LEARNING OUTCOMES BASED CURRICULUM FRAMEWORK (LOCF)
FOR
SIX SEMESTER B. Sc. (GEOLOGY PROGRAMME)
UNDER
CHOICE-BASED CREDIT SYSTEM (CBCS)

(*w.e.f. A.Y. 2022-2023*)

BANKURA UNIVERSITY
BANKURA, WEST BENGAL, PIN 722155

1. Scheme for CBCS Curriculum for B. Sc (Geology Programme)

All UG Programme courses will have 3 subjects/disciplines of interest. Student will select 4 core courses each from three disciplines of choice including Geology as one of the disciplines. Student will also select 2 elective courses each from discipline of choice including Geology as one of the disciplines. Student may also choose Skill Enhancement courses in Geology.

Abbreviations Used:

AECC= Ability Enhancement Compulsory Course, C= Core Course, DSE= Discipline Specific Elective, ESE= End-Semester Examination, GE= Generic Elective, GEL= Geology, IA= Internal Assessment, Lec.= Lecture, Prc.=Practical, SEC= Skill Enhancement Course, and Tu.= Tutorial

1.1 Credit distribution across courses

Course Type	Total Papers	Total Credits
		Theory + Practical
Core Courses (CC) **[**4 papers each from 3 disciplines of choice]	12	[12*4 = 48] + [12*2 =24]
Department Specific Elective Courses (DSE) **[**2 papers each from 3 discipline of choice including interdisciplinary papers]	6	[6*4=24] + [6*2=12]
Ability Enhancement Language Courses (AECC) [2 papers, one of 2 credits and the other of 4 credits]	1 1	1*4=4 1*2=2
Skill Enhancement Courses (SEC)	4	4*2=8
Totals	**24**	**122**

*Tutorials of 1 Credit will be conducted in case there is no practical component

1.2 Semester-wise distribution of courses and credit (Geology as one of the disciplines)

Courses/ (Credits)	Sem-I	Sem-II	Sem-III	Sem-IV	Sem-V	Sem-VI	Total No. of Courses	Total Credit
CC-1,2,3 (6)	3 (1A*, 2A, 3A)	3 (1B*, 2B, 3B)	3 (1C*, 2C, 3C)	3 (1D*, 2D, 3D)			12	72
DSE-1,2,3 (6)					3 (1A*, 2A, 3A)	3 (1B*, 2B, 3B)	6	36
AECC (2)	1	1					2	06
SEC (2)			1*	1*	1*	1*	4	08
Total no. of courses per Sem.	4	4	4	4	4	4	24	
Total Credit per Sem.	22	20	20	20	20	20		122

***May be opted from courses of Geology**

2. Detailed course Structure

The details for core courses, elective courses and skill enhancement courses in Geology is given below:

SEMESTER-I

COURSE CODE	COURSE TITLE	CREDIT	MARKS			No. of hours		
			IA	ESE	TOTAL	Lec	Tu	Pr
UGP/GEL/101/CT-1A & UGP/GEL/101/CP-1A	Introduction to Geology/ Pedology	4	10	25	35	4	0	0
	Introduction to Geology Lab/Pedology Lab	2	0	15	15	0	0	4
UGP/102/C-2A	Discipline-2	4	10	25	35	4	0	0
	Discipline-2 Lab	2	0	15	15	0	0	4
UG/103/C-3A	Discipline-3	4	10	25	35	4	0	0
	Discipline-3 lab	2	0	15	15	0	0	4
UG/104/AECC-ENV	Environmental Studies	4	10	40	50	4	0	0
Total in Semester-I		**22**	**40**	**160**	**200**			

SEMESTER-II

COURSE CODE	COURSE TITLE	CREDIT	MARKS			No. of hours		
			IA	ESE	TOTAL	Lec	Tu	Pr
UGP/GEL/201/C-T1B& UGP/GEL/201/C-P1B	Minerology and Petrology/ Introduction to Palaeontology	4	10	25	35	4	0	0
	Minerology and PetrologyLab/ Introduction to Palaeontology Lab	2	0	15	15	0	0	4
UGP/SC/202/C-2B	Discipline-2	4	10	25	35	4	0	0
	Discipline-2 Lab	2	0	15	15	0	0	4
UGP/SC/203/C-3B	Discipline-3	4	10	25	35	4	0	0
	Discipline-3 Lab	2	0	15	15	0	0	4
UG/204/AECC-E/MIL	English/MIL/Hindi	2	10	40	40	2	0	0
Total in Semester- II		**20**	**40**	**190**	**160**			

SEMESTER-III

COURSE CODE	COURSE TITLE	CREDIT	MARKS			No. of hours		
			IA	ESE	TOTAL	Lec	Tu	Pr
UGP/GEL/301/C-T1C & UGP/GEL/301/C-P1C	Earth External Processes/ Physical Geology and Geochemistry	4	10	25	35	4	0	0
	Earth External Processes Lab/ Physical Geology and GeochemistryLab	2	0	15	15	0	0	4
UGP/302/C-2C	Discipline-2	4	10	25	35	4	0	0
	Discipline-2 Lab	2	0	15	15	0	0	4
UGP/303/C-3C	Discipline-3	4	10	25	35	4	0	0
	Discipline-3 Lab	2	0	15	15	0	0	4
UGP/GEL/304/SEC-1	Field Geology-I	2	10	40	50	0	0	4
Total		**20**	**40**	**160**	**200**			

SEMESTER-IV

COURSE CODE	COURSE TITLE	CREDIT	MARKS			No. of hours		
			IA	ESE	TOTAL	Lec	Tu	Pr
UGP/GEL/401/C-T1D & UGP/GEL/401/C-P1D	Natural Resources/ Introduction to Natural Hazards and Disaster Management	4	10	25	35	4	0	0
	Natural Resources Lab/ Introduction to Natural Hazards and Disaster Management lab	2	0	15	15	0	0	4
UGP/402/C-2D	Discipline-2	4	10	25	35	4	0	0
	Discipline-2 Lab	2	0	15	15	0	0	4
UGP/403/C-3D	Discipline-3	4	10	25	35	4	0	0
	Discipline-3 Lab	2	0	15	15	0	0	4
UGP/GEL/404/SEC-2	Field Geology-II	2	10	40	50	0	0	4
Total		**20**	**40**	**160**	**200**			

SEMESTER-V

COURSE CODE	COURSE TITLE	CREDIT	MARKS			No. of hours		
			IA	ESE	TOTAL	Lec	Tu	Pr
UGP/GEL/501/DSE-1TA & UGP/GEL/501/DSE-1PA	Introduction to Fuel Geology/ Mineral Exploration	4	10	25	35	4	0	0
	Introduction to Fuel GeologyLab/ Mineral Exploration Lab	2	0	15	15	0	0	4
UGP/502/DSE-2B	Discipline-2	4	10	25	35	4	0	0
	Discipline-2 Lab	2	0	15	15	0	0	4
UGP/503/DSE-3B	Discipline-3	4	10	25	35	4	0	0
	Discipline-3 Lab	2	0	15	15	0	0	4
UGP/GEL/504/SEC-3	Field Geology-III	2	0	15	15	0	0	4
Total		**20**	**40**	**160**	**200**			

SEMESTER-VI

COURSE CODE	COURSE TITLE	CREDIT	MARKS			No. of hours		
			IA	ESE	TOTAL	Lec	Tu	Pr
UGP/GEL/601/DSE-1TB& UGP/GEL/601/DSE-1PB	Basics of River Science/Geotectonics	4	10	25	35	4	0	0
	Basics of River ScienceLab/Geotectonics Lab	2	0	15	15	0	0	4
UGP/602/DSE-2B	Discipline-2	4	10	25	35	4	0	0
	Discipline-2 Lab	2	0	15	15	0	0	4
UGP/603/DSE-3B	Discipline-3	4	10	25	35	4	0	0
	Discipline-3 Lab	2	0	15	15	0	0	4
UGP/GEL/604/SEC-4	Field Geology-IV	2	0	15	15	0	0	4
Total		**20**	**40**	**160**	**200**			

2.1 Choices for Core Courses

Core subjects (to be chosen 4 subjects out of the following)			
Introduction to Geology	Pedology	Minerology and Petrology	Introduction to Palaeontology
Earth External Processes	Physical Geology and Geochemistry	Natural Resources	Introduction to Natural Hazards and Disaster Management

2.2 Choices for Discipline Specific Electives

Discipline Specific Elective (to be chosen 2 subjects out of the following)			
Introduction to Fuel Geology	Mineral Exploration	Basics of River Science	Geotectonics

2.3 Choices for Skill Enhancement Courses

Skill Enhancement Course-1	Field Geology I
Skill Enhancement Course-2	Field Geology I
Skill Enhancement Course-3	Field Geology III
Skill Enhancement Course-4	Field Geology IV

3. Core Courses

3.1 CoreT1–Introduction to Geology 4 Credits

(i) Course objectives:

This course aims to explore, understand, communicate, and teach the Earth as a planet, its complex processes, past and future evolution and interactions with the society. The main objective is to study the atmosphere, hydrosphere, and lithosphere, including their interaction and interrelationships with the biosphere.

(ii) Course learning outcomes:

Upon completion of this course the students will be able to (a) analyse the interactions between biological, chemical, and physical processes that shape and define the earth system; (b) correlate between the past Earth's evolution and its current changes; and (c) develop effective communication skills to help diffusing major current environmental problems.

(iii) Content of the Course:

Unit 1: Introduction

1. Geology- scope, sub-disciplines and relationship with other branches of sciences

Unit 2: Origin of earth

1. Solar System- Introduction to various planets - Terrestrial Planets and Jovian Planets
2. Meteorites and Asteroids
3. Earth in the solar system, origin of earth
3. Earth's size, shape, mass, density

Unit 3: Solid Earth, Hydrosphere, Atmosphere and Biosphere

1. Seismic waves and Internal layering of the Earth: crust, mantle and core
2. Mechanical layering of the earth- lithosphere, asthenosphere, mesosphere and centrospere.
3. Formation of hydrosphere, atmosphere and biosphere
4. Concept of isostasy

Unit 4: Plate Tectonics

1. Concept of Plate tectonics.
2. Plates and Plate boundaries.
3. Origin of oceans, continents, mountains and rift valleys
4. Earthquake and earthquake belts
5. Volcanoes and volcanism, distribution of volcanoes

Unit 5: Earth's Surface Processes

1. Weathering and Erosion.

2. Soils: types, soil profile, formation of soil.
3. Landforms in deserts, glaciated region and river valleys

Unit 6: Age of Earth

1. Concept of time and geological time scale
2. Concept of Radioactivity and its application in determining the age of the Earth, rocks, minerals and fossils

Suggested Readings:

- Holmes' Principles of Physical Geology. 1992. Chapman & Hall.
- Emiliani, C, 1992. Planet Earth, Cosmology, Geology and the Evolution of Life and Environment. Cambridge University Press.
- Gross,M.G., 1977. Oceanography: A view of the Earth, Prentice Hall.

3.2 Core P1 – Introduction to Geology Lab 2 Credits

List of Practical

1. Study of topographic sheets and description of physiographic features of an area.
2. Study of geological maps with simple outcrop patterns
3. Study of distribution of major lithostratigraphic units on the map of India
4. Study of important rocks and fossils (the items may be fixed by the department concern)

3.3 Core T2- Pedology 4 Credits

(i) Course Objective:

Students will be able to interpret landscapes and their related soil profile, physical, chemical and biological properties of soil affecting different natural parameters and environmental resources, evolution of paleosols through geological timescale.

(ii) Course Outcomes:

At the end of the course the student can appreciate the value of soil

(iii) Content of the course:

Unit 1:

1. Soil forming processes: Physical weathering: loosening and particle size reduction; pressure release; thermal expansion; growth of foreign crystal
2. Chemical weathering: Oxidation; Carbonation; Hydrolysis; Hydration
3. Major buffer maintaining ocean/atmosphere/biosphere O_2 and CO_2, new compounds/minerals of greater volume and lower density; Base Exchange; Chelation
4. Microbial weathering.

Unit 2:

1. General soil forming regimes: Gleization; podzolization; lessivage; ferrallitizatin; calcification; salinization

Unit 3:

1. Modern soils and key pedofeatures: Soil structures; horizons; roots

Unit 4:

1. Introduction to paleopedology and paleosols; role of factors controlling paleosol formation- parent material, climate, vegetation, topography, time.

Unit 5:

1. Introduction to soil taxonomy and paleosol taxonomy

Unit 6:

1. Geochemistry: molecular rations; chemical weathering indices

Unit 7:

1. Diagenetic overprinting in fossil soils: compaction; oxidation of organic matter; cementation; illitization

Unit 8:

1. Geological record of fossil soils: Precambrian paleosols- evolution of palaeo-atmospheric conditions; Paleozoic paleosols- evolution of land animals and plants, coal; Permian-Triassic transition paleosols and extinction events; Mesozoic-Cenozoic paleosols- fossil soils at K-T extinction event, Paleogene fossil soils at green house to ice house transition, evolution of Asian monsoon system; Pleistocene-Holocene paleosols- human impact on landscape and soils, climate change, neotectonics.

Suggested Readings:

- Retallack, G.J. (2001) Soils of the Past: An Introduction to Paleopedology (2nd edition): Oxford, Blackwell Science, Ltd., 416 p.
- Birkeland, P.W. (1999) Soil and Geomorphology. Oxford University Press (430 pp.).
- Bullock, P., Fedoroff, N., Jongeroius, A., Stoops, G., Tursina, T. (1985) Handbook of Soil Thin Section Description. Waine Research Publication, Wolverhampton (152 pp.).
- Sheldon, N.D., Tabor, N.J. (2009) Quantitative paleoenvironmental and paleoclimatic reconstruction using paleosols. Earth-Science Reviews 95, 1–52.
- Stoops, G. (2003) Guidelines for analysis and distribution of soil and regolith thin sections. Soil Sci. Soc. Am., Madison, Wisconsin, 184 pp.
- Soil Survey Staff, (2006) Key to Soil Taxonomy, 10th ed. USDA Resources Conservation Service, Washington D.C. (341 pp.)
- Bhattacharyya T., Sarkar, D., Pal, D. K. (Eds.) Soil Survey Manual. NBSSLUP Publication No 146.

3.4 Core P2 – Pedology Lab **2 Credits**

List of Practical

1. Micromorphic detailing of the paleosols- structure, horizonation, color, rhizocretions, pedogenic carbonate etc.
2. Particle size analysis and clay mineral analysis of the paleosols

3.5 Core T3 Minerology and Petrology **4 Credits**

(i) Course objectives:

This course helps to understand the fundamentals and internal structure of minerals along with descriptive mineralogy. The students will be able to learn the physical and optical properties of the minerals and their occurrences. The course provides better understanding of mineralogy and optical mineralogy and their application involved during the origin and evolution of the rocks. This course aims to enable students to identify different types of rocks (igneous, metamorphic, sedimentary), process of formation and their classification.

(ii) Course learning outcomes:

After studying the course, the students will be able to (a) recognize and describe various physical as well as optical properties of minerals, and (b) identify different types of rocks on Earth and classify them as per their composition and genesis.

(iii) Content of the Course:

Unit 1

1. Minerals-Definitions, Physical and optical properties of minerals
2. Chemical classification of minerals.
3. Internal structure of minerals
4. Atomic structure of silicate minerals

Unit 2

1. Mineralogical Composition of common crustal rocks
2. Mineralogical Composition of mantle
3. Mineralogical Composition of core.

Unit 3

1. Nature of light and optical behavior of crystals
2. Classification of minerals on the basis of optical character

Unit 4

1. Rocks-Definitions and types; Processes of formation of Igneous rocks, sedimentary rocks and metamorphic rocks
2. Classification of Igneous rocks (Hatch, Hatch and Wells and IUGS), sedimentary rocks (Folk) and metamorphic rocks.

Suggested Readings:

- Earth Materials- Introduction to Mineralogy and Petrology, Cornelis Klein and Anthony Philpotts, Cambridge University Press, 2013.
- Understanding Earth (Sixth Edition), John Grotzinger and Thomas H. Jordan, 2010, W.H. Freeman and company, New York.

3.6 CoreP3 – Minerology and Petrology Lab 2 Credits

List of Practical

1. Study of physical properties of common rock forming minerals
2. Study of optical properties of common rock forming minerals
3. Study of common sedimentary, igneous and metamorphic rocks in hand specimens
4. Study of common sedimentary, igneous and metamorphic rocks under microscope

3.7 Core T4 – Introduction to Palaeontology 4 Credits

(i) Course objectives:

The major objectives of this course are to understand the fossilised ancient invertebrate, vertebrate and micro-organisms in the light of their morphology, adaptation, ecology, and evolution. The present course will also throw light on the evidences and records of the earliest life on the earth and major events in the course of evolution of life through the Geological time.

(ii) Course learning outcomes:

The students will be able to (a) identify older life forms with their external and internal features; (b) deduction of ecology with the application of morphological modifications, and (c) apply principles of speciation and evolution.

(iii) Content of the course:

Unit 1: Fossils

1. Definition of fossil; body fossils and trace fossils
2. Fossilization processes
3. Taphonomy: modes of fossil preservation
4. Role of fossils in development of geological time scale

5. Nature and importance of fossil record
6. Fossils sampling techniques.

Unit 2: Species concept

1. Definition of species, species problem in paleontology, speciation
2. Taxonomy: methods of description and naming of fossils, code of systematic nomenclature

Unit 3: Introduction to various fossils groups

1. Brief introduction of important fossils groups: macrofossils (invertebrate, vertebrate), microfossils (forams, spore, pollens), plant fossils and trace fossils.
2. Important age-diagnostic fossils; index fossil
3. Significant fossiliferous horizons of different Phanerozoic basins of India.

Unit 4: Application of fossils

1. Principles and methods of paleoecology, application of fossils in the study of paleoecology, paleobiogeography and paleoclimate; concept of biostratigraphy and biostratigraphic correlation.

Suggested Readings:

- Schoch, R.M. 1989. Stratigraphy, Principles and Methods. VanNostrand Reinhold.
- Clarkson, E.N.K.1998. Invertebrate Paleontology and Evolution George AlIen&Unwin
- Prothero, D.R. 1998. Bringing fossils to life – An introduction to Paleobiology, McGraw Hill.
- Benton, M.J. 2005. Vertebrate paleontology (3rd edition). Blackwell Scientific, Oxford.
- Colbert's Evolution of the Vertebrates: A History of the Backboned Animals Through Time, EdwinH. Colbert, Michael Morales, Eli C. Minkoff, John Wiley & Sons, 1991.

3.8 Core P4 –Introduction to Palaeontology Lab 2 Credits

List of Practical

1. Study of fossils showing various modes of fossilization
2. Study of important fossils from India (list may be prepared by the department concern)
3. Identification of common invertebrate fossils (Bivalvia, Gastropoda, Cephalopoda)
4. Identification of Gondwana flora.

3.9 Core T5–Earth's External Processes 4 Credits

(i) Course objectives:

The course provides an overview of landforms, land forming processes, landscape evolution and how these depend on climate and tectonic regimes, and time. In addition the course also shed light on applied aspects of geomorphology and basic knowledge of natural hazards.

(ii) Course learning outcomes:

Students will be able to analyze how variations in climate, tectonics and environment control the development of landforms, scales of time and space over geomorphological processes. It also explains the applications of geomorphological methods used in research today. Students will also get an preliminary idea on Natural calamities.

(iii) Content of the Course:

Unit 1

1. Introduction to exogenic processes
2. Earth surface processes and geomorphology
2. Historical development in concepts, terrestrial relief, scales in geomorphology.

Unit 2

1. Energy flow and relative energy of surface processes.
2. Weathering and associated landforms; erosion; formation of soils, processes of formation of important landforms on Earth.

Unit 4

1. Controlling factors (tectonics, climate, sea level changes and anthropogenic) of surface processes
2. Climate change and geomorphic response of fluvial systems of arid and humid regions Geomorphic response to tectonics, sea level/base level change, anthropogenic affects

Unit 5

1. Surface processes and natural hazards
2. Applied aspects of geomorphology

Suggested Readings:

- Alien, P.A., 1997. Earth Surface Processes, Blackwell publishing.
- Bloom, A.L., 1998. Geomorphology: A Systematic Analysis of Late Cenozoic Landforms, Pearson Education.
- Bridge, J.S. and Demicco, R.V., 2008. Earth Surface Processes, Landforms and Sediment Deposits,
- Cambridge University Press.
- Esterbrook, D.J., 1992. Surface Processes and Landforms, MacMillan Publ.
- Kale, V.S. and Gupta A 2001 1ntoduction to Geomorphology, Orient Longman Ltd.
- Leeder, M. and Perez-Arlucea M 2005 Physical processes in earth and environmental sciences, Blackwell' publishing.
- Summerfield M A 1991Globle Geomorphology Prentice Hall.
- Wllcock, P.R., Iverson R M (2003) Prediction in geomorphology ' AGU Publication.

3.10 Core P5 – Earth's External Processes Lab 2 Credits

List of Practical

1. Reading topographic maps. Preparation of a topographic profile.
2. Study and interpretations of different landforms on maps
3. Preparation of longitudinal profile of a river.

3.11 Core T6 – Physical Geology and Geochemistry 4 Credits

(i) Course objectives:

This course aims to explore, understand, communicate, and teach the Earth as a planet, its internal structure and evolution. The course also aims to give an introduction to formation of earth and solar system, cosmic abundances and geochemical classification of elements, basic concepts of Geochronology.

(ii) Course learning outcomes:

Upon completion of this course the students will be able to (a) analyse the interactions physical processes that shape and define the earth system; (b) correlate between the past Earth's evolution and its current changes; and (c) develop knowledge on age of planet earth, rocks and minerals.

(iii) Content of the course:

Unit 1

1. Continents, continental margins, oceans

Unit 2

1. Earth's interior – variation of physical quantities and seismic wave velocity inside the earth, major sub divisions (crust, mantle, core) and discontinuities.
2. Concepts of Isostasy; Airy and Pratt Model
3. Constitutions of Core and mantle: Seismological and other geophysical constraints; phase transition within the mantle
4. Convection in the mantle

Unit 3

1. Geothermal gradient and internal heat of the Earth
2. Earth's magnetic field: Character and genesis.

Unit 4

1. Origin of elements/nucleosynthesis. Cosmic abundance of the elements in the solar system and in the planet earth

2. Geochemical classification of elements.
3. Earth accretion and early differentiation
4. Isotopes and their applications in understanding Earth processes. Stable isotopes: Stable isotope fractionation; basic introduction to radiogenic isotopes; Concept of Geochronology; radiometric dating of rocks and minerals

Unit 5

1. Basic concept of environmental geochemistry
2. Geological disposal of nuclear waste
3. Lead and other heavy metals in environment and their effect on human health

Suggested Readings

- Holmes, A., Principles of Physical Geology, 1992, Chapman and Hall
- Condie, K.C. Plate Tectonics and Crustal Evolution, Pargamon Press, 1989.
- Krauskopf, K. B., & Dennis, K. Bird, 1995, Introduction to Geochemistry. McGraw-Hill Faure, G. Principles and Applications of Geochemistry, 2/e (1998), Prentice Hall, 600 pp.
- Anderson, G. M. (1996). Thermodynamics of natural systems. John Wiley & Sons Inc.
- Steiner, E. (2008). The chemistry maths book. Oxford University Press.
- Yates, P. (2007) Chemical calculations. 2nd Ed. CRC Press.
- Turcotte, D. and Schubert, G. Geodynamic. Second Edition. Cambridge

3.12 Core P6 – Physical Geology and Geochemistry Lab 2 Credits

List of Practical

1. Method of plotting in triangular diagrams
2. Projection of major element data on Harker's diagram to characterize magmatic differentiation
3. Study of trace elements through a) Projection of chondrite/primitive normalized trace elements to characterize sources b) Projection of trace elements on tectonic discrimination diagrams
4. Problems on isostasy

3.13 Core T7 – Natural Resources 4 Credits

(i) Course objectives:

To impart knowledge of formation and utilization of natural resources to train students about the occurences and exploration techniques of minerals and fuels, and estimation of their reserves.

(ii) Course learning outcomes:

Upon successful completion of course the students would be able to (a) understand the basic concept of occurrences, distribution and exploration of natural resources (coal, petroleum, nuclear fuels and other unconventional natural resources).

(iii) Content of the Course:

Unit 1: Earth Resources

1. Definitions: Resource reserve; mineral, energy; water resources
2. A brief overview of classification of mineral deposits with respect to processes of formation

Unit 2: Definition of Energy: Primary and Secondary Energy

1. Difference between Energy, Power and Electricity
2. Renewable and Non-Renewable sources of energy
3. The concept and significance of Renewability: Social, Economic, Political and Environmental dimension of energy

Unit 3: Major Types and Sources of Energy

1. Petroleum and Natural Gas
2. Coal
3. Nuclear Fuel; Gas Hydrate
4. Potential of Hydroelectric Power, Solar Energy, Wind, Wave and Biomass Based power and Energy

Unit 4: Ground Water, Hydropower, Solar power

1. Ground water resources in India and its role in economic development of the country
2. Current scenario and future prospects of Solar Power, Hydrogen Power and Fuel Cells.

Suggested Readings:

- Energy and the Environment by Fowler, J.M 1984. McGraw-Hill
- Global Energy Perspectives by Nebojsa Nakicenovic 1998, Cambridge University Press.
- Energy Resources and Systems: Fundamentals and Non-Renewable Resources by Tushar K. Ghosh and M. A. Prelas. 2009, Springer
- Introduction to Wind Energy Systems: Hermann-Josef Wagner and Jyotirmay Mathur. 2009, Springer.
- Renewable Energy Conversion, Transmission and Storage. Bent Sorensen, 2007, Springer.

3.14 Core P7 – Natural Resources Lab **2 Credits**

List of Practical

1. Study of coal in hand specimen
2. Plotting of major Indian oil fields on map of India
3. Plotting of major Indian coal fields on map of India
4. Problems related to assessment of possible oil exploration site from geological maps and sections.
5. Reserve estimation of coal
6. Construction of cross section of mineral deposits from maps and drill hole data.
7. Preparation and interpretation of depth to water level maps and water level contour maps

3.14 Core T8–Introduction to Natural Hazards and Disaster Management 4 Credits

(i) Course objectives:

The course provides knowledge on foundations of hazards, disasters and associated natural/anthropogenic phenomena, familiarity with disaster management theory, risk assessment, techniques of monitoring and design regarding the pre-, syn- and post-disaster Management.

(ii) Course learning outcomes:

Upon completion of this course the students will be able to aware and get knowledge on the vulnerability and susceptibility, mitigation, recovery and rehabilitation and other related issues on natural hazards and disaster management.

(iii) Content of the Course:

Unit 1

1. Natural Hazards: Concept, Types of hazards

Unit 2

1. Concepts of Disaster
2. Types of disaster: natural and manmade - cyclone, flood, landslide, land subsidence, fire, earthquake, tsunami and volcanic eruption
3. Issues and concern for various causes of disasters

Unit 3

1. Disaster management, mitigation, and preparedness
2. Techniques of monitoring and design regarding the Disaster Management issues

Unit 4

1. Disaster Management in India:
2. Assessing Hazards and Risks, Vulnerability and Susceptibility, Hazard Mitigation through capacity building
3. Legislative responsibilities of disaster management; disaster mapping, assessment Pre-disaster risk & vulnerability reduction
4. Disaster preparation: Pre- disaster: reduction of risk & vulnerability; Syn-disaster and Post-disaster: recovery and rehabilitation
5. Citation of examples from India regarding different issues of Disaster Management

Unit 5

1. Hazard Zonation Mapping

Suggested Readings:

- Bell, F.G., 1999. Geological Hazards, Routledge, London.
- Bryant, E., 1985. Natural Hazards, Cambridge University Press.
- Smith, K., 1992. Environmental Hazards. Routledge, London.
- Subramaniam, V., 2001. Textbook in Environmental Science, Narosa International

3.16 Core P8–Introduction to Natural Hazards and Disaster Management Lab 2 Credits

List of Practical

1. Study of seismic profile of a specific area and its interpretation
2. Plotting of earthquake prone zone on map of India
3. Exercise on Hazard Zonation Mapping

4 Department Specific Electives

4.1 DSE T1 – Introduction to Fuel Geology 4 Credits

(i) Course objectives:

To impart knowledge of formation and utilization of fossil fuels and nuclear fuels and to train students about the exploration techniques of fuels and estimation of their reserves.

(ii) Course learning outcomes:

Upon successful completion of course the students would be able to (a) understand the basic concept of occurrences, distribution and exploration of coal, petroleum and nuclear fuels.

(iii) Content of the Course:

Unit 1: Energy Resources

1. Different Sources of energy: Global and Indian scenario.

Unit 2: Coal

1. Definition and origin of Coal.
2. Basic classification of coal.
3. Fundamentals of Coal Petrology - Introduction to lithotypes, microlithotypes and macerals in coal.
4. Proximate and Ultimate analyses.
5. Major coal basins of India.

Unit 3: Coal as a fuel

1. Concept of clean coal technology.
2. Coal Bed Methane (CBM): global and Indian scenario.

3. Underground coal gasification
4. Liquefaction of coal

Unit 4: Petroleum

1. Chemical composition and physical properties of crudes oil
2. Origin and migration of petroleum
3. Kerogen: Maturation of kerogen; Biogenic and Thermal effect

Unit 5: Petroleum Reservoirs and Traps

1. Reservoir rocks: general attributes and petrophysical properties.
2. Classification of reservoir rocks - clastic and chemical
3. Cap Rocks: definition and general properties, anticline theory and trap theory
4. Hydrocarbon traps: definition, Classification of hydrocarbon traps - structural, stratigraphic and combination
5. Time of trap formation and time of hydrocarbon accumulation.
6. Petroliferous basins of India
7. Plate tectonics and global distribution of hydrocarbon reserves

Unit 6: Other fuels

1. Nuclear Fuel
2. Gas Hydrate

Suggested Readings:

- Chandra D. (2007). Chandra's Textbook on applied coal petrology. Jijnasa Publishing House.
- Shelly R. C. (2014). Elements of Petroleum geology: Third Edition, Academic Press
- Bjorlykke, K. (1989). Sedimentology and petroleum geology. Springer-Verlag.
- Bastia, R., & Radhakrishna, M. (2012). Basin evolution and petroleum prospectively of the continental margins of India (Vol. 59). Newness.

4.2 DSE P1 – Introduction to Fuel Geology Lab 2 Credits

List of Practical

1. Study of hand specimens of coal
2. Reserve estimation of coal
3. Section correlation and identification of hydrocarbon prospect
4. Panel and Fence diagrams
5. Study of different types of well logs in petroleum exploration

4.2 DSE T2 – Mineral Exploration 4 Credits

(i) Course objectives:

The course provides the essential and basic concepts of mineral exploration techniques and the art and science of mining mineral resources.

(ii) Course learning outcomes:

The course envisages to expose the students to the topics such as geology in mining industry, methods of exploration, sampling principle, methods, estimation of reserves.
Thus, this course tries to impart skills related to Geology in mining and enable him/her to perform duties of a geologist at the mining site.

(iii) Content of the Course:

Unit 1: Mineral Resources

1. Resource: Definitions, Mineral resources in industries – historical perspective and present scenario, classification of mineral deposits with respect to processes of formation; exploration strategies.

Unit 2: Concept of Mining, Drilling and Logging

1. Basic **Concept of Mining**
2. Mining Methods
3. Core and non-core drilling
4. Planning of bore holes and location of boreholes on ground Core-logging

Unit 3: Mineral Prospecting and Exploration.

1. Principles of mineral exploration
2. Prospecting and exploration: conceptualization, methodology and stages, Sampling, subsurface sampling including pitting, trenching and drilling
3. Geochemical exploration
4. Outline of exploration techniques for ferrous and non-ferrous metals, limestone and coal and petroleum

Unit 4.: Evaluation of data

1. Evaluation of sampling data - Mean, mode, median, standard deviation and variance

Unit 5: Reserve estimations and Errors

1. Principles of reserve estimation, Factors affecting reliability of reserve estimation
2. Reserve estimation based on geometrical models (square, rectangular, triangular and polygon blocks)
3. Regular and irregular grid patterns
4. Statistics and error estimation

Unit 6: Mineral resources in India

1. Temporal and geographic distribution of major mineral resources in India

Suggested Readings:

- Clark, G.B. 1967. Elements of Mining. 3rd Ed. John Wiley & Sons.
- Arogyaswami, R.P.N. 1996 Courses in Mining Geology. 4th Ed. Oxford-IBH.
- Moon, C.J., Whateley, M.K.G., Evans, A.M., 2006, Introduction to Mineral Exploration, Blackwell Publishing.

4.4 DSE P2 – Mining and Mineral Exploration Lab 2 Credits

List of Practical

1. Identification of anomaly: Gravity and Magnetic
2. Concept of weighted average in anomaly detection
3. Geological cross-section
4. Models of reserve estimation

4.5 DSE T3 – Basics of River Science 4 Credits

(i) Course objectives:

The objectives of the river science are to understand the action of rivers, the related products and fluvial hydrodynamics.

(ii) Course learning outcomes:

The students will be able to understand about the stream hydrology, river basin, river drainage, rivers in space and time, channels and landscapes, and fluvial hazards.

(iii) Content of the Course:

Unit 1: Stream hydrology

1. Basic stream hydrology
2. Physical properties of water, sediment and channel flow
3. River discharge, River hydrographs and its application

Unit 2: River basin

1. Sediment source and catchment erosion processes Sediment load and sediment yield
2. Sediment transport processes in rivers
3. Erosion and sedimentation processes in channel.

Unit 3: Drainage

1. Drainage network
2. Evolution of drainage network in geological time scale.
3. Concept of Watershed

Unit 4: Rivers in time and space

1. River diversity in space, Patterns of alluvial rivers - braided, meandering and anabranching channels, Dynamics of alluvial rivers
2. Channel patterns in stratigraphic sequences
3. Different classification approaches in fluvial geomorphology and its applications.

Unit 5: Channels and Landscapes

1. Bedrock channels, Bedrock incision process
2. River response to climate, tectonics and human disturbance
3. Bedrock channel processes and evolution of fluvial landscapes.

Unit 6: Fluvial hazards

1. Integrated approach to stream management
2. Introduction to river ecology.

Suggested Readings:

- Davies, T. (2008) Fundamentals of hydrology. Routledge Publications.
- Knighton, D. (1998) Fluvial forms and processes: A new perspective. Amold Pubs.
- Richards. K. (2004) Rivers: Forms and processes in alluvial channels. Balckburn Press.
- Bryirely and Fryirs (2005) Geomorphology and river management. Blackwell Pub.,
- Julien, P.Y. (2002) River Mechanics. Cambridge University Press.
- Robert, A. (2003) River Processes: An introduction to fluvial dynamics. Arnold Publications.
- Vanoni, V.A. (2006) Sedimentation Engineering. ASCE Manual, Published by American Society of Civil Engineering,
- Tinkler, K.J., Wohl, E.E. (eds.) 1998. Rivers over rock. American Geophyscial Union Monograph, Washington, DC.

4.6 DSE P3 – Basics of River Science Lab 2 Credits

List of Practical

1. Stream power calculation, Longitudinal profile analysis
2. Study of drainage pattern
3. Hydrograph analysis and other related problems

4.7 DSE T4 –Geotectonics **4 Credits**

(i) Course objective:

To impart knowledge about Geotectonic Processes, and to train the students about the Crustal evolution, internal processes of earth, concept of internal layering of earth.

(ii) Course learning outcomes:

Upon successful completion of course the students would be able to understand the origin and evolution of early earth systems, continental drift, sea floor spreading and plate tectonics, origin and evolution of continental crust.

(iii) Content of the Course:

Unit 1: Introduction

1. Definition. Continents and oceans. Origin of Continental and oceanic crust. Internal processes of earth
2. Concept of lithosphere and asthenosphere. Physical character of lithosphere and asthenosphere. Concept of plate.
3. Concept of hot spot and mantle plume. Ophiolites. Palaeomagnetism.

Unit 2: Plate and Plate boundaries

1. Plates: Physical character of plates. Macro and micro plates.
2. Plate boundaries: types, character, Identification of boundaries. Movement of plates along boundaries. Plate velocities.
3. Volcanic arcs, island arcs, trenches, accretionary prisms, oceanic ridges, transform faults. Magmatism in oceanic ridges and in subduction zones

Unit 3: Continental Drift, Sea floor spreading and Plate tectonics

1. Wegner Continental drifts hypothesis and its evidences. Continental position in the past
2. Sea-floor spreading process and its evidences.
3. Plate tectonics model and its evidences. Distribution of plates in the Earth

Unit 4: Plate Motion

1. Palaeomagnetism and motion of plates
2. Driving mechanisms of plates. Plate tectonics and mantle convection.
3. Supercontinents and their breakup and assembly. Wilson cycle

Suggested Readings:

- Turcotte, D.L. and Schubert, G. Geodynamics. Second Edition. Cambridge
- Kearey, p., Klepeis, K. A., and Vine, F. J. (2009). Global Tectonics. Third edition. Wiley-Blackwell, Oxford.

4.8 DSE P4 – Geotectonics Lab 2 Credits

List of Practicals

1. Position of Indian sub-continent during different geological times between break-up of Gondwanaland and formation of the Himalayas.
2. Different satges of Atlantic Ocean formation with respect to continental rift system.
3. Distribution of volcanoes along Ring of Fire in Pacific Ocean.
4. Schematic drawings of different stages of ocean-continent collision and continent-continent collision.

5. Skill Enhancement Course

5.1 SEC T1 – Field Geology I

Field Geology I - Basic Field Training 2 Credits

Unit 1

1. Topographic sheet: Toposheet indexing, Legend of different geomorphic and man-made features, scale of toposheet. Map reading.

Unit 2

1. Use of topographic sheets in field. Marking location in topographic sheet using physical features and bearing.
2. Use of GPS in field.
3. Distance, height and pace approximation in field.

Unit 3

1. Identification of rock types.
2. Identification of sedimentary and tectonic structures in field.

Unit 4

1. Clinometer and Brunton compass: Use of the instruments in measuring geological data in field. Techniques of measurement of orientation data in field.
2. Litholog measurement

Unit 5

1. Recording field data in maps and notebooks.
2. Report writing.

5.2 SEC T2 - Field Geology II Geological Mapping and Structural Geology Field
2 Credits

Unit 1

1. Preparation of a geological map of a small area with homoclinal or gently folded beds.

Unit 2

1. Stereographic plots of orientation data and their interpretation.

5.3 SEC T3 – Field Geology III

Field Geology III- Stratigraphy and Palaeontology-related field **2 Credits**

List of Visits

1. Study of primary sedimentary structures,
2. Study of taphonomic features,
3. Preparation of stratigraphic column of an area, etc.

5.4 SEC T4 - Field Geology IV

Field Geology IV - Himalayan Geology Field **2 Credits**

List of Visits

1. Preparation of a geological transect map in the Himalayas

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
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

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 honors).

Qualification descriptors for a bachelor's degree programme (General):

Some of the expected learning outcomes that a student should be able to demonstrate on completion of a degree-level programme may include the following:

(a) Demonstrate (i) a fundamental/systematic or coherent understanding of an academic field of study, its different learning areas and applications, and its linkages with related disciplinary areas/subjects; (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.

(b) Use knowledge, understanding and skills required for identifying problems and issues, collection of relevant quantitative and/or qualitative data drawing on a wide range of sources, and their application, analysis and evaluation using methodologies as appropriate to the subject(s) for formulating evidence-based solutions and arguments;

(c) 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).Meet one's own learning needs, drawing on a range of current research and development work and professional materials.

(d) Apply one's disciplinary knowledge and transferable skills to new/unfamiliar contexts, rather than replicate curriculum content knowledge, to identify and analyze problems and issues and solve complex problems with well-defined solutions.

(e) 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. (Geology (Programme) should be able to

A) Acquire

a) 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, 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;

b) 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.

c) 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&GIS, mathematical modeling 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, analyze 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 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. 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 need; e) ICT skills; f) personal skills such as the ability to work both independently and in Teams

Demonstrate professional behavior such as being objective, unbiased, and truthful in all aspects of work and avoiding unethical, irrational behavior 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.