences.

Unit 4: Plate tectonics [15 Hours]

Plate tectonics model and its evidences; Distribution of plates on the Earth; Macro- and micro-plates; Physical character of plates; Plate boundaries: types, character, identification of plate boundaries; Plate tectonics and mantle convection; Movement of plates along their boundaries; Plate velocities; Magmatism in oceanic ridges and in subduction zones; Intraplate magmatism.

Unit 5: Geodynamic elements [05 Hours]

Volcanic arcs; Island arcs; Trenches; Accretionary prisms; Oceanic ridges; Transform faults.

Unit 6: Plate motion [05 Hours]

Driving mechanisms of plates; Supercontinents and their breakup and assembly; Wilson cycle.

Unit 7: Neotectonics [05 Hours]

Study of recent and ongoing tectonic activities: earthquake, crustal deformation, and the formation of landscape.

Suggested Readings

- Brown, G.C. and Mussett, A.E. (1993). *The Inaccessible Earth*. 2nd Edition. Chapman & Hall, London.
- Condie, K.C. (1982). *Plate Tectonics and Crustal Evolution.* 2nd Edition. Pergamon Press.
- Kearey, P., Klepeis, K. A., and Vine, F. J. (2009). Global Tectonics. Third edition. Wiley-Blackwell, Oxford.
- Moores, E.M. and Twiss, R.J. (1995). *Tectonics.* W.H. Freeman.
- Turcotte, D.L. and Schubert, G. (2002). Geodynamics. Second Edition. Cambridge.

4.1.4 GEOMORPHOLOGY, REMOTE SENSING AND GIS [SGEL-504MJC-12]

[4 Credits: Th.-3; Pr.-1]

(i) Course objectives:

The course provides an overview on:

(a) landforms, land forming processes, and landscape evolution, and how these depend on climate and tectonic regimes and time,
(b) different concepts on remote sensing and exposure to students leading to modelling of earth resources management,
(c) acquiring skills in storing, managing digital data for planning and development, and
(d) hands-on training on the study of geomorphic maps and aerial photo interpretation.

(ii) Course learning outcomes:

Students will be able to:

(a) analyse how variations in climate, tectonics and environment affect the development of landforms,
(b) assess how different scales of time and space affect geomorphological processes and explain and apply geomorphological methods used in research today,
(c) understand fundamental physical principles of remote sensing, including the electromagnetic spectrum, the emission, scattering, reflection, and absorption of electromagnetic (EM) radiation, and
(d) interpret the geomorphic maps and aerial photographs.

(iii) Content of the course:

THEORY

[*45 Hours*]

Unit 1: Introduction to Geomorphology [05 Hours]

Relationship between the landforms and the properties of earth material and different kind of endogenic and exogenic processes.

Unit 2: Topographic variation on earth surface [05 Hours]

Definition: geoid; topography, hypsometry; Major morphological features of the earth surface; Large scale topography; Plate tectonics overview; Large scale mountain ranges (with special emphasis on Himalaya).

Unit 3: Geomorphic processes [05 Hours]

Surficial processes and geomorphology; Weathering, erosion and associated landforms; Landforms produced by glacial, periglacial, fluvial, aeolian and coastal processes; Landforms associated with igneous activities.

Unit 4: Landform dynamics [05 Hours]

Endogenic-exogenic interactions; Rates of uplift and denudation; Tectonics and drainage development; Sea-level changes and long-term landscape development; Landform dating techniques.

Unit 5: Photogeology [10 Hours]

Types and acquisition of aerial photographs; Scale and resolution; Principles of stereoscopy: relief, displacement, vertical exaggeration and distortion; Elements of air photo interpretation; Identification of sedimentary, igneous and metamorphic rocks and various aeolian, glacial, fluvial and marine landforms.

Unit 6: Concepts in Remote Sensing [05 Hours]

Sensors and scanners; Satellites and their characteristics; Data formats: raster and vector.

Unit 7: Digital Image Processing [05 Hours]

Image errors; Rectification and restoration; FCC; Image enhancement; Filtering; Image rationing and image classification.

Unit 8: GIS and GPS [05 Hours]

Datum; Coordinate systems and projection systems; Introduction to DEM analysis; Concepts of GPS, GIS and their applications in Earth System Sciences.

PRACTICAL

[*30 Hours*]

Reading topographic maps; Preparation of a topographic profile; Preparation of longitudinal profile of a river; Calculation of stream length-gradient index; Morphometry of a drainage basin; Interpretation of geomorphic features from geomorphological maps; Aerial Photo interpretation: identification of sedimentary, igneous and metamorphic rocks and associated structures, various aeolian, glacial, fluvial and marine landforms.

Suggested Readings

- Demers, M.N. (1997). Fundamentals of Geographic Information System, John Wiley & sons. Inc.
- Gupta, R. P. (2018). Remote Sensing Geology. 3rd Edition. Springer, 438 pp.
- Hoffmann-Wellenhof, B., Lichtenegger, H. and Collins, J. (2001). GPS: Theory & Practice. Springer.
- Jensen, J.R. (1996). Introductory Digital Image Processing: A Remote Sensing Perspective. Springer Verlag.
- Lillesand, T. M. and Kiefer, R.W. (2007). Remote Sensing and Image Interpretation. Wiley.
- Richards, J.A. and Jia, X. (1999). Remote Sensing and Digital Image Analysis. Springer Verlag.
- Robert, S. and Suzzane, P. (2010). Geomorphology - The Mechanics and Chemistry of Landscapes. Cambridge University Press.
- Summerfield M.A. (1991). Global Geomorphology. Wiley & Sons.

4.1.5 PRINCIPLES OF STRATIGRAPHY AND PRECAMBRIAN STRATIGRAPHY OF INDIA [S/GEL/601/MJC-13 & S/GEL/605/MN-6] [4 Credits: Th.-4; Pr.-0]

(i) Course objectives:

Objective of the course is to perform:

(a) lithostratigraphic correlation,
(b) construct rank charts for lithostratigraphy, biostratigraphy and chronostratigraphy, and
(c) studies on different Precambrian stratigraphic successions of India.

(ii) Course learning outcomes:

On successful completion of the course, the student will be able to:

(a) analyse basic principles of stratigraphy, different types of stratigraphic units and how they are named,
(b) use the fossil records in establishing age of the rock units and correlation with other area,
(c) give an account of criteria of stratigraphic correlation, and
(d) appreciate how plate tectonic movements separated Indian plate from contiguous landmasses and shaped the depositional basins of the Indian Phanerozoic, and their effects on climate and life.

(iii) Content of the course:

THEORY

[*60 Hours*]

Unit 1: Principles of stratigraphy [15 Hours]

Fundamental laws of stratigraphy: concept of uniformitarianism, laws of superposition, faunal succession and their validity; Fundamentals of lithostratigraphy, biostratigraphy and

chronostratigraphy; Introduction to concepts of dynamic stratigraphy: sequence stratigraphy, seismic stratigraphy, chemostratigraphy, magnetostratigraphy; Relevance of type section; Principles of stratigraphic correlation.

Unit 2: Code of stratigraphic nomenclature [05 Hours]

International Stratigraphic Code; Development of a standardized stratigraphic nomenclature; Concepts of stratotypes; Global Stratotype Section and Point (GSSP).

Unit 3: Facies concept in stratigraphy [05 Hours]

Introduction to sedimentary facies; Walther's law of facies; Concept of paleogeographic reconstruction.

Unit 4: Stratigraphic boundaries in India [05 Hours]

Archaean-Proterozoic boundary; Precambrian-Cambrian boundary and their status in global perspective.

Unit 5: Physiographic and tectonic subdivisions of India [15 Hours]

Brief introduction to the physiographic and tectonic subdivisions of India; Distribution of Indian shields, cratons and other Precambrian belts; Proterozoic basins of India.

Unit 6: Geologic evolution of important Precambrian terrains [15 Hours]

Study of Proterozoic supercontinent reconstructions; Evolution of Indian sub-continent; Geologic evolution with emphasis on sedimentation, lithology, magmatism, structure, metamorphism, mineral deposit and geochronology of Dharwar, Aravalli, Bundelkhand, Bastar and Singhbhum cratons; Proterozoic basins of India: Vindhyan, Cudappah and Chattisgarh basins.

Suggested Readings

- Doyle, P. and Bennett, M. R. (1996). Unlocking the Stratigraphic Record. John Wiley.
- Geological Survey of India (1977). Code of Stratigraphic Nomenclature of India. GSI Miscellaneous Publication No. 20, 28 pp.
- Krishnan, M. S. (1982). Geology of India and Burma. CBS Publishers, Delhi.
- Kumar, R. (1998). Fundamentals of historical geology and stratigraphy of India. New Age International Publishers, New Delhi, 254 pp.
- Ramakrishnan, M. and Vaidyanadhan, R. (2008). Geology of India. Volumes 1 & 2, Geological Society of India, Bangalore.
- Valdiya, K. S. (2010). The Making of India, Macmillan India Pvt. Ltd.

4.1.6: PHANEROZOIC STRATIGRAPHY OF INDIA [S/GEL/602/MJC-14]

[4 Credits: Th.-4; Pr.-0]

(i) Course objectives:

The course focusses on:

(a) Precambrian-Cambrian boundary, Permian-Triassic boundary, and Cretaceous-Tertiary boundary in India, and

(b) different Phanerozoic stratigraphic successions of India

(ii) Course learning outcomes:

On successful completion of the course the students will gather knowledge on:

a) different Phanerozoic stratigraphic units, and

b) correlation with the respective fossil assemblages.

(iii) Content of the course:

THEORY

[*60 Hours***]**

Unit 1: Stratigraphic boundaries [15 Hours]

Phanerozoic time scale; Important Stratigraphic boundaries during Phanerozoic period in India: Permian-Triassic and Cretaceous-Tertiary boundaries.

Unit 2: Phanerozoic successions in India [25 Hours]

Study of important Palaeozoic successions in India with emphasis on succession, lithology, flora and fauna, correlation and palaeoenvironment: Kashmir and its correlatives from Spiti and Zanskar in Extra-peninsular India; stratigraphy, structure, coal and hydrocarbon potential of different Gondwana basins in peninsular India; Mesozoic stratigraphy of India, such as: Triassic succession of Spiti, Jurassic of Kutch, Triassic and Jurassic non-marine successions of peninsular India (Upper Gondwana Formations and relevant Formations of Rajasthan basin); Cretaceous succession of Cauvery and Narmada Basins: Bagh and Lameta Formations; Cenozoic stratigraphy of India: Kutch basin, Siwalik successions, Assam, Arakan and Bengal basins; Stratigraphy and structure of Krishna-Godavari basin, Cauvery basin, Bombay offshore basin, Kutch and Saurashtra basins and their potential for hydrocarbon exploration.

Unit 3: Volcanic provinces of India and the intertrappeans [10 Hours]

Deccan, Rajmahal and Sylhet Traps and important intertrappeans beds.

Unit 4: Quaternary Geology [10 Hours]

Definition; Principles of sub-division of Quaternary succession in India.

Suggested Readings

- Doyle, P. and Bennett, M. R. (1996) Unlocking the Stratigraphic Record. John Wiley.
- Krishnan, M. S. (1982) Geology of India and Burma, CBS Publishers, Delhi.

- Kumar, R. (1998). Fundamentals of historical geology and stratigraphy of India, New Age International Publishers, New Delhi, 254 pp.
- Ramakrishnan, M. and Vaidyanadhan, R. (2008) Geology of India Volumes 1 & 2, Geological Society of India, Bangalore.
- Valdiya, K. S. (2010). The Making of India, Macmillan India Pvt. Ltd.

4.1.7: FUEL GEOLOGY [S/GEL/603/MJC-15]

[4 Credits: Th.-4; Pr.-0]

(i) Course objectives:

To impart knowledge of formation and utilization of:
(a) Fossil, nuclear and other fuels
(b) The exploration techniques of fuels and estimation of their reserves.

(ii) Course learning outcomes:

Upon successful completion of course the students will be able to:
(a) understand the basic concept of occurrences, distribution and exploration of coal, petroleum and nuclear fuels, and
(b) understand the proper and optimal utilization of fuel keeping environment in mind.

(iii) Content of the course:

THEORY
[*60 Hours*]

Unit 1: Energy Resources **[05 Hours]**

Different sources of energy; Global and Indian scenario of energy resources.

Unit 2: Coal **[10 Hours]**

Definition and origin; Grade and rank; Basic classification based on rank; Fundamentals of coal petrology: lithotypes, microlithotypes and macerals; Proximate and ultimate analyses; Seyler's and Indian classification of coal; Major coal basins of India.

Unit 3: Coal as a fuel **[10 Hours]**

Concept of clean coal technology; Coal Bed Methane (CBM); Underground coal gasification; Liquefaction of coal.

Unit 4: Petroleum **[10 Hours]**

Chemical composition and physical properties of crudes oil; Origin; Kerogen: type, maturation, and biogenic and thermal effect.

Unit 5: Petroleum system **[15 Hours]**

Source rocks; Reservoir rocks; Cap Rocks; Migration; Entrapment; Traps: structural, stratigraphic, combination and hydrodynamic; Plate tectonics and global distribution of hydrocarbon reserves; Petroliferous basins of India.

Unit 6: Nuclear fuels **[10 Hours]**

Geochemistry and mineralogy of uranium and thorium; Modes of occurrence and Indian occurrences of uranium and thorium-bearing minerals; Radioactive waste management.

Unit 7: Other fuels **[10 Hours]**

Shale gas and Gas hydrate; Proper and optimal utilization of fuel keeping environment in mind

Suggested Readings

- Bastia, R., and Radhakrishna, M. (2012). Basin Evolution and Petroleum Prospectively of the Continental Margins of India (Vol. 59). Newness.
- Bjorlykke, K. (1989). Sedimentology and Petroleum Geology. Springer-Verlag.
- Chandra, D. (2007). Chandra's Textbook on Applied Coal Petrology. Jijnasa Publishing House.
- Chandra, D., Singh, R. M. and Singh, M. P. (2000). Text Book of Coal (Indian context), Tara Book Agency, Kamachha, Varanasi, 402 pp.
- Dhana Raju, R. (2005). Radioactive Minerals. Geological Society of India, 65 pp
- Levorsen, A. I. (2004). Geology of Petroleum, 2nd Edition, Paperback (W. H. Freeman and Company, San Francisco), 724 pp.
- North, F. K. (1985). Petroleum Geology, George Allen and Unwin (Publishers) Ltd. 607 pp.
- Shelly R. C. (2014). Elements of Petroleum Geology: 3rd Edition, Academic Press.
- Virnave, S. N. (1995). Nuclear Geology and Atomic Mineral Resources. Bharathi Bhawan Publishers and Distributors, Patna, 226 pp.

4.1.8: OCEANOGRAPHY [S/GEL/604/MJC-16] [4 Credits: Th.-4; Pr.-0]

(i) Course objectives:

The objectives of the course is to provide essential concepts of:
(a) ocean science, and
(b) to study the tectonics, geology, economic resources with respect to the oceans.

(ii) Course learning outcomes:

The students will understand and learn about the basic concepts of:
a) oceanography so as to enable them to work as a marine researcher, and
b) equip themselves with knowledge and skills related to dealing with the physical and chemical components and phenomena related to oceanography and marine geology.

(iii) Content of the course:

THEORY
[*60 Hours*]

Unit 1: Fundamentals of ocean [05 Hours]

Concept of land and ocean; Land-ocean distribution; Marine provinces; Plate tectonics and sea floor spreading; Ocean dynamics; Marine sediments; Sea-air interaction.

Unit 2: Waves, Tides and Coasts [10 Hours]

Ocean circulation; Waves and water dynamics; Ocean energy; Tides: types, controlling factors, and equilibrium and dynamic theories; Coast: beach, shoreline, classification of coast, features of primary and secondary coasts; Ocean migration causing coastal erosion; Estuaries; Lagoons and wetlands; Human interferences in coastal processes.

Unit 3: Oceanic currents [05 Hours]

Oceanic circulation, Oceanic currents – types and controlling factors.

Unit 4: Marine Geology [15 Hours]

Morphological and tectonic domains of the ocean floor; Mid oceanic ridge systems; Hydrothermal vents and seawater-basalt interaction; Modes and rates of sedimentation in the oceans; Nature of deep-sea sediments and processes regulating sedimentary composition

Unit 5: Marine Resources [10 Hours]

Types of marine resources: physical, energy, biological and non-extractive resources; Laws related to oceans.

Unit 6: Marine Chemistry [15 Hours]

Sea water chemistry: major and minor constituents of sea water and their residence times; Processes controlling the composition of sea water, Dissolved gases in sea water; Interrelationships between ocean circulations, primary productivity and chemical composition of the atmosphere and ocean; Marine pollution: pathways of transfer of various pollutants and their fates in the sea

Suggested Readings

- Banerjee, Pronab K. (2005). Oceanography for Beginners, Allied Publishers Pvt Limited.
- Harold, V. Thurman, Mt. San Antonio College, Charles E. (1988). Introductory Oceanography (5th Edition), Merrill Publishing Company.
- Muir, A.M. and Fleming, C. A. (1981). Coastal Hydraulics, The MacMillan Press Ltd, London.

5. INTERNSHIP/APPRENTICESHIP [ACS506-INT-3] [2 Credits: Th.-0; Pr.-2]

In the internship, the students should be associated to take up any of the activities like: (a) different laboratory analytical techniques; (b) sample preparation for specific study purposes; (c) exploration work for economic minerals, coal, coal bed methane etc.; (d) handling different geological and mining soft-wares etc. They may undergo such internship in Geological Survey of India, Central Mine Planning and Designing Institute Limited, Coal India Limited, ESSAR oil, River Research Institute and so on following the Programme and Course structure and modalities of Internship of Bankura University.

6. Programme Outcome

A. **Graduate Attributes**: The quality and feature or characteristics of an individual, including the knowledge, skills, attitudes, and values that are expected to be acquired by a graduate through studies at the higher education institution.

Some of the characteristic attributes that a graduate should demonstrate:
i) Disciplinary knowledge
ii) Communication Skills
iii) Critical thinking
iv) Problem solving ability
v) Analytical reasoning
vi) Research-related skills vii) Cooperation/Teamwork viii) Scientific reasoning
ix) Reflective thinking
x) Information/digital literacy xi) Self-directed learning
xii) Multicultural competence
xiii) Moral and ethical awareness/reasoning
xiv) Leadership readiness/qualities
xv) Lifelong learning, and
xvi) Development of pleasing personality and readiness to share responsibilities.

B. **Qualification descriptors:** The generic outcomes and attributes expected for the award of a particular type of qualification (for e.g. a bachelor's degree or a bachelor's degree with honours).

Qualification descriptors for a bachelor's degree with honours

(a) Demonstrate (i) a systematic, extensive and coherent knowledge and understanding of an academic field of study as a whole and its applications, and links to related disciplinary areas/subjects of study; including a critical understanding of the established theories, principles and concepts, and of a number of advanced and emerging issues in the field of study; (ii) procedural knowledge that creates different types of professionals related to the disciplinary/subject area of study, including research and development, teaching and government and public service; (iii) skills in areas related to one's specialization and current developments in the academic field of study, including a critical understanding of the latest developments in the area of specialization, and an ability to use established techniques of analysis and enquiry within the area of specialization.

(b) Demonstrate comprehensive knowledge about materials, including current research, scholarly, and/or professional literature, relating to essential and advanced learning areas pertaining to the chosen disciplinary areas (s) and field of study, and techniques and skills required for identifying problems and issues relating to the disciplinary area and field of study.

(c) Demonstrate skills in identifying information needs, collection of relevant quantitative and/or qualitative data drawing on a wide range of sources, analysis and interpretation of data using methodologies as appropriate to the subject(s) for formulating evidence-based solutions and arguments.

(d) Use knowledge, understanding and skills for critical assessment of a wide range of ideas and complex problems and issues relating to the chosen field of study.

(e) Communicate the results of studies undertaken in an academic field accurately in a range of different contexts using the main concepts, constructs and techniques of the subject(s) of study.

(f) Address one's own learning needs relating to current and emerging areas of study, making use of research, development, and professional materials as appropriate, including those related to new frontiers of knowledge.

(g) Apply one's disciplinary knowledge and transferable skills to new/unfamiliar contexts and to identify and analyze problems and issues and seek solutions to real-life problems.

(h) Demonstrate subject-related and transferable skills that are relevant to some of the job trades and employment opportunities.

7. Programme Specific Outcome

The student graduating with the degree B. Sc. (Honours/Honours with Research) in Geology should be able to

a) Acquire

i. a fundamental/systematic or coherent understanding of the academic field of Geology, its different learning areas and applications in basic Geology like Mineralogy, Petrology, Stratigraphy, Structural Geology, Palaeontology, Economic geology, Hydrogeology, etc. and its linkages with related interdisciplinary areas/subjects like Geography, Environmental sciences, Physics, Chemistry, Mathematics, Life sciences, Atmospheric sciences, Remote Sensing, Computer science, Information Technology;

ii. procedural knowledge that creates different types of professionals related to the disciplinary/subject area of Geology, including professionals engaged in research and development, teaching and government/public service and industrial geology.

iii. skills in areas related to one's specialization area within the disciplinary/subject area of Geology and current and emerging developments in the field of Geosciences.

(b) Demonstrate the ability to use skills in Geology and its related areas of technology for formulating and tackling geosciences-related problems and identifying and applying appropriate geological principles and methodologies to solve a wide range of problems associated with geosciences.

(c) Recognize the importance of RS and GIS, mathematical modelling, simulation and computing, and the role of approximation and mathematical approaches to describing the physical world.

(d) Plan and execute Geology-related experiments or investigations, analyse and interpret data/information collected using appropriate methods, including the use of appropriate software such as programming languages and purpose-written packages, and report accurately the findings of the experiment/investigations while relating the conclusions/findings to relevant theories in Geology.

Demonstrate relevant generic skills and global competencies, such as:

(a) problem-solving skills that are required to solve different types of geoscience-related problems with well-defined solutions and tackle open-ended problems that belong to the disciplinary area boundaries;
(b) investigative skills, including skills of independent investigation of geoscience-related issues and problems.
(c) communication skills involving the ability to listen carefully, to read texts and research papers analytically and to present complex information in a concise manner to different groups/audiences of technical or popular nature;
(d) analytical skills involving paying attention to detail and ability to construct logical arguments using correct technical language related to Geology and ability to translate them with popular language when needed;
(e) ICT skills; and
(f) personal skills such as the ability to work both independently and in teams

Demonstrate professional behaviour such as being: (a) objective, unbiased, and truthful in all aspects of work and avoiding unethical, irrational behaviour such as fabricating, falsifying or misrepresenting data or committing plagiarism; b) the ability to identify the potential ethical issues in work-related situations; c) appreciation of intellectual property, environmental and sustainability issues; and d) promoting safe learning and working environment.