The University of Burdwan

Syllabus for 3-Year Degree/4-Year Honours
in
Geology
under Curriculum and Credit Framework for Undergraduate Programmes (CCFUP) as per NEP, 2020
with effect from 2023-24

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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, Equivalent Course from SWAYAM etc.); DSC - Department Specific Core Course; ESE – End Semester Examination; IA – Internal Assessment; L – Lecture, P/Pr.- Practical; SEC – Skill Enhancement Course; T – Tutorial Th. – Theoretical; CVA – Common Value-Added Course (e.g., Environmental Science / study).

2. Semester-wise credit distribution in different UG programmes of Geology with a single major

Year	Semester	Category of Courses (Credit of each course** x No. of courses)								Semester-wise total credits (No. of courses)
		Major(DSC)	Minor Discipline	Multi-disciplinary	AEC	SEC	CVA Course	Internship/ Apprenticeship	Research Project/ Dissertation	
1st	**I**	(4x1) = 4	(4x1) = 4	(3x1) = 3	(2x1) = 2	(3x1) = 3	(4x1) = 4	--	--	**20**(6)
	II	(4x1) = 4	(4x1) = 4	(3x1) = 3	(2x1) = 2	(3x1) = 3	(4x1) = 4	(4x1) = 4##	-	**20**(6)
	Total credits (courses) up to 2nd Semester	**8**(2)	**8**(2)	**6**(2)	**4**(2)	**6**(2)	**8** (2)	**4** (2)##		**40** (12)
2nd	**III**	(5x2) = 10	(4x1) = 4	(3x1) = 3	(2x1) = 2	(3x1) = 3	-	(2x1) = 2##	-	**22**(6)
	IV	(5x3) = 15	(4x1) = 4	-	(2x1) = 2	-	-	(2x1) = 2##	-	**21**(5)
	Total credits (courses) up to 4th Semester	**33** (7)	**16** (4)	**9**(3)	**8**(4)	**9**(3)	**8**(2)	**4**##	-	**83** (23)
3rd	**V**	(5x3) = 15	(4x1) = 4	-	-	-	-	(2x1) = 2	-	**21** (5)
	VI	(4x4) = 16	(4x1) = 4	-	-	-	-	-		**20** (5)
	Total credits (courses)up to 6th Semester	**64**(14)	**24** (6)	**9**(3)	**8**(4)	**9**(3)	**8**(2)	**2** (1)	-	**124** ((33)
4th	**VII**	(6x4) =24	(4x1) = 4	-	-	-	-	-	-	**28** (5)
	VIII	(6x1) = 6 (4x3) = 12@	(4x1) = 4	-	-	-	-	-	12$$	**22** (3/5)
	Total credits (courses) up to 8th Semester for UG Hons. with research	**94** (19)	**32** (8)	**9**(3)	**8**(4)	**9**(3)	**8**(2)	**2** (1)	**12**$$	**174** (41)
	Total credits (courses)up to 8th Semester for UG Hons. without research	**106** (22)	**32** (8)	**9**(3)	**8**(4)	**9**(3)	**8**(2)	**2** (1)		**174** (43)

** ***Credit of each course***: Major courses (DSC) – 4 / 5 / 6; Minor discipline – 4; Multidisciplinary – 3; AEC – 2; SEC – 3; CVA – 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.

@@Required if a student opt for certification of B. Sc. (Honours) after 4th year and not required if a student is eligible and opt for B. Sc. (Honours with Research) after 4th year.

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

3. Semester-wise detailed course curriculum

SEMESTER-I

COURSE CODE	COURSE TYPE	COURSE TITLE	Credit	Lecture	Tutorial	Practical/ Viva	Full Marks	Distribution of Marks		
								Theory	Pr. /Tuto/ Viva	IA
GEOL1011	Major	Earth System Science	4	3	1	0	75	60	0	15
GEOL1021	Minor*	Earth System Science	4	3	1	0	75	60	0	15
GEOL1031	Multi-disciplinary-1*	Introduction to Geology	3	2	1	0	50	40	0	10
	AEC [L_1-1 MIL]	Arabic/Bengali/Hindi/Sanskrit/ Santali/Urdu or equivalent Course from SWAYAM	2	2	0	0	50	40	0	10
GEOL1051	SEC-1	Techniques in Field Geology	3	2	1	0	50	30	10	10
	Common Value Added (CVA) Course	Environmental Science / Education	4	3	0	1	100	60	20	20
Total in Semester- I			**20**				**400**			

SEMESTER-II

COURSE CODE	COURSE TYPE	COURSE TITLE	Credit	Lecture	Tutorial	Practical/ Viva	Full Marks	Distribution of Marks		
								Theory	Pr. /Tuto/ Viva	IA
GEOL2012	Major	Mineral Science	4	3	1	0	75	60	0	15
GEOL2022	Minor*	Mineral Science	4	3	1	0	75	60	0	15
GEOL2032	Multi-disciplinary-2*	Rocks and minerals	3	2	1	0	50	30	10	10
	AEC [L_2-1]	English or equivalent Course from SWAYAM	2	2	0	0	50	40	0	10
GEOL2052	SEC-2	Study of minerals and rocks	3	0	0	3	50		40	10
	Common Value Added (CVA) Course	Understanding India / Digital & Technological Solutions / Health & Wellness, Yoga Education, Sports & Fitness	4	3/ 3	1/ 0	0/1	100	80/60	0/20	20
Total in Semester- II			**20**				**400**			

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

Skill based vocational course (additional 4 Cr) during summer term for 8 weeks, who will exit after securing 40 Cr

For UG Certificate 40 Cr + Additional 4 Cr (work based vocational course) = 44 Cr students are allowed to re-enter within 3 years within the stipulated maximum period of 7 years.

SEMESTER-III

COURSE CODE	COURSE TYPE	COURSE TITLE	Credit	Lecture	Tutorial	Practical/ Viva	Full Marks	Distribution of Marks		
								Theory	Pr. /Tuto/ Viva	IA
GEOL3013	Major	Elements of Geochemistry	5	4	1	0	75	40	20	15
GEOL3014	Major	Structural Geology	5	3	0	2	75	40	20	15
	Minor*	Intermediate Level Course (Voc.Edn. & Training	4	3/ 3	1/ 0	0/1	75	60/40	0/20 or 60	15
GEOL3033	Multi-disciplinary-3*	Introduction to Geomorphology	3	2	1	0	50	40	0	10
	AEC [L_1-2 MIL]	Arabic/Bengali/Hindi/Sanskrit/ Santali/Urdu or equivalent Course from SWAYAM	2	2	0	0	50	40	0	10
GEOL3053	SEC-3	Field Work (Basic Field Traning)	3	0	0	3	50	0	40	10
Total in Semester- III			**22**				**375**			

SEMESTER-IV

COURSE CODE	COURSE TYPE	COURSE TITLE	Credit	Lecture	Tutorial	Practical/ Viva	Full Marks	Distribution of Marks		
								Theory	Pr. /Tuto/ Viva	IA
GEOL4015	Major	Igneous Petrology	5	3	0	2	75	40	20	15
GEOL4016	Major	Sedimentology	5	3	0	2	75	40	20	15
GEOL4017	Major	Metamorphic Petrology	5	3	0	2	75	40	20	15
	Minor*	Intermediate Level Course (Voc. Edn. & Training	4	3/ 3	1/ 0	0/1	75	60/40	0/20 or 60	15
	AEC [L_2-2]	English or equivalent Course from SWAYAM	2	2	0	0	50	40	0	10
Total in Semester- IV			**21**				**350**			

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

Skill based vocational course (additional 4 Cr) during summer term for 8 weeks, who will exit after securing 83 Cr

For UG Certificate 83 Cr + Additional 4 Cr (work based vocational course) = 87 Cr. students are allowed to re-enter within 3 years within the stipulated maximum period of 7 years.

SEMESTER-V

COURSE CODE	COURSE TYPE	COURSE TITLE	Credit	Lecture	Tutorial	Practical/ Viva	Full Marks	Distribution of Marks		
								Theory	Pr. /Tuto/ Viva	IA
GEOL5018	Major	Palaeontology	5	3	0	2	75	40	20	15
GEOL5019	Major	Petrology Lab	5		0	5	75	0	60	15
GEOL50110	Major	Geodynamics	5	4	1	0	75	60	0	15
GEOL5023	Minor	Introduction to Palaeontology	4	3	0	1	75	40	20	15
	Internship (for all Students)		2	0	0	2	50	Project-30 + Viva-20		
Total in Semester- V			**21**				**350**			

SEMESTER-VI

COURSE CODE	COURSE TYPE	COURSE TITLE	Credit	Lecture	Tutorial	Practical/ Viva	Full Marks	Distribution of Marks		
								Theory	Pr. /Tuto/ Viva	IA
GEOL60111	Major	Introduction to economic geology & Indian Mineral Deposits	4	3	1	0	75	40	20	15
GEOL60112	Major	Fuel Geology	4	3	1	0	75	40	20	15
GEOL60113	Major	Advanced Structural Geology Lab	4	0	0	4	75	0	60	15
GEOL60114	Major	Geomorphology, Remote Sensing & GIS	4	3	0	1	75	40	20	15
	Minor*	Intermediate Level Course (Voc. Edn. & Training	4	3/ 3	1/ 0	0/1	75	60/40	0/20 or 60	15
Total in Semester- VI			**20**				**350**			

SEMESTER-VII

COURSE CODE	COURSE TYPE	COURSE TITLE	Credit	Lecture	Tutorial	Practical/ Viva	Full Marks	Distribution of Marks		
								Theory	Pr. /Tuto/ Viva	IA
GEOL70115	Major	Principles of Stratigraphy & Stratigraphy of India	6	5	1	0	75	60		15
GEOL70116	Major	Ore Geology	6	4	0	2	75	40	20	15
GEOL70117	Major	Field Geology (Geological mapping, Structural Geology / Economic Geology)	6	0	0	4	75		60	15
GEOL70118	Major	Hydrogeology	6	5	0	1	75	40	20	15
GEOL7024	Minor*	Groundwater Geology	4	3	0	1	75	40	20	15
Total in Semester- VII			**28**				**375**			

SEMESTER-VIII

With Research

COURSE CODE	COURSE TYPE	COURSE TITLE	Credit	Lecture	Tutorial	Practical/ Viva	Full Marks	Distribution of Marks		
								Theory	Pr. /Tuto/ Viva	IA
GEOL80119	Major	**Exploration Geology**/Mining Geology	6	5	1	0	75	60		15
GEOL8025	Minor*	Invertebrate Palaeontology	4	3	0	1	75	40	20	15
GEOL8091	Dissertation		12	0	0	12	225	Seminar Presentation, Preparation & submission of Research Project/Dissertation-135 + Viva-90		
Total in Semester- VIII			**22**				**375**			

Without Research

COURSE CODE	COURSE TYPE	COURSE TITLE	Credit	Lecture	Tutorial	Practical/ Viva	Full Marks	Distribution of Marks		
								Theory	Pr. /Tuto/ Viva	IA
GEOL80119	Major	**Exploration Geology**/Mining Geology	6	5	1	0	75	60		15
GEOL80120	Major	**Mineral Beneficiation & Mineral Economics**/ Petroleum Exploration	4	3	1	0	75	40	20	15
GEOL80121	Major	**Engineering Geology** / Physical Geology / natural Hazards & its management	4	3	1	0	75	40	20	15
GEOL80120	Major	Oceanography / **Environmental Geology** / Mathematical Geology / Gemology	4	3	1	0	75	60		15
GEOL8025	Minor*	Invertebrate Palaeontology	4	3	0	1	75	40	20	15
Total in Semester- VII			**22**				**375**			
TOTAL CREDITS / MARKS			**174**				**3000**			

***** To be opted by the students having major course of other discipline
$ Exclusively for programme certification of B. Sc. (Honours) in Geology after 4th year
@ Exclusively for programme certification of B. Sc (Honours with Research) in Geology after 4th year

Detailed Syllabus

SEMESTER I

DSC-1/MINOR-1: EARTH SYSTEM SCIENCE

[DSC: Cr. 4 (L:3 T:1 P:0)]
[MINOR: Cr. 4 (L:3 T:1 P:0)]

(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) Course Content:

Unit 1: Introduction to Earth System Science
Branches of Earth Science and their objectives and applications; General characteristics and origin of the Universe, Solar System and its planets; Terrestrial and jovian planets; Meteorites and Asteroids; Earth in the solar system - origin, size, shape, mass, density, rotational and revolution parameters and age of Earth.

Unit 2: Solid Earth and associated spheres
Internal structure of the Earth- crust, mantle and core; Major and minor discontinuities in the Earth; Seismic wave velocity inside the Earth; Layering of the Earth based on rheological properties of earth material - lithosphere, asthenosphere, mesosphere and centrosphere; Convection in Earth's core and mantle; Preliminary knowledge of distribution of elements in crust, mantle and core; Earth's magnetic field; Sources of Earth's internal heat.Pressure and temperature variations with depth within the Earth; Heat flow in Earth; Elementary idea of hydrosphere, atmosphere and biosphere; Rock cycle and geochemical cycle.

Unit 3: Earth's processes
Surface processes: weathering, erosion, mass wasting and deposition; Endogenic and exogenic processes; Geological action of river, wind and glacier; Geomorphological features of Earth: Concept of geoid, topography, hypsometry and bathymetry; Drainage basin and drainage pattern; Formation of soil and soil profile; Palaeosol.

Unit 4: Tectonics and magmatism in the Earth
Elementary idea of the concept of continental drift, sea-floor spreading and plate tectonics; Concept of plates and plate boundaries. Definition of important geodynamic elements of the Earth e.g., Mid Oceanic Ridges (MOR), trenches, transform faults, island arcs, volcanic islands; Oceanic plateau; Origin of mountain belts and rift valleys. Earthquake – its causes and effects; Earthquake belts of the Earth; Scales of measurement of earthquake; Prevention and mitigation of earthquake; Prediction of earthquake; Volcanoes - types, products and their distribution, origin; Concept of geodesy and isostasy.

Unit 5: Earth's Resources
A brief introduction of minerals and rocks of economic importance, fossil fuel and nuclear fuel.

Unit 6: Understanding the past histories from geologic records
Brief history of development of concepts of Plutonism and Neptunism. Stratigraphy – its definition and scope; Fundamental laws of stratigraphy - concept of uniformitarianism, laws of superposition and faunal succession Geological time scale; Absolute and relative time in geology; Preliminary concept of geochronology and its application in geological studies.

Suggested Readings

- Duff, P. M. D., & Duff, D. (Eds.). (1993). Holmes' principles of physical geology. Taylor & Francis.
- Emiliani, C. (1992). Planet earth: cosmology, geology, and the evolution of life and environment. Cambridge University Press.
- Gross, M. G. (1977). Oceanography: A view of the earth.
- Tarback, E. J. and Lutgens, F.K. (2006). Earth Science. Pearson Prentice Hall. New Jersey.
- Grotzinger, J., Jordan, T.H., Press, F and Siever, R. (2007) Understanding Earth (Fifth Edition). W. H. Freeman and company. New York.
- Environmental Science – Earth as a Living Planet. By – Daniel B. Botkin & Edward A. Keller, John Wiley & Sons.

Multidisciplinary course

[Cr. 3 (L:2 T:1 P:0)]

MULTIDISCIPLINARY-1: INTRODUCTION TO GEOLOGY

(i) Course objectives:

This course gives an overall introduction to Geology. The course presents an understanding of the processes in action on the earth's surface and their impact on man and his institutions

(ii) Course learning outcomes:

The study of this paper strengthens students' knowledge with respect to understanding the essentials of the structural dynamics of the earth. The students will understand the origin of our solar system and planets, including earth. The students are exposed to the Geological time scale and be able to appreciate the dynamics of earth evolution through time.

(iii) Course Content:

Unit 1: Introduction
Introduction to geology: its scope, different branches, and relationship with other branches of sciences.

Unit 2: Solar System and its planets
Solar System: Introduction to various planets - terrestrial and jovian planets. Origin of Earth, it's size, shape, mass, density, rotational and evolutional parameters.

Unit 3: Solid Earth, Hydrosphere, Atmosphere and Biosphere
Seismic waves and internal structure of the Earth – crust, mantle and core; Major and minor discontinuities within the Earth; Mechanical layering of the Earth-lithosphere, asthenosphere, mesosphere and centrosphere. Convection in the Earth's core and mantle; Earth's magnetic field. Geothermal gradient and internal heat of the Earth Elementary idea of formation of atmosphere, hydrosphere and biosphere; Interaction among four spheres – lithosphere, atmosphere, hydrosphere and biosphere.

Unit 4: Earth's External and Internal Processes
Surface processes: weathering and erosion; Various landforms in river valleys, deserts and glaciated region; Earthquake and earthquake belts; Volcanoes and its type; Distribution of volcanoes; Different models of isostasy.

Unit 5: Tectonics, magmatism and mineral resources of the Earth
Preliminary idea of the development of the concept ofplate tectonics. Plates and plate boundaries; Origin of oceans, continents, mountains and rift valleys; Tectonic settings and magmatism; Minerals and fuel resources of the Earth.

Unit 6: Introduction to the concept of time in geological studies
Age of the Earth; Radioactivity and its application in determining the age of the Earth; Absolute and relative time in geology; Geological Time Scale; Concept of Uniformitarianism; Basic laws of stratigraphy.

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.

Skill Enhancement courses

[Cr. 3 (L:2 T:1 P:0)]

SEC-1: TECHNIQUES IN FIELD GEOLOGY

(i) Course objectives:

Students will be acquainted with the equipment used in the geological fieldwork. They will also understand how preliminary surveys are carried out especially in geological terrains. The students will be imparted practical training mainly in the classroom so that they can work independently in the field under the guidance of faculty members.

(ii) Course learning outcomes:

This course is devised to provide basic knowledge of geological equipment and surveying techniques. It also will upgrade and relate the theoretical knowledge of geological aspects to field observations.

(iii) Course Content:

Introduction of field equipment required for geological fieldwork; Concept of scale of maps; Geographical and topographical maps; Topographic map indexing; Reading of topographic sheet: Study of contour pattern and slope interpretation based on contour spacing; Distance, height and pace approximation in the field; Use of clinometer and Brunton compasses: Use of other instruments in measuring geological data in field; Methods of fixing location in topographic sheet by taking back-bearing, using natural and man-made features; How to take field note and Report writing.

SEMESTER II

DSC-2/MINOR-2 – MINERAL SCIENCE

[DSC: Cr. 4 (L:3 T:1 P:0)]
[MINOR: Cr. 4 (L:3 T:1 P:0)]

(i) Course objectives:

This course helps to understand the fundamentals of crystallography and structural chemistry of minerals along with descriptive mineralogy. The students will be able to learn the optical and crystallographic properties of the minerals and their occurrences. The course provides better understanding of crystallography, mineralogy and optical mineralogy and their application involved during the origin and evolution of the rocks.

(ii) Course learning outcomes:

After studying the course, the students will be able to (a) describe and recognize various physical properties of minerals, including lustre, cleavage, hardness, density etc. as well as optical properties; and (b) explain different symmetry elements of the crystals and how these relate to crystal systems.

(iii) Course Content:

Unit 1: Crystallography
Concept of crystalline and amorphous matter; Definition of crystal, Crystal faces and edges; Form and zone; Elementary ideas about crystal morphology in relation to internal structures; Crystal lattice and concept of space group; Classification of crystals into crystal systems and classes; Stereographic projection of crystal faces, symmetry elements and forms; Hermann Mauguin notation.

Unit 2: Atomic arrangements and Mineralogical structure
Atomic arrangements: Unit cell, CCP, FCC and HCP; Ionic radius and coordination, Pauling's rules. Solid solution; Substitution principles – Goldschmidt's rule of substitution of elements; Partitioning of elements between coexisting phases; Brief idea about isomorphism, polymorphism and pseudomorphism: Elementary concept on principle types of common polymorphic forms of C, SiO_2, $CaCO_3$ and Al_2SiO_5

Unit 3: Rock forming minerals
Minerals: definition, physical and other properties (density, cleavage, fracture, parting, habit, hardness, streak, tenacity, elasticity, magnetism., radioactivity, fluorescence, piezoelectricity and pyroelectricity); Classification of minerals (based on structures and chemical parameters) with examples of common silicates, oxides, carbonates, sulphides, sulphates and phosphates; Silicate structures and its classification; Major rock forming mineral groups (viz., feldspar, feldspathoids, olivine, pyroxene, amphibole, mica and garnet) – (a) structural formula, (b) members of the mineral groups, (c) structure, and (d) paragenesis.

Unit 4: Optical Mineralogy
Optical behaviour of crystals - isotropic and anisotropic minerals; Uniaxial and biaxial minerals; Relation between crystallographic and optic axes of crystals; Optical microscope; Nicol prism and its principle of construction; Polaroid in microscope; Refractive index/indices of minerals; Pleochroism and pleochroic scheme; Interference and interference colour; Birefringence; Extinction and extinction angle; Optical indicatrix; Study of interference figure, optic sign of uniaxial and biaxial minerals; Variation of optical and physical properties with chemical composition of mineral groups.

Suggested Readings

- Klein, C., Dutrow, B., Dwight, J., & Klein, C. (2007). The 23rd Edition of the Manual of Mineral Science (after James D. Dana). J. Wiley & Sons.
- Verma, P. K. (2010). Optical Mineralogy (Four Colour). Ane Books Pvt Ltd.
- Deer,W. A., Howie, R. A., &Zussman, J. (1992). An introduction to the rock-forming minerals (Vol. 696). London: Longman.
- Nesse, W. D. (2011). Introduction to Optical Mineralogy (Fourth Edition). Oxford University Press.
- Putnis, A. (1992): Introduction to Mineral Sciences. Cambridge University Press.
- Klein and Hurlbut, Manual of Mineralogy, 21stEdn.

MULTIDISCIPLINARY-2: ROCKS AND MINERALS

[Cr. 3 (L:2 T:1 P:0)]

(i) Course objectives:

Studying the basics of mineralogy and petrology helps in understanding and building the overall knowledge in Geology

(ii) Course learning outcomes:

The students will be able to identify common rock-forming minerals in hand specimens as well as in thin sections. Besides, they will familiarise themselves with Bavarias crystal lattice and crystal systems. The course deals with the study of minerals, their chemistry and identification in hand specimen. Further, it also deals with the study of crystals with respect to their morphology, symmetry and the normal crystal classes.

(iii) Course Content:

Unit 1: Mineralogy
Definitions of minerals Study of crystals; Physical properties of minerals; Optical properties of minerals; Chemical properties of mineral; Classification of minerals based on their chemistry; Origin of minerals; Occurrence of minerals. Introduction to petrological microscope.

Unit 2: Petrology
Rocks-Definitions; Types of rock – igneous, sedimentary and metamorphic;
Igneous Rocks – Modes of occurrence; Structure and texture; Forms of igneous bodies; Magma and its formation within the Earth, consolidation and emplacement; Classification.
Sedimentary Rocks – Modes of formation; Structure and texture; Classification.
Metamorphic Rocks –Agents of metamorphism; Metamorphic grade; Progressive and retrogressive metamorphism; Concept of metamorphic facies; Structure and texture; Classification

Suggested Readings

- Anthony Philpotts (2013) Earth Materials- Introduction to Mineralogy and Petrology, Cornelis Klein and, Cambridge University Press.
- John Grotzinger and Thomas H. Jordan (2010) Understanding Earth (Sixth Edition), WH. Freeman and company, New York.
- Mukherjee Pratip Kumar (1982) A Text book of Geology, The World Press Private Ltd., Calcutta

SEC-2: STUDY OF MINERALS AND ROCKS

[Cr. 3 (L:0 T:0 P:3)]

(i) Course objectives:

Students will be expected to study the minerals and rocks in laboratory and if possible in the field outcrop.

(ii) Course learning outcomes:

This course is devised to enhance the basic knowledge on the study of minerals and rocks.

Course Content:

Unit 1: Study of physical properties of minerals in hand specimen: Study of physical properties of minerals in hand specimen - (a) quartz, feldspar, olivine, pyroxene, hornblende, actinolite and tremolite, muscovite, biotite, garnet, andalusite, sillimanite, kyanite, staurolite, beryl, tourmaline, serpentine, talc, nepheline, zeolite asbestos, (b) chert, chalcedony, agate, jasper, amethyst (c) pyrite, chalcopyrite, galena, sphalerite barite and gypsum; magnetite, haematite, ilmenite, chromite, pyrolusite and psilomelane, graphite, corundum, bauxite; fluorite, calcite, dolomite, apatite.

Unit 2: Study of the symmetry of crystals. Stereographic projection of normal classes;

Unit 3: Study of rocks in hand specimen
Igneous: Granite, granodiorite, diorite, syenite, nepheline syenite, gabbro, anorthosites, ultramafic rocks, basalts, andesites
Metamorphic: Common schists, gneisses, amphibolites marbles and granulites.

Sedimentary: Conglomerate, breccia, sandstone, limestone, shale, mudstone

Unit 4: Study of some important minerals in thin section under microscope: Study of optical properties of common rock-forming minerals: quartz, orthoclase, microcline, plagioclase, perthite and antiperthite, nepheline, olivine, orthopyroxene, clinopyroxene, hornblende, actinolite and tremolite, staurolite, garnet, muscovite, biotite, calcite, kyanite, sillimanite and andalusite.

Special optics (elongation, pleochroic scheme, Z'ΛC, Optic sign).

INTERNSHIP/APPRENTICESHIP

Total Cr. 4

Internship/apprenticeship/work-based vocational education and training can be carried out especially by students who wish to exit after two semesters or four semesters of study.

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 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.

Programme Specific Outcome

The student graduating with the Degree B. Sc. (Honours) 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, 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.

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&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

i. 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.
ii. 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; f) personal skills such as the ability to work both independently and in Teams

Demonstrate professional behaviour such as being 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.