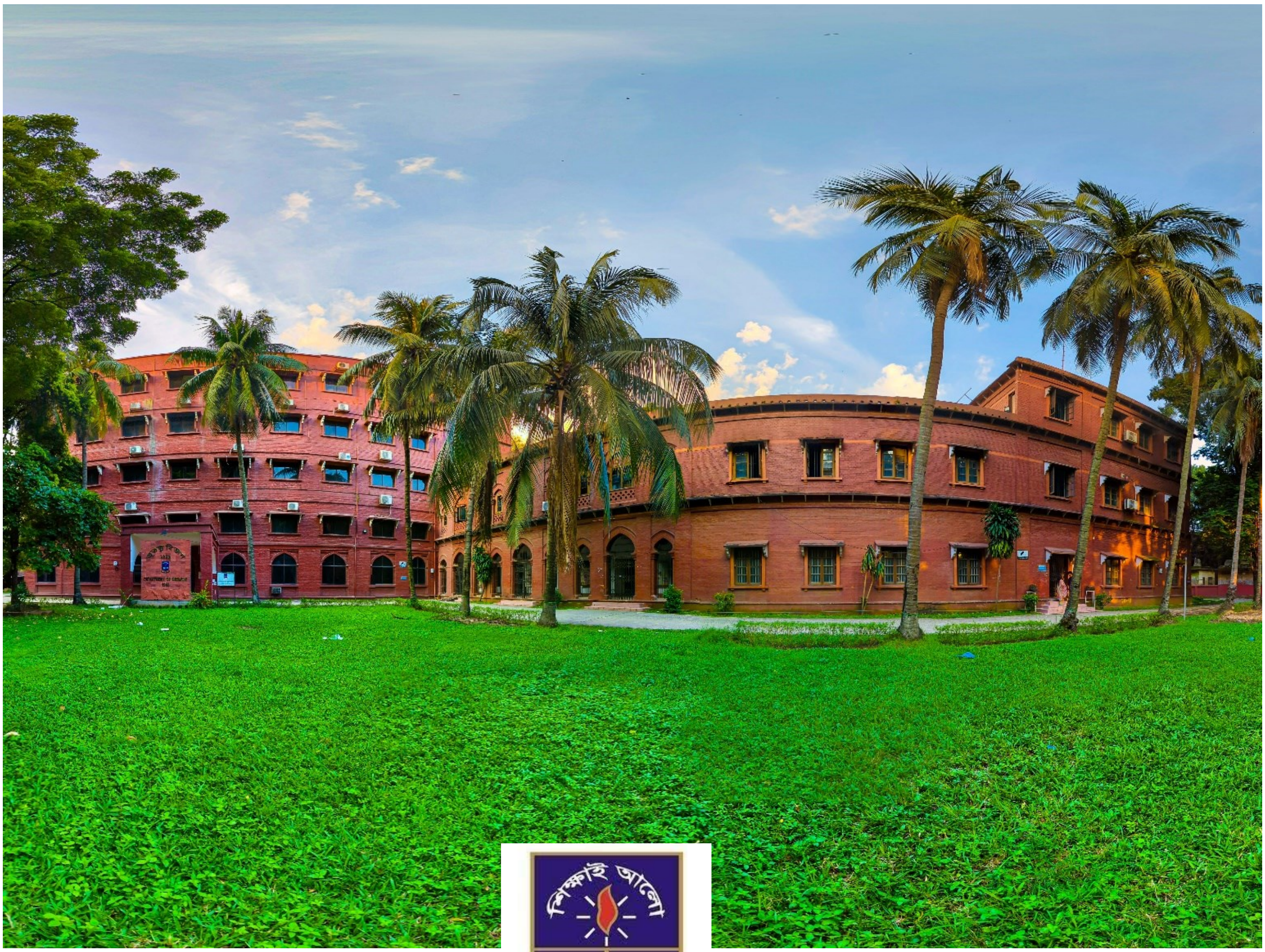
Outcome Based Education (OBE) Curriculum

Bachelor of Science (Honours)

Program in Geology

BS Session: 2024-2025

April 2025



Department of Geology

Faculty of Earth and Environmental Sciences

University of Dhaka

Department of Geology
Faculty of Earth and Environmental Sciences
University of Dhaka (DU)
OBE Curriculum for Bachelor of Science (Honours) Degree in Geology
(Semester System)

1. Introduction to the University of Dhaka

On the first day of July 1921 the University of Dhaka opened its doors to students with Sir P.J. Hartog as the first Vice-Chancellor of the University. The University was set up in a picturesque part of the city known as Ramna on 600 acres of land. The University started its activities with 3 Faculties, 12 Departments, 60 teachers, 877 students and 3 dormitories for the students. At present, the University consists of 13 Faculties, 83 Departments, 12 Institutes, 20 residential halls, 3 hostels, and more than 56 research centers. The number of students and teachers has risen to about 44,895 and 1992, respectively.

At the beginning a distinctive feature of the University of Dhaka was its non-affiliating, residential character like that of the Oxford of England. However, since 1947 the University was given an affiliating mandate in place of an exclusive residential-cum-teaching character. Currently, the University enrolls more than 5,800 students, on merit basis, in the first year Honours Programme in different Departments of the Faculties and the Institutes. Besides conducting teaching courses in the 4- year Bachelor and 1-year Masters Programs, the University also trains up many researchers in different disciplines. More than 1429 PhD and 1377 MPhil Researchers have obtained their degrees from this University.

Renowned for its contributions to education and research, the University of Dhaka is ranked #554 in the QS World University Rankings 2025, #634 in the QS Sustainability Rankings, and #112 in the QS Asia Rankings, securing its place as the top university in Bangladesh. These accolades reflect its commitment to academic excellence, sustainability, and regional leadership. The University of Dhaka is dedicated to the advancement of learning and is committed to promoting research in all fields of knowledge. As there are plans for further expansion of facilities, plans for new avenues and opportunities, the course curricula are updated, and new research projects are undertaken every year. As the pioneer and the largest seat of learning in the country, the University of Dhaka has taken the task of fostering the transformation processes of the individual students and the country through its educational and research facilities keeping up with demands of the day. The University of Dhaka is at this moment one of the leading institutions of higher education in Asia.

2. Introduction to the Faculty of Earth & Environmental Sciences:

The Faculty of Earth and Environmental Sciences (FEES) is one of the newest faculties in the almost a century old University of Dhaka. The FEES started functioning in 2008 with a vision to create a new hub of teaching and research in various fields of earth and environmental sciences to face the major environmental challenges of the 21st Century and achieve sustainable development. The Faculty started with two departments, Geology and Geography and Environment, and subsequent three more, Disaster Sciences and Management, Oceanography, and Meteorology, have been included. Currently FEES teaching and research programs include all the major branches of earth and environmental sciences encompassing aspects covering space to the center of the Earth. The Faculty is led by a Dean, elected by all the teachers of constituting departments once every two years.

Teachers and students in the Faculty of Earth and Environmental Sciences study the physical, chemical, and biological systems of the earth. Using modern observational, analytical, and computational methods, they examine how the planet's interior, surface, hydrosphere, biosphere, and atmosphere have evolved since Earth was born in the solar system 4.6 billion years ago. Topics commonly studied in the constituting departments include how plate movements cause earthquakes, volcanoes, and mountain building; global climate change and how climate change and catastrophic events cause changes in biodiversity; mass extinctions and patterns of evolution through Earth history; how and where economic resources are generated on Earth; how these resources are located and used in modern society; aspects of blue economy; harnessing marine resources; sustainable urbanization; disaster management; spatial planning.

Dean's Award

Students obtaining a BS Honours degree in Geology with CGPA of 3.75 or above without taking any improvement examination or readmission in any academic session shall be eligible for the Dean's Award under the Faculty of Earth and Environmental Sciences. In addition, the student must have an attendance record of 75% or more during the course of study.

3. Introduction to the Department:

Geoscience education in Bangladesh has begun since the establishment of the Geology department in Dhaka University on 23rd April 1949. The department started with only a graduate program (BSc Pass) with the prime aim of providing trained geoscientists to be engaged in the profession of geological mapping, surveying, exploration, extraction/production and management of the country's natural/mineral resources. To fulfill the increasing demand of professional geoscientists, curriculum leading to MSc and BSc honours degrees were introduced in 1957 and in 1967, respectively. Until now the Department remains the largest academia in the country that offers state-of-the-art geoscience education.

The aim is to integrate earth science, social science, and engineering to generate multidisciplinary and comprehensive knowledge and skills, to understand and address complex risk and emergency scenarios and eventually create a resilient society. The Department runs with the vision to provide international standard and high-quality education, engage in collaboration and has particular focus on basic and applied research.

3.1 Research Facilities

The Department presently has 28 academic staff with a wide range of research interests and expertise. Good laboratory facilities are available in the fields of Sedimentology, Petrography, Optical Mineralogy, Paleontology, GIS & Remote sensing, Geochemistry, Structure & Tectonics, Seismology, Geodesy, Geo-resource Exploration, Geohazards, Geotechnical Engineering, Geophysics and Hydrogeology.

The Department also undertakes collaborative research programs with other departments and institutions such as Geological Survey of Bangladesh (GSB), Bangladesh Oil, Gas and Mineral Corporation (Petrobangla), Bangladesh Water Development Board (BWDB), Bangladesh Atomic Energy Commission (BAEC), Department of Public Health Engineering (DPHE), Bangladesh University of Engineering and Technology (BUET), Bangladesh Petroleum Institute (BPI) and other Non-Governmental Organizations. The Department also maintains liaison with geology departments of other universities home and abroad.

3.2 Computer Laboratory

The Department has a good number of IBM compatible PCs which provide support for research in the field of Remote Sensing, GW Modelling and other geological applications. Recently, the Department has established a computer-based GIS laboratory equipped with Scanner, Digitizer, Laser Printer and more PCs.

3.3 Remote Sensing and GIS Lab

This laboratory was established first in 2006 with significant funding support from Columbia University, NY and Geology Department of Dhaka University with 20 PCs. Later, the laboratory was furnished with 50 high performance Desktop PCs built into a Local Area Network through a Server that hosts the floating licenses of ArcGIS software under HEQEP funding of UGC and World Bank. Currently the lab is using the 10.3 version of this software. Both ArcGIS and ERDAS Imagine software are used to teach the 4th year students' fundamental courses in Remote Sensing and GIS. The MS students engaged in thesis research also use this lab to facilitate spatial data interpretation relevant to their research topics. Faculty members also make good use of the lab facilities in their research projects

3.4 Cartographic Facilities

The department has a drafting section equipped with necessary cartographic and drafting gears. The section provides necessary support to the students in preparing base maps and geological maps for field work. The section also provides cartographic services in research activities of the department.

3.5 Geochemistry Lab

The lab is equipped with Atomic Absorption Spectrometer (AAS), Ion Chromatograph (IC) UV-Visible Spectrometer, Flame photometer, Total Organic Carbon (TOC) analyzer to conduct research for the postgraduate students in the field of hydrogeology and environmental geology focusing environmental pollution, groundwater contamination, water quality assessment and management of groundwater resources.

3.6 Engineering Geology Lab

The Geology Department of Dhaka University has a Geological and Geotechnical Engineering Laboratory equipped with the most technologically advanced testing equipment. The laboratory has Fully Automated Cyclic Triaxial Testing Equipment, Universal Triaxial Testing Equipment, Direct Shear Testing Equipment, Consolidation Testing Equipment, PS Logging Equipment. These equipment's have been donated by the European Commission (EC) through the United Nations Development Programme (UNDP) under the Earthquake and Tsunami Preparedness Component of the Comprehensive Disaster Management Programme (CDMP). The Cyclic Triaxial Testing Equipment is used for earthquake research to evaluate the liquefaction potential of the subsurface geological materials subjected to earthquakes that include an evaluation of the dynamic strength of the soil under the foundations of the civil engineering structures. Universal Triaxial Test and Direct Shear Test Equipment are used to determine the shear strength parameters such as internal friction angle and cohesion of geological materials. The shear strength parameters are essential for the foundation design of civil engineering structures, such as building, road, bridge, tunnel, etc. These parameters are also necessary for slope stability analysis of mines and road-cutting in hilly regions. The Consolidation Test Equipment is used to evaluate the consolidation or settlement characteristics of geological materials. Differential settlement under the foundations of civil engineering structures can cause foundation failures. The PS Logger is used to determine the shear wave velocity of the geological materials up to the depth of engineering bed rock. The shear wave velocity is important for the preparation of engineering geological maps which are used in seismic (earthquake) hazard and vulnerability assessment.

3.7 Geology and Geophysics (G&G) Lab

This laboratory was established in 2008 supported by Schlumberger. Schlumberger donated industry standard Software -"Petrel" for Seismic to simulation workflow along with two high end workstations. This software is used for 2D/3D Seismic Visualization and Interpretation, Geological modeling, Reservation characterization and Reservoir Simulation. Hands on training support to the research students and faculty members are provided under University-Industry collaboration with assistance of Schlumberger. The MS students use this advanced lab for their research work which helps them to enhance their capability for a career in Industry and Research. Faculty members also make good use of the lab facilities in their research projects.

3.8 Groundwater Modeling Lab

The research focuses of this laboratory are Groundwater Exploration, Groundwater Flow System Conceptualization, Mapping and Modeling, Groundwater Management & Monitoring, Managed Aquifer Recharge (MAR), Groundwater Arsenic Mitigation, Water Quality Analysis & Monitoring, Pollution source identification and characterization, Agricultural and Industrial Impacts on Groundwater Quality.

3.9 Geoinformatics lab

This laboratory was established in 2020 with three highly configured PCs and required software (ArcGIS, ERDAS Imagine, ENVI) to conduct research in spatial geosciences, mostly for graduate students.

3.10 Sedimentology and Petrography Lab

The sedimentology section of this lab is equipped with a Thin sectioning system to prepare thin section of rock samples, one (1) Trim saw to make accurate cross section cuts through large and heavy pieces of specimens and core samples, one (1) Vacumet to remove the trapped air from the mounting material and eliminate the gap between the specimen and resin during slide preparation, one (1) Magnetic Separator to extract magnetically susceptible minerals from target sample, Two (2) sieve shakers and One (1) laboratory oven for drying the wet samples.

The Petrography section is equipped with, fifty (50) Binocular Microscope for thin section analysis, one (1) Leica DM750 broad field Polarizing Microscope with Leica ICC50 E digital microscope camera set-up for taking photos and projection to large screen with LCD projector, one (1) Photo Polarization Microscope for taking picture of thin sections. Grain size analysis, identification and separation of light and heavy minerals with their proportion, separation of magnetically susceptible minerals from a given sample, thin section preparation, petrographic examination according to the standards (CSA A23.2-15A or ASTM C295) of rock cores and granular materials (fine and coarse aggregates) and petrographic analysis for petroleum reservoir characterization is done in this lab.

3.11 Microscopy Lab

This laboratory is mainly designed for the undergraduate laboratory courses on microscopic examinations of rocks, mineral and microfossils as well as for the graduate students conducting research on various aspects of petrography, mineralogy and micropaleontology.

3.12 Micropaleontology and palynology Lab

This lab is equipped with Research Stereo Microscope, Research Palynological microscope, Laboratory Fume Hood and other instruments related to the extraction of microfossils and pollen from sediment samples. Extraction and analysis of microfossil and pollen from sediment samples, environmental stress monitoring using micropaleontological indicators, paleoenvironmental reconstructions, micrography, identification and classification of microfossils and pollen, identification and characterization of pollutants from marine sediments is studied with the aid of high magnification stereo microscopes.

3.13 Museum

The Department has a geological museum, named after Shaheed Md. Abdul Muktadir, a martyr of the liberation war, who was a faculty of the Department until 1971. The museum has quite a large collection of fossils, minerals, rocks, models, maps and charts. The museum is used as a teaching laboratory for Mineralogy, Crystallography, Petrology, Paleontology and Structural Geology courses.

3.14 Library

Departmental seminar library has a modest collection of books, journals, geological and topographic maps, aerial photographs and satellite images. The library provides reading facilities only for the departmental students.

3.15 Fieldwork

Students of the Department have to take a field mapping course in a geologically suitable area (Mostly in the Chittagong Hill Tracts and Sylhet) in Bangladesh every year during BS (Hons) course. Standard field equipment including geological hammer, survey apparatus, clinometer, Brunton pocket transit, hand GPS, range finder, altimeter, binocular, etc. are available for fieldwork. The duration of the fieldwork is 4 weeks spread over 4 academic years in BS (Honours).

3.16 Advanced Research Centre

The Delta Study Centre, a centre of excellence for advanced research in the field of Bengal delta, was established within the framework of the department in 1991. The centre is equipped with moderate computer facilities. The centre also provides research grant for the students to undertake MS research in the above-mentioned fields.

3.17 Dhaka University Earth Observatory

Bangladesh having situated in an active tectonic region bears, by and large, a character of earthquake proneness. The present seismicity and tectonic setting envisage that about 60% of the country falls in a high-risk zone.

The Department of Geology of Dhaka University has initiated extensive research on earthquake and crustal dynamics in collaboration with Lamont-Doherty Earth Observatory (LDEO) of Columbia University in New York, USA since 2000. The department is housed with the state-of-the-art technology for monitoring earthquakes and three-dimensional crustal deformations known as ‘Dhaka University Earth Observatory (DUEO)’ established in February 2003. The observatory is equipped with a digital broadband seismograph and Global Positioning System (GPS). DUEO is a Foreign Affiliate Member of ‘Incorporated Research Institutions for Seismology (IRIS).

DUEO is a consortium formed in cooperation with Rajshahi University, Khulna University, Chittagong University, Chittagong University of Engineering and Technology (CUET), Patuakhali Science and Technology University (PSTU), Shahjalal University of Science and Technology (SUST).

Dhaka University Earth Observatory operates a network of 6 permanent seismic stations, 6 portable seismographs and 18 continuous geodetic GPS stations in the country. The objective of the Observatory is to carry out research on crustal dynamics, plate motions and to monitor the seismic activity in Bangladesh and surrounding countries, as well as to disseminate information of earthquakes to the government and the public. Data is open to the scientific community.

3.18 Extracurricular Activities

Students of the department actively participate in the Departmental and interdepartmental indoor and outdoor events of games, sports and other cultural activities regularly. There are several student chapters of professional organizations including American Association of Petroleum Geologist (AAPG), Society of Exploration Geophysicist (SEG), and Society of Petroleum Engineers (SPE). Besides, there is an Earth Club, a Cultural Club and a Photographic Club responsible for the arrangement of various cultural activities in the department.

3.19 Scholarship

The department has a few scholarships, and a gold medal award funded under various trust funds donated by alumni and families of former faculty members. **Parvez Memorial Scholarship** has been established since 2000 by the family members of deceased faculty Mr. Parvez Hasan offered a monthly award of Tk 350 to an MS student who secured the highest CGPA at the BS final examination. **Prof. Abdul Hai and Prof. Manzoor Hasan Scholarship** was established in 2009 by former faculty Prof. Manzoor Hasan offering a one-time award of Tk 10,000 to the student securing the highest GPA in 3rd Year Final Examination. **Shah Alam Mazumder Trust Fund** was established in 2017 by Dr. Md Shah Alam Majumder, a geology alumnus to award a **Gold Medal** to the student securing the highest CGPA in BS Honours Final Examination. **Sabrina Sharmin Memorial Trust Fund** was established in 2017 by the students of 32nd Geology Honours batch offering a one-time award of Tk 10,000 to the student securing the highest GPA in 1st Year Final Examination. **Prof. M A Latif Scholarship Fund** has been set up at the Department in 2018 with contributions from the family members of Prof. M A Latif. A monthly scholarship of Tk. 5000 will be awarded preferably to a female student of 2nd year B.S. Honours class, with provisions for renewal up to 4th year, based on both economic conditions and 1st Year Final Examination result.

3.20 Career Opportunity

On completion of their BS honours degree, the graduates from this department are eligible to join various governments, autonomous, private and multinational organizations. Major governmental and autonomous organizations include: Geological Survey of Bangladesh (GSB), Petrobangla, Bangladesh Petroleum Exploration Company (BAPEX), Bangladesh Water Development Board (BWDB), Bangladesh Atomic Energy Commission (BAEC) and Department of Public Health Engineering (DPHE). Other national and international organizations where geologists may build up their career are Institute of Water Modelling (IWM), Centre for Geographic Information Services (CEGIS), International Oil Companies (IOCs) and Mining companies. Besides, these graduates may also join the cadre services through open competition conducted by the Bangladesh Public Service Commission (PSC).

Fresh graduates also get opportunities to work in the different research projects carried out by the faculties of the department in national and international level. Students with better academic records may also pursue higher studies in the department leading to MS (in specialized fields) followed by MPhil or PhD. After achieving the requisite academic qualification, they may be appointed as faculty in the Universities of the country. In addition, a good number of graduates proceed to overseas universities every year for higher studies.

Department of Geology

Faculty of Earth and Environmental Sciences, University of Dhaka

OBE Curriculum for Bachelor of Science (Honours) Degree in Geology

PART A: Introduction

1. **Title of the Academic Program:** Bachelor of Science (Honours) in Geology
2. **Name of the University:** University of Dhaka
3. **Vision of the University**

   The University of Dhaka (DU) strives to build a world-class educational environment that empowers individuals to become skilled, ethical leaders committed to shaping a sustainable future.
4. **Mission of the University (MU)**

The university's established missions for the students are to

- **MU1:** Deliver transformative education that nurtures lifelong learning, supports a knowledge-based society, and promotes scholarship, humanistic values, and technological advancement.
- **MU2:** Advance collaborative research and innovation by building partnerships that push the frontiers of knowledge.
- **MU3:** Cultivate an educational environment rooted in excellence, transparency, inclusivity, and accountability.
- **MU4:** Collaborate with communities and stakeholders to promote justice, equity, diversity, and sustainability.
- **MU5:** Inspire students to become ethically responsible global citizens who contribute positively to society.
- **MU6:** Foster a strong sense of national heritage and pride, while connecting students to their historical roots and the global community.

5. **Name of the Degree:** Bachelor of Science (Honours) in Geology
6. **Name of the Faculty Offering the Program:** Faculty of Earth and Environmental Sciences
7. **Name of the Department Offering the Program:** Department of Geology
8. **Duration of the Program**

   Under the Semester System, the Bachelor of Science (Honours) program in Geology at the University of Dhaka consists of eight semesters spread over four academic years.

9. Eligibility for Admission

- HSC or Equivalent degree in science group
- Other conditions of admission are determined by the University Central Admission Committee in each academic year.

10. Vision of Program

The Bachelor of Science (Honours) in Geology program at the University of Dhaka envisions becoming a regional leader in geoscience education and research, producing globally competent geologists who:

- Advance sustainable exploration and management of Earth's resources.
- Innovate in disaster risk reduction and climate resilience through applied geology.
- Drive scientific and technological progress in collaboration with industry and communities.
- Uphold ethical standards and environmental stewardship in geological practices.

By integrating cutting-edge research, field-based learning, and multidisciplinary approaches, the program aims to empower graduates to address Bangladesh's and the world's pressing geological challenges while fostering academic excellence and societal impact.

11. Mission of the Program (M)

The Bachelor of Science (Honours) in Geology program at the University of Dhaka aims to:

- **M1:** Provide advanced knowledge and practical skills in geosciences to address societal challenges related to natural resources, hazards, and environmental sustainability.
- **M2:** Foster multidisciplinary research and innovation in geology through collaboration with industry, government, and academic institutions.
- **M3:** Prepare graduates for professional careers in geological exploration, hazard mitigation, and resource management, while promoting ethical practices and lifelong learning.

12. Program Educational Objectives (PEOs)

Graduates of the Geology program will:

- **PEO1:** Demonstrate expertise in geological principles, including Earth processes, resource exploration, and hazard assessment.
- **PEO2:** Apply technical and analytical skills to solve real-world problems in geosciences, leveraging modern tools like GIS, remote sensing, and geological-geophysical methods.
- **PEO3:** Contribute to sustainable development by managing natural resources responsibly and mitigating geo-hazards.
- **PEO4:** Engage in collaborative research and professional development to advance geological sciences locally and globally.
- **PEO5:** Communicate geological concepts effectively to diverse stakeholders, including policymakers, communities, and industry partners.

13. Program Learning Outcomes (PLOs)

By graduation, students will be able to:

- **PLO1:** Explain fundamental geological concepts, including Earth's structure, composition and geologic processes.
- **PLO2:** Analyze geological data using field, laboratory, and computational techniques (e.g., GIS, seismic interpretation).
- **PLO3:** Assess natural resource potential and environmental risks through fieldwork and modeling.
- **PLO4:** Design strategies for disaster risk reduction and climate resilience using geological insights.
- **PLO5:** Conduct independent research, interpret findings, and present results adhering to scientific standards.

14. Mapping Program Educational Objectives (PEOs) with Mission of the Program

Mission / PEOs	M1	M2	M3
PEO1	✓	✓	
PEO2	✓	✓	✓
PEO3	✓	✓	✓
PEO4		✓	✓
PEO5	✓		✓

15. Mapping PLOs with PEOs

PEOs / PLOs	PEO1	PEO2	PEO3	PEO4	PEO5
PLO1	✓				
PLO2		✓			
PLO3	✓	✓	✓		
PLO4			✓		
PLO5			✓	✓	✓

16. Graduate Attributes

Sl. No.	Attribute	Description
1	Disciplinary Knowledge	Demonstrate comprehensive knowledge in geological science.
2	Problem Solving	Apply appropriate methods to analyze and propose solutions for complex geological problems.
3	Critical Thinking and Analysis	Evaluate information critically and apply evidence-based reasoning to understand and manage geological issues.
4	Communication Skills	Communicate effectively in oral and written forms across academic, professional, and community settings.
5	Use of Modern Tools and Techniques	Utilize geological-geophysical, GIS, remote sensing, modeling software, numerical simulation, and analytical tools in geological issues.
6	Research and Inquiry	Conduct independent research using scientific methodology to investigate geological problems.
7	Teamwork and Leadership	Work collaboratively in multidisciplinary teams and demonstrate leadership in project and field activities.
8	Ethical, Legal, and Professional Understanding	Understand and uphold ethical, legal, and professional standards in geological science and public service.
9	Lifelong Learning	Recognize the need for continuous learning to remain professionally relevant in the changing global context of geological issues.
10	Social and Environmental Responsibility	Appreciate the socio-environmental implications of geological issues and work for sustainable and inclusive solutions.

PART B: Structure of the Curriculum

1. Grading of the Department according to Higher Education Qualification Levels:

Level	Qualification Grade	Grading Credits
7	Bachelor with Honors/Bachelor‘s (4 years)/BS	140

Students are required to attend the entire program equivalent to 140 credit hours in Geology BS program. Out of total courses, theory courses involve 96 credit hours; laboratory 29 credit hours, field and project work involve 15 credit hours, and viva vocé in every even semester with Satisfactory (S) or Unsatisfactory (U) as non-credit compulsory course.

2. Learning and Teaching Activities Hours:

No.	Teaching-Learning Activities	Notional Hours for 1 Credit
1	Lecture, Seminar and Other Theory Course Activities	40
2	Lab work	60
3	Fieldwork/Research Project	80

Each semester shall be 21 weeks

- 15 weeks for classroom teaching
- 2 weeks for preparatory leave
- 4 weeks for holding the semester final examination (Including Lab and Viva)

3. Total Credit Distribution:

No.	Credit (Theory Course/Lab/Field Work/Research Project	Total Contact Hour (Classroom/Face to Face Teaching)	Total Non-contact Hour (Library Work/Self-Study/ Assignments/Report Writing/ Group Study etc.)
1	3 Credit Theory Course	45 Hours	75 Hours
2	2/3 Credit Lab Course	60/90 Hours	60/90 Hours
3	3 Credit Field Work	7 Days in Field (84 Hours)	96 Hours
4	3 Credit Internship/Research Project	80 Hours	160 Hours

***** (For lecture, tutorial, or seminar: 3 hours of classroom learning per week for 15 weeks. For lab, studio, or clinical work: 6 hours of lab work per week. For Industrial/Workplace Learning: 40 hours of hands-on learning per week for 2 weeks, with non-contact hours equivalent to 3 credits.)

4. The course and credit over eight semesters are illustrated below:

Year	Semester	Number of Courses	Credit
Year One	1st Semester	5	14
	2nd Semester	7	18
Year Two	3rd Semester	6	18
	4th Semester	7	18
Year Three	5th Semester	6	18
	6th Semester	7	18
Year Four	7th Semester	6	18
	8th Semester	7	18
4 Years	8 Semesters	51 Courses	140 Credits

Course and Credit Distribution:

Course/Credit	**Theory**	**Laboratory**	**Viva**	**Field, Internship and Research Project**	**Total**
No. of Courses	32	10	4	5	51
Credit	96	29	S/U*	15	140

*S and U indicate Satisfactory and Unsatisfactory level respectively as non-credit compulsory course.

5. Continuous assessment (40%)

Forty percent of the total marks of a course will be assessed continuously throughout the semester. Ten percent (10%) of the total marks will be awarded for class attendance in both theory and laboratory courses, as outlined in the following table. For theoretical courses, thirty percent (30%) of the marks will be derived from one midterm or in-course examination (20%), and presentations, quizzes, and/or assignments (10%). The midterm or in-course examination will be conducted after covering 40% of the course topics, and the semester coordinator will announce the examination dates at the beginning of the course. Each semester, the midterm examination will be held within a designated 'Midterm Test Week.' For laboratory courses, thirty percent (30%) of the marks will be allocated for continuous class assessment, where the course teacher will award marks based on student performance during laboratory sessions. The field team, as designated by the academic committee, will be responsible for the execution of field courses, the assessment of student field performance (40%), and the evaluation of field reports (60%).

Attendance Marks will be given based on the table below:

Attendance %	**Marks** (Theory Class)	**Marks** (Laboratory Class)
90 and above	10	10
85 to 89	8	8
80 to 84	6	6
75 to 79	4	4
60 to 74	2	2
Less than 60	0	0

6. Course Final Examination (Theory and Laboratory Courses) (60%)

The final exam will account for 60% of the marks. Students must have an official examination admit card, provided by the Controller of Examinations after payment of all semester dues, to appear in the final examination.

7. Eligibility of Sitting for the Final Exam

Eligibility of students will be decided based on the percentage of attendances in all of the courses During the academic session as per following table:

% of Class Attendance	Category	Eligibility
75% and above	Collegiate	Eligible
<75 to 60%	Non-collegiate	Eligible with payment of penalty fee
<60%	Dis-collegiate	Not eligible, however, if he/she has 30% or more attendance can seek readmission if otherwise eligible

8. Duration of Exam

The duration of theoretical course final examinations will be as follows:

Course Type	Credit	Duration of Examination (Hours)
Theory	3	3
	2	2.5
Laboratory	3	4

9. Internship/Research Project

To cultivate personnel adept at problem identification, methodological application, scientific interpretation, and the production of standard reports, each student will have to undertake an internship at a relevant government/semi-government/private organization or an independently supervised study on a specific topic as approved by the academic committee of the department. After completion of the internship, the student will have to submit a written report which will be evaluated by the Examination Committee of the Department and a designated supervisor from the internship-providing organization.
For research project, each student will have developed a project under the guidance of their supervisor and/or co-supervisor, subject to approval by the department's Academic Committee. Students should contact faculty members within their field of interest to select a supervisor and/or co-supervisor. The Academic Committee will approve the final list of supervisors. Upon completion of the project, each student will defend their work and submit a written Project Report. At the discretion of the Academic Committee, projects may also be completed through group work, potentially involving field visits. The written proposal, proposal defense, and final defense will be evaluated by the Examination Committee. The written Project Report will be evaluated by the Project Supervisor or Co-supervisor and an assigned expert designated by the Academic Committee.

10. Viva voce

The examination committee will conduct a Viva-Voce in every even semester upon completion of all theory and practical courses. This non-credit course will be graded as Satisfactory (S) or Unsatisfactory (U). In the 8th semester Viva-Voce, students may be evaluated on all courses taken throughout the four academic years. The students must get Satisfactory (S) grade in all the viva voce.

11. Award of Degree or Graduation

The requirements for a Bachelor of Science (Honours) degree include the successful completion of 140 credit hours without any F grades, a satisfactory grade in the Viva Voce examination, a minimum Cumulative Grade Point Average (CGPA) of 2.0, and completion of the program within six consecutive academic years from the date of admission. The students must also get Satisfactory (S) grade in all the viva voce.

12. Other General regulations

The existing rules for the Bachelor of Science (Honours) program of the University of Dhaka will apply to any matters not covered by the above guidelines.

13. Categories of Courses

i) General Education Courses (GC): Total 39 Credit (28%)
ii) Core Courses (CC): Total 86 Credit (61%)
iii) Capstone Course: 15 Credit (11%)
iv) Semester Wise Course Distribution

1st Semester			
Course ID	**Course Title**	**Course Type**	**Credit**
GHT 1101	Fundamentals of Geology	CC	3
GHT 1102	Mineralogy and Crystallography	CC	3
GHT 1103	Earth's History and Geomorphology	GC	3
GHL 1104	Mineralogy and Crystallography Lab	CC	3
GHL 1105	Maps and Map Reading Lab	CC	2
	Total Credit in the 1st Semester		14
2nd Semester			
GHT 1201	Environmental Sciences	GC	3
GHT 1202	Petrology	CC	3
GHT 1203	Essential Physics for Geosciences	GC	3
GHT 1204	Essential Chemistry for Geosciences	GC	3
GHL 1205	Petrology Lab	CC	3
GHF 1206	Geological Field Mapping	Capstone	3
GHV 1207	Viva Voce	Capstone	-
	Total Credit in the 2nd Semester		18
3rd Semester			
GHT 2101	Structural Geology, Tectonics and Geodynamics	CC	3
GHT 2102	Sedimentology	CC	3
GHT 2103	Planetary Geology	CC	3
GHT 2104	Statistics for Geosciences	GC	3
GHT 2105	Essential Mathematics for Geosciences	GC	3
GHL 2106	Petrography Lab	CC	3
	Total Credit in the 3rd Semester		18

4th Semester			
GHT 2201	Stratigraphy	CC	3
GHT 2202	Paleontology and Micropaleontology	CC	3
GHT 2203	Hydrology and Climatology	CC	3
GHT 2204	Fundamentals of Geophysics	CC	3
GHL 2205	Paleontology Lab	CC	3
GHF 2206	Geological Field Mapping	Capstone	3
GHV 2207	Viva Voce	Capstone	-
	Total Credit in the 4th Semester		18
5th Semester			
GHT 3101	Oceanography and Coastal Geology	CC	3
GHT 3102	Applied Geophysics	CC	3
GHT 3103	Regional Geology	CC	3
GHT 3104	Quaternary Geology	CC	3
GHT 3105	Economic Geology and Georesources	GC	3
GHL 3106	Structural Geology and Geological Map Lab	CC	3
	Total Credit in the 5th Semester		18
6th Semester			
Course ID	**Course Title**	**Course Type**	**Credit**
GHT 3201	Mining Geology	CC	3
GHT 3202	Geochemistry	CC	3
GHT 3203	Remote Sensing and GIS	GC	3
GHT 3204	Geohazard and Risk Analysis	GC	3
GHL 3205	Remote sensing and GIS Lab	GC	3
GHF 3206	Geological Field Mapping	Capstone	3
GHV 3207	Viva Voce	Capstone	-
	Total Credit in the 6th Semester		18
7th Semester			
GHT 4101	Hydrogeology	CC	3
GHT 4102	Seismology and Geodesy	CC	3
GHT 4103	Geotechnical Engineering and Urban Geology	CC	3
GHT 4104	Petroleum Geology & Reservoir Characterization	CC	3
GHL 4105	Hydrogeology and Engineering Geology Lab	CC	3
GHL 4106	Geophysics and Petroleum Geology Lab	CC	3
	Total Credit in the 7th Semester		18
8th Semester			
GHT 4201	Data Science and Numerical Methods	GC	3
GHS 4202	Research Methodology and Scientific Writing	GC	3
GHT 4203	Geosciences for Sustainable Development	CC	3
GHL 4204	Data Science and Numerical Modeling Lab	GC	3
GHF 4205	Comprehensive multidisciplinary Geological Field Work	Capstone	3
GHI/GHP 4206	Internship/Project	Capstone	3
GHV 4207	Viva Voce	Capstone	-
	Total Credit in the 8th Semester		18
	Total Credit in BS Program		140

[Note: For Geology Majors, each Theory course is denoted by the three-letter code GHT (Geology

Honours Theory), Laboratory/Lab course by GHL (Geology Honours Lab), Field Works course by GHF (Geology Honours Field), Internship/Project work by GHI (Geology Honours Internship), Seminar Course by GHS (Geology Honours Seminar), and viva voce by GHV (Geology Honours Viva voce). These codes are followed by a four-digit number where the first digit indicates the year and the second digit indicates the semester.

Part C

Description of all courses of the Program including the required information for each course

GHT-1101 Fundamentals of Geology

Credit Hour: 3

Course Type: Core Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description: This course provides a broad introduction to geology, covering fundamental principles of Earth's structure, materials, and dynamic processes. It explores the formation and evolution of the planet, key geological concepts such as plate tectonics, earthquakes, and volcanism, and the role of geological forces in shaping the Earth's surface. The course also introduces structural geology, focusing on rock deformation, faulting, folding, and geological mapping. Through lectures, discussions, and assignments, students will develop a foundational understanding of how geologic processes influence landscapes, natural hazards, and resource distribution.

Course Learning Objectives (CLOs):

- Understand the historical development of geology and its significance in Earth sciences.
- Learn about the origin of the universe, Earth's formation, and the basic characteristics of minerals and rocks.
- Explore the Earth's internal structure, seismic activity, and plate tectonic mechanisms.
- Examine geomorphic processes such as weathering, mass wasting, and soil formation.
- Analyze the formation of geological features including mountains, earthquakes, volcanoes, and various landforms.
- Study the principles of structural geology, including stress-strain relationships, folds, faults, joints, and unconformities.
- Develop skills in geological mapping, reading topographic maps, and interpreting geologic structures.
- Apply geological concepts to understanding natural hazards, resource exploration, and environmental challenges.

Course Learning Outcomes (COs):

At the end of the course the students will be able to:

CO1: Demonstrate an understanding of Earth's structure, materials, and dynamic processes, including plate tectonics, rock formation, and geologic time.

CO2: Identify and classify common rocks and minerals based on physical and chemical properties.

CO3: Interpret basic geological maps, cross-sections, and stratigraphic relationships to analyze Earth's surface and subsurface features.

CO4: Explain the processes of weathering, erosion, sedimentation, and the rock cycle, and how they shape the Earth's landscape.

CO5: Evaluate the role of geology in natural resource management and hazard mitigation, including issues related to earthquakes, landslides, and groundwater

Mapping CO vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓	✓	✓		
CO2	✓	✓	✓		
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	
CO5	✓	✓	✓	✓	✓

No of Lecture: 30 (1.5 hours each)

Course Content:

Lecture	Topic	Details	Homework/ Assignments
1 and 2	Introduction to Geology and Its Historical Development	● Definition, scope, and significance of geology. ● Historical milestones: uniformitarianism (Hutton, Lyell), plate tectonics (Wegener), and geological discoveries. ● Geology's relevance to society (resource exploration, natural hazards).	
3	Origin of the Universe and Earth	● Big Bang Theory and cosmic evolution. ● Formation of the solar system: nebular hypothesis. ● Earth's accretion and differentiation.	
4	Introduction to Minerals and Rocks	● Definition of minerals and rocks ● Common rock forming minerals and their composition ● Major types of rocks and classification of each type ● Rock cycle	

5	Seismic Waves and Their Characteristics	Types of seismic waves (P, S, surface waves). Wave propagation. Seismographs and seismograms. Locating earthquakes.	Assignment-1
6	Earth's Internal Structures	● Compositional layers: crust, mantle, core. ● Mechanical layers: lithosphere, asthenosphere, mesosphere, and core. ● Evidence for Earth's internal structure (seismic data, heat flow, etc.).	
7-8	Earth's Physical Features	● Global topography and bathymetry. ● Major features: continents (craton, shield, platform, basin), ocean basins, plateaus, and trenches. ● Continental shelves, slopes, rises, abyssal plains, trenches, mid-ocean ridges. Seafloor topography and features.	
9	Continental Drift, Seafloor Spreading, and Plate Tectonics	● Historical background: continental drift, paleomagnetism and seafloor spreading. ● Components of plate tectonics: lithospheric plates, asthenosphere, and driving mechanisms.	
10	Plate Boundaries and Associated Features	● Divergent, convergent, and transform boundaries. ● Features: mid-ocean ridges, trenches, volcanic arcs, and transform faults.	Assignment-2
11	**In-course/midterm-1**		
12	Mountain Building and Isostasy	● Types of mountains: fold, fault-block, and volcanic mountains. ● Isostasy: concept and examples (Himalayas, Appalachians).	
13	Earthquakes and Seismic Activity	● Causes of earthquakes: stress, strain, and plate tectonics. ● Distribution of earthquake and relation to plate tectonics ● Measuring earthquakes: magnitude, intensity, and seismic hazards.	
14	Volcanoes and Volcanism	● Magma formation and types. ● Volcanic landforms: shield volcanoes, stratovolcanoes, and calderas. ● Volcanic hazards and benefits. ● Distribution of volcanoes and plate	

		tectonics	
15 & 16	Weathering and Mass Wasting	● Physical and chemical weathering processes. ● Mass wasting: types (slides, flows, falls) and triggers.	Assignment-3
17	Soil Formation and Characteristics	● Soil formation factors: parent material, climate, organisms, topography, and time. ● Soil horizons and profiles. ● Soil erosion and conservation methods.	
18-19	Introduction to Structural Geology	● Definition and scope ● Importance of structural geology. ● History of the development of structural geology as branch of geology	
20	Mechanical Principles	Force, pressure, stress, and strain. Physical properties of rocks. Stress-strain diagrams. Factors controlling rock behavior.	
21	**Midterm/In-course-2**		
22	Folds: Geometry and Types (Part 1)	Geometry of folds (anticlines, synclines, limbs, axial plane, hinge line). Describing fold orientation (strike and dip).	
23	Folds: Geometry and Types (Part 2)	Types of folds (e.g., concentric, similar, chevron, parasitic folds, box folds, kink folds). Fold recognition in the field.	
24	Faults: Geometry and Types	Geometry of faults (hanging wall, footwall, fault plane, fault trace). Types of faults (normal, reverse, strike-slip, oblique-slip). Fault recognition in the field. Plate Tectonic and fault types	

25	Joints: Geometry and Types	Geometry of faults (hanging wall, footwall, fault plane, fault trace). Types of faults (normal, reverse, strike-slip, oblique-slip). Fault recognition in the field.	Assignment-4
26	Unconformities	Unconformities (angular, nonconformity, disconformity). Significance of unconformities in geological history. Recognizing unconformities in the field.	
27	Cleavage and Lineation	Cleavage, schistosity, and lineation: definitions, formation, and relationship to stress. Types of cleavage (e.g., fracture cleavage, slaty cleavage). Relationship to folding and faulting.	
28	Topographic Maps and Contours	Understanding topography. Contour lines: characteristics and interpretation. Reading and interpreting topographic maps. Calculating gradients.	
29-30	Introduction to Geological Structures and Mapping	Combining the concepts of folds, faults, joints, and unconformities. Principles of geological mapping. Constructing cross-sections.	

Instructional Strategies: Lectures**,** Class discussions**,** Use of multimedia resources (videos, animations, images) and In-class exercises

Assessment Pattern:

Assessment Pattern level no.	Knowledge level	Level of CO	In-course	Assignment	Final Examination
K1	**Remember**	**CO1, CO2**	04	02	10
K2	**Understand**	**CO1-CO4**	04	02	20
K3	**Apply**	**CO3-CO5**	08	04	15
K4	**Analyze**		00	00	00
K5	**Evaluate**	**CO3 & CO5**	04	02	15
K6	**Create**		00	00	00
Total Marks 100 (Class attendance 10 + In-course 20+ Assignment 10+ Final examination 60)			20	10	60

Recommended References:

Text Book:

1. Plummer, C., Carlson, D., Hammersley, L. (2015) Physical Geology (15th Edition). McGraw-Hill Education

Reference Book:

2. Tarbuck, E. J., Lutgens F.K., Tasa, D. G. (2013) Earth: An Introduction to Physical Geology (11th Edition). Pearson.
3. Montgomery, C.W. (1990) Physical Geology. William C Brown Pub.
4. Leet, L., & Leet L.D. (1982) Physical Geology (6th Edition). Prentice Hall.
5. Bradshaw, M.J. et al. (1978) The Earth's Changing Surface. Hodder Arnold H&S.
6. Billings, M. P. 1972. Structural geology. Prentice Hall College Div.
7. Twiss R.J. and Moores, E. M. 1992. Structural Geology, Freeman.
8. Hills, E.S. 1972. Elements of Structural Geology. Chapman & Hall.
9. Spencer, E.W. 1969. Introduction to the Structure of the Earth. McGraw-Hill.
10. Ramsay, J.G. 1967. Folding and Fracturing of Rocks. McGraw-Hill.

GHT-1102 Mineralogy and Crystallography

Credit Hours: 3

Course Type: Core Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description: This course provides a comprehensive foundation in mineralogy and crystallography. Origin, properties and classification of minerals, mineral identification techniques, economic importance and the significance of minerals in Earth systems. Optical properties of minerals and identify minerals in thin sections under polarizing microscopes. Concepts of crystal structure, crystal systems, crystal classes and symmetry elements. Relation between crystal structure and crystal form or habit.

Course Learning Objectives (CLOs):

Upon successful completion of this course, students will be able to:

- Explain the criteria of a mineral and understand the processes of mineral formation.
- Recognize the physical properties of minerals, and understand the relationship between physical properties with their chemical features and atomic structure.
- Identify the rock-forming and other common minerals based on their physical properties in hand specimen.
- Know the Economic importance and uses of minerals.
- Understand the properties of light and principles of polarizing microscope.
- Know the basic optical properties of minerals in thin section under polarizing microscope and identify rock- forming minerals in thin section.
- Describe the atomic structure of crystals such as motif, unit cells, crystal lattices,
- Define and understand crystal systems, crystal classes, and symmetry elements.
- Utilize stereographic projections to visualize crystallographic data.

Course Learning Outcomes (COs):

CO1: To infer and know the basic physical properties and chemistry of common rock-forming minerals in hand specimen, explain the crystallization process and formation of minerals

CO2: To describe and identify crystal symmetry, directions and crystal projections

CO3: To identify common rock forming minerals using thin sections and understand the optical properties of different minerals

Mapping Co vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓

No of Lecture: 30 (1.5 hours for each)

Course Content:

Lecture No.	Topic	Details	Assignment
1	Introduction to mineralogy and minerals	Definitions, formation of mineral, historical development, its significance in Earth systems, and uses.	
2	Physical properties of minerals	Detailed discussion of each physical property and their importance in mineral identification in hand specimen.	
3	Physical properties of minerals	Detailed discussion of each physical property and their importance in mineral identification in hand specimen.	
4	Chemistry of minerals	Structure of minerals - atomic structure, chemical composition and chemical bonds; Relationship between atomic structure and chemical composition - polymorphism, isomorphism, pseudomorphism.	
5	Chemistry of minerals	Chemical constituents of minerals and earth's crust; compositional variation in minerals; solid solution, phase rule and stability of minerals.	Assignment-1
6	Classification and nomenclature of minerals	Basis of classification, major classes with examples, Nomenclature of mineral species.	
7	Silicate minerals	Fundamental structure of silicates, subclasses of silicates and their structure; important minerals and their properties of subclasses: Tectosilicates.	
8	Silicate minerals	Important minerals and their properties of subclasses: Phyllosilicates and inosilicates.	
9	Silicate minerals	Important minerals and their properties of subclasses: Cyclosilicates, sorosilicates, nesosilicates.	
10	Non-silicate minerals	Native elements; sulphides, oxides and hydroxides	Assignment-2
11	**In-course/Midterm-1**		
12	Non-silicate minerals	Halides, carbonates, sulphates and phosphates	
13	Determinative mineralogy	Chemical tests for mineral identification- acid test, blowpipe test and other wet tests.	

		Special Techniques for mineral identification- XRD, SEM, Raman spectrophotometry.	
14	Introduction to optical mineralogy	Polarizing microscope; working principle of polarizing microscope; preparation of thin sections; objectives of optical mineralogy for mineral identification.	Assignment-3
15	Properties and polarization of light	Properties of light; ways of polarization, transmission of light; indicatrix (Uniaxial and Biaxial).	
16	Observations under plane polarizing light	Orthoscopic observations - Relief, colour, pleochroism and cleavage.	
17	Observations under crossed polarized light	Orthoscopic observations - Birefringence, interference colors and color chart, extinction, and other optical phenomena.	
18	Observations under crossed polarized light	Conoscopic observations - Uniaxial interference figures.	
19	Observations under crossed polarized light	Conoscopic observations - Biaxial Interference figures.	
20	Systematic identification of minerals in thin section	Isotropic, anisotropic and opaque minerals; Optical properties of common rock-forming minerals.	Assignment-4
21	**In-course/Midterm-2**		
22	Introduction and scope of crystallography	Definition of a Crystal and Crystallography, The origin and growth of crystal, Laws of Crystallography, The Crystal Chemistry (Coordination, Metal Structures, Structures of Noble Gases and Molecules, Ionic Structures, Covalent Structures, Isotypes, Solid Solutions and Isomorphism, Polymorphism), Scope and Importance	
23	The Lattice and Its Properties	Space Lattice or Crystal Lattice, Unit Cell and Lattice Parameters, Line Lattice, Plane Lattice, Space Lattice, The Designation of Points, Lines and Planes in a Space Lattice , The Lattice Point uvw, Lattice Lines [uvw], Lattice Planes (hkl), The Zonal Equation, Applications of the Zonal Equation	
24	Crystal system and	Systematic Study of Crystal Systems, Classes and	

	Symmetry operations	Forms; Distinction between trigonal and hexagonal systems, Symmetry elements (Center of Symmetry, Axis of Symmetry, Plane of Symmetry, Axis of Rotatory Inversion), Derivation of all summetry classes in crystal	
25	Fourteen Bravais Lattices	The Symmetry of the Primitive (P) Lattices (Triclinic P-Lattice, Monoclinic P-Lattice, Orthorhombic P-Lattice, Tetragonal P-Lattice, Hexagonal P-Lattice, Cubic P-Lattice), The Symmetry of the Centered Lattices (Face centered F), The Symmetry of the End centered or Base centered (C) Lattices and the Symmetry of the Body centered (I) lattices	
26	Point Groups	The 32 Point Groups, Crystal Forms of theTetragonal System, Crystal Forms of the Hexagonal (Trigonal) System, Crystal Forms of the Cubic System, Crystal Forms in the Orthorhombic, Monoclinic and Triclinic Systems, Molecular Symmetry, Determination of Point Groups.	
27	Space Groups	The 230 Space Groups, Glide Planes and Screw Axes, Glide Planes, Screw Axes, Properties of Space Groups, International Tables for Crystallography, Space Group and Crystal Structure, Relationships Between Point Groups and Space Groups.	
28	Law of Rational Indices and Twining in crystals	Miller Indices; Zones; Zone Laws; Hermann-Mauguin Symbols; The Schoenflies (or Schönflies) notation, Common Method of Twinning; Frequency of Twinning, Effects of twinning	
29	Stereographic Projections	Crystal Projections, The Wulff Net, Indexing of a Crystal, The Gnomonic and Orthographic Projections	Assignment-5
30	X-ray Crystallography	The Bragg Equation, The Debye-Scherrer Method, The Reciprocal Lattice, The Determination of a Crystal Structure	

Instructional Strategies: Lectures**,** Class discussions**,** Use of multimedia resources (videos, animations, images) and In-class exercises

Assessment Pattern

Assessment Pattern level no.	Knowledge level	Level of CO	In-course	Assignment	Final Examination
K1	**Remember**	**CO1-CO3**	10	00	15
K2	**Understand**	**CO2-CO3**	05	00	10
K3	**Apply**	**CO3**	05	02	10
K4	**Analyze**	**CO1-CO3**	00	03	10
K5	**Evaluate**	**CO1-CO3**	00	02	10
K6	**Create**	**CO1-CO3**	00	03	05
Total Marks 100 (Class attendance 10 + In-course 20+ Assignment 10+ Final examination 60)			20	10	60

Recommended References:

Textbook for Mineralogy

1. Berry, L.G., Mason, B. and Dietrich, R. V. (2004) Mineralogy: Concepts, Descriptions and Determinations. CBS Publishers & Distributors Pvt. Ltd.

References:

1. Deer, W.A., Howie, R.A. &Zussman, J. (2013) An Introduction to the Rock-Forming Minerals (3rd Edition).

2. Mineralogical Society of Great Britain and Ireland.

3. Perkins, D. (2010) Mineralogy (3rd Edition). Pearson.

4. Hibbard, M.J. (2002) Mineralogy: A geologist's point of view. McGraw-Hill Higher Education.

5. Gribbles, C.D. (1988) Rutley's Elements of Mineralogy (27th Edition). Unwin Hyman.

6. Klein, C. & Hurlbut, C. S. (1985) Manual of Mineralogy (after James D. Dana). Wiley.

Read H.H. (Ed.) (1970) Rutley's Elements of Mineralogy. T. Murby& Company.

Textbook for Crystallography:

1. Klein, C. & Hurlbut, C. S. (1985) Manual of Mineralogy (after James D. Dana). Wiley.

References:

2. Gribbles, C.D. (1988) Rutley's Elements of Mineralogy (27th Edition). Unwin Hyman.

3. Phillips, F.C. (1977) An Introduction to Crystallography. Longman Higher Education.

4. Read H.H. (Ed.) (1970) Rutley's Elements of Mineralogy. T. Murby & Company.

5. Mason, B., & Berry, L.G. (1968) Elements of Mineralogy. Freeman, W. H. & Company.

6. Wade, F.A. & Mattox, R.B. (1960) Elements of crystallography and mineralogy. Harper & Brothers

Textbook for Optical Mineralogy

1. Kerr, P. F. (1977) Optical mineralogy (4th Edition). McGraw-Hill College.

References:

2. Nesse, W. D. (1991) Introduction to Optical Mineralogy (2nd Edition). Oxford University Press.

3. Shelley, D. (1985) Optical mineralogy (2nd Edition). Elsevier Science Ltd.

GHT-1103 Earth's History and Geomorphology

Credit Hour: 3

Course Type: Core Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description: This course provides an introduction to the dynamic processes that shape the Earth's surface and the history of our planet through geologic time. The first part of the course focuses on geomorphology, exploring exogenic and endogenic processes, fluvial, glacial, coastal, and desert landforms, and the physiographic subdivisions of Bangladesh and the Indian subcontinent. The second part covers historical geology, including geologic time principles, relative and absolute dating methods, and Earth's evolutionary history from the Precambrian to the present. Emphasis is placed on major geological events, orogenic cycles, mass extinctions, and the evolution of life, culminating in the rise of modern ecosystems and humans. The course integrates theoretical knowledge with real-world examples to develop a deeper understanding of Earth's dynamic systems and their impact on the environment.

Course Learning Objectives (CLOs):

- Understand fundamental geomorphic processes and the role of various agents in shaping the Earth's surface.
- Identify and classify different landforms associated with rivers, glaciers, deserts, and coastlines.
- Examine the physiographic characteristics of Bangladesh and the Indian subcontinent in relation to tectonics and landform evolution.
- Learn the principles of geologic time, including relative and absolute dating techniques.
- Explore Earth's history from the Precambrian to the present, emphasizing key geological events and their impact on life evolution.
- Analyze the causes and effects of major mass extinctions and their role in shaping biodiversity.
- Develop a broad understanding of the interplay between geologic processes, climate change, and the evolution of life on Earth.

Course Learning Outcomes (COs):

CO1: To Understand the geological time scale, major eons, eras, periods, and epochs, and be able to describe key events such as mass extinctions, continental drift, and the evolution of life.

CO2: To Analyze rock strata and fossil assemblages to reconstruct past environments and understand the processes of sedimentation and biostratigraphy.

CO3: Students will gain knowledge of physical and chemical processes (e.g., weathering, erosion, deposition) that shape landscapes, and be able to explain the formation of landforms such as mountains, valleys, rivers, and coastal features.

CO4: Students will explore how plate tectonics, uplift, and subsidence contribute to geomorphic change over time and how these processes interact with surface dynamics.

CO5: Students will develop the ability to use geological maps, cross-sections, satellite imagery, and field data to interpret Earth's surface features and reconstruct geological history for academic or applied geoscience purposes.

Mapping Co vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓

No of Lecture: 30 (1.5 hours for each)

Course Content:

Lecture	Topic	Details	Homework/ Assignments
1	Introduction, Scope, and Importance	Definition of geomorphology & historical geology, significance in geomorphology, relevance to human society	
2	Exogenic and Endogenic Processes and Agents of Geomorphic Change	Exogenetic (weathering, erosion, transportation, deposition, mass movement) and endogenetic processes (folding, faulting, volcanism, earthquake, landslide, diastrophism), agents and their origin	
3	Fluvial Processes	Flowing water, longitudinal river profile (channel roughness, gradient, discharge, and velocity); fluvial equilibrium, drainage patterns and stream network	
4	Fluvial Landforms	Fluvial erosional (rills, gullies, valleys, gorges, canyons, waterfalls, rapids, etc.) and	

		depositional landforms (floodplains, meanders, oxbow lakes, deltas, alluvial fans, river terraces	
5	Glacial Processes	Types of glaciers, ice movement, erosion, deposition	Assignment-1
6	Glacial Landforms	Moraines, drumlins, eskers, glacial lakes, fjords	
7	Desert Processes	Wind erosion and deposition, desertification, types of dunes, Sand dunes, playas, mesas, buttes, inselbergs	
8	Karst Topography: Time & Dissolution	How does karst topography develop *over long periods* of time? The role of changing water tables and climate.	
9	Coastal Processes	Tides, waves, currents, marine erosion and deposition Beaches, barrier islands, spits, sea cliffs, estuaries	
10	Landscape Evolution: Models & Theories Human Impact: An Accelerating Force	Overview of landscape evolution models (Davisian cycle, etc.), but with a *critical eye*. How well do they explain real-world landscapes? The increasing role of humans as a dominant geomorphic agent. How are we changing the Earth's surface at an unprecedented rate?	Assignment-2
11	**In-course/midterm-1**		
13	Physiographic Subdivisions of Bangladesh	Major landforms, river systems	
14	Physiographic Subdivisions of the Indian Subcontinent	Himalayas, Indo-Gangetic Plain, Peninsular India, coastal and desert regions	Assignment-3
15	Geologic Time: Fundamental Principles	Superposition, cross-cutting, inclusions, unconformities	
16	Relative and Absolute Dating	Radiometric dating, isotopic methods, dendrochronology, varves	
17	Geological Time	Development, Eons, eras, periods, epochs;	

	Scale	major events in Earth's history	
18	Precambrian: Formation of Earth & Atmosphere	Hadean, Archean, Proterozoic; early atmosphere and hydrosphere formation	
19	Origin of Life & Precambrian Earth Conditions	Stromatolites, banded iron formations, evidence of early life	
20	Paleozoic: Plate Tectonics & Life Evolution	Cambrian Explosion, Paleozoic orogenies, marine vs. terrestrial life	Assignment-4
21	**In-course/midterm-2**		
22-23	Mesozoic: Tectonics & Climate	Breakup of Pangea, seafloor spreading, Cretaceous transgression	
24	Mesozoic Life: Dinosaurs, Reptiles & Mammals	Dominance of reptiles, first birds and mammals, flowering plants	
25-27	K-T Mass Extinction	Causes (asteroid impact, volcanism), evidence, recovery	
28-29	Cenozoic: Tectonic & Climatic Events	Alpine-Himalayan orogeny, glaciations, major landform changes	Assignment-5
30	Mammalian Radiation & Human Evolution	Evolution of primates, early hominins, environmental adaptations	

Instructional Strategies: Lectures**,** Class discussions**,** Use of multimedia resources (videos, animations, images) and In-class exercises

Assessment Pattern

Assessment Pattern level no.	Knowledge level	Level of CO	In-course	Assignment	Final Examination
K1	**Remember**	**CO1, CO2**	04	02	08
K2	**Understand**	**CO2-CO3, CO5**	04	02	18

K3	**Apply**	**CO3-CO5**	04	02	08
K4	**Analyze**	**CO3, CO5**	04	02	08
K5	**Evaluate**		04	02	18
K6	**Create**		00	00	00
Total Marks 100 (Class attendance 10 + In-course 20+ Assignment 10+ Final examination 60)			20	10	60

Recommended References:

Textbooks:

1. "Geomorphology: The Mechanics and Chemistry of Landscapes" – Andrew Goudie and Heather Viles
2. "Process Geomorphology" (5th Edition) – Dale F. Ritter, R. Craig Kochel, and Jerry R. Miller
3. "Earth System History" (4th Edition) – Steven M. Stanley and John A. Luczaj
4. "Historical Geology: Evolution of Earth and Life Through Time" (8th Edition) –Supplementary Readings (For Further Exploration)
5. "Principles of Geomorphology" – William D. Thornbury
6. "The Surface of the Earth" – Arthur L. Bloom
7. "Tectonic Geomorphology" (2nd Edition) – Douglas W. Burbank and Robert S. Anderson
8. "The Story of Earth: The First 4.5 Billion Years, from Stardust to Living Planet" – Robert M. Hazen
9. "The Geologic Time Scale 2012" – Felix M. Gradstein, James G. Ogg, Mark Schmitz, and Gabi Ogg

Other References

10. "The Geological Society of America (GSA) Bulletin" – Provides research papers on historical geology and geomorphology. https://www.geosociety.org/
11. "USGS Geomorphology and Geology Resources" – Free reports and case studies. https://www.usgs.gov/
12. "International Commission on Stratigraphy" – Updates on geologic time scale. https://stratigraphy.org/

GHL-1104 Mineralogy and Crystallography Lab

Credit Hours: 3

Course Type: Core Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description: This 3-credit laboratory course provides hands-on experience in mineralogy and crystallography, complementing the theoretical concepts learned in the accompanying lecture course. Students will develop observational skills, learn to identify minerals using a variety of techniques, and gain proficiency in basic crystallographic concepts.

Course Learning Objectives (CLOs):

Upon successful completion of this course, students will be able to:

- **Mineral Identification:**
  - Identify common rock-forming minerals based on their physical and optical properties.
  - Utilize a systematic approach to mineral identification using hand specimens and a petrographic microscope.
  - Develop observational skills and critical thinking abilities for mineral identification.
- **Crystallography:**
  - Construct and analyze crystal models to understand crystal systems and symmetry elements.
  - Utilize stereographic projections to represent crystallographic data and visualize crystal forms.
  - Understand the relationship between crystal structure and external crystal form.
- **Optical Mineralogy:**
  - Prepare and analyze thin sections of rocks under the petrographic microscope.
  - Identify basic optical properties of minerals in thin section (color, pleochroism, birefringence, extinction, interference figures).
  - Classify minerals based on their optical properties.
- **Laboratory Skills:**
  - Develop proficiency in using laboratory equipment such as the petrographic microscope, hand lens, and other relevant tools.
  - Maintain a clean and organized laboratory workspace.
  - Follow proper laboratory safety procedures.

Course Learning Outcomes (COs):

CO1: To infer and know the basic physical properties and chemistry of common rock-forming minerals in hand specimen

CO2: To describe and identify crystal symmetry, directions and crystal projections

CO3: To identify common rock forming minerals using thin sections and understand the optical properties of different minerals

Mapping Co vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓

No of Lab Class: 30 (3 hours each)

Course Content:

Lab	Topic	Activities	Assignments
PART-1: Identification of minerals in hand specimen			
1	Introduction to Mineralogy Laboratory	Safety procedures, laboratory equipment, and basic mineral identification techniques. Demonstration of physical properties of minerals: habit, color, diaphaneity streak, luster, hardness, cleavage, fracture and some special properties.	Assignment-1
2-10	Mineral Identification-1	Systematic identification of common rock-forming and other important minerals of different classes: Native elements, Silicates, Oxides and hydroxides, Sulphides and sulphosalts, Sulphates, Halides, and Phosphates in hand specimens.	Assignment-2
11	**In-course/Midterm-1**		
12	Mineral Identification-II	Systematic identification of common rock-forming and other important minerals of different classes: Carbonates in hand specimens	Assignment-3
PART 2: Identification of minerals in thin sections			
13	Introduction to Optical Mineralogy	Basic operation of the petrographic microscope, Observation of basic optical phenomena (e.g., pleochroism, extinction)	Assignment-4
14-19	Optical Properties of Minerals	Identification of common rock-forming minerals in thin section, Determination of optical properties of minerals (e.g., color, pleochroism, birefringence).	Assignment-5
PART-3: Study of crystals/crystal models			
20	Basics of Crystallography:	Study and identification of Crystal models (understanding different forms under 32 classes along with their symmetry operations)	Assignment-6
21	**In-course/Midterm-2**		
22-23	Crystal (models) identification	Study of Crystal Models using the theories of 4 Bravais lattices, Miller indices and zone axis calculations (explain the concept of Miller Indices and calculation, plus representation of zone axis in stereo net)	Assignment-7
24-26	Crystal symmetry of Normal and Combined form	Crystal class and symmetry element determination in Cubic, hexagonal, tetragonal, orthorhombic, triclinic, monoclinic systems	Assignment-8
27-28	Stereographic projections of some important crystal faces	crystallographic data in stereonet and to interpret angular information from projected data.	Assignment-9
29	X-ray Diffraction	Determination of cell parameter (d spacing) from single-crystal XRD data	Assignment-10
30	**In-course/Midterm-3**		

Instructional strategies:

Laboratory work, Demonstration, Discussion, Quizzes, Question-Answer

Assessment Pattern

Assessment Pattern level no.	Knowledge level	Level of CO	In-course	Assignment	Final Examination
K1	**Remember**	**CO1-CO3**	10	02	30
K2	**Understand**	**CO2-CO3**	06	06	15
K3	**Apply**	**CO3**	04	02	15
K4	**Analyze**	**CO1-CO3**	00	00	
K5	**Evaluate**	**CO1-CO3**	00	00	00
K6	**Create**	**CO1-CO3**	00	00	00
Total Marks 100 (Class attendance 10 + In-course 20+ Assignment 10+ Final examination 60)			20	10	60

Recommended References:

Textbook for Mineralogy

1. Berry, L.G., Mason, B. and Dietrich, R. V. (2004) Mineralogy: Concepts, Descriptions and Determinations. CBS Publishers & Distributors Pvt. Ltd.

References:

1. Deer, W.A., Howie, R.A. &Zussman, J. (2013) An Introduction to the Rock-Forming Minerals (3rd Edition).

2. Mineralogical Society of Great Britain and Ireland.

3. Perkins, D. (2010) Mineralogy (3rd Edition). Pearson.

4. Hibbard, M.J. (2002) Mineralogy: A geologist's point of view. McGraw-Hill Higher Education.

5. Gribbles, C.D. (1988) Rutley's Elements of Mineralogy (27th Edition). Unwin Hyman.

6. Klein, C. & Hurlbut, C. S. (1985) Manual of Mineralogy (after James D. Dana). Wiley.

Read H.H. (Ed.) (1970) Rutley's Elements of Mineralogy. T. Murby& Company.

Textbook for Crystallography:

1. Klein, C. & Hurlbut, C. S. (1985) Manual of Mineralogy (after James D. Dana). Wiley.

References:

2. Gribbles, C.D. (1988) Rutley's Elements of Mineralogy (27th Edition). Unwin Hyman.

3. Phillips, F.C. (1977) An Introduction to Crystallography. Longman Higher Education.

4. Read H.H. (Ed.) (1970) Rutley's Elements of Mineralogy. T. Murby & Company.

5. Mason, B., & Berry, L.G. (1968) Elements of Mineralogy. Freeman, W. H. & Company.

6. Wade, F.A. & Mattox, R.B. (1960) Elements of crystallography and mineralogy. Harper & Brothers

Textbook for Optical Mineralogy

1. Kerr, P. F. (1977) Optical mineralogy (4th Edition). McGraw-Hill College.

References:

2. Nesse, W. D. (1991) Introduction to Optical Mineralogy (2nd Edition). Oxford University Press.

3. Shelley, D. (1985) Optical mineralogy (2nd Edition). Elsevier Science Ltd.

GHL-1105 Maps and Map Reading Lab

Credit Hour: 2

Course Type: Core Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description:
This course integrates laboratory and field components to develop foundation skills in structural geology and geological mapping. The laboratory sessions cover map scale computations, topographic profiling, structural data plotting, contour and cross-section construction, and interpretation of topographic and geological maps. Complementing the lab work, a seven-day field excursion to the hill tracts of Bangladesh focuses on the observation and mapping of large-scale geological structures such as folds, faults, and unconformities within Mio-Pliocene sedimentary strata. Students will gain hands-on experience in measuring bed attitudes, interpreting three-dimensional geological structures, and reconstructing the geological history of the area. Independent work is emphasized, supported by teaching assistants during lab sessions.

Course Learning Objectives (CLOs):

- To develop foundational skills in geological map interpretation and structural data analysis through hands-on laboratory exercises.
- To enhance students' ability to construct and interpret topographic profiles, geological cross-sections, and contour maps.
- To provide practical experience in measuring and plotting geological structures such as dip, strike, folds, faults, and unconformities.
- To enable students to conduct field-based geological mapping and reconstruct the geological history of an area using three-dimensional spatial reasoning.
- To familiarize students with the identification of sedimentary rocks and the application of field techniques in structural geology.

Course Learning Outcomes (COs):

At the end of the course the student will be able to

CO1: To reconstruct and convert maps into various scale

CO2: To construct and interpret topographic maps

CO3: To prepare cross-section from Geological maps and reconstruct the geological history of the area

CO4: To interpret and describe various geomorphological and cultural features from topo sheets

Mapping Co vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

No of Lab Classes: 20 (3.0 hours each)

Course Content:

Lab	Topic	Details	Homework/ Assignments
1-3	Introduction to course contents	Introduction to map projection and datum, maps and map scales, computation and conversion of scales	Assignment-1
4	Map Reproduction	Map enlargement and reduction; bearing, azimuth, grid location	Assignment-2
5-9	Construction and interpretation of topographic map	Construction of contours from spot heights, identification of geomorphic features and measurement of slope angle from contour map	Assignment-3
10	Attitude of beds	Dip and strike determination and plotting	Assignment-4

11	**In-course/midterm-1**		
12-18	Cross section of Geological maps and interpretation	Geological maps: Structural interpretation and constructing geological cross section along with stratigraphic successions of representative geological maps including horizontal, homoclines, folds, faults and unconformity	Assignment-5-9
11	**In-course/midterm-1**		
19-20	Topo sheet interpretation	Interpretation of topographic maps including geological and structural interpretation, cultural interpretation, drainage pattern identification and regional development interpretation	Assignment-10

Instructional strategies:

Lecture, Class practice and on field training

Assessment Pattern

Assessment Pattern level no.	Knowledge level	Level of CO	In-course	Assignment	Final Examination
K1	**Remember**	**CO1-CO3**	00	00	10
K2	**Understand**	**CO2-CO3**	00	00	15
K3	**Apply**	**CO3**	06	03	15
K4	**Analyze**	**CO1-CO3**	04	02	10
K5	**Evaluate**	**CO1-CO3**	00	05	10
K6	**Create**	**CO1-CO3**	10	00	00
Total Marks 100 (Class attendance 10 + In-course 20+ Assignment 10+ Final examination 60)			20	10	60

Recommended References

1. Beninson, G.M. (1990) An Introduction to Geological Structures and Map (5th Edition). Edward Arnold Publishers.

2. Lisle, R.J. (2004) Geological Structures and Maps - A Practical Guide (3rd Edition). Elsevier

3. Maltman, A. (1990) Geological maps: An introduction. Open University Press.

4. Platt, J.I. (1951) Selected Exercises upon Geological Maps. T. Murby Publishers.

5. Lisle, R.J., Brabham, P.J., Barnes, J.W. & (2011) Basic Geological Mapping (5th Edition), Wiley-Blackwell.

6. Barnes, J.W. & Lisle, R.J. (2004) Basic Geological Mapping (4th Edition). John Wiley & Sons.

7. McClay, K.R. (1987) The Mapping of Geological Structures (Reprinted 2007). John Wiley & Sons.

GHT-1201 Environmental Sciences

Credit Hour: 3

Course Type: General Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description: This introductory course provides a comprehensive overview of environmental science, exploring the complex interactions between humans and the natural world. We will examine key environmental issues, including climate change, biodiversity loss, pollution, and resource depletion, while exploring the scientific principles and societal challenges associated with environmental sustainability.

Course Learning Objectives (CLOs): Upon successful completion of this course, students will be able to:

- Understand fundamental ecological concepts and principles.
- Identify and analyze major environmental problems facing the planet.
- Evaluate the scientific evidence for and impacts of environmental issues.
- Explore the social, economic, and political dimensions of environmental problems.
- Critically evaluate environmental policies and solutions.
- Develop critical thinking and problem-solving skills related to environmental issues.
- Understand their role as responsible citizens in addressing environmental challenges.

Course Learning Outcomes (COs):

At the end of the course the student will be able to

CO1: Gain insight into how Earth's natural systems operate and how human activities impact these systems.

CO2: To attain skills in Environmental Data Collection and Analysis

CO3: To identify and evaluate major environmental challenges

CO4: Education fosters environmental stewardship and encourages informed decision-making to support sustainable living and policies.

Mapping Co vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓	✓	✓	✓	
CO2	✓	✓	✓		✓
CO3	✓	✓	✓		
CO4				✓	✓

Number of Lectures: 30 (1.5 hours for each)

Course Content:

Lecture	Topic	Details	Homework/ Assignments
1	Introduction to Environmental Science	What is environmental science? Scope and importance, Key concepts and principles	
2	Ecosystems: Structure and Function	Basic ecology: populations, communities, ecosystems, Energy flow and nutrient cycling	
3	Biodiversity and Ecosystem Services	Biodiversity: levels and importance, Ecosystem services and their value	
4	Human Population and Consumption	Human population growth and its impacts, Consumption patterns and resource use	
5	Climate Change: Causes and Impacts	The greenhouse effect and global warming, Evidence for climate change, Impacts of climate change	Assignment-1
6	Climate Change Mitigation and Adaptation	Strategies for reducing greenhouse gas emissions, Adapting to the impacts of climate change	
7	Air Pollution	Sources and types of air pollution, Health and environmental impacts and Air quality regulations	
8	Water Pollution	Sources and types of water pollution, Water quality management and conservation	

9	Soil Pollution and Degradation	Soil erosion, desertification, and soil contamination and Sustainable agriculture practices	
10	Biodiversity Loss	Causes of biodiversity loss (habitat destruction, overexploitation, and invasive species), Conservation strategies	Assignment 2
11	**In-course/Midterm-1**		
13	Waste Management	Solid waste disposal and recycling and Waste reduction and minimization	
14	Energy Resources	Renewable and non-renewable energy sources, Energy efficiency and conservation	
15	Environmental Policy	Environmental laws and regulations, Environmental policymaking process	Assignment 3
16	Environmental Economics	Economic valuation of environmental goods and services, Cost-benefit analysis	
17	Environmental Justice and Equity	Environmental impacts on marginalized communities, Environmental justice movements	
18	Human Health and the Environment	Environmental factors affecting human health, Environmental health risks	
19	Environmental Toxicology	Toxic substances and their effects, Risk assessment and management	
21	**In-course/midterm-2**		
22	Sustainable Development	Principles of sustainable development, Achieving sustainable societies	Assignment 4
23	Conservation Biology	Principles of conservation biology and Protected areas and wildlife management	
24	Restoration Ecology	Principles of ecological restoration and Case studies in ecosystem restoration	

25	Environmental Ethics	Ethical perspectives on environmental issues, Environmental values and worldviews	Assignment 5
26	Environmental Communication, Advocacy and Environmental Careers	Communicating environmental messages effectively, Environmental activism and advocacy and Careers in environmental science and related fields	
27	Case Study: Climate Change in Bangladesh	Local impacts of climate change, Adaptation and mitigation strategies	
28	Case Study: Water Resources Management	Water scarcity and water quality issues in [Your Region/Country]	
29-30	Case Study: Biodiversity Conservation	Biodiversity hotspots and conservation efforts in [Your Region/Country].	Assignment 10

Instructional Strategies: Lectures**,** Class discussions**,** Use of multimedia resources (videos, animations, images) and In-class exercises

Assessment Pattern

Assessment Pattern level no.	Knowledge level	Level of CO	In-course	Assignment	Final Examination
K1	**Remember**	**CO1-CO3**	04	02	10
K2	**Understand**	**CO2-CO3**	04	02	15
K3	**Apply**	**CO3**	04	02	10
K4	**Analyze**	**CO1-CO3**	04	02	15
K5	**Evaluate**	**CO1-CO4**	04	02	10
K6	**Create**	**CO1-CO4**	00	00	00
Total Marks 100 (Class attendance 10 + In-course 20+ Assignment 10+ Final examination 60)			20	10	60

Recommended References:

1. Cunningham, W., & Cunningham, M. A. (2020). Environmental Science: A Global Concern. (Latest Edition). McGraw-Hill.

2. Botkin, D. B., & Keller, E. A. (2011). Environmental Science: Earth as a Living Planet. (Latest Edition). Wiley.

3. Kump, L. R., Kasting, J. F., & Crane, R. G. (2009). The Earth System. (Latest Edition). Pearson.

4. Miller, G. T., & Spoolman, S. (2014). Living in the Environment. (Latest Edition). Cengage Learning.

5. Montgomery, C. W. (2020). Environmental Geology. (Latest Edition). McGraw-Hill.

6. Keller, E.A. (1992) Environmental Geology (6^{th} Edition). C.E. Merrill Publication Co.

7. Patniaik, L.N. (1990) Environmental Impacts of Industrial and Mining Activities. Ashish Publishing House.

8. Howard, Arthur D, & Remson, I. (1978) Geology in Environmental Planning. McGrow Hill Inc.

9. Hattener-Frey, Holly A., and Travis, C. (1991) Health Effects of Municipal Waste. CRC Press.

GHT-1202 Petrology

Credit Hour: 3

Course Type: Core Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description:
This course focuses on the detailed study of igneous, metamorphic, and sedimentary rocks, including their origin, classification, and description. Emphasis will be given to their macroscopic and microscopic examination, mineral identification, textural and structural analyses, and formation environments.

Course Learning Objectives (CLOs): Upon successful completion of this course, students will be able to

- Know the properties of magma and classify igneous rocks based on texture, mineral composition, and chemical composition.
- Understand the processes of magma generation, differentiation, and crystallization.
- Classify metamorphic rocks based on structure, texture, and mineral assemblages
- Know the processes of metamorphism (contact, regional, dynamic), metamorphic grade, and metamorphic facies.
- Relate igneous and metamorphic rocks to plate tectonic settings and tectonic environments.

- Understand the processes of weathering, erosion, transport, and deposition.
- Classify sedimentary rocks based on texture, composition, and sedimentary structures.
- Interpret sedimentary structures to decipher depositional environments.

Course Learning Outcomes (COs):

At the end of the course the student will be able

CO1: gain detailed knowledge of how igneous, sedimentary, and metamorphic rocks form, transform, and interact within the Earth's crust and mantle.

CO2: develop practical skills to classify and identify rocks in hand specimens and thin sections using mineralogical and textural characteristics.

CO3: to interpret the geological history of an area by analyzing rock assemblages, mineral compositions, and textures.

CO4:
Link Petrology to Tectonics and Earth Processes

Mapping CO vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓	✓	✓		
CO2	✓	✓			✓
CO3		✓	✓	✓	✓
CO4	✓	✓			✓

No of Lecture: 30 (1.5 hours each)

Course Content:

Lecture No.	Topic	Details
1	Fundamental concepts of igneous petrology	Types and properties of magma; Heat sources and heat flow in the Earth, Tectonism and magmatism; Thermodynamics in petrology.
2	Generation of magma	Causes and environments of magmatic melting; Movement and ascent of magma; Reaction relationship in magma; Magma differentiation.
3	Crystallization of magma	Phase equilibrium diagrams; Crystallization of unary system; Binary system – binary eutectic, binary peritectic system.

4	Crystallization of magma	Crystallization of binary system – binary solid solution and binary solid solution with eutectic system; Ternary system.
5	Texture, structure, and landforms of igneous rocks	Factors affecting igneous textures; Types of igneous textures and structure; Relationship between texture and formation of igneous rocks; Volcanic and plutonic landforms.
6	Classification of igneous rocks	Problems and schemes of classification; Normative and modal classification; IUGS classification.
7	Petrotectonic association of igneous rocks	Oceanic intraplate volcanism; Mid-oceanic ridge volcanism; Subduction zone igneous activity – Island Arc and continental Arc; Continental magmatism.
8	Common igneous rocks of the continent and ocean basins.	Igneous rocks of the continental lithosphere and oceanic lithosphere.
9	The chemistry of igneous rocks	Major element indices of differentiation; Use of trace elements in identifying differentiation processes; Application of isotopes.
10	Fundamentals of Metamorphism	Concepts of Metamorphism, Agents of metamorphic processes, factors controlling metamorphism rate, Migmatites, and Granitisation.
11	**Incourse-1**	
12	Metamorphic Differentiation	Layering and transposition of original bedding, solution and re-precipitation, and preferential nucleation.
13	Classification of metamorphic rocks	Introduction to different classification schemes, detailed description of metamorphic types (contact, regional, dynamic, hydro-thermal, and impact metamorphism).
14	Metamorphic textures and structures	Various textures associated with metamorphism, resulting structures and their impacts, the Mechanism of Foliated and Unfoliated rocks, and Cataclastic rocks.
15	Petrologic and petrographic description	Detailed study of common metamorphic rocks along with their occurrence and identification.
16	Metamorphic zones, facies, and different grades	Burrow's Metamorphic Zones - describes metamorphic facies and their characters; describes metamorphic facies series, and provides an understanding of paired metamorphic belts.
17	Mineral assemblages and noteworthy reactions in various facies	Introduction to index minerals, their applications, concepts, and mechanisms of critical metamorphic reactions, metamorphism of different protoliths.

18	Origin and Petrotectonic association of Metamorphic Rocks	Different geological settings encouraging various metamorphism, their impacts, and associations.
19	Introduction to Sedimentary Rocks	Introduction to sediments and sedimentary rocks.
20	Sedimentary processes	Sedimentary processes- Weathering, erosion, transportation, deposition, and diagenesis.
21	**Incourse-2**	
22	Basics of sedimentary rocks	Definition and concept of clastic and nonclastic sedimentary rocks. Texture, structure, and classifications of sedimentary rocks.
23	Texture and Structure of Sedimentary Rock	Texture and other properties and attributes of sedimentary rocks, Sedimentary structures – primary (erosional, depositional, biogenic), soft-sediment deformation, and postdepositional.
24	Composition of sedimentary rocks	Identification of framework grains, matrix, cement, and pores. Mineral and chemical composition of sedimentary rocks.
25	Classification of sedimentary rocks	Classification of clastic sedimentary rocks (conglomerate, sandstone, siltstone, and shale). Classification of nonclastic deposits (limestone, dolomite, evaporites, chert, and iron-magnesium).
26	Sedimentary processes and flow regime	Sedimentary processes, properties of fluids, types of fluids, and fluid motions. Flow regime — concept, definition, types; bed forms and interpretation; types of fluid flows and their deposits (and associated facies).
27	Textural properties and attributes	Textural and other properties and attributes of sediment, their measurement, interrelationships, and representations, processes controlling these properties and characteristics, and grain size analyses of sandstone.
28	Sedimentary structures and their uses.	Sedimentary structures — primary depositional (inorganic — physical, chemical, biochemical, organic/biogenic), secondary / soft-sediment deformation structures, and processes responsible for their development (interpretation). Sediment gravity flows — their origin, types, classification, description, occurrences, and uses of Sedimentary structures.
29	Palaeocurrent analysis and Factors controlling sedimentation	Palaeocurrent analysis —various attributes and directional properties of sediment as criteria for palaeocurrent interpretation. Factors controlling sedimentation — tectonics, subsidence, climate, and sea-level changes.

30	Diagenesis of sedimentary rocks	Diagenesis of sedimentary rocks – concretions, nodules, and other diagenetic segregations.

Instructional Strategies: Lectures**,** Class discussions**,** Use of multimedia resources (videos, animations, images) and In-class exercises

Assessment Pattern:

Assessment Pattern level no.	Knowledge level	Level of CO	In-course	Assignment	Final Examination
K1	**Remember**	**CO1-CO3**	04	02	10
K2	**Understand**	**CO2-CO3**	04	02	15
K3	**Apply**	**CO4**	04	02	10
K4	**Analyze**	**CO3-CO4**	04	02	15
K5	**Evaluate**	**CO3-CO4**	04	02	10
K6	**Create**	**CO4**	00	00	00
Total Marks 100 (Class attendance 10 + In-course 20+ Assignment 10+ Final examination 60)			20	10	60

Recommended References:

Textbook:

1. Best, M.G. (2002) Igneous and Metamorphic Petrology (2nd Edition). Wiley-Blackwell.
2. Blatt, H., Ethler, E.G., and Tracy, R. (2005) Petrology: Igneous, Sedimentary and Metamorphic (3^{rd} Edition). W.H. Freeman.
3. Nackolds, S. R. et al. (1978) Petrology for students. Cambridge University Press.
4. Pettijohn, F.J. (2004) Sedimentary Rocks (3rd edition). CBS Publisher.
5. Tucker, M.E. (Ed.) (2001) Sedimentary petrology: an introduction to the origin of sedimentary rocks (3rd edition). John Wiley & Sons.
6. Tyrrell, G.W. (1973) The Principles of Petrology. John Wiley & Sons.

Reference Books:

1. Best, M.G. and Christiansen, E.H. (2000) Igneous Petrology. Wiley-Blackwell.
2. Blatt, H., Middle, G.V., and Murray, Raymond (1980). Origin of sedimentary rocks. Prentice-Hal.
3. Bowen, N. (1928) The Evolution of Igneous Rocks. Dover Publications
4. Folk, R.L. (1980) Petrology of sedimentary rocks. Hemphill Publishing Company

5. Friedman, G.T. and Sanders, J.E. (1978) Principles of sedimentology. Wiley.
6. Hatch, F.H. and Wells, A.K. (1973) The Petrology of Igneous Rocks (13^{th} Edition). Thomas Murby & Co.
7. Hyndman, D. W. (1985). Petrology of Igneous and Metamorphic Rocks (2nd Edition). McGraw-Hill International Series in the Earth and Planetary Sciences.
8. Leeder, M.R. (1982) Sedimentology — Process and product. 3 edn., Springer.
9. Pettijohn, F. J., Potter, P. E., and Siever, R. (1973) Sand and sandstone. Springer Science & Business Media.
10. Pettijohn, F.J. (1975) Sedimentary rocks. 3 edn., Harper & Row, Publishers, New York (USA), London (UK).
11. Philpotts, A. (2003) Petrography of Igneous and Metamorphic Rocks. Waveland Press.
12. References:
13. Scoffin, T. P. (1987) Introduction to carbonate sediments and rocks. The University of California.
14. Shrock, R.R. (1948) Sequence in layered rocks. McGraw-Hill.
15. Spry, A. (1969) Metamorphic Textures. Pergamon Press.
16. Tucker, M. E. (ed.) (2013) Sedimentary petrology: an introduction to the origin of sedimentary rocks. 3 edn. John Wiley & Sons.
17. Turner F.J. (1981) Metamorphic Petrology (2^{nd} Edition). Hemisphere Pub. Corp.
18. Turner, F.J. and Verhoogan, J. (1960) Igneous and Metamorphic Petrology (2^{nd} Edition). McGraw-Hill.
19. Twenhofel, W.H. (1960) Principles of sedimentation. 2 edn., McGraw-Hill.
20. Winker, H.G.F. (2013) Petrogenesis of Metamorphic Rocks (4^{th} Edition). Springer Science & Business Media.
21. Winter, J.D. (2001) An Introduction to Igneous and Metamorphic Petrology. Prentice Hall.

GHT-1203 Essential Physics for Geosciences

Credit Hour: 3

Course Type: General Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description: This introductory physics course focuses on fundamental principles with specific relevance to geological phenomena. We will explore concepts in mechanics, thermodynamics, waves, and electricity and magnetism, emphasizing their applications in understanding Earth's processes, geophysical techniques, and the environment.

Course Learning Objectives (CLOs): Upon successful completion of this course, students will be able to:

- Apply fundamental concepts of mechanics (motion, forces, and energy) to geological problems such as slope stability, erosion, and plate tectonics.
- Understand the principles of thermodynamics and their relevance to Earth's internal heat, geothermal energy, and climate change.
- Explain the behavior of waves and their applications in seismology, geophysics, and remote sensing.

- Understand the principles of electromagnetism and their applications in geophysical exploration methods.
- Develop problem-solving skills and apply physics concepts to real-world geological scenarios.

Course Learning Outcomes (COs):

At the end of the course the student will be able

CO1: learn how core physics concepts—such as force, energy, heat, pressure, and wave motion—apply to geological phenomena.

CO2: develop the capacity to interpret processes like seismic wave propagation, gravity, magnetism, and heat flow within the Earth.

CO3: apply mathematical and physical models to analyze and predict Earth system behavior.

CO4: build the groundwork needed for further studies in geophysics, seismology, and exploration methods using physical principles.

Mapping Co vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

No of Lectures: 30 (1.5 hours each)

Course Content:

Lecture	Topic	Details	Homework/ Assignments
1	Introduction to Physics & Measurement	Units, dimensions, significant figures, scientific notation, vectors and scalars.	
2	Kinematics	Motion in one dimension: position, velocity, acceleration. Graphs of motion.	
3	Kinematics in Two Dimensions	Projectile motion, circular motion, relative motion.	

4	Newton's Laws of Motion	Newton's first, second, and third laws of motion. Applications to geological forces (e.g., gravity, friction).	
5	Work, Energy, and Power	Work, kinetic energy, potential energy. Conservation of energy.	Assignment-1
6	Momentum and Impulse	Linear momentum, conservation of momentum. Collisions.	
7	Rotational Motion	Torque, angular momentum, rotational kinetic energy.	
8	Gravity and Gravitation	Newton's law of universal gravitation. Gravitational potential energy.	
9	Fluid Mechanics	Density, pressure, buoyancy. Fluid flow. Applications to groundwater and hydrology.	
10	Temperature and Heat	Temperature scales, heat transfer (conduction, convection, radiation).	Assignment-2
11	**In-course/midterm-1**		
12	Thermodynamics	First law of thermodynamics (conservation of energy).	
13	Thermodynamics II	Second law of thermodynamics. Entropy.	
14	Waves	Types of waves (mechanical, electromagnetic). Wave properties (wavelength, frequency, amplitude).	
15	Sound Waves	Sound propagation, the Doppler effect.	Assignment-3
16	Seismic Waves	Types of seismic waves (P-waves, S-waves, surface waves). Earthquake seismology.	

17	Electromagnetic Waves	Electromagnetic spectrum, properties of light.	
18	Optics	Reflection, refraction, diffraction.	
19	Electricity	Electric charge, Coulomb's law, electric fields.	
20	Magnetism	Magnetic fields, magnetic forces, magnetic materials.	Assignment-4
21	**In-course/midterm-2**		
22	Electromagnetism	Electromagnetic induction, Faraday's law.	
23	DC Circuits	Ohm's law, electrical resistance, electrical power.	
24	AC Circuits	Alternating current, voltage, and current.	
25	Remote Sensing	Principles of remote sensing. Electromagnetic radiation and Earth observation.	Assignment-5
26-27	Environmental Physics	Atmospheric physics, climate change, environmental radioactivity.	
28	Nuclear Physics	Radioactivity, nuclear reactions, applications in geochronology.	
29-30	Review and Applications	Review of key concepts and applications to geological problems.	Assignment-6

Instructional Strategies: Lectures**,** Class discussions**,** Use of multimedia resources (videos, animations, images) and In-class exercises

Assessment Pattern:

Assessment Pattern level no.	Knowledge level	Level of CO	In-course	Assignment	Final Examination
K1	**Remember**	**CO1-CO4**	05	2.5	15
K2	**Understand**	**CO1-CO4**	05	2.5	15
K3	**Apply**	**CO1-CO4**	05	2.5	15
K4	**Analyze**	**CO1-CO4**	05	2.5	15
K5	**Evaluate**	**CO1-CO4**	00	00	00
K6	**Create**	**CO1-CO4**	00	00	00
Total Marks 100 (Class attendance 10 + In-course 20+ Assignment 10+ Final examination 60)			20	10	60

Recommended References:

Textbook and Reading Materials:

Text Book:
Serway, R. A., Jewett, J. W., & Peroomian, V. (2000). Physics for scientists and engineers (Vol. 2). Fort Worth, TX: Saunders college publishing.

Reference Book:

Stacey, F. D., & Davis, P. M. (2008). *Physics of the Earth*. Cambridge University Press.

GHT-1204 Essential Chemistry for Geosciences

Credit Hour: 3

Course Type: General Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description: This introductory course provides a foundation in fundamental chemical principles with a specific emphasis on their relevance to Earth sciences. We will explore the building blocks of matter, chemical reactions, and the properties of substances, while highlighting their applications in understanding geological processes, environmental issues, and the chemistry of our planet.

Course Learning Objectives (CLOs): Upon successful completion of this course, students will be able to:

- Understand the basic structure of atoms and the organization of the periodic table.
- Describe the different types of chemical bonding and their implications for mineral structures.

- Write and balance chemical equations, and perform stoichiometric calculations relevant to geochemical processes.
- Understand the states of matter and the factors that influence phase changes in Earth systems.
- Explain the concepts of acids and bases, and their role in natural waters and soil systems.
- Understand the basic principles of thermodynamics and their application to geological processes.
- Apply chemical principles to understand environmental issues such as pollution, climate change, and water quality.

Course Learning Outcomes (COs):

At the end of the course the student will be able

CO1: gain foundational knowledge of chemical principles (e.g., bonding, thermodynamics, and kinetics) as they apply to geological systems.

CO2: develop the skills to interpret the chemical composition of minerals, rocks, and fluids to understand Earth processes.

CO3: learn how stable and radiogenic isotopes, along with trace elements, are used to date rocks and trace geologic processes.

CO4: explore chemical interactions in Earth systems, such as weathering, hydrothermal alteration, and atmospheric exchange.

CO5: acquire experience in geochemical lab methods (e.g., titration, spectroscopy, chromatography) to investigate geological materials.

Mapping Co vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓

No of Lectures: 30 (1.5 hours each)

Course Content:

Lecture	Topic	Details	Homework/ Assignments
1	Introduction to Chemistry	The scientific method, measurement, units, significant figures.	
2	Matter and Classification	States of matter, physical and chemical properties, changes of state.	
3	Atoms and Elements	Atomic structure, isotopes, atomic mass, the mole concept.	
4	The Periodic Table	Organization of the periodic table, trends in properties (electronegativity, ionization energy).	
5	Chemical Bonding	Ionic, covalent, and metallic bonding. Bonding in minerals.	Assignment-1
6	Nomenclature	Naming inorganic compounds (ionic, covalent, acids).	
7	Chemical Reactions	Types of chemical reactions (synthesis, decomposition, single-replacement, double-replacement, combustion).1	
8	Stoichiometry	Balancing chemical equations, mole ratios, limiting reactants, percent yield. Stoichiometry of geochemical reactions.	
9	Gases	Gas laws (Boyle's, Charles', Avogadro's, Ideal Gas Law), kinetic molecular theory. Atmospheric chemistry.	
10	Liquids and Solids	Intermolecular forces, properties of liquids and solids. Water as a solvent.	Assignment-2
11	**In-course/Midterm-1**		

12	Solutions	Solubility, concentration units (molarity, molality), colligative properties. Aqueous solutions in natural systems.	
13	Acids and Bases	Arrhenius, Brønsted-Lowry, and Lewis definitions of acids and bases. pH and pOH. Acid rain.	
14	Acid-Base Equilibria	Strong and weak acids and bases, buffers. Buffers in natural waters.	Assignment-3
15	Oxidation-Reduction Reactions	Oxidation numbers, balancing redox reactions. Redox reactions in the environment.	
16	Thermodynamics I	Energy, heat, work, enthalpy, exothermic and endothermic reactions.	
17	Thermodynamics II	Entropy, Gibbs free energy, spontaneity of reactions. Mineral stability.	
18	Kinetics	Reaction rates, factors affecting reaction rates, catalysts. Weathering reactions.	
19	Equilibrium	Chemical equilibrium, equilibrium constants, Le Chatelier's principle.	Assignment-4
20	**In-course/Midterm-2**		
21	Water Chemistry	Water quality parameters, water treatment, water pollution.	
22	Soil Chemistry	Soil composition, soil acidity, nutrient cycling.	
23	Atmospheric Chemistry	Composition of the atmosphere, air pollution, greenhouse effect.	
24	Geochemical Cycles	The water cycle, carbon cycle, nitrogen cycle.	Assignment-5
26	Geochemical Exploration	Techniques used in geochemical exploration for mineral resources.	

27-29	Organic Geochemistry	Introduction to organic compounds in the environment.	
28-30	Laboratory Skills (if applicable)	Basic laboratory techniques and safety procedures.	Assignment-6

Instructional Strategies: Lectures**,** Class discussions**,** Use of multimedia resources (videos, animations, images) and In-class exercises

Assessment Pattern:

Assessment Pattern level no.	Knowledge level	Level of CO	In-course	Assignment	Final Examination
K1	**Remember**	**CO1-CO4**	05	2.5	15
K2	**Understand**	**CO1-CO4**	05	2.5	15
K3	**Apply**	**CO1-CO4**	05	2.5	15
K4	**Analyze**	**CO1-CO4**	05	2.5	15
K5	**Evaluate**	**CO1-CO5**	00	00	00
K6	**Create**	**CO1-CO5**	00	00	00
Total Marks 100 (Class attendance 10 + In-course 20+ Assignment 10+ Final examination 60)			20	10	60

Recommended References:

Textbook

1. Chang R (2012) Chemistry (11th Edition), McGraw-Hill Education
2. Ebbing, D. and Gammon, S.D. (2016) General Chemistry, Cengage Learning

References:

1. J. M. Coxon, J. E. Fergusson and L. F. Philips. Edward Arnold, First Tear Chemistry, London
2. Koltz and Treichel General Chemistry: A molecular picture
3. Chemistry: A molecular nature of matter and change, Martin Silberberg, McGraw Hill.
4. A-level Chemistry, E. N. Ramsden

GHL-1205 Petrology Lab

Credit Hour: 3

Course Type: Core Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description:
This is a basic course on petrology laboratory required as partial fulfillment of the four-year B.S Honours degree in Geology. The course deals with the description and identification of igneous, metamorphic and sedimentary rock samples in hand specimen. The course is designed to impart practical knowledge to describe physical characters, structure, texture, mineral composition and origin of the rocks in hand specimen and thereby different types of igneous, metamorphic and sedimentary rocks are identified and classified. The course extends beyond identification to include advanced laboratory techniques such as manual and instrumental grain-size analysis, statistical interpretation of sedimentary data, magnetic mineral separation, and macroscopic coal analysis.

Course Learning Objectives (CLOs):
By the end of the course, the learners will be able to –

a. Identify and classify different types of igneous, metamorphic and sedimentary rocks in hand specimen based on their physical characters, structure, texture mineral composition and origin of all three types of rocks.
b. Identify granite, syenite, gabbro, basalt, rhyolite, trachyte, obsidian, pitchstone etc.
c. Identify and classify clastic and non-clastic sedimentary rocks such as sandstone, shale conglomerate, breccia, limestone etc.
d. Identify mica-schists, hornblende-schist, chlorite-schist, talc-schist, gneiss, quartzite, marble etc.
e. Analyze sedimentary rock textures and fabrics, recognizing features like grain imbrication, deformation structures, biogenic features, and top-bottom criteria.
f. Conduct grain-size analyses using manual measurements, dry and wet sieving, and particle-size analyzers, and interpret results through graphical representation and statistical parameters.
g. Interpret environmental and geological processes from lab data and integrate theoretical knowledge with practical observation.

Course Learning Outcomes (COs):

At the end of the course the students will be able to
CO1: gain hands-on experience in identifying igneous, sedimentary, and metamorphic rocks using hand specimens and thin sections.

CO2: learn to interpret the origin and evolution of rocks based on mineral composition, texture, and field relationships.

Mapping Co vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓

No of Lab classes: 30 (3 hours each)

Course Content:

Lab	Topic	Activities	Assignments
1	Igneous Rock Identification	Description and identification of acid (intrusive and extrusive) igneous rocks in hand specimen based on physical characters, structure, texture, mineral composition and origin	
2	Igneous Rock Identification	Description and identification of intermediate (intrusive and extrusive) rocks in hand specimen based on physical characters, structure, texture, mineral composition and origin	
3	Igneous Rock Identification	Description and identification basic (intrusive and extrusive) igneous rocks in hand specimen based on physical characters, structure, texture, mineral composition and origin	
4	Igneous Rock Identification	Description and identification of ultra-basic igneous rocks in hand specimen based on physical characters, structure, texture, mineral composition and origin	
5	Sedimentary Rock Identification	Identification of clastic (sandstone- ferruginous, calcareous, siliceous, carbonaceous etc.) rocks in hand specimen based on physical characters, structure, texture, mineral composition and origin	Assignment-1
6	Sedimentary Rock Identification	Identification of clastic (sandstone- ferruginous, calcareous, siliceous, carbonaceous etc.) rocks in hand specimen based on physical characters, structure, texture, mineral composition and origin	
7	Sedimentary Rock Identification	Identification of clastic (shale, conglomerate, breccia etc.) rocks in hand specimen based on physical characters, structure, texture, mineral composition and origin	
8	Sedimentary Rock Identification	Identification of non-clastic (limestone both crystalline) and bio-clastic rocks in hand specimen based on physical characters, structure, texture, mineral composition and origin	
9	Metamorphic Rock Identification	Identification of metamorphic rocks in hand specimen such as gneiss, mica-schists, hornblende-schist etc. on the basis of their physical characters, structure, texture, mineral composition, origin and metamorphic grade	
10	Metamorphic Rock Identification	Identification of metamorphic rocks in hand specimen such as chlorite-schist, talc-schist etc. on the basis of their physical characters, structure, texture, mineral composition, origin and metamorphic grade	Assignment-2
11	**In-course/Midterm-1**		
12-15	Metamorphic Rock Identification	Identification of metamorphic rocks in hand specimen such as quartzite, marble, slate etc. on the basis of their physical characters, structure,	Assignment-3

		texture, mineral composition, origin and metamorphic grade	
16-18	Study of Sedimentary Rock in Hand Specimens	Examination of sedimentary rock hand specimens to understand fabric, imbrication, soft sediment deformation, chemical and biogenic structures, and top-bottom criteria.	
19	Manual Grain Size Analysis	Manual measurements of individual clasts in unconsolidated sediments and disaggregated sedimentary rocks: pebbles, cobbles, and boulders	
20–21	Grain Size Analysis by Dry Sieving	Sample preparation and dry-sieve analysis of unconsolidated sediments (gravel, sand, silt) and disaggregated sedimentary rocks	Assignment-4
22	Grain Size Analysis by Wet Sieving	Conducting hydrometer analysis to determine the finer fraction of sediment samples.	
23	Mechanically grain size analysis	Utilizing a particle-size analyzer for precise grain-size analysis.	
24	**In-course/Midterm-2**		
25–27	Graphical Representation and Statistical Analysis	Graphical representation and statistical analysis and interrelationships of grain-size parameters, and their (environmental) interpretation	
28-29	Magnetic/Magnetically-Susceptible Mineral Separation	Isodynamic technique/procedure/method employed to study the magnetic/magnetically-susceptible mineral species	
30	Coal petrology	Study macroscopic component of coal (visible to the necked eye; vitrain, clarain, durain, fusain)	Assignment-5

Instructional strategies:

Laboratory work, Demonstration, Discussion, Question-Answer

Assessment Pattern:

Assessment Pattern level no.	Knowledge level	Level of CO	In-course	Assignment	Final Examination
K1	**Remember**	**CO1-CO2**	10	05	30
K2	**Understand**	**CO1-CO2**	05	03	20
K3	**Apply**	**CO1-CO2**	05	02	10
K4	**Analyze**	**CO1-CO2**	00	00	00
K5	**Evaluate**	**CO1-CO2**	00	00	00
K6	**Create**	**CO1-CO2**	00	00	00

Total Marks 100 (Class attendance 10 + In-course 20+ Assignment 10+ Final examination 60)		20	10	60

Recommended References:

1. Tyrrell, G.W. (1973) The Principles of Petrology, John Wiley and Sons.

2. Folk, R.L. (1980) Petrology of sedimentary rocks. Hemphill Publishing Company.

3. George Allen & Unwin Ltd., London, (UK). Bouma, A.H., (1969) Methods for the study of sedimentary structures.

4. Wiley-Interscience, New York. Carver, R.E., ed., (1971) Procedures in sedimentary petrology. Wiley-Interscience, New York; Sydney.

GHF-1206 Geological Field Mapping

Credit Hour: 3

Course Type: Capstone Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description:
This course integrates laboratory and field components to develop foundation skills in structural geology and geological mapping. The laboratory sessions cover map scale computations, topographic profiling, structural data plotting, contour and cross-section construction, and interpretation of topographic and geological maps. Complementing the lab work, a seven-day field excursion to the hill tracts of Bangladesh focuses on the observation and mapping of large-scale geological structures such as folds, faults, and unconformities within Mio-Pliocene sedimentary strata. Students will gain hands-on experience in measuring bed attitudes, interpreting three-dimensional geological structures, and reconstructing the geological history of the area. Independent work is emphasized, supported by teaching assistants during lab sessions.

Course Learning Objectives (CLOs):

- To develop foundational skills in geological map interpretation and structural data analysis through hands-on laboratory exercises.
- To enhance students' ability to construct and interpret topographic profiles, geological cross-sections, and contour maps.
- To provide practical experience in measuring and plotting geological structures such as dip, strike, folds, faults, and unconformities.
- To enable students to conduct field-based geological mapping and reconstruct the geological history of an area using three-dimensional spatial reasoning.
- To familiarize students with the identification of sedimentary rocks and the application of field techniques in structural geology.

Course Learning Outcomes (COs):

CO1: learn how to identify, describe, and document rock types, structures, and stratigraphic relationships in natural outcrops.

CO2: acquire practical skills in using topographic maps, compass-clinometers, GPS, and field notebooks to create accurate geological maps and cross-sections.

CO3: gain the ability to reconstruct the geological evolution of an area based on field relationships, structural features, and stratigraphy.

CO4: apply critical thinking and field data analysis to interpret tectonic settings, resource potential, and geohazards.

Mapping CO vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓	✓	✓	✓	
CO2	✓	✓	✓		
CO3	✓	✓	✓	✓	✓
CO4	✓	✓		✓	✓

Course Content:

Lecture	Topic	Details	Homework/ Assignments
1-5	Introduction to Geological Field	Fundamentals of analytical techniques used in field, field equipments, sampling strategy and field safety measures	Assignment-1
6-25 (6hrs/day X 5days; 30 hours equivalent to 20 lectures)	Geological Fieldwork and Map preparation	Geological fieldwork will involve observing, measuring, and sampling rocks, structures, and landforms to interpret an area's geological history. Tasks will encompass identifying lithologies, mapping structures, collecting samples, and recording precise locations with GPS. The collected data are later compiled to create a geological map showing surface geology and structural features	Assignment-2

26-29 (6hrs/day; equivalent to 4 lectures)	Assessment of Field Performance and Field Viva
30	Overall Field Summary and Instructions on Field Report preparation

Instructional strategies:
Lecture, Class practice and on field training

Assessment Pattern:

Assessment Pattern level no.	Knowledge level	Level of CO	Field Performance	Field report
K1	**Remember**	**CO1-CO4**	00	00
K2	**Understand**	**CO1-CO4**	15	10
K3	**Apply**	**CO1-CO4**	15	20
K4	**Analyze**	**CO1-CO4**	05	10
K5	**Evaluate**	**CO1-CO4**	05	10
K6	**Create**	**CO1-CO4**	00	10
Total Marks 100 (Class attendance 10 + In-course 20+ Assignment 10+ Final examination 60)			40	60

Recommended References:

Text Book:

1. Coe, A.L. (2010) Geological Field Techniques. John Wiley & Sons.

Reference Book:

2. Beninson, G.M. (1990) An Introduction to Geological Structures and Map (5th Edition). Edward Arnold Publishers.

3. Lisle, R.J. (2004) Geological Structures and Maps - A Practical Guide (3rd Edition). Elsevier

4. Maltman, A. (1990) Geological maps: An introduction. Open University Press.

5. Platt, J.I. (1951) Selected Exercises upon Geological Maps. T. Murby Publishers.

6. Lisle, R.J., Brabham, P.J., Barnes, J.W. & (2011) Basic Geological Mapping (5th Edition), Wiley-Blackwell.
7. Barnes, J.W. & Lisle, R.J. (2004) Basic Geological Mapping (4th Edition). John Wiley & Sons.
8. McClay, K.R. (1987) The Mapping of Geological Structures (Reprinted 2007). John Wiley & Sons.
9. Compton, R.R. (1962) Manual of Field Geology. Wiley.
10. Lahee, F.H. (1961) Field Geology (6th Edition). McGraw-Hill Book Co.
11. Low, J.W. (1957) Geological Field Methods. Harper & Bros

GHV-1207 Viva Voce

Credit Hour: Non-Credit Course

Course Type: Capstone Course

Total Marks: Satisfactory / Unsatisfactory

Course Description:

Viva voce will be conducted towards the end of the academic year which will be covering the complete syllabus. This will assess the student's knowledge and understanding during the course of their graduate programme. In doing so, the main objective of this course is to prepare the students to face interview both at the academic and the professional arenas.

Course Learning Objectives (CLOs):

The primary aim of the course is to develop students' confidence in oral assessments and to evaluate the conceptual understanding gained during their second year of undergraduate education.

Course Learning Outcomes (COs):

Upon successful completion of the course the students will be able to

CO1: To describe and explain their understanding of the theoretical and practical geology courses

CO2: Get prepared to face the interview both at the academic and the professional arenas

Mapping CO vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓	✓	✓		
CO2				✓	✓

Assessment Pattern:
Oral Examination

GHT-2101 Structural Geology, Tectonics and Geodynamics

Credit Hour: 3

Course Type: Core Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description:
This course introduces students to the principles of structural geology, tectonics, and geodynamics. It covers the analysis of rock structures formed through deformation processes, the dynamics of plate tectonics, and the internal mechanisms that shape the Earth's crust and mantle. The course integrates theory with practical techniques such as map interpretation and structural analysis to prepare students for advanced geoscience applications.
This course will also focus on the basic concepts and theories of tectonics. The megascopic structure of the earth, oceanic and continental crust and lithosphere, and the asthenosphere will be introduced and compared. The basic dynamic potentials acting on the Earth (heat, gravity) will be examined, and their diverse first order effects will be explored (isostasy, convection, exhumation, pluming). The concepts of rifting and ocean formation will be examined, as will those of subduction and mantle plumes. Processes of orogenesis will be described in depth. Additionally, the above-mentioned theoretical aspects will be applied in studying the tectonics of the Indian subcontinent.

Course Learning Objectives (CLOs):
By the end of this course, students will be able to:

- Understand the principles of rock deformation and the classification of geological structures.
- Analyze tectonic processes including plate motions, subduction, and orogeny
- Apply structural geology techniques such as stereographic projection and map interpretation.
- Explore the Earth's dynamic behavior using geodynamic concepts and models
- Evaluate real-world geological phenomena through an integrated structural, tectonic, and geodynamic framework
- Describe the tectonic processes that operate at plate boundaries and their effects on the plate interior
- Explain the main forces that impact the Earth's surface and subsurface, what drives them and how the Earth responds
- Describe models for the lithosphere and asthenosphere including their physical properties
- Identify various tectonic features and processes operating in the past based on appropriate structural, metamorphic, geophysical, geochemical evidence
- Apply the knowledge of tectonic processes explaining regional tectonic features
- Explore the relationship between tectonic processes and natural hazards to improve disaster preparedness.

Course Learning Outcomes (COs):
Upon successful completion of this course, students will be able to:

CO1: Understand the forces and stress involved in the crustal deformation, the structural element, and top-bottom criteria
CO2: Perceive the mechanical processes involved in the formation of the minor structures, and their relationship with major structures.
CO3: Describe the general characteristics, geometric elements, and nomenclature and classification of fold, fault, and identify the criteria to determine the relationship between the fold and fault in the field

CO4: Understand the mechanism of stress trajectory, measurement of strain of deformed objects, and adept in data collection and analysis of stress-strain relationship using stereographic projection.
CO5: Explain the petro-fabric deformation criteria for lineament identification
CO6: Understand the basics of tectonics, history of the evolution of tectonic theories, Earth's crustal deformation
CO7: Perceive Mantle-plume generation, its mechanisms and role in explaining rift and drift of tectonic plates, formation of triple junction, and understanding the basin configuration and subsidence.
CO8: Understand the deformation of plate margins, impact of plate reconstruction in tectonic stratigraphy and able to deduce tectonic deformation
CO9: Perceive the tectonic evolution of Bengal Basin, Himalaya and Indo-Barmese Range

Mapping CO vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓	✓	✓		
CO2	✓	✓	✓	✓	
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓
CO6	✓	✓	✓	✓	
CO7	✓	✓	✓	✓	✓
CO8	✓	✓	✓	✓	✓
CO9	✓	✓	✓	✓	✓

No of Lecture: 30 (1.5 hours each)

Course Content:

Lecture No.	Lecture Topic	Topic Details	Assignment
1	Introduction to Structural Geology	Course outline, structural elements, classification, coding, penetrative vs. non-penetrative features, tectonites, and fabric	
2	Top and Bottom Criteria	Facing indicators, sedimentary structures, way-up criteria, implications in structural interpretation	
3	Minor Structures – Part 1	Drag folds, cleavage types, schistosity development, micro-structural features	
4	Minor Structures – Part 2 and Their Relationship with Major Structures	Lineation (stretching, mineral, intersection), relation of minor to major structures	
5	Mechanics of Folding and Thrust Relationship	Fold formation mechanisms, fold-thrust relationships, recognition of folds in the field	Assignment-1
6	Stereographic Projection – Principles and	Concept of stereonets, π and β diagrams, plotting planes and lines, structural data analysis	

	Applications		
7	Stress Analysis in Structural Geology	Stress theory, stress ellipsoid, faulting mechanisms, stress trajectories, tectonic stress fields	
8	Strain Analysis and Geological Significance	Strain ellipsoid and ellipse, homogeneous vs. inhomogeneous strain, finite vs. infinitesimal strain	
9	Strain Measurement and Analysis	Strain from deformed objects, measurement techniques, graphical and restoration methods	
10	Lineaments and Petrofabric Studies	Definition, mapping lineaments, petrofabric principles, deformation mechanisms, oriented sampling	Assignment-2
11	**In-course/Midterm-1**		
12	Introduction to tectonics and Basic concepts of tectonics	Comprehensive introduction to the dynamic processes shaping Earth's surface; foundational ideas that explain the dynamics of Earth's lithosphere	
13	Tectonic theories and Evolution of tectonic theories	Basic ideas and evidence that explain the movement and interaction of Earth's tectonic plates; historical development and refinement of ideas explaining Earth's tectonic processes.	
14	Crustal Types and Crustal Provinces	Different types of Earth's crust and their characteristics; distinct regions of Earth's crust that have unique geological characteristics and histories.	
15	Mantle-plume	Definition, structure, formation, geological impact and controversies.	Assignment-3
16	Mantle-plume Generation and Mechanisms of Mantle-plume Generation	Deep Earth processes driving mantle plume generation; processes and dynamics that lead to the formation of mantle plumes.	
17	Rifting and Drifting	Geological process where Earth's lithosphere is stretched and pulled apart, leading to the formation of rift valleys or basins; gradual movement of Earth's continents over geological time due to the tectonic plate activities.	
18	Triple Junction	Definition, Types of Triple Junctions, Formation and Stability, Historical Development, Geological Significance and Examples.	
19	Hot Spots	Definition, Formation, Geological Significance, Hot Spot Tracks and Examples	
20	Concept of Basin and Basin Formation	Definition, Types of Basins; processes and mechanisms that lead to the creation of basins on Earth's surface.	Assignment-4
21	**In-course/Midterm-2**		
22	Concept of Subsidence and Subsidence	Definition, Causes, Types and Impacts; processes and factors that lead to the sinking or lowering of Earth's surface.	

	Mechanism		
23	Classification and Characteristics of Plate Margins	Different types of boundaries where tectonic plates interact; features and processes associated with the boundaries where tectonic plates interact.	
24	Plate Reconstruction	Historical positions and movements of tectonic plates to understand Earth's geological past.	
25	Tectonics and Magma Association	Relationship between tectonic processes and the generation, movement, and evolution of magma.	Assignment-5
26	Ophiolites and its significance	Definition, Formation, Significance in Plate Tectonics.	
27	Tectono-Stratigraphy	The study of how tectonic processes influence stratigraphic sequences, shaping Earth's geological history.	
28	Tectonic Evolution of the Bay of Bengal and Bengal Basin	Formation and Early Development, Influence of Mantle Plumes, Sediment Supply and Depositional Changes, Tectonic Activity and Basin Evolution and Modern Geological Features.	
29	Tectonic Evolution of the Himalayas	The Collision of Plates, Stages of Evolution, Tectonic Subdivisions, Structural Features and Geological Significance.	
30	Tectonic Evolution of the Indo-Burman Ranges	The Formation and Early History, Ophiolites and Metamorphism, Sedimentary Records, Structural Features and Modern Tectonics	Assignment-6

Instructional Strategies: Lectures**,** Class discussions**,** Use of multimedia resources (videos, animations, images) and In-class exercises

Assessment Pattern

Assessment Pattern level no.	Knowledge level	Level of CO	In-course	Assignment	Final Examination
K1	**Remember**	**CO1, CO2, CO9**	00	00	10
K2	**Understand**	**CO2-CO4, CO6-CO8, CO9**	03	00	15
K3	**Apply**	**CO3-CO4, CO5, CO7, CO9**	03	02	15
K4	**Analyze**	**CO3, CO4, CO9**	04	02	10
K5	**Evaluate**	**CO3-CO9**	05	03	10
K6	**Create**	**CO3-CO5**	05	03	00
Total Marks 100 (Class attendance 10 + In-course 20+ Assignment 10+ Final examination 60)			20	10	60

Recommended References:

1. Billings, M. P. 1972. Structural geology. Prentice Hall College Div.
2. Ramsay, J.G. and Huber, M.I. 1983. The techniques of Modern Structural Geology. Vol. 1: 3. Strain Analysis. Academic Press.
3. Ramsay, J.G and Huber, M.I. 1997. The techniques of Modern Structural Geology. Vol. 2: Folds and Fractures. Academic Press.
4. Fossen, H., 2016. Structural geology. Cambridge university press.
5. Moores, E.M. and Twiss, R.J., 2014. *Tectonics*. Waveland Press.
6. Turcotte, D.L. and Schubert, G., 2002. *Geodynamics*. Cambridge university press.

GHT-2102 Sedimentology

Credit Hour: 3

Course Type: Core Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description:

This course provides a detailed understanding of sedimentary processes, sedimentary rocks, and depositional environments, essential for interpreting Earth's geological history. It begins with sedimentary processes and fluid dynamics, introducing flow regimes, bed forms, and sediment transport mechanisms. Students will then explore sedimentary textures and structures, including primary depositional and soft-sediment deformation features. The course covers sediment gravity flows and paleocurrent analysis, which are essential for interpreting provenance, transport mechanisms, and depositional settings.

A major emphasis is placed on facies analysis and facies models, including Walther's Law, cyclic sedimentation, and the construction of facies models. The study of continental, transitional, and marine depositional environments will provide insights into modern and ancient sedimentary systems. The final part of the course focuses on sedimentary basins, basin-fill dynamics, and subsidence history, integrating sequence stratigraphy, accommodation space, sediment supply, and tectonic controls. Students will apply their knowledge through fieldwork, sedimentary logging, facies modelling, and case studies, preparing them for careers in geological research, petroleum exploration, and environmental geoscience.

Course Learning Objectives (CLOs):

By the end of this course, students will be able to:

- Explain sedimentary processes and the role of fluids in sediment transport
- Analyze sedimentary textures and structures to interpret depositional environments
- Understand sediment transport mechanics and interpret paleocurrent data
- Classify and interpret sedimentary rocks, including detrital, chemical, and biogenic sediments
- Conduct facies analysis and construct facies models for different depositional systems
- Understand the role of tectonics, climate, and sea-level changes in sedimentation
- Apply sequence stratigraphy to reconstruct sedimentary basin evolution
- Analyze sedimentary basins using source-to-sink concepts and stratigraphic principles
- Use field and laboratory techniques such as sedimentary logging, grain-size analysis, and paleogeographic reconstructions

Course Learning Outcomes (COs):

Upon successful completion of this course, students will be able to:

CO1: Understand the basics of sedimentary rock formation and sedimentary cycle, the processes and the products involved in sedimentary rock formation
CO2: Identify and describe the properties of the sedimentary rock (texture and structure) to deduce nature, composition, classification and genetic conditions for formation of sedimentary rocks
CO3: Relate the physical properties of the sedimentary rock to the sedimentary processes with the directional properties for paleocurrent analysis
CO4: Discriminate the factors controlling the environments of the sedimentary depositional environments (for siliciclastic and carbonate sedimentary rocks)
CO5: Understand the concepts associated with facies analysis, models and its applications
CO6: Evaluate the sedimentary rock considering facies analyses to deduce basin-fill history
CO7: Perceive the processes of accommodation and correlate with the regional and global subsidence history

Mapping CO vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓	✓	✓		
CO2	✓	✓	✓		✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓
CO6	✓	✓	✓	✓	✓
CO7	✓	✓	✓	✓	✓

No of Lecture: 30 (1.5 hours each)

Course content:

Lecture	Topic	Details	Homework/ Assignments
1	Introduction to Sedimentology	Scope, importance, and career in sedimentology, Sedimentary processes	Assignment -1
2–3	Fluid dynamics and flow regime	Properties of fluids, Types of fluids and fluid motions, Flow regime concept, definition, types, Bedforms and interpretation; types of fluid flows and their deposits (and associated facies)	Assignment-2
4	Sedimentary Texture	Textural and other properties and attributes of sediment and their measurement, interrelationships and representations; processes controlling these properties and attributes	Assignment-3
5–8	Sedimentary structures	Primary depositional (inorganic — physical, chemical biochemical, organic/biogenic), Secondary /soft-sediment deformation structures,	Assignment-4

		and processes responsible for their development (interpretation)	
9	Sediment gravity flows	Origin, types (debris flows, turbidity currents), description, and occurrences	Assignment-5
10	Paleocurrent analysis	Various attributes and directional properties of sediment as criteria for paleocurrent interpretation	Assignment-6
11	**In-course/midterm-1**		
12	Factors controlling sedimentation	Role of tectonics, subsidence, climate, sea-level changes	Assignment-7
13–16	Facies analysis	Concept, facies successions (sequence and association), interpretations, Facies models — its construction, function, and applications	Assignment-8
17	Cyclic sedimentation	Cyclicity and its recognition in facies sequence, basin margin and deep-basin facies and sequence	Assignment-9
18–20	Depositional environments	Major continental, transitional, and marine depositional environments and sedimentary records	Assignment-10
21	**In-course/midterm-2**		
22–25	Sedimentary basin and basin fill	Basic concepts, classification of sedimentary basin, and mechanisms of basin formation, Sedimentary basin-fill — sediment routing system, erosional engine, measurements of erosion rates, channel-Hillslope processes, sediment transport and deposition, analysis of source-to-sink systems	
26–30	Basin stratigraphy and subsidence history	Process stratigraphy, accommodation, sediment supply, and sea level, hierarchy from beds to mega-sequences, forcing mechanism, dynamical approaches to stratigraphy, Subsidence analysis, compressibility and compaction of porous sediments, and subsidence history and backstripping. Case studies - Bengal Basin and surroundings.	

Instructional Strategies: Lectures**,** Class discussions**,** Use of multimedia resources (videos, animations, images) and In-class exercises

Assessment Pattern:

Assessment Pattern level no.	Knowledge level	Level of CO	In-course	Assignment	Final Examination
K1	**Remember**	CO1-CO3	05	00	10
K2	**Understand**	CO2-CO5	05	00	20
K3	**Apply**	CO3-CO5	04	00	10
K4	**Analyze**	CO3-CO6	03	00	10
K5	**Evaluate**	CO5-CO7	03	05	10
K6	**Create**	CO6-CO7	00	05	00
Total Marks 100 (Class attendance 10 + In-course 20+ Assignment 10+ Final examination 60)			20	10	60

Recommended References:

1. Allen, P. A., & Allen, J. R. (2013). *Basin Analysis: Principles and Application to Petroleum Play Assessment* (3rd ed.). Wiley-Blackwell.
2. Bridge, J., & Demicco, R. (2008). *Earth Surface Processes, Landforms and Sediment Deposits.* Cambridge University Press.
3. Leeder, M.R. (1982) Sedimentology - Process and Product. Springer.
4. Leeder, M. R. (2011). *Sedimentology and Sedimentary Basins: From Turbulence to Tectonics* (2nd ed.). John Wiley & Sons.Leeder, M.R. (2011) Sedimentology and Sedimentary Basins: From Turbulence to Tectonics (2nd Edition). John Wiley & Sons.
5. Potter, P. E., & Pettijohn, F. J. (2013). *Palaeocurrent and Basin Analysis.* Springer Science & Business Media.
6. Reineck, H. E., & Singh, I. B. (2012). *Depositional Sedimentary Environment: With Reference to Terrigenous Clastics.* Springer.
7. Selley, R. C., & Sonnenberg, S. A. (2014). *Elements of Petroleum Geology.* Elsevier.
8. Posamentier, H. W., & Walker, R. G. (2006). *Facies Models Revisited.* SEPM Special Publication Vol. 84.

GHT-2103 Planetary Geology

Credit Hour: 3

Course Type: Core Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description: This course provides an in-depth exploration of the geological processes shaping planetary bodies, including planets, moons, asteroids, and other celestial objects. Topics include planetary formation, surface and internal processes, impact cratering, volcanism, tectonics, and climate evolution. The course also introduces planetary exploration techniques using spacecraft data, remote sensing, and geophysical methods.

Course Learning Objectives (CLOs): The objectives of the course are:

- Understand planetary formation and evolution.
- Analyze geological processes on different celestial bodies.
- Compare planetary surfaces and interiors.
- Study planetary atmospheres, climate evolution, and habitability.
- Evaluate past, present, and future planetary exploration missions.

Course Learning Outcomes (COs):

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

CO1: Understand the formation of solar system and planetary bodies, different planetary materials and internal structures of the celestial bodies
CO2: Explain the historical development of astronomy, key planetary missions and discoveries
CO3: Relate the physical properties of the Earth and other planets/ satellites in terms of tectonics and crustal deformation
CO4: Discriminate the factors shaping different planetary systems to understand the driving mechanisms
CO5: Understand the basic astronomical concepts and ideas to analyze data collected from extraterrestrial bodies for planetary chronology
CO6: Perceive the past, present and fate of planetary bodies (Earth, Mars, Venus, Mercury)

Mapping CO vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓				
CO2	✓		✓		
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓		✓
CO6	✓	✓	✓	✓	✓

No of Lecture: 30 (1.5 hours each)

Course Content:

Lecture	Topic	Details	Homework/ Assignments
1 & 2	Introduction to Planetary Geology	Definition, scope, and history of planetary science. Key planetary missions and discoveries.	
3	Formation of the Solar System & Planetary Bodies	The nebular hypothesis, accretion, differentiation, and planetary system formation.	
4	Planetary Materials	Minerals, rocks, and ice in the Solar System. Classification of meteorites.	
5	Internal Structure of	Differentiation of cores, mantles, and crusts.	Assignment-1

	Planets	Geophysical techniques for studying planetary interiors.	
6	Planetary Surfaces & Remote Sensing	Global topography, planetary landforms, and remote sensing techniques.	
7	Tectonics & Crustal Deformation	Plate tectonics on Earth vs. stagnant-lid tectonics on other planets. Faults, folds, and planetary stress regimes.	
8	Volcanism on Planets & Moons	Types of volcanic activity, lava compositions, and volcanic landforms on Earth, Venus, Mars, Io and Triton.	
9-10	Impact Cratering	The physics of impact events, crater formation, and planetary resurfacing.	Assignment 2
11	**In-course/Midterm-1**		
12	Planetary Atmospheres & Climate Evolution	Atmospheric dynamics of Venus, Earth, Mars, and Titan. Role of greenhouse gases.	
13	Aeolian Processes & Wind-Shaped Landforms	Sand dunes, wind streaks, and dust storms on Earth, Mars, and Titan.	
14 & 15	Fluvial & Lacustrine Processes	Evidence of water on Mars, Titan, and Europa. River and lake formations.	Assignment 3
16	Weathering & Surface Alteration	Chemical and physical weathering in different planetary environments. Soil formation on Mars.	
17	Glacial & Cryovolcanic Processes	Ice-related processes on Earth, Mars, Europa, and Enceladus.	
18-20	Desert & Periglacial Landforms	Formation of permafrost, patterned ground, and desert landscapes in planetary environments.	Assignment 4
21	**Discussion for In-course/Midterm-2**		
22-23	Planetary Chronology & Dating Techniques	Crater counting, radiometric dating, and planetary stratigraphy.	
24	Earth as a Model Planet	Geological history of Earth, internal structure, surface processes, and tectonics.	
25	The Moon: Geology & Evolution	Formation of the Moon, major surface features, cratering history, and volcanic activity.	Assignment 5

26	Mars: The Red Planet	Geological history of Mars based on data from orbiters and rovers. Volcanism, river valleys, and evidence of past water.	
27	Mercury: The Extreme Planet	Surface composition, tectonics, impact craters, and comparison with the Moon.	
28	Venus: A Tectonic Enigma	Surface geology, volcanic activity, and atmospheric effects shaping Venus.	
29-30	The Outer Planets: Jupiter & Beyond	Geology of Jupiter, Saturn, Uranus, and Neptune. Icy moons and their geological features.	Assignment 6

Instructional Strategies: Lectures**,** Class discussions**,** Use of multimedia resources (videos, animations, images) and In-class exercises

Assessment Pattern:

Assessment Pattern level no.	Knowledge level	Level of CO	In-course	Assignment	Final Examination
K1	**Remember**	CO1-CO2	03	00	10
K2	**Understand**	CO3-CO5	05	00	20
K3	**Apply**	CO4-CO6	03	00	10
K4	**Analyze**	CO4-CO5	05	00	10
K5	**Evaluate**	CO4-CO6	04	05	10
K6	**Create**	CO5-CO6	00	05	00
Total Marks 100 (Class attendance 10 + In-course 20+ Assignment 10+ Final examination 60)			20	10	60

Recommended References:

1. Faure, G., & Mensing, T. (2007). Introduction to planetary science. Berlin/Heidelberg, Germany: Springer.
2. McSween, H. Y., Moersch, J. E., & Burr, D. M. (2019). Planetary geoscience. Cambridge University Press.
3. Melosh, H. J. (2011). Planetary surface processes (Vol. 13). Cambridge University Press.
4. Tarbuck, E. J., Lutgens F.K., Tasa, D. G. (2013) Earth: An Introduction to Physical Geology (11th Edition). Pearson.

GHT-2104 Statistics for Geosciences

Credit Hour: 3

Course Type: General Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description: This course introduces statistical methods essential for geoscientists, focusing on spatial statistics, geostatistics, and data analysis techniques. Topics include descriptive statistics, regression analysis, spatial pattern analysis, interpolation, and geostatistical modeling. Students will work with real-world geological datasets and apply ArcGIS/QGIS/GMT, Surfer, R, and Python for hands-on analysis.

Course Learning Objectives (CLOs):

- Apply fundamental statistical methods in geosciences
- Perform regression analysis and hypothesis testing
- Analyze spatial patterns and cluster geological data
- Use interpolation techniques (IDW, kriging) for spatial prediction
- Apply geostatistical methods for resource estimation and environmental studies
- Integrate GIS and statistical tools for spatial analysis
- Work with geostatistical software (ArcGIS, Surfer, SGeMS, R, Python)
- Handle real-world datasets from mining, geology, and environmental studies
- Assess sampling errors and uncertainty in geological data

Course Learning Outcomes (COs):
At the end of the course, the students will be able to:

CO1: Understand basic statistical knowledge to organize, analyze and visualize data for research
CO2: Use geological data for probabilistic approach, hypothesis testing, spatial analysis, correction of database
CO3: Operate geospatial interpolation using software packages
CO4: Predict geological phenomena based on forecasting through time series analyses

Mapping CO vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓	✓	✓		✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

No of Lecture: 30 (1.5 hours each)

Course Content:

Lecture	Topic	Details	Homework/ Assignments
1 & 2	Introduction to Statistics in Geosciences	Importance of statistics in geology, types of data (qualitative, quantitative).	
3	Descriptive Statistics I	Measures of central tendency (mean, median, mode), measures of dispersion (variance, standard deviation).	
4	Descriptive Statistics II	Data visualization (histograms, box plots, scatter plots).	
5	Data Transformation & Outlier Detection	Identifying and handling outliers, normalization, log transformations.	Assignment 1
6	Probability Basics	Definitions, axioms of probability, conditional probability, Bayes' Theorem.	
7	Random Variables & Probability Distributions	Discrete vs. continuous variables, probability density functions.	
8	Normal Distribution	Properties of normal distribution, standard normal distribution, geological applications.	
9	Other Probability Distributions	Binomial, Poisson, and their relevance in geosciences.	
10	Hypothesis Testing: T-tests & Chi-Square Tests	One-sample t-test, two-sample t-test, paired t-test, chi-square tests for goodness-of-fit and independence.	Assignment 2
11	**In-course/Midterm-1**		
12	Analysis of Variance (ANOVA)	One-way ANOVA, two-way ANOVA, post-hoc tests.	
13	Sampling and Error Estimation	Sampling techniques, sample size determination, measurement errors, and confidence intervals.	
14-15	Simple Linear Regression	Model fitting, least squares method, interpretation of results.	Assignment-3
16-17	Multiple Linear Regression	Multiple regression models, model selection, interpretation of coefficients.	
18-19	Introduction to Spatial Statistics & Geostatistics	Concepts of spatial statistics, spatial dependence, spatial autocorrelation (Moran's I, Geary's C).	
20	Point & Cluster Pattern	Types of spatial patterns (random, clustered,	Assignment-4

	Analysis (NEW)	uniform), nearest neighbor analysis, hotspot detection (Getis-Ord Gi*).	
21	**In-course/Midterm-2**		
22-23	Spatial Interpolation Techniques	Deterministic methods: Inverse Distance Weighting (IDW), Trend Surface Analysis.	
24	Geostatistical Interpolation	Overview of stochastic methods, introduction to kriging (Ordinary, Universal).	
25-26	Geostatistical Software Overview	Introduction to software for spatial statistics: ArcGIS/QGIS/GMT Geostatistical Analyst, Surfer, SGeMS, R, Python.	Assignment 5
27	Geostatistical Applications in Geosciences	Case studies in ore reserve estimation, groundwater modeling, and environmental geostatistics.	
28-29	Time Series Analysis in Geosciences	Introduction to time series, trends, Stationarity, autocorrelation.	
30	GIS in Spatial Statistics	Integrating GIS with statistical techniques for geospatial analysis.	Assignment 6

Instructional Strategies: Lectures**,** Class discussions**,** Use of multimedia resources (videos, animations, images) and In-class exercises

Assessment Pattern:

Assessment Pattern level no.	Knowledge level	Level of CO	In-course	Assignment	Final Examination
K1	**Remember**	CO1-CO2	03	00	10
K2	**Understand**	CO3-CO4	05	00	20
K3	**Apply**	CO3-CO4	03	00	10
K4	**Analyze**	CO2-CO4	05	00	10
K5	**Evaluate**	CO3-CO4	04	05	10
K6	**Create**	CO2-CO4	00	05	00
Total Marks 100 (Class attendance 10 + In-course 20+ Assignment 10+ Final examination 60)			20	10	60

Recommended References:

1. J.C. Davis, Statistics and Data Analysis in Geology, 3rd edition (not 2nd or 1st!!!).
2. Mann, P. S. (2010). Introductory statistics. John Wiley & Sons.

3. Jensen, J. (2000). Statistics for petroleum engineers and geoscientists (Vol. 2). Gulf Professional Publishing.
4. Trauth, M. H. (2022). Python recipes for earth sciences. Springer.
5. Ma, Y. Z., & Zhang, X. (2019). Quantitative geosciences: Data analytics, geostatistics, reservoir characterization and modeling (p. 640). Cham: Springer International Publishing.
6. Pyrcz, M. J., & Deutsch, C. V. (2014). Geostatistical reservoir modeling. Oxford University Press, USA.

GHT-2105 Essential Mathematics for Geosciences

Credit Hour: 3

Course Type: General Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description: This course introduces fundamental concepts in Calculus, Linear Algebra and Differential Equations, focusing on their applications in geoscience. We begin by exploring the basics of functions, including their domains, ranges, and graphical representations. Students will study various types of functions and their corresponding graphs, followed by an introduction to limits, continuity, and differentiation, which are foundational for understanding calculus. Special attention will be given to how differentiation and integration can be used in geoscience to understand and model real-world phenomena. The course introduces differential equations, focusing on first-order ordinary differential equations (ODEs), their degree, order, and linearity. Students will learn to solve ODEs using methods like separation of variables and apply these techniques to real-world geoscientific problems. The course also covers matrix algebra, including basic matrix operations, eigenvalues, and eigenvectors, with a particular focus on their geological applications. Throughout the course, students will work on examples and problems that connect mathematical theory to geoscientific practices, making the concepts more relevant and practical. By the end of the course, students will have a solid foundation in calculus, differential equations, and matrix algebra, with specific insight into their use in geosciences.

Course Learning Objectives (CLOs):

Upon successful completion of this course, students will be able to:

- **Calculus**:
  - Analyze and graph various types of functions and interpret their behavior in different contexts.
  - Gain concepts in calculus, including functions, limits, continuity, differentiation, and integration.
  - Have a solid understanding of the basic rules of differentiation and the application of derivatives to solve real-world problems in geoscience.
- **Ordinary Differential Equations**:
  - Be introduced to the theory and methods of solving ordinary differential equations (ODEs), including first-order ODEs and separation of variables.
  - Achieve the ability to model and solve geoscientific problems using differential equations.
- **Linear Algebra**:
  - Know the principles of matrix algebra, including matrix operations, eigenvalues, and eigenvectors, and their applications in geoscience.
  - Solve complex mathematical and scientific problems using matrix algebra.

Course Learning Outcomes (COs):

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

CO1: Understand basics of calculus, differential equations and linear algebra
CO2: Apply mathematical operations in solving real world problems
CO3: Implement mathematical functions and equations to perceive geological phenomenon.

Mapping CO vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓	✓			
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓

No of Lecture: 30 (1.5 hours each)

Course Content:

Lecture	Topic	Details	Homework/ Assignments
1-4	Calculus	Functions and their Graphs, Functions of one variable, limits, and continuity, coordinate transformation	Assignment 1
5-8		Basic rules of Differentiation, Derivatives of different functions, Applications of Differentiation, Applications of Differentiation in Geoscience	Assignment 2-3
9-13		Antiderivatives, Integrations of several functions, Integrations of several functions, Applications of Integration (Area enclosed by curves, Volume of a solid), Applications of Integration in Geoscience.	Assignment 4-5
14	**In-course/Midterm-1**		
15-18	Ordinary Differential Equations	Introduction to differential equations, basic terminology, Solving ODE by separation of variables, numerical solution of 1st order ODE and PDE	Assignment 6-7
19-21		Applications of ODEs in solving real word problems, including in geoscience	Assignment 8
22-25	Linear Algebra	Introduction to the algebra of matrices, Basic matrix operations	Assignment 9
26-29		Eigenvalues and Eigenvectors, Geological applications and examples.	Assignment 10

30	**In-course/Midterm-2**

Instructional Strategies: Lectures**,** Class discussions**,** Use of multimedia resources (videos, animations, images) and In-class exercises

Assessment Pattern:

Assessment Pattern level no.	Knowledge level	Level of CO	In-course	Assignment	Final Examination
K1	**Remember**	CO1-CO3	05	00	10
K2	**Understand**	CO1-CO3	05	00	10
K3	**Apply**	CO1-CO3	05	00	20
K4	**Analyze**	CO1-CO3	05	00	10
K5	**Evaluate**	CO1-CO3	00	05	10
K6	**Create**	CO1-CO3	00	05	00
Total Marks 100 (Class attendance 10 + In-course 20+ Assignment 10+ Final examination 60)			20	10	60

Recommended References:

1. Calculus for Scientists and Engineers, William L. Briggs, Lyle Cochran, and Bernard Gillett, Peason, 2013.
2. Elementary Linear Algebra, Howard Anton and Anton Kaul, 12th Ed., Wiley, 2019.
3. Differential Equations and Linear Algebra, Stephen W. Goode and Scott A. Annin, 4th Ed., Pearson, 2015.
4. Mathematical Methods in the Earth and Environmental Sciences, Adrian Burd, Cambridge University Press, 2019.
5. Mathematics in Geology, John Ferguson, Springer-Verlag London Ltd , 1980

GHL-2106 Petrography Lab

Credit hour: 3

Course Type: Core Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description: This laboratory course provides hands-on experience in petrographic microscopy, focusing on the identification and analysis of igneous, sedimentary, and metamorphic rocks in thin section. Students will develop observational skills, learn to identify structure, textures and mineral composition of rocks in thin sections under petrographic microscopes and understand the relationships between rock composition, texture, and their geological history. The course also includes the separation of light and heavy minerals from the unconsolidated or poorly consolidated sediments and identifying light and heavy minerals in grain-mounted slides under petrographic microscopes.

Course Learning Objectives (CLOs):

Upon successful completion, students will be able to:

- Igneous Petrography:
  - Recognize common igneous rock textures under microscope.
  - Understand the relationship between igneous rock textures and cooling histories.
  - Classify igneous rocks based on their texture and mineral composition.
- Metamorphic Petrography:
  - Recognize and interpret metamorphic structures and textures under microscope
  - Classify metamorphic rocks based on structure, texture and mineral assemblages.
  - Understand the relationship between metamorphic grade and mineral assemblages.
- Sedimentary Petrography:
  - Light and heavy minerals separation and identification under petrographic microscope.
  - Analyze sedimentary textures and micro-structures in thin section.
  - Classify sedimentary rocks based on texture and composition.
  - Interpret depositional environments based on sedimentary rock textures, microstructures and fossil contents (if present).
- Laboratory Skills:
  - Proper use and care for petrographic microscopes.
  - Observations and interpretations effectively.

Course Learning Outcomes (COs):

Upon successful completion of this course, students will be able to:

- **CO1:** Learn about the operating procedures of thin sections for petrographic study
- **CO2:** Identify and classify igneous and metamorphic rock samples in thin section and evaluate the petrogenesis of major igneous and metamorphic rocks for studying tectonic association and mode of origin
- **CO3:** Apply sieving techniques for grain size analysis of the sedimentary rock for provenance study
- **CO4:** Identify heavy and light minerals from sediments/sedimentary rocks for source rock study
- **CO5:** Conduct study of clastic and non-clastic rocks under microscope

Mapping CO vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓

No of Lab Classes: 30 (3 hours each)

Course Content:

Lab	Topic	Details	Assignments
1	Igneous rock textures	Igneous rock textures in thin section: Crystallinity, granularity, fabric etc.	Assignment-1
2-10	Thin section Study	Systematic study of common igneous rocks in thin section (Plutonic rocks: Granite, Syenite, Granodiorite, Diorite, Gabbro, Dunite and Peridotite; Volcanic rocks: Rhyolite, Trachyte, Andesite, Dacite and Basalt)	Assignment-2-7
11	**In-course/Midterm-1**		
12	Introduction to Metamorphic Rock	Introduction to metamorphic structure and texture in thin section	Assignment-8
13-16	Microscopic Study of Metamorphic Rock	Microscopic study of foliated rocks (gneiss, schist, slate, phyllite).	Assignment-9
17-19	Microscopic Study of Metamorphic Rock	Microscopic study of non-foliated rocks (marble, quartzite, hornfels).	Assignment-10
20	Heavy & Light Mineral Study	Separation of light and heavy minerals ; preparation of grain-mounted and thin section slides	Assignment-11
21	**In-course/Midterm-2**		
22-26	Identification of heavy and Light Minerals	Identification of light minerals (quartz, feldspar: plagioclase, microcline and orthoclase) and heavy minerals (silicates: olivine, zircon, garnet, kyanite, staurolite, epidote, tourmaline; pyroxene: hypersthene, diopside, augite; amphibole: tremolite, actinolite, hornblende; oxides: rutile; phosphate: apatite, monazite)	Assignment-12
27-29	Clastic Rock Thin section Study	Microscopic study of clastic rocks in thin section (sandstone: quartz arenite, arkose, litharenite, greywacke, shale)	Assignment-13-14
30	Non-Clastic Rock Thin section Study	Microscopic study of non-clastic rocks in thin section (limestone, Oolitic limestone, fossiliferous limestone) heavy mineral assemblages in unconsolidated sands.	Assignment-15

Instructional strategies:

Laboratory work, Demonstration, Discussion, Question-Answer

Assessment Pattern:

Assessment Pattern level no.	Knowledge level	Level of CO	In-course	Assignment	Final Examination
K1	**Remember**	CO1-CO2	00	00	10
K2	**Understand**	CO2	00	00	10
K3	**Apply**	CO2-CO5	05	02	10
K4	**Analyze**	CO4-CO5	05	03	10
K5	**Evaluate**	CO2-CO5	05	02	10
K6	**Create**	CO3-CO5	05	03	10
Total Marks 100 (Class attendance 10 + In-course 20+ Assignment 10+ Final examination 60)			20	10	60

Recommended References:

1. Philpotts, A. (2003) Petrography of Igneous and Metamorphic Rocks. Waveland Press.
2. Hyndman, D.W. (1985) Petrology of Igneous and Metamorphic Rocks (2nd Edition). McGraw-Hill international series in the earth and planetary sciences.
3. Winter, J.D. (2001) An Introduction to Igneous and Metamorphic Petrology. Prentice Hall.
4. Best, M.G. and Christiansen, E.H. (2000) Igneous Petrology. Wiley-Blackwell.
5. Turner F.J. (1981) Metamorphic Petrology (2nd Edition). Hemisphere Pub. Corp.
6. Hatch, F.H. and Wells, A.K. (1973) The Petrology of Igneous Rocks (13th Edition). Thomas Murby& Co.
7. Spry, A. (1969) Metamorphic Textures.Pergamon Press.
8. Turner, F.J. and Verhoogan, J. (1960) Igneous and Metamorphic Petrology (2ndEditon). McGraw-Hill.
9. Bowen, N. (1928) The Evolution of Igneous rocks. Dover Publications.
10. Milner, H.B. (1962) Sedimentary petrography (vols. I and II) (4th revised edition).
Mange, M.A. and Maurer, H.F.W. (1992) Heavy Minerals in Colour. Chapman & Hall, London, 147.http://dx.doi.org/10.1007/978-94-011-2308-2
11. Tucker, M.B. (2001) Sedimentary Petrology: An Introduction to the Origin of Sedimentary Rocks, Blackwell Science, London (3rd edition).
12. Adams, A.E., MacKenzie, W.S. and Guilford C. (1987) Atlas of sedimentary rocks under the microscope, Longman Scientific & Technical (1st edition).

GHT-2201: Stratigraphy

Credit Hour: 3

Course Type: Core Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description:

This course introduces the principles and applications of stratigraphy, focusing on rock layering, sedimentary processes, and basin analysis. Topics include lithostratigraphy, biostratigraphy, chronostratigraphy, and sequence stratigraphy, emphasizing their role in reconstructing Earth's history and resource exploration. Through lectures, case studies, and hands-on assignments, students will develop essential skills for interpreting stratigraphic records, correlating sedimentary sequences, and solving geological problems. This course is valuable for students pursuing careers in petroleum geology, hydrogeology, mineral exploration, and environmental geosciences.

Course Learning Objectives (CLOs):

By the end of this course, students will be able to:

- Understand and apply key principles of stratigraphy
- Analyze stratigraphic sequences and interpret their historical and geological significance
- Understand the relationship between lithology, biostratigraphy, chronostratigraphy, and sequence stratigraphy
- Apply stratigraphic principles to real-world geological problems
- Appreciate the integration of stratigraphy with other geological disciplines, including structural geology and basin analysis

Course Learning Outcomes (COs):

At the end of the course the student will be able to:

CO1: describe the principles, objectives and application of stratigraphy and their role to explain differences in geological processes operated in various depositional environments

CO2: interpret the stratigraphic record to explain temporal and spatial relationships for representing the sequence of physical and biological events of the earth's history

CO3: Explain the principles, techniques, concepts and application of different stratigraphic approach and their significance

CO4: evaluate different stratigraphic databases and operate stratigraphic correlation techniques

CO5: do advanced stratigraphic analysis and identify the ambiguity in the stratigraphy of Bangladesh and Bengal Basin

Mapping Co vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓	✓		✓	
CO2	✓	✓	✓		✓
CO3	✓	✓	✓		✓
CO4	✓	✓	✓		
CO5	✓	✓	✓	✓	✓

No of Lecture: 30 (1.5 hours each)

Course content:

Lecture	Topic	Details	Assignment
1 - 2	Introduction to Stratigraphy	Overview and History: Early development and evolution of stratigraphy. Stratigraphy vs. Sedimentology: Discuss the overlap and distinction. Scope of Stratigraphy: Types (chronostratigraphy, lithostratigraphy, biostratigraphy, sequence	

		stratigraphy, etc.). Basic Stratigraphic Principles: Law of superposition, original horizontality, lateral continuity, and faunal succession.	
3-4	Lithostratigraphy	Definition and Principles: Lithostratigraphic units (formations, members, beds). Identification of Lithologic Units: How to delineate and interpret boundaries. Stratigraphic Column: Construction and interpretation.	Assignment-1
5-6	Biostratigraphy	Principles and Techniques: Use of fossils to date and correlate rock layers. Biostratigraphic Zones: Zones, biozones, range zones, event stratigraphy. Index Fossils: Characteristics, examples, and their importance in stratigraphy. Application of Biostratigraphy, biocorrelation.	
7-8	Chronostratigraphy and Time Stratigraphy	Concepts of Geological Time: Geochronological methods (radiometric and isotopic dating) and applications in stratigraphy. Stratigraphic Units: Eons, eras, periods, and epochs. Time Correlation Methods: Radiometric dating, isotopic dating, other chronological methods, and chrono-correlation.	
9-10	Sequence Stratigraphy Introduction	Key concepts: Base level, accommodation space, eustasy, relative sea-level change. Stratal stacking pattern, stratal units- sequence, parasequences and system tracts. Sequence stratigraphic framework, sequence stratigraphic model	Assignment-2
11	**In-course/Midterm-1**		
12	Data in sequence stratigraphy	Geological data- sedimentology, pedology, body fossil, trace fossils, geochemistry, age dating; well-log data; seismic data	
13-15	Sequence stratigraphic surfaces	Subaerial Unconformity (SB); Correlative Conformity (CC); Basal Surface of Forced Regression; Regressive Surface of Marine Erosion; Maximum Regressive Surface; Flooding surface (FS)/ Transgressive Surface (TS); Maximum flooding surface (MFS); Marine flooding surface; Transgressive Ravinement surface; Tidal and Wave Ravinement surface Recognition in different datasets (seismic, well logs, outcrops). Significance of sequence boundaries in basin evolution.	Assignment-3

16-18	Systems Tracts:	Systems tracts: Definition, stacking pattern, economic potential, and petroleum plays; Highstand Systems Tract (HST); Falling Stage Systems Tract (FSST); Lowstand systems tract (LST); Transgressive systems tract (TST)	
19-20	Integration of Data	Stratigraphic Correlation: Techniques for correlating layers across distances and between basins. Stratigraphic Mapping: Tools and methods for interpreting outcrops, core data, and well logs. Integrated Stratigraphy: Combining lithological, biostratigraphic, and sequence stratigraphic data for comprehensive analysis.	Assignment-4
21	**In-course/Midterm-2**		
22-23	Event Stratigraphy	Concept and Importance: Major global events and their stratigraphic signature. Event Stratigraphy vs. Biostratigraphy: Comparison of their roles in geological time scale. Natural Events in Stratigraphy: Mass extinctions, volcanic events, climate shifts.	
24	Magnetostratigraphy and Isotope Stratigraphy	Principles and applications	
25-26	Advanced Stratigraphic Analysis and Case Studies	Unconformities: Types (angular, disconformity, nonconformity) and their significance in the stratigraphic record. Stratigraphic Interpretation in Oil and Gas Exploration: How stratigraphy is used in hydrocarbon reservoir identification. Case Studies: Detailed case studies from various geological settings (basins, orogenic belts, etc.).	Assignment-5
27-28	Stratigraphy in Basin Analysis	Basin Formation: Tectonic processes and sedimentation. Stratigraphic Record in Basins: Analyzing basin subsidence and sedimentary facies. Regional Stratigraphy: How regional geodynamics influence stratigraphic records.	
29-30	Stratigraphy of Bangladesh and its ambiguities	Stratigraphic succession of Bangladesh, existing ambiguities and techniques to resolve.	Assignment-6

Instructional Strategies: Lectures**,** Class discussions**,** Use of multimedia resources (videos, animations, images) and In-class exercises

Assessment Pattern

Assessment Pattern level no.	Knowledge level	Level of CO	In-course	Assignment	Final Examination
K1	**Remember**	**CO1-CO3**	00	00	10
K2	**Understand**	**CO2-CO3**	05	00	15
K3	**Apply**	**CO2-CO4**	06	03	15
K4	**Analyze**	**CO2-CO5**	04	02	10
K5	**Evaluate**	**CO4-CO5**	05	00	10
K6	**Create**	**CO3**	00	05	00
Total Marks 100 (Class attendance 10 + In-course 20+ Assignment 10+ Final examination 60)			20	10	60

Recommended References:

1. Boggs, S. (2011). Principles of Sedimentology and Stratigraphy. Pearson.

2. Prothero, D. R., & Schwab, F. (2013). Sedimentary Geology: An Introduction to Sedimentary Rocks and Stratigraphy. W.H. Freeman.

3. Gradstein, F. M., Ogg, J. G., Schmitz, M. D., & Ogg, G. M. (2012). The Geologic Time Scale 2012. Elsevier.

4. Harland, W. B., Armstrong, R. L., Cox, A. V., Craig, L. E., Smith, A. G., & Smith, D. G. (1989). A Geologic Time Scale 1989. Cambridge University Press.

5. Catuneanu, O. (2006). Principles of Sequence Stratigraphy. Elsevier.

6. Van Wagoner, J. C., Mitchum, R. M., Campion, K. M., & Rahmanian, V. D. (1990). Siliciclastic Sequence Stratigraphy in Well Logs, Cores, and Outcrops: Concepts for High-Resolution Correlation of Time and Facies. AAPG.

7. Embry, A. F., & Johannessen, E. P. (1992). Tethyan and Boreal Sequence Stratigraphy. SEPM Special Publication.

8. Alvarez, L. W., Alvarez, W., Asaro, F., & Michel, H. V. (1980). Extraterrestrial Cause for the Cretaceous-Tertiary Extinction. Science.

9. Nichols, G. (2009). Sedimentology and Stratigraphy. Wiley-Blackwell.

10. Allen, P. A., & Allen, J. R. (2005). Basin Analysis: Principles and Application to Petroleum Play Assessment. Wiley-Blackwell.

GHT-2202 Paleontology and Micropaleontology

Credit Hour: 3

Course Type: Core Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description:
The course is designed to acquire knowledge about the various types of fossils and their significance. This will help the students to understand various morphological features of fossils; their classification, identification and distribution in geologic time. This course will concentrate on important aspects of evolution, palaeoecology and extinction of the main invertebrate and vertebrate groups of organisms.
Micropaleontology covers all the major marine microfossil groups - foraminifera, coccolithophores, dinoflagellates and ostracoda – as well as terrestrial pollen and spore communities. One of the most fascinating aspects - and perhaps underappreciated by most people - is how landscapes change over time in terms of the plant life that grows there. Students can learn much about the landscape itself, the natural and human history of that landscape (including the changes it has undergone as a result of natural or human processes), and of the changing climate and what impact that has upon plant life. Flora - trees, flowers, grasses, mosses, lichen and even fungi have environmental conditions that they prefer and other conditions in which they will not survive for very long. Moving from a dry to wet climate (or vice versa), from temperate to ice age (or vice versa) and even whether and when a piece of land was once tidal salt marsh but is now pasture, can all affect the makeup of the landscape's flora.

Course Learning Objectives (CLOs):
On completion of this course, the student will be able to:

a. To describe the world's past biodiversity of botanical and zoological origin by discussing their morphology, taxonomy, mode of life, environments and stratigraphic distribution and outline the history of life on earth
b. To determine the evolutionary identity of living and past organisms
c. To understand the relative magnitude of changes happening in today's world
d. To reconstruct long-term macroevolutionary patterns, short-term ecosystems perturbations and the relationship between climate, environments and life
e. To understand the Palaeoceanography and Palaeoclimatology and the evolution of the biosphere
f. An appreciation of the importance of fossils; how they are used in biostratigraphy, recognition of paleo environments and knowledge of patterns of evolution and extinction throughout the Paleozoic, Mesozoic and Cenozoic
g. To emphasis on groups of geological importance by elucidating their application for dating, correlation and facies interpretation of sedimentary successions
h. To understand the increased evolutionary knowledge of Tertiary and Quaternary microfossils of Bangladesh during this course

Course Learning Outcomes (COs):
At the end of the course the student will be able to:

CO1: identify and classify different invertebrate fossils and describe their geological significance

CO2: explain the evolutionary trend of important vertebrate fossils and their geological significance

CO3: select major groups of microfossils under microscope and classify them using morphological features

CO4: apply techniques of using paleontological data for reconstructing past climates and environment

CO5: Analyze the fossil record to measure the magnitude of quaternary climate change

Mapping Co vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓		✓		
CO2	✓		✓		
CO3	✓	✓	✓		
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓

No of Lecture: 30 (1.5 hours each)

Course Content:

Lecture No.	Topic	Details	Assignment
1	Fossilization and fossil record,	Nature and importance of fossil record; Fossilization processes and modes of preservation	
2	Taxonomy and Species concept	Species concept with special reference to paleontology; Taxonomic hierarchy; Theory of organic evolution interpreted from fossil record	
3	Invertebrates	Brief introduction to important invertebrate groups (Phylum-Mollusca, Brachiopoda) and their biostratigraphic significance;	
4	Invertebrates	(Phylum- Coelentrata, Arthopoda) and their biostratigraphic significance; Significance of ammonites in Mesozoic biostratigraphy and their paleobiogeographic implications; Functional adaptation in trilobites and ammonoids.	
5	Origin of life: Archean life	Earth's oldest life, Transition from Archean to Proterozoic, the oxygen revolution and radiation of life, Climate Change during the Phanerozoic - continental break-ups and collisions Plate tectonics and its effects on climate and life, Effects of life on climate and geology	Assignment-1
6	Precambrian macrofossils	The garden of Ediacara; The Snow Ball Earth Hypothesis	
7	Paleozoic Life (Fish	The Cambrian Explosion; Biomineralization	

	and Tetrapods)	and skeletalization; Origin of vertebrates and radiation of fishes; Origin of tetrapods - Life out of water; Early land plants and impact of land vegetation	
8	Mesozoic Life (Reptiles and Birds)	Life after the largest (P/T) mass extinction; life in the Jurassic; Rise and fall of dinosaurs; Origin of birds and spread of flowering	
9	Cenozoic Life (Mammals)	Radiation of placental mammals; Evolution of modern grasslands and co-evolution of hoofed grazers; Rise of modern plants and vegetation Back to water – Evolution of Whales; The age of humans Hominid dispersals and climate setting	
10	Application of fossils	Biozones; index fossils; correlation Role of fossils in sequence stratigraphy; Fossils and paleoenvironmental analysis; Fossils and paleobiogeography; biogeographic provinces, dispersals and barriers Paleoecology; fossils as a window to the evolution of ecosystems, The relevance of time to phylogenetic reconstruction; Plate tectonics and vertebrate biogeography; Vertebrate diversity, disparity, and extinction	Assignment-2
11	**In-course/Midterm-1**		
12	Introduction to Microfossils	Introduction; History of Micropaleontology; A journey through morphological micropaleontology to molecular micropaleontology ; Taxonomic classification; Precondition for fossilization	
13	INORGANIC WALLED MICROFOSSILS Foraminifera (Calcareous-Walled Microfossils)	Introduction; Biology of foraminifera; Life strategy; Buildup of Foraminifera; Way of living and Ecology; The evolution of early Foraminifera; Taxonomy and Elements of systematic; Geologic history; Smaller Benthic and Planktic Foraminifera; The Test Morphology; Larger Benthic foraminifera; Application of Foraminifera	
14	Ostracoda (Calcareous-Walled Microfossils)	Introduction; The evolution of early Ostracodes; Morphology; Classification; Application	
15	Coccolithophore (Calcareous walledNannoplankton) and Pteropods	Introduction; History of Study; Biology; Classification; Application and environment of deposition; Introduction; Taxonomy; Ecology and Environment; Application	Assignment-3

16	Radiolarians and Diatoms	Introduction; General history of radiolarians; Radiolarian distribution and ecology; Classification of radiolarians; Application; Introduction; Classification; Application	
17	Silicoflagellates (Siliceous walled) and Conodonts (phosphatic walled), ORGANIC WALLED MICROFOSSILS Acritarch and Chitinozoa and Dinoflagellates	Introduction; Morphology; Classification; Geologic History; Application, **Acritarch**– Introduction; Biology; Morphology; Classification; Applications **Chitinozoa-** Introduction; Morphology; Paleoecology; Geologic History, Introduction; Biology; Morphology; Life cycle of Dinoflagellates; Classification; Tabulation in Dinoflagellates; Ecology; Applications	
18	Palynology (Spore and Pollen)	What is palynology? A history of palynology; Reproduction and Diversity; Pollen production and Pollen dispersal (Pollination ecology); Nomenclature and systematic; Morphology of spore-pollen;	
19	Environmental Micropaleontology	Cenozoic flora of Bangladesh, Paleoenvironment and Paleoecological utility on biostratigraphy; Palynostratigraphic zonation of Tertiary succession of Bangladesh; Modern and fossil mangroves and mangals: their climatic and biogeographic variability; Evolutionary trend in angiosperm plants, Pre-Gondwana and Paleogene flora, A brief idea about Indian subcontinent and surroundings;	
20	Marine Paleoenvironmental Analysis from Fossils	An introduction to the techniques, limitations and landmarks of carbonate oxygen isotope palaeothermometry, Palaeo-oxygenation: effects and recognition, Organic carbon as a palaeoenvironmental indicator in the marine realm; Microfossil indicators of ocean water masses, circulation and climate	Assignment-4
21	**In-course/Midterm-2**		
22	Palynofacies analysis and interpretation	Marine palynomorphs and organic particles classification, Holocene palynology and its application; Application of palynology in geochronology, paleoclimate and paleoenvironment interpretation; Significance of palynology in source rock evaluation and organic matter maturation; Fluorescence	

		palynology and its application; Application to geological problems- stratigraphy, environmental factors, sequence stratigraphy, Stratigraphic or Ecological discordance, Variation in Natural vs. Anthropogenic Eutrophication of Shelf Areas in Front of Major Rivers**,** Establishing a Hydrostratigraphic Framework Using Palynology**,** Pollen analysis and meteorology;	
23	Palynodebris and evaluation of hydrocarbon generation potential	Qualitative estimation of palynodebris and evaluation of Hydrocarbon generation potential; Organic matter type and classification; Organic matter facies, Thermal Alteration Index Values and Spectral Analysis for maturation assessment; Application of palynodebris in the interpretation of Paleoenvironment; Applicability to petroleum source rock evaluation	
24	Biogeography and Paleobiogeography	The Relevance of Hierarchy Theory to Biogeography and Paleobiogeography: Introduction, Hierarchies and Biogeography, Climate Change and Biogeographic Patterns, Geological Change and Biogeographic Patterns over Even Longer Timescales, Mass Extinctions and Biogeography	
25	Basic considerations and shell geochemistry	Foraminifera as Proxies of Change and Concept of Environmental Variability and Change, Importance of baseline studies for monitoring environmental Change**,** Environmental variation and Foraminiferal test abnormalities; Effects of marine pollution on benthic Foraminifera**,** Foraminifera of oxygen depleted environments, Chemical ecology of Foraminifera, Benthic Foraminiferal distributions in analogues to historical changes; Quantitative methods of data analysis in foraminiferal ecology	Assignment-5
26	The Proxy Record on Bioindicators and Biomonitoring of pollution	Distribution Trends of Foraminiferal Assemblages in Paralic Environments, Trace elements in foraminiferal calcite, Benthic Foraminifera as Bioindicators of Heavy Metal Pollution, Stable oxygen and carbon isotopes in foraminiferal carbonate shells, Impact of Anthropogenic Environmental Change on Larger Foraminifera; Ostracoda in Detection of Sewage Discharge and River water ecosystem, Ostracoda as	

		Proxies for Quaternary Climate Change Sedimentary facies; Bio facies; Depth biotopes and estimation of paleodepth of the ocean using benthic foraminiferal assemblages; Identification of modern and ancient surface water mass with the help of planktic foraminiferal assemblages; Identification of benthic foraminifera characteristic of Low oxygen environment; Identification of planktic foraminifera characteristic of warm and mixed layer, thermocline and deep surface water of the modern oceans; Study of modern surface water, mass assemblages of planktic foraminifera from Indian ocean, Atlantic ocean and Pacific ocean.	
27	Larger Foraminifera as Indicators of Coral-Reef Vitality	Taphonomy and temporal resolution of foraminiferal assemblages, Analogies and differences between Foraminifera and Corals, Potential application of Foraminifera to Reef Studies, Larger Foraminifera and Global change; Larger foraminiferal zones and resolution of the stratigraphic records; Quantitative approaches to palaeozonation and palaeobathymetry of corals and coralline algae in Cenozoic reefs	
28	Features of Distribution and application	Cenozoic plankton biostratigraphy, Sequence biostratigraphy, Benthic foraminiferal microhabitats below the sediment-water interface, Environmental Stratigraphy: Reconstructing bottom Water Oxygen Conditions; Micropaleontology in mineral and hydrocarbon exploration. Biogeography of neritic benthic Foraminifera, Biogeography of planktonic Foraminifera, Symbiont-bearing Foraminifera, Foraminifera in marginal marine environments	
29-30	Palaeoecology and Paleoceanography	Palaeoecology – principles and methods; application of fossils in the study of palaeoecology, paleobiogeography and palaeoclimate. Ichnology-classification of trace fossils and their utility in Paleoenvironmental reconstructions	Assignment-6

Instructional Strategies: Lectures**,** Class discussions**,** Use of multimedia resources (videos, animations, images) and In-class exercises

Assessment Pattern

Assessment Pattern level no.	Knowledge level	Level of CO	In-course	Assignment	Final Examination
K1	**Remember**	**CO1-CO3**	02	00	10
K2	**Understand**	**CO3-CO4**	03	00	10
K3	**Apply**	**CO4**	03	03	10
K4	**Analyze**	**CO4-CO5**	04	02	10
K5	**Evaluate**	**CO4-CO5**	03	02	10
K6	**Create**	**CO5**	00	03	10
Total Marks 100 (Class attendance 10 + In-course 20+ Assignment 10+ Final examination 60)			20	10	60

Recommended References:

Textbook:

1. Armstrong, H. & Brasier, M. (2005) Microfossils. Wiley.
2. Shukla, A. C., & Misra, S. P. (1975). Essentials of paleobotany. Vikas Publisher

Reference Books:

1. Cushman, J.A. (2013) Foraminifera: Their Classification and Economic Use, 4th Revised and Enlarged Edition. Harvard University Press.
2. Bignott, G. (1985) Elements of Micropaleontology. Springer Science & Business Media. Brasier, M.D. (1980) Microfossils. Chapman & Hall.
3. Ager, D.V. (1963) Principles of paleoecology: an introduction to the study of how and where animals and plants lived in the past. McGraw-Hill.
4. Pokomy, V. (1963) Principles of Zoological Micropaleontology (Vol 1 & 2). University of California.
5. Markhovan, F.P. C.M.V. (1962) Post Paleozoic Ostracods (Vol 1 & 2). Elsevier.

GHT-2203 Hydrology and Climatology

Credit Hour: 3

Course Type: Core Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description:

Hydrology deals with the Distribution of Water, Hydrologic Cycle, Watershed, Stream flow Analysis, Flood and Drought, Hydrograph, Climate and Hydrology, Coastal Hydrology and Stochastic Hydrology. The Hydrologic Cycle will cover Precipitation (Rainfall, Snow etc.), Runoff, Evaporation,

Evapotranspiration and Infiltration; Watershed part will focus on its Introduction and quantitative Evaluation. Stream flow Analysis will include stream velocity, River-Stage and Discharge; Flood and Drought part will cover different types of flood and drought and their causes and control. Hydrograph part will focus on concepts and construction of its different components; Climate and Hydrology will describe the relationship between climate and hydrology; Coastal Hydrology will cover the hydrological phenomena and processes involved in the coastal area; Stochastic Hydrology will focus on concepts, random variables and their applications in Hydrology.
Climatology deals with atmospheric properties and physical processes that determine current weather and long-term climate trends. It incorporates the physical, chemical and dynamic processes of the troposphere and the physical aspects of Earth's climate system. It also explores the global balance of energy and transfer of radiation in the atmosphere, atmospheric disturbances and severe weather and techniques of weather forecasting. Moreover, this course includes the climate system of the Earth and the science of climate change.

Course Learning Objectives (CLOs):

By the end of the course, the learners will be able to

a. introduce Hydrology, a branch of geology
b. describe different components of Hydrologic Cycle and their importance
c. explain various aspects of watershed
d. analyze stream flow in terms of Velocity, River-Stage and Discharge
e. evaluate the significance and application of Hydrograph
f. determine the relationship between Climate and Hydrology
g. explain different hydrologic processes active in coastal areas
h. classify different types of Flood and Drought
i. explain the importance of Stochastic Hydrology in water resources management
j. to understand different atmospheric layers and the climate system of the Earth
k. Learn global circulation of wind and temperature and how it contributes on local and global weather and climate
l. to understand the relationship between global and local climate system and different types of hydro-meteorological hazards
m. perceive the concepts of Contemporary Climate Change
n. Understand the interactions between climate and hydrological processes

Course Learning Outcomes (COs):

At the end of the course the student will be able to

CO1: understand basic principles of the occurrence, distribution and movement of water on the earth and explain the processes and role of different components involved in the water cycle

CO2: record, collect and utilize hydrologic data and apply to analyze the data set for deducing spatial and temporal variations, hydrograph preparation and hazard analyses

CO3: understand foundation of climatology, the parameters of air, climate variability, hydroclimatology and mechanism of climatic changes

CO4: know the instrumentation of weather forecasting and analysis, geoengineering solution for climate change interventions, mitigations and adaptation strategies

CO5: utilize climatic data, land based and satellite monitoring for climate modeling and forecasting

Mapping Co vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

No of Lecture: 30 (1.5 hours each)

Course Content:

Lecture	Topic	Details	Homework/Assignments
1	Introduction to hydrology	Introduction and scope, distribution of water, Hydrologic cycle and its components, Global Water Budget	
2	Watershed & Drainage Basin	Introduction and Basic concept of watershed, Quantitative Evaluation of Watershed	
4	Precipitation	Condensation, Cloud formation, Types of precipitation, and Forms of precipitation	
5	Precipitation	Measurement of precipitation, Analysis & Interpretation of rainfall data and Bangladesh perspective	Assignment-1
6	Infiltration & Runoff	Mechanism, Measurement, Instrumental set-up, Estimation of Infiltration. Surface run-off, Streamflow basics, Components, Effects, Estimation	
7	Evaporation	Introduction, Factors Affecting Evaporation, Estimation of Evaporation, Measurement of Evaporation, Evaporation Reduction from Water Surface	
8	Evapotranspiration	Evaporation & Transpiration Processes, Evapotranspiration (ET), Estimation, Evapotranspiration Measurements, Evapotranspiration control	
9-10	Runoff, stream flow & event flow. Streamflow Velocity; River-	Streamflow basics. Streamflow Velocity; River-Stage and Discharge, Instrumentation, Field techniques of measurement, Data collection, Data analysis and interpretation.	Assignment-2

	Stage and Discharge	Spatial and temporal variability.	
11	In-course/Midterm-1		
12	Hydrographs	Components of Hydrograph, analyses and interpretation and Unit Hydrograph, Applications	
13	Floods and Droughts	Causes, Consequences, Monitoring, Forecasting, and Management	
14	Coastal hydrologic Processes	Coastal zone dynamics, Estuarine hydrology, Influence of tide, Fresh water-salt water interaction, Hydrological problems in coastal regions, Causes and Impacts	
15	Introduction to Groundwater	Role of groundwater in hydrologic cycle, Origin, Occurrence and distribution of Groundwater, Types of aquifer, recharge and discharge.	Assignment-3
16	Introduction to Climatology	Definition and Scope, Basic concepts of climatology and meteorology Difference Between Climate and Weather, Importance of climatology in Earth and Environmental Sciences.	
17	Introduction to Atmosphere	Atmospheric Composition and Structure, Layers of the Atmosphere, Role of the Atmosphere in Climate Regulation. Atmospheric parameters: Air temperature, pressure, Mean sea level pressure and wind.	
18	Temperature, Humidity and Precipitation (will be covered in hydrology)	Temperature variations: Diurnal, seasonal and annual variations of surface air temperature, global temperature distribution, factors affecting temperature. The physical controls of temperature; the geographic controls of temperature; air temperature data sources; air temperature and human comfort; measuring air temperature. Humidity and moisture, Temperature and Humidity relationships; Humidity and human comfort levels.	
19-20	Solar radiation and energy balance	Earth's Energy Budget, Albedo Effect, Greenhouse Effect and Global Warming, Energy: Warming and Cooling of Earth and the Atmosphere: Energy, temperature, and heat; heat transfer in the atmosphere; incoming solar energy; radiation, absorption, emission, and equilibrium; annual and daily energy balances.	Assignment-4
21	In-course/Midterm-2		
22	Atmospheric pressure and wind system and Oceanic circulation	Pressure Belts and Wind Circulation, Coriolis Effect, Ekman Spiral Circulation, Jet Streams and Local Winds, Winds at Different Scales-Small and Local: Scales of motion; microscale winds interacting with	

		the environment; local wind systems; large-scale thermal circulations; determining wind direction and speed, wind belts. Wind, Global Systems and Air Fronts: General circulation of the atmosphere; atmosphere-ocean interactions; Air masses. Tides; Waves; Major Ocean Currents and Their Impact, El Niño and La Niña Phenomena, Thermohaline Circulation	
23	Climate Classification and Koppen System	Global Climate: A world with many climates; Basis of Climate Classification, Köppen-Geiger Climate Classification System, Biomes and Their Climate Characteristics.	
24	Climate Change , Drivers and Feedback Mechanisms	Definition; Causes and consequences of climate change; The Time Scales of climate change, Climate Change: Evidence for climate change, natural and anthropogenic factors, Reconstructing past climate, Greenhouse Effect and Global Warming: Greenhouse gases, radiative forcing, and climate models. Carbon Cycle and Climate, Climate Feedback Loops	
25	Hydro-climatology	Impacts of Climate Change: Impacts on hydrological process, Impacts on precipitation, runoff and streamflow. Impacts on water resources, ecosystems, and human society. Consequence of climate change: Drought, Floods	Assignment-5
26	Extreme Weather Events and Climate Variability	Thunderstorms and Lightning and Tornadoes, Hurricanes, Cyclones, Tropical storms, Droughts, and Heatwaves, Role of Climate Change in Extreme Weather,	
27	Agriculture and Climate Change, Urban Climate and Microclimates	Impact of Changing Climate on Food Production, desertification and Soil Degradation, Climate-Resilient Crops and Farming Techniques, Urban Heat Island Effects, Climate Change and City Planning Smart Cities and Climate Adaptation	
28	Geoengineering and Climate Intervention, Mitigation and Adaptation Strategies	Solar Radiation Management, Carbon Capture and Storage, Ethical and Environmental Risks, Carbon Sequestration Techniques. Impacts of fossil fuel burning; use of benign/Renewable Energy.	
29	Weather Forecasting and Analysis,	Instruments of observatory; Weather forecasting; Forecasting methods, Types of forecasts, assessing forecasts; Data acquisition and dissemination; Forecast procedures and products: Phases in numerical modeling, Medium-range forecasts, Long-range forecasts and Seasonal outlooks,	

		Weather maps and images.	
30	Climatic Data, Land based and satellite monitoring and Climate Modeling and forecasting	Climatic and Meteorological Data Source (National and International): Bangladesh Meteorological Department (BMD) and Bangladesh Space Research and Remote Sensing Organization (SPARRSO), WMO, etc. Satellite Monitoring of Climate, GIS and Climate Data Analysis, Emerging Climate Issues and Solutions. Introduction to Climate Models, long term trend of climatic variations. Global Climate Models (GCMs) and regional climate models and their Uses, Uncertainties in Climate Predictions.	Assignment-6

Instructional Strategies: Lectures**,** Class discussions**,** Use of multimedia resources (videos, animations, images) and In-class exercises

Assessment Pattern

Assessment Pattern level no.	Knowledge level	Level of CO	In-course	Assignment	Final Examination
K1	**Remember**	**CO1, CO3-CO4**	02	00	10
K2	**Understand**	**CO1-CO3**	02	00	15
K3	**Apply**	**CO2-CO5**	02	03	15
K4	**Analyze**	**CO2-CO4**	04	02	10
K5	**Evaluate**	**CO2, CO3-CO4**	05	02	10
K6	**Create**	**CO2,CO4**	05	03	00
Total Marks 100 (Class attendance 10 + In-course 20+ Assignment 10+ Final examination 60)			20	10	60

Recommended References:

Hydrology

1. Dingman, L. (2014) Physical Hydrology (3rd Edition). Waveland Press, Inc.
2. Hornberger et.al. (2014) Elements of Physical Hydrology (2nd Edition). JHU Press
3. Shaw, E. M., Beven, K. J., Chappell, N. A., & Lamb, R. (2010) Hydrology in Practice (4th Edition). CRC Press.
4. Raghunath, H.M. (1987) Groundwater. New Age International.

5. Engineering Hydrology – K Subramanya, Tata McGraw-Hill Publishing Co Ltd, New Delhi, Second Edition, 1994.
6. Chow, V.T. (1964) Handbook of Applied Hydrology. McGraw-Hill.
7. Meinzer, O. E. (1949) Hydrology. Dover Publications.
8. Wisler, C.O. & Brater, E.F. (1959) Hydrology. John Wiley & Sons Inc.
9. Chow, V. T., David R. Maidment, and Larry W. Mays (1988). Applied hydrology.
10. Herschy, R. W. (2008). Streamflow measurement. CRC press.
11. Singh, V. P., & Xu, Y. J. (2006). Coastal Hydrology and Processes. Colorado: Water Resources Publications LLC, 465-479.
12. Philip B. Bedient, Wayne C. Huber, and Baxter E. Vieux (?). Hydrology and Floodplain Analysis.

Climatology

1. Rohli R.V. and Vega A.J. (2012) Climatology (2nd edition). Jones and Bartlett Learning. Wall Street. US.
2. Ahrens, C. D., Jacson, P.L., and Jackson, C.E. J. (2012): Meteorology Today: An Introduction to Weather, Climate, and The Environment, First Edition. Nelson Education. Canada.
3. Ahrens, C. D. (2001) Essentials of Meteorology: An Invitation to the Atmosphere, Brooks/Cole, US.
4. Aguado, E. and Burt, J. E. (2010). Understanding Weather and Climate, Prentice Hall, New York,
5. Allaby M. (2007) Encyclopedia of Weather and Climate. Vol I and II. Facts on File Inc. US.
6. Barry R. G. and Chorley R.J. (1987) Atmosphere, Weather and Climate. Methuen. UK.
7. Byers H.B. (1974) General Meteorology. 4th Edition. McGraw-Hill Co. US.
8. Hartman D.L. (1994) Global Physical Climatology. International Geophysics Series. Volume 56. PP. 412. Academic Press. US.
9. Hidore J.J. and Oliver J.E. (2009) Climatology: An Atmospheric Science. 3rd Edition. Prentice Hall. US.
10. Reynolds, R., (2004). Guide to Weather, Bounty Books, London
11. Wallace, J.M. and Hobbs, P. V. (2006). Atmospheric Science: An Introductory Survey, ELSEVIER, Amsterdam.
12. Helmis, C., Nastos, P. T. Ed (2013) Advances in Meteorology, Climatology and Atmospheric Physics.
13. John Marshall; R. Alan Plumb, Atmosphere, Ocean and Climate Dynamics by Elsevier Science 1979.
14. Farmer G.T. and Cook J. (2013). Climate Change Science: A Modern Synthesis. Springer. Netherlands.

GHT-2204 Fundamentals of Geophysics

Credit Hour: 3

Course Type: Core Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description: This course provides a comprehensive introduction to the fundamental principles and techniques of geophysics, emphasizing the use of physical laws to explore and understand the Earth's interior and surface processes. Key topics include gravitational and magnetic fields, seismic wave propagation, Earth's thermal structure, and electrical and electromagnetic methods. Students will learn how geophysical data are collected, analyzed, and interpreted to investigate subsurface structures and processes. Emphasis is placed on the practical applications of geophysics in resource exploration, environmental studies, and tectonic research, equipping students with a strong foundation for advanced study or applied geoscience work.

Course Learning Objectives (CLOs): The objectives of this course are:

• Understand the Earth's internal structure and the physical principles governing geophysical processes

• Learn the basic concepts of gravity, magnetism, heat flow, and seismic wave propagation used in subsurface investigations

• Gain knowledge of the techniques and instruments used in geophysical surveys and data acquisition

• Develop the ability to interpret geophysical anomalies and relate them to geological structures and processes

• Explore the practical applications of geophysics in natural resource exploration, earthquake studies, and environmental assessment

Course Learning Outcomes (COs):

At the end of the course the student will be able to

CO1: gain foundation knowledge of Earth’s internal structure, common geophysical methods and their applications and earth’s geophysical entities

CO2: understand the working principles, driving forces, application and anomalies associated with different geophysical properties of the Earth

CO3: attain knowledge of instrumentation for recording geophysical anomalies in a heterogeneous environment, analyze the data for geophysical interpretation for explaining various geological phenomena

CO4: Apply the geophysical methods to solve different environmental and geological problems

Mapping Co vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓	✓	✓		
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

No of Lecture: 30 (1.5 hours each)

Course Content:

Lecture No.	Title	Topic	Homework/ Assignment
1	Introduction to Geophysics	Scope, history, and branches of geophysics; relevance in Earth sciences	
2	The Earth System	Earth's interior: layers, composition, physical properties, methods of study	
3	Geophysical Fields	Overview of gravity, magnetic, electrical, and electromagnetic fields	
4	Basic Physics in Geosciences	Review of Newtonian mechanics, energy, force fields relevant to geophysics	Assignment -1
5	Wave Motion I	Wave types (mechanical, body, surface), properties of waves	
6	Wave Motion II	Seismic wave velocity, reflection, refraction, attenuation	
7	Earth's Gravity Field	Geoid, reference ellipsoid, variations in Earth's gravity field	
8	Principles of Gravity Measurement	Gravimeters, corrections (latitude, elevation, drift, tide)	
9	Basics of Gravity Anomalies	Concept of gravity anomalies and qualitative insights	Assignment - 2
10	Gravity in Geological Context	Fundamental understanding of how density differences affect gravity (no advanced interpretation)	
11	**In-course 1**	**Covers Lectures 1–10**	
12	Earth's Magnetic Field	Origin of geomagnetic field, dipole approximation, secular variation	
13	Paleomagnetism	Magnetic minerals, remanent magnetization, rock magnetic behavior	
14	Magnetic Field Measurement	Magnetometers and field surveys, introduction to magnetic maps	
15	Magnetic Field Variations	Diurnal, seasonal, and storm-related variations in magnetic field	Assignment - 3
16	Earthquakes and Tectonics	Stress and strain, faulting, earthquake genesis	
17	Seismic Waves	Body waves and surface waves, velocity dependence on rock type	
18	Seismic Data Basics	Travel-time curves, seismic ray paths, shadow zones	
19	Earth's Internal Structure	Seismology-based layers (Moho, outer/inner core), basic models	
20	Heat Flow in the Earth	Internal heat sources, geothermal gradient, global heat flow patterns	Assignment - 4
21	**In course 2**		
22	Geothermal Energy	Geothermal provinces, basic principles of energy extraction	
23	Introduction to	Resistivity, current flow in subsurface,	

	Electrical Methods	basic configurations	
24	Basic Electrical Surveys	Field procedures and fundamental interpretation of resistivity profiles	
25	Electromagnetic Induction	Time-varying EM fields, skin depth, overview of EM techniques	
26	Introduction to Geophysical Data	Nature of geophysical data, noise vs signal, simple data processing	
27	Introduction to Geophysical Instrumentation	Basic overview of instruments for gravity, magnetic, seismic, electrical methods	
28	Environmental Applications	Role of geophysics in groundwater, contamination, and shallow subsurface mapping	
29-30	Frontiers of Geophysics	Brief intro to satellite geophysics, AI in data processing (non-technical)	Assignment - 5

Instructional Strategies: Lectures**,** Class discussions**,** Use of multimedia resources (videos, animations, images) and In-class exercises

Assessment Pattern

Assessment Pattern level no.	Knowledge level	Level of CO	In-course	Assignment	Final Examination
K1	**Remember**	**CO1-CO3**	03	00	10
K2	**Understand**	**CO2-CO3**	00	00	15
K3	**Apply**	**CO4**	05	03	15
K4	**Analyze**	**CO3-CO4**	04	02	10
K5	**Evaluate**	**CO2-CO4**	00	05	10
K6	**Create**	**CO2-CO4**	05	00	00
Total Marks 100 (Class attendance 10 + In-course 20+ Assignment 10+ Final examination 60)			20	10	60

Recommended references:

Textbook

1. Lowrie, W. (2007). *Fundamentals of Geophysics* (2nd Edition). Cambridge University Press.

Reference Books

2. Sheriff, R. E. & Geldart, L. P. (1995). *Exploration Seismology* (2nd Edition). Cambridge University Press.

3. Telford, W. M., Geldart, L. P. & Sheriff, R. E. (1990). *Applied Geophysics* (2nd Edition). Cambridge University Press.

4. Kearey, P., Brooks, M. & Hill, I. (2002). *An Introduction to Geophysical Exploration* (3rd Edition). Wiley-Blackwell.

5. Hinze, W. J., Von Frese, R. R. B. & Saad, A. H. (2013). *Gravity and Magnetic Exploration: Principles, Practices, and Applications*. Cambridge University Press.

6. Mussett, A. E. & Khan, M. A. (2000). *Looking into the Earth: An Introduction to Geological Geophysics*. Cambridge University Press.

7. Reynolds, J. M. (2011). *An Introduction to Applied and Environmental Geophysics* (2nd Edition). Wiley-Blackwell.

8. Dobrin, M. B. & Savit, C. H. (1988). *Introduction to Geophysical Prospecting* (4th Edition). McGraw-Hill.

GHL-2205 Paleontology Lab

Credit Hours: 3

Course Type: Core Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description:
The course is designed to study the multidisciplinary use and application of microfossils in paleontological investigations. Coverage includes macrofossils and microfossils classified as animals (invertebrates and vertebrates). This lab course encompasses the hands-on training in identification of invertebrate macrofossils (Brachiopods, Pelecypods, Gastropods, Cephalopods and trilobites). Emphasis is also placed on the morphology and taxonomy of several major groups including foraminiferas and ostracodes.

Course Learning Objectives (CLOs):
By the end of the course, the learners will be able to:
a. Explain how and why fossils were formed
b. Classify the different types of fossils based on their distinguished morphology
c. Identify different morphological features of invertebrate macrofossils & microfossils
d. Explain depositional environment and geological significance based on the presence of specific fossil

Course Learning Outcomes (COs):

At the end of the course the student will be able to:

CO1: identify all the major macrofossils from the classified group with the help of their morphological features, and learn their geological significance

CO2: recognize planktonic and benthonic foraminifera, ostracoda, pollens and spores under microscope

CO3: separate the microfossils from loose bulk sediments, analyze the morphological features and classify accordingly

CO4: analyze and interpret oxygen isotope data for climatic and paleoclimatic reconstructions

Mapping CO vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓		✓		✓
CO2	✓		✓		✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

No of Lecture: 30 (3 hours each)

Course Content:

Lab	Topic	Details	Assignments
1-14	Hand specimen analysis	Identification of fossil in hand specimen (Brachiopods, Pelecypods, Gastropods, Cephalopods and trilobites)	Assignment 1-5
15	**In-course/Midterm-1**		
16-29	Microscopic Study	Identification of microfossils and pollen under microscope	Assignment 6-10
30	**In-course/Midterm-2**		

Instructional strategies:

Laboratory work, Demonstration, Discussion, Group work, Question-Answer

Assessment Pattern

Assessment Pattern level no.	Knowledge level	Level of CO	In-course	Assignment	Final Examination
K1	**Remember**	**CO1-CO3**	00	00	10
K2	**Understand**	**CO2-CO3**	05	00	10
K3	**Apply**	**CO3**	05	03	15
K4	**Analyze**	**CO3**	03	02	10
K5	**Evaluate**	**CO3-CO4**	03	05	10
K6	**Create**	**CO3-CO4**	04	00	05
Total Marks 100 (Class attendance 10 + In-course 20+ Assignment 10+ Final examination 60)			20	10	60

Recommended References:

Textbook:

1. Benton, M. (2014) Vertebrate palaeontology (4th Edition). Wiley-Blackwell. 2. Clarkson, E.N.K. (1998)
2. Invertebrate palaeontology and evolution (4th Edition).
3. Armstrong, H. & Brasier, M. (2005) Microfossils. Wiley.
4. Traverse, A. (2007) Paleopalynology (2nd Edition). Springer

References:

5. Colbert, E.W. Colbert, E.H. (2001) Evolution of the Vertebrates: A History of the Backboned Animals through Time. Wiley Blackwell.
6. Laporte, LF. (Edition) (1978) Evolution and the Fossil Record: Readings from "Scientific American".
7. Romer, A.S. (1966) Vertebrate paleontology. University of Chicago Press.
8. Moore, R.C. (Ed.) (1952) Invertebrate fossils. McGraw-Hill College.
9. Shrock, R.R., & Towenhofel, W.H. (1953). Principles of invertebrate paleontology. McGraw-Hill.
10. Wood, H. (1893) Paleontology Invertebrates. The Cambridge University Press
11. Cushman, J.A. (2013) Foraminifera: Their Classification and Economic Use, 4th Revised and

GHF-2206 Geological Field Mapping

Credit Hours: 3

Course Type: Capstone Course

Total Marks: 100 (Field Attendance-10, Field Viva-20, Assignment-10 and Final Field Report Submission-60)

Course Description:
This course provides students with foundational training in geological field techniques through a combination of classroom preparation and an immersive seven-day fieldwork program in the hill tracts of

Bangladesh. The course focuses on developing practical skills for geological mapping, sedimentary logging, structural measurements, and field interpretation. Emphasis is placed on understanding and documenting large-scale geological features such as folds, faults, and unconformities, as well as the identification and analysis of stratigraphic units and sedimentary structures. Students are trained to collect and synthesize field data, construct lithological columns, correlate stratigraphic sections, and produce geological maps and reports based on field observations. The course integrates hands-on exercises, field lectures, and laboratory work to reinforce geological reasoning and reporting.

Course Learning Objectives (CLOs):

By completing this course students will be able to:

a) Identify and locate geological exposures in the field using topographic maps and field navigation techniques
b) Accurately measure and record bed attitudes (strike and dip) and other structural features such as folds and faults
c) Construct lithological columns and stratigraphic logs to represent vertical rock successions
d) Correlate stratigraphic sections across different outcrops and interpret facies changes
e) Interpret sedimentary structures and depositional environments based on field observations
f) Prepare geological maps that incorporate lithological boundaries, structural elements, and stratigraphic units
g) Document field data systematically using field notebooks, sketches, photographs, and standardized note-taking techniques
h) Write a comprehensive geological field report, including maps, sections, interpretations, and summaries of field data

Course Learning Outcomes (COs):

At the end of the course the student will be able to:

CO1: Recognize and record major structures, primary and secondary sedimentary structures, rock types, to construct litho-columns for construction of litho-stratigraphic succession

CO2: Construct litho-logs for interpreting and describing depositional environment of study area and compared with the stratigraphic column of Bangladesh

CO3: Be adept in grain size analysis, prepare cross-sections from Geological maps and reconstruct the geological history of the area

CO4: Infer the facies change scenario, prepare cross-sections, learn geological database management

Mapping Co vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

No of Lectures: 30 (1.5 Hours/each)

Course contents:

Lec.	Topic	Details	Assignment
1–10	Preparation for fieldwork	● Introduction to geological fieldwork ● Field equipment and safety ● Field observation at different scales ● Field notebook: sketches, written notes, correlation with other data, etc. ● Recording features of sedimentary logs and constructing graphic logs ● Recording palaeontological data ● Recording structural information ● Making a geological map ● Photography, sampling, etc. ● Laboratory analysis of samples and interpretation ● Field report writing	
11	**In-course Examination/Class test**		
12-30	Geological Fieldwork	Conduct a seven-day geological fieldwork program (comprising five days of fieldwork and two days of travel) in a well-exposed outcrop section to study the general geology of the area. The program focuses on developing essential field skills, including geological observation, documentation, and mesoscopic-scale mapping. Activities include observing exposed rock facies, mapping exercises, maintaining standardized field notes, constructing lithological columns, collecting rock samples, correlating lithological sections from different locations, interpreting the depositional environment and summarizing and plotting field data on a map at the end of each field day.	

Instructional strategies: Classroom lecture and discussion**,** Hands-on exercise, on-site field training, and discussions

Assessment Pattern

Assessment Pattern level no.	Knowledge level	Level of CO	Field Performance	Field Viva	Field Report Assessment
K1	**Remember**	**CO1-CO3**	05	03	00
K2	**Understand**	**CO2-CO3**	05	03	10
K3	**Apply**	**CO3**	05	04	10
K4	**Analyze**	**CO1-CO3**	02	04	10
K5	**Evaluate**	**CO1-CO3**	03	03	10
K6	**Create**	**CO1-CO3**	00	03	20

Total Marks 100 (Field Performance 20+ Field Viva 20+ Final examination 60)		20	20	60

Recommended References:

1. Lisle, R.J., Brabham, P.J., Barnes, J.W. (2011) Basic Geological Mapping (5th Edition). Wiley-Blackwell.
2. Coe, A.L. (2010) Geological Field Techniques. John Wiley & Sons.
3. Collinson, J., Mounney, J.N. and Thompson, D. (2006) Sedimentary Structures. 3rd Edition. Terra Publishing, England, 292 p. https://www.amazon.com/Sedimentary-Structures-Third-John-Collinson/dp/190354419X
4. Barnes, J.W. & Lisle, R.J. (2004) Basic Geological Mapping (4th Edition). John Wiley & Sons.
5. McClay, K.R. (1987) The Mapping of Geological Structures (Reprinted 2007). John Wiley & Sons.
6. Compton, R.R. (1962) Manual of Field Geology. Wiley.
7. Lahee, F.H. (1961) Field Geology (6th Edition). McGraw-Hill Book Co.
8. Low, J.W. (1957) Geological Field Methods. Harper & Bros.
9. Pettijohn, F.J. (2004) Sedimentary Rocks (3rd edition). CBS Publisher.
10. Tucker, M. E. (Ed.) (2013) Sedimentary petrology: an introduction to the origin of sedimentary rocks (3rd Edition). John Wiley & Sons.
11. Boggs, S. Jr. (2014) Principles of sedimentology and stratigraphy (5th Edition). Pearson.
12. Reimann, K. U. (1993) Geology of Bangladesh. Gebruder Borntraeger Verlagsbuchhandlung, Science Publishers.
13. Khan, F. H. (1991). Geology of Bangladesh. Wiley Eastern.

GHV-2207 Viva Voce

Credit Hours: Non-Credit course

Course Type: Capstone Course

Total Marks: Satisfactory / Unsatisfactory

Course Learning Objectives (CLO):
Viva voce will be conducted towards the end of the academic year which will be covering the complete syllabus. This will assess the students' knowledge and understanding during their graduate programme. In doing so, the main objective of this course is to prepare the students to face interviews both at the academic and the professional arenas.

Course Learning Outcomes (COs):

At the end of the course the student will be able to:

CO1: describe and explain the theoretical and practical knowledge gained in the second year 4th semester geology courses

CO2: present and communicate the concepts and knowledge confidently orally

Mapping CO vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓		✓	✓	✓
CO2	✓		✓		✓

Instructional strategies: Classroom lecture and discussion**,** Hands-on exercise, on-site field training, and discussions of all second-year 4^{th} semester courses

Assessment Pattern:

Oral Examination

GHT-3101 Oceanography and Coastal geology

Credit Hour: 3

Course Type: Core Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description: This course offers a comprehensive introduction to the core principles of oceanography and coastal geology, with a particular focus on the dynamic environment of the Bangladesh coast and the Bay of Bengal. Key topics include ocean-atmosphere interactions, marine sediment dynamics, geological history and evolution of the Bay of Bengal, coastal geomorphic processes, coastal resources, hazards and coastal zone management. Emphasis is placed on understanding the unique physical, chemical, and geological characteristics that define this critical region, equipping students with a solid foundation for advanced study or research in marine and coastal science.

Course Learning Objectives (CLOs):

- Understand the key physical properties of ocean water, circulation patterns and influence of atmospheric forces on ocean dynamics.
- Know about major ocean floor features and the processes of marine sedimentation.
- Learn about the origin, evolution and sediment characteristics of the Bay of Bengal, including the Bengal Fan.
- Learn about the geomorphic classification of coasts, Quaternary Sea level fluctuation, coastal resources, coastal hazards, and coastal zone management with focus on Bangladesh coast.

Course Learning Outcomes (COs):
Upon successful completion of this course, students will be able to:

CO1: Understand the physical, chemical, geological, and biological processes governing the ocean system.

CO2: Analyze coastal landforms and the dynamic interactions between waves, tides, and sediment transport.

CO3: Evaluate the impacts of climate change and human activities on coastal environments.

CO4: Apply oceanographic and geological data to assess coastal hazards and support sustainable coastal management.

Mapping CO vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓	✓	✓		
CO2		✓	✓		
CO3	✓		✓	✓	
CO4			✓	✓	✓

No of Lecture: 30 (1.5 hours for each)

Course Content:

Lecture	Topic	Details	Homework/ Assignments
1	Introduction to Oceanography	Scope, importance, and major branches of oceanography.	
2	Physical Properties of Seawater.	Temperature, salinity, density, distributions, and surface/deep-sea currents (gyres, upwelling, down welling).	
3	Ocean Morphology	Physical Features of continental margins and deep-ocean floor, ocean ridges, rises, and trenches; Submarine Canyons.	
4	Ocean Circulation Waves & Tides	Wave generation, propagation, breaking, tidal forces, types of tides, and tidal currents.	
5	Evolution of the Oceanic Crust: Rifting, Sea-floor Spreading and Sea level change	Major Tectonic Features and Evolution of the Oceans; Mid- Ocean Ridges and Volcanism; Eustasy and Relative Sea-level Changes.	Assignment-1
6	Marine Sediments	Terrigenous, biogenic, hydrogenous sediments.	
7	Bay of Bengal	Origin, evolution, major morphometric features, circulation patterns and major currents.	
8	Sedimentary	Continental shelf, slope, deep-sea	

	environments and sedimentation in the Bengal Delta	environments; Sediment sources, transport, and deposition in the Bay of Bengal;	
9	Bengal Deep Sea Fan	Formation, characteristics, and significance.	
10	Monsoon Influence on the Bay of Bengal:	Impact of monsoons on circulation, sedimentation, and coastal processes.	Assignment -2
11	**In-course/Midterm-1**		
12	Marine Pollution, Climate Change, & Environmental Issues in the Bay of Bengal	Overview of marine pollution, effects of climate change, and their impact on ecosystems in the Bay of Bengal.	
13	Recent research and developments in Bay of Bengal studies.	Critical issues and emerging research in the Bay of Bengal, contributing to a comprehensive understanding of the region's challenges and opportunities.	
14	Introduction to Coastal Geomorphology and Geology of Bangladesh	Overview of coastal geomorphology, key processes, geological framework of coastal regions, and the importance of studying Bangladesh's coastal system.	
15	Tectonic and Geological Setting of the coastal region of Bangladesh	Active and passive margin settings, subsidence, sedimentation processes, and the evolution of the Ganges delta	Assignment-3
16	Coastal divisions of Bangladesh	Overview of coastal classification of Bangladesh and their respective criteria's	
17-18	Major Coastal Landforms/physiography of Bangladesh	Classification and characteristics of deltas, estuaries, tidal flats, barrier islands, and mangrove coastlines in Bangladesh.	
19-20	Geomorphology of Active and inactive Ganges delta	Overview of geomorphological units and their characteristics across the active portion of Ganges deltaic coast of Bangladesh	Assignment-4
21	**In-course/Midterm-2**		
22	Geomorphology of inactive Ganges delta	Overview of geomorphological units and their characteristics across the inactive portion of Ganges deltaic coast of Bangladesh	

23	Geomorphology of Meghna estuarine coast and cliff coast of Bangladesh	Overview of geomorphological units and their characteristics across Estuarine and cliff coast	
24	Sediment Dynamics, Coastal Processes and subsidence	Coastal sediment transport, tidal influences, wave actions, and monsoon-driven changes in sedimentation patterns and rate of subsidence	
25	Holocene evolution of various coastal settings of Bangladesh	Overview of geological evolution of western deltaic coast, central estuarine coast and eastern cliff coast of Bangladesh with island like Kutubdia and Moheskhali	Assignment-5
26	Geological evolution of Saint Martin island	The island's formation, geological characteristics, tectonic influences, and environmental changes over time	
27	Blue economy and Sustainable coastal resources of Bangladesh	Sustainable utilization of marine and coastal resources for economic growth while ensuring environmental conservation and social well-being.	
28	Coastal hazards of Bangladesh	The impact of tropical cyclones, sea level change, and storm surges, erosion, salinity intrusion, the coastal zone.	
29-30	Climate Change and Resilience in coastal Bangladesh and Integrated Coastal Zone Management and Policy Implementation	Impact of climate change on Bangladesh's coast, adaptation strategies, and resilience-building for coastal communities, Challenges of the coastal region and the future trend of sustainable Coastal Zone Management in Bangladesh	Assignment-6

Instructional Strategies: Lectures**,** Class discussions**,** Use of multimedia resources (videos, animations, images) and In-class exercises

Assessment Pattern:

Assessment Pattern level no.	Knowledge level	Level of CO	In-course	Assignment	Final Examination
K1	**Remember**	**CO1, CO2, CO4**	00	00	10
K2	**Understand**	**CO2-CO4,**	03	00	15
K3	**Apply**	**CO3-CO4,**	03	02	15

K4	**Analyze**	**CO3, CO4,**	04	02	10
K5	**Evaluate**	**CO3-CO4**	05	03	10
K6	**Create**	**CO3-CO4**	05	03	00
Total Marks 100 (Class attendance 10 + In-course 20+ Assignment 10+ Final examination 60)			20	10	60

Recommended References:

Textbook

1. Kennett, U.P. (1982) Marine Geology. Prentice-Hall.

2. Duxbury, A.C and Duxbury, A. (1999) An Introduction to the World's Oceans (6th Edition). William C Brown Pub.

3. Shepard, F.P. (1973) Submarine Geology (3rd Edition). Harper & Row.

4. McLellan, H.J. (1965) Elements of Physical Oceanography. Pergamon Press.

Reference Books:

5. Scientific American (2007) Oceans: A Scientific American Reader. Scientific American,

6. Paul, B. & Rashid, H. (2016) Climatic Hazards in Coastal Bangladesh: Non-Structural and Structural Solutions. Elsevier.

7. Masselink, G., Hughes, M. G. and Knight, J. (2014) Introduction to Coastal Processes and Geomorphology. Routledge.

8. Ramanathan, A. L., Bhattacharya, P., Dittmar, T., Bala Krishna Prasad, M., Neupane, B. R. (Eds.) (2010) Management and Sustainable Development of Coastal Zone Environments. Springer Science.

9. Kamphuis, J.W. (2000) Introduction to Coastal Engineering and Management. World Scientific.

GHT-3102 Applied Geophysics

Credit Hour: 3

Course Type: Core Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description: This advanced course builds upon fundamental geophysical principles by exploring the practical applications of geophysical methods in addressing real-world problems. Students will learn about the theory, instrumentation, data acquisition, processing, interpretation, and limitations of various geophysical techniques used in diverse fields such as mineral exploration, environmental studies, and engineering.

Course Learning Objectives (CLOs):

- Understand Advanced Geophysical Principles.
- Analyze and Interpret Geophysical Data.
- Evaluate Methodological Limitations.
- Apply Geophysical Methods to Real-World Problems.
- Instrumentation and Data Acquisition.

Course Learning Outcomes (COs):

Upon successful completion of this course, students will be able to:

CO1: Understand the principles and methods of geophysical data acquisition and interpretation.

CO2: Apply seismic, magnetic, gravity, electrical, and electromagnetic methods to subsurface investigations.

CO3: Analyze and process geophysical data using appropriate software and techniques.

CO4: Interpret geophysical survey results for geological, environmental, and engineering applications.

CO5: Evaluate the suitability and limitations of various geophysical methods for specific site conditions**.**

Mapping CO vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓	✓	✓		
CO2	✓	✓	✓	✓	
CO3			✓	✓	
CO4		✓	✓	✓	✓
CO5			✓	✓	✓

No of Lecture: 30 (1.5 hours each)

Course Outline

Lecture	Topic	Details	Homework/ Assignments
1-2	Introduction to Applied Geophysics	• Overview of Applied Geophysics • Historical Development: Early Applications, Modern Evolution • Scope of Applied Geophysics • Applications in Real-World Problems	

		• Limitations of Geophysical Methods and Mitigation Strategies	
3-4	Gravity Methods: Principles and Data Acquisition	• Introduction to Gravity Methods • Data Acquisition Techniques • Data Processing and Interpretation • Application and challenges in interpretation	
5 -6	Magnetic Methods	• Principles of magnetic surveys • Data acquisition, interpretation, and applications	Assignment-1
7 - 8	Electrical Methods	• Introduction to Electrical Methods • Principles of Electrical Methods • Instruments, data acquisition and interpretation techniques	
8-10	Seismic Methods	• Principles of seismic methods • Acquisition, processing and interpretation • Applications and case studies	Assignment-2
11	**In-course-1**		
12	Geophysical Instrumentation	• Introduction and applications of Geophysical Instrumentation • Limitations of Geophysical Instruments	
13	Filed Procedure	• Planning and conducting geophysical surveys • Field safety	
14	Data Processing	• Data reduction • Filtering and enhancement.	
15	Data Presentation and Interpretation	• Geophysical Maps • Profiles • 3D Models	Assignment-3
16	Mineral exploration geophysics	• Integration of Geophysical Data in Mineral Exploration	
17	Groundwater Geophysics	• Methods for ground water exploration and monitoring • Integration of different methods.	
18-20	Engineering & Environmental Geophysics	• Introduction to engineering geophysics • Geophysical methods in engineering • Environmental Geophysics • Advantages and Limitations of Geophysical Methods	Assignment-4

21	In-course-2		
22	Archaeological Geophysics	● Geophysical methods in Archaeology, Techniques and applications	
23-25	Borehole Geophysics	● Wireline logs : principle , application and limitations ● LWD ● Log Motif	Assignment 5
26 -27	Geophysical Inversion and Modelling	● Fundamentals of geophysical inversion ● Modelling approaches ● Application	Assignment-6
28	Remote sensing in geophysics	● Fundamental of remote sensing ● Techniques and instruments ● Application	Assignment-7
29	Geophysical data instigation and interpretation	● Types of geophysical data ● Instigation techniques ● Interpretation strategies	Assignment-8
30	Case Studies of successful geophysical applications	● Application of different geophysical methods for successful field development / discovery.	Assignment-9, 10

Instructional Strategies: Lectures**,** Class discussions**,** Use of multimedia resources (videos, animations, images) and In-class exercises

Assessment Pattern:

Assessment Pattern level no.	Knowledge level	Level of CO	In-course	Assignment	Final Examination
K1	**Remember**	**CO1, CO2, CO5**	00	00	10
K2	**Understand**	**CO2-CO4, CO5**	03	00	15
K3	**Apply**	**CO3-CO4, CO5,**	03	02	15
K4	**Analyze**	**CO3, CO4, CO5**	04	02	10
K5	**Evaluate**	**CO3-CO5**	05	03	10
K6	**Create**	**CO3-CO5**	05	03	00
Total Marks 100 (Class attendance 10 + In-course 20+ Assignment 10+ Final examination 60)			20	10	60

Recommended References:

1. Reynolds, J. M. (2011). *An introduction to applied and environmental geophysics*. John Wiley & Sons.

2. Robinson, E. S. (1988). Basic exploration geophysics
3. Sharma, P. V. (1985). Geophysical methods in geology.
4. Kearey, P., Brooks, M., & Hill, I. (2013). *An introduction to geophysical exploration*. John Wiley & Sons.
5. Dentith, M., & Mudge, S. T. (2014). *Geophysics for the mineral exploration geoscientist*. Cambridge University Press.

GHT-3103 Regional Geology

Credit Hour: 3

Course Type: Core Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description:

This course focuses into the detailed study of overall geology and stratigraphy of the Bengal Basin and Indian Subcontinent. The students will develop an understanding of the tectonics, structural and stratigraphic succession of the Bengal Basin from the traditional view to plate tectonic concepts. The course will introduce the tectonic-geologic setting of the south Asian region, i.e., Indian subcontinent (Pakistan, India, Nepal, Bhutan, Bangladesh and Myanmar) and the Himalayan Orogen as well as the Indian Ocean. It systematically describes and discusses the Hadean to Cenozoic stratigraphy, geochemistry, structure and tectonics of the various Cratonic blocks and platform deposits of the Indian protocontinent and later geologic events. A major focus is given on physical (inorganic) and biological events of the region including Gondwana and Deccan deposits as well as Cretaceous/Tertiary extinction events (paleontological evolution of Gondwana flora, extinction of dinosaurs). It also entails the climatic vicissitudes and amelioration during the Paleozoic- Mesozoic time and the corresponding deposits. The Northeastern India particularly the Meghalaya/Shillong Massif, Assam Shelf and Tripura, Manipur, Mizoram, Cachhar along with the Belt of Schuppen areas are also discussed highlighting the tectonic-geologic episodes from Archean to Tertiary.

Course Learning Objectives (CLOs):

Upon successful completion of this course, students will be able to:

- Describe the tectonic elements of Bengal Basin, identify and describe the physiographic units of Bangladesh
- Explain the geo-tectonic provinces of Bengal Basin - the platform, hinge zone and geosynclines and their stratigraphic successions
- Unearth the evolution of the Bengal Basin in terms of plate tectonics and evaluate different stages from Gondwanaland rifting through the drifting stage of the collision
- Describe the tectonic evolution of Ganges-Brahmaputra- Meghna (GBM) Delta
- Understand the proposed stratigraphic concept of the geo-tectonic provinces of the Bengal Basin specifically Chittagong-Tripura Fold Belt (CTFB) in the light of Allostratigraphy

- Understand the tectono-geologic framework of South Asia
- Learn through stratigraphic and geochemical context the evolution of the South Asia
- Evaluate the origin of the Indian proto-continent: its cratons — shield, platform, intervening and peripheral fold belts — and their secular and temporal variations and distributions
- Unearth the ancient supercontinents and their break-ups through geologic times
- Interpret the gaps (hiatuses) in the stratigraphic successions
- Recognize the tectonic — geological evolution of the Himalayan Orogen and the Indian Ocean
- Apply this knowledge and comprehension to the potential occurrences and extensions of mineral resources of South Asia in order to exploit / mine these Earth resources
- Explain the Indo-Burman Orogen and the occurrences of flysch, molasse and ophiolite in Indo-Burman fold belt
- Discuss the geology and tectonics of Shillong /Meghalaya craton, Assam, Mizoram, Tripura and Cachhar and the Dauki Fault and their implications to the evolution of Bangladesh/Bengal Basin

Course Learning Outcomes (COs):

Upon successful completion of this course, students will be able to:

CO1: Understand the geological evolution and tectonic framework of Bangladesh and its surrounding regions.

CO2: Identify and describe the major lithostratigraphic units and their spatial distribution across Bangladesh.

CO3: Analyze the structural features and deformational history of key geological provinces such as the Bengal Basin and the Chittagong Hill Tracts.

CO4: Interpret regional geological maps and cross-sections relevant to Bangladesh.

CO5: Evaluate the implications of regional geology on natural resources, geohazards, and land-use planning in Bangladesh.

Mapping CO vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓	✓	✓		
CO2	✓	✓	✓		✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓

No of Lecture: 30 (1.5 hours each)

Course Content:

Lecture No.	Topic	Details	Assignments
1	Tectonic Elements and geomorphic divisions of Bangladesh	Location and Tectonic Elements surrounding the Bengal Basin, geomorphic divisions of Bangladesh	
2	General geological characteristics of Bangladesh	Uniqueness of geology of Bangladesh, striking features and associations	
3	Tectonic Subdivisions of Bengal Basin	Tectonic framework of Bangladesh (Stable shelf, hinge zone and geo-synncline)	
4	Tectonic and structural characteristics of CTFB	Detailed tectonic characteristics of Chittagong-Tripura Fold Belt (CTFB), structural elements and their descriptions	
5	Stratigraphic succession of stable shelf and Deep Basin	Litho-chrono stratigraphy of Stable Platform (Dinajpur Shield and Bogra Shelf) and Geo-syncline (Foredeep and Fold Belt), important structural features	Assignment-1
6	Tertiary Stratigraphy of Bengal Basin based on Assam stratigraphy	Tertiary Litho-chrono stratigraphy of Bengal Basin− Problems and prospects	
7	Changes of sedimentary Depositional Environments in and around Bangladesh	Different depositional environments in and around Bangladesh in geological past and their impacts of stratigraphy	
8	Major limitations of Tertiary stratigraphy of Bangladesh and the importance of revision	Problems associated with the application of Assam Stratigraphy in Bangladesh−concepts of diachronous units and the necessity of revision of Tertiary Stratigraphy	
9-10	Evolution of the Bengal Basin	Structural and Tectonic evolution of the Bengal Basin in the light of plate Tectonic theory	Assignment-2
11	**In-course/Midterm-1**		
12	Revised/proposed stratigraphic succession of the CTFB (allostratigraphy)	Introduction to allostratigraphy/sequence stratigraphy and proposed allostratigraphic succession of CTFB	
13	Geological evolution of	Stages of geological evolution of Ganges-	

	the Bengal Delta (GBM) and their evolution	Brahmaputra-Meghna Delta and associated features	
14	General introduction to the structure and tectonics of the Indian subcontinent	Physiography and structure of the Peninsular, Extra-peninsular India and Indo-Gangetic Plain/Trough	
15	River system of the Indian subcontinent	Major river systems of the Extra-peninsular, and Indo-Gangetic Trough	Assignment-3
16	River system of Pakistan and Myanmar	Major river systems of Pakistan and Myanmar and their influence on Bengal Deep Sea Fan	
17	Rock systems of the Archaean cratons of the Peninsular India	Hadean-Archaean synopsis of Indian subcontinent; Low- and high-grade basement units; Archaean cratons of the Peninsular India	
18	Fold Belts of the Peninsular India	Fold Belts of the Peninsular India and the corresponding basins like Cuddapah Basin etc.	
19-20	Gondwana geology of the Indian subcontinent and the climatic condition during Gondwana period	Introduction to Gondwana geology of the subcontinent with respect to plate tectonics, Climatic vicissitudes and amelioration (cold, glacial to arid, semi-arid conditions through fluvial and lacustrine deposits) during Gondwana period	Assignment-4
21	**In-course/Midterm-2**		
22	Coal deposits of the Gondwanas	Mechanism of coal formation in the subcontinent during Gondwana period with emphasis on that in the Bengal Basin	
23	Introducing Deccan Trap of the Peninsular India	Origin of the Deccan Continental Flood Basalt Province (DCFBP) − geology and stratigraphy	
24	Origin and evolution of the Himalayas	Geological evolution of the Himalayas	
25	Classification/major divisions of the Himalayas	N-S and E-W classification of the Himalayas and the major thrusts	Assignment-5
26	Geology of the Himalayas	Nappes, overthrusts, plutonism and metamorphism in the Himalayas	
27	Geology of the	Geology of the Shillong Plateau/Massif:	

	Shillong/Meghalaya	Archaean to Tertiary stratigraphy; the Dauki Fault and its significance	
28	Geology of Assam−Arakan Basin	Structure and stratigraphy of the Assam Shelf/Upper Assam Valley, the Schuppen Belt, the Assam−Arakan Fold Belt; Geology of Tripura−Cachhar−Mizoram	
29-30	Evolution of the Indo−Burman Orogen	Accretionary prism−Palaeogene and Neogene accretionary prisms in the Indo−Burman Orogen; occurrences of Flysch, molasse and ophiolite in the Indo-Burman Ranges	Assignment-6

Instructional Strategies: Lectures**,** Class discussions**,** Use of multimedia resources (videos, animations, images) and In-class exercises

Assessment Pattern:

Assessment Pattern level no.	Knowledge level	Level of CO	In-course	Assignment	Final Examination
K1	**Remember**	CO1-CO3	05	00	10
K2	**Understand**	CO2-CO5	05	00	20
K3	**Apply**	CO3-CO5	04	00	10
K4	**Analyze**	CO3-CO5	03	00	10
K5	**Evaluate**	CO3-CO5	03	05	10
K6	**Create**	CO3-CO5	00	05	00
Total Marks 100 (Class attendance 10 + In-course 20+ Assignment 10+ Final examination 60)			20	10	60

Recommended References:

Textbooks:

1. Krishnan, M.S. (2006) Geology of India and Burma (6th Edition). CBS Publishers & Distributors.

2. Reimann, K. U. (1993) Geology of Bangladesh. Gebruder Borntraeger Verlagsbuchhandlung, Science Publishers.

References:

1. Sharma, R.S. (2009) Cratons and fold belts of India. Lecture Notes in Earth Sciences 127, Springer-Verlag, Berlin (Germany).

2. Naqvi, S.M. (2005) Geology and evolution of the Indian plate: from Hadean to Holocene — 4 Ga to 4 Ka. Capital Publishing Co., New Delhi, India, 450p.

3. Alam, M.M & Curray, J.R. (2003) Sedimentary geology of the Bengal Basin, Bangladesh. Spec. Issue, Sedimentary Geology, V 155, issue 3-4. Pp. 175-421.

4. Kumar, R. (1998) Fundamentals of Historical Geology and Stratigraphy of India. New Age.

5. Khan, F. H. (1991). Geology of Bangladesh. Wiley Eastern.

6. Wadia, D.N. (1975) Geology of India (4th Edition). McGraw-Hill, Inc.

7. Gignoux, M. (1955) Stratigraphic Geology.

8. W H Freeman. Chibber, H.L. and Ramamirtham, R. (1934) The Geology of Burma. Macmillan and Co.

GHT -3104 Quaternary Geology

Credit Hour: 3

Course Type: Core Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description: This is a course designed to make the students acquainted with the characteristics, climate change, glacial Geology, classical models, geological history, stratigraphy, structure, Sedimentology, Neotectonics and sea level changes and their impacts during Quaternary periods with reference to global and Bangladesh perspectives. This course focuses on the development of scientific knowledge in the field of Quaternary history and evolution of Bengal basin.

Course Learning Objectives (CLOs): Upon successful completion of this course, students will be able to:

a. Introduce the scope and general characteristics of the Quaternary periods
b. Explain classical models like Alpine, North American, Siwalik etc.
c. Describe climatic and sea-level change, glacial and periglacial geology.
d. Compare and contrast between the Pleistocene and Holocene geological history of the Bengal basin.
e. Analyze the types of Quaternary sediments, landforms, stratigraphy and depositional environment of the Bengal basin.
f. Explain the concepts, criteria and implication of neotectonic activity to the Quaternary landform development.
g. Explain the principal paleo-magnetic dating and Oxygen isotope analysis and their implications in Stratigraphy.
h. Describe the soil profiles and Paelosols with emphasis on their micromorphology.
i. Analyze the impacts of Pleistocene-Holocene sea level changes along the coast of Bengal Basin.
j. Evaluate economic importance of Quaternary deposits.

Course Learning Outcomes (COs):

CO1: Upon successful completion of this course, students will be able to:

CO2: Understand the key climatic and geological processes that shaped the Earth during the Quaternary period.

CO3: Interpret Quaternary deposits and landforms using stratigraphic and geochronological methods.

CO4: Analyze the impacts of glaciation, sea-level changes, and tectonics on landscape evolution.

CO5: Evaluate the significance of Quaternary records in reconstructing past environments and climate change.

Mapping CO vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓	✓	✓		
CO2	✓	✓	✓		✓
CO3	✓	✓			✓
CO4		✓	✓	✓	✓
CO5		✓	✓	✓	✓

No of Lecture: 30 (1.5 hours each)

Course Content:

Lecture No.	Topic	Details	Assignment
1	Concept and general characteristics	Quaternary Geology; Importance of studying Quaternary geology; Scope of the subject.	
2	Quaternary Glaciations	Extent and chronology: Ideas about Quaternary glaciations; Evidence of glaciations; Quaternary Cryosphere reconstruction; Causes and feedback mechanism of the glacial and deglacial episodes;	
3	Classical Models of Glacial and Interglacial stages	Alpine, NW European and North-American, Pluvial and inter-pluvials	
4	Glacial effect and features	The mechanism of atmospheric CO_2 change; Methene and its role in glacial cycles; the role of the tropics and the tropical climate change; and Quaternary Environment Glacial action and recognition of the Ice Ages, Louis Agassiz and the Glacial	

		Theory, The Croll–Milankovitch Hypothesis	
5	Quaternary Geology of the Bengal basin	Physical framework, geological history, landforms, depositional environments and climatic episodes	Assignment-1
6	Quaternary Stratigraphy of Bangladesh	Stratigraphic definition and physiographic sub-division of Bangladesh, Madhupur, Barind, Panchghar, Chalanbil, Greater Sylhet area, Mymensing area and Ganges delta	
7	Neotectonics	Concept of neotectonics, criteria, overview and impacts of neotectonics to the development of Quaternary landforms.	
8	Pedological Features of Soils	Type A, B, C, D Soil Series; Laterite over Late Tertiary Sediments; Paleosols and Micromorphology	
9	Geomagnetism and Paleomagnetism	Geomagnetism: Historical, Main Features of the Geomagnetic Field, Origin of the Main Field, Variations of the Dipole Field with Time Paleomagnetism: Early Work in Paleomagnetism, Magnetism in Rocks, Geocentric Axial Dipole Hypothesis, Archeomagnetism, Paleointensity over Geological Times, Paleosecular Variation Rock Magnetism: Basic Principles of Magnetism, Magnetic Fields, Remanent and Induced Magnetism Magnetostratigraphy: Terminology in Magnetostratigraphy, Methods in Magnetostratigraphy; application of paleomagnetism to plate tectonics with respect to Bengal basin.	
10	Quaternary age dating	Dating Quaternary Deposits: Oxygen isotope, Magnotostratigraphy, Radiocarbon dating, Potassium/Argon dating, Thorium/Uronium dating, Fission-track dating, Thermoluminescence, Optical stimulated luminescence and electron spin resonance, Beryllium dating, Amini acid racemisation	Assignment-2

		dating, Cosmo genic dating, Varves.	
11	**In-course/Midterm-1**		
12	Sea Level Research: Methods and Techniques	Sea Level Changes from Geological Records (Index point), Geographic Location (Age, Altitude), Indicative Meaning and Reference Tide Level, Beachrock: modern indicator Evidence from the ocean: Microfossils, palaeo-chemistry, pollen and coral as records of environmental change, Sedimentary Facies and structure, Sea Level Changes from Tide Gauge Data	
13	Sea Level Changes Scenarios During Holocene in Bangladesh	Nature, description and causes of sea-level fluctuation: Quaternary sea levels; the Holocene transgression; recent and historic changes in sea level on Phase 1, Phase 2, Phase 3, Phase 4, Phase 5 Paleo-Coastline of Bangladesh During Early to Middle Holocene, Recent Pattern and Future Projection of Sea Level Change in the World with Reference to Bangladesh.	
14	Mid-Holocene climatic episodes	Evidences of marine transgression in around Dhaka city, Sundarbans, Maheskhali, Kutubdia, St Martin's Island	
15	Quaternary Terrestrial flora and fauna	A global synthesis: present day distribution, modern pollen spectra; the fossil database; the late tertiary/ Quaternary transition; glacial/interglacial cycles; the development of the present vegetation pattern: Biome Models	Assignment-3
16	Human origins, innovations and migrations	From *Homo erectus* to *Homo sapiens;* Stone Age; Pleistocene faunal extinctions; Neolithic plant and animal domestication	

17-18	Atmospheric circulation during the Quaternary	Modelling of tropical environments during the Quaternary; Present day circulation pattern; Global palaeohydrology and links between oceanic and atmospheric circulation.	
19-20	Environmental Changes- Past, Present and Future:	The human population in the context of Late Quaternary; Biota in the Quaternary; Drought, Overgrazing, Desertification, Irrigation and Salinization; Human effects on the atmosphere; Future actions.	Assignment-4
21	**In-course/Midterm-2**		
22-24	Landforms Development in Bangladesh	Historical Evolution of Bangladesh Since Mesozoic Era, Delta Formation and Landform Development in Response to Sea Level Changes During Quaternary Period (Early Development: 18000–7000 cal year BP, Late Development: 7000 cal year BP to Present), Physiographic Regions in Bangladesh	
25-26	Regional environmental change 1	Tropical oceans in the global climate system; Reconstructing past ocean conditions; Tropical oceans throughout the Quaternary; The past 20 000 years	Assignment-5
27	Regional environmental change 2	Quaternary of India and Tibet; Quaternary of the Arabian Sea and Bay of Bengal; Quaternary of Arabia and the Middle East; China and Southeast Asia,	
28-30	Palaeo-sea-level indicators	Introduction, Pleistocene and Holocene palaeo-sea-level indicators compared, Corals and coral reefs, Biological sea-level indicators, Geomorphological and geological sea-level indicators, Geoarchaeology and sea-level changes	Assignment-6

Instructional Strategies: Lectures**,** Class discussions**,** Use of multimedia resources (videos, animations, images) and In-class exercises

Assessment Pattern:

Assessment Pattern level no.	Knowledge level	Level of CO	In-course	Assignment	Final Examination
K1	**Remember**	CO1-CO3	05	00	10
K2	**Understand**	CO2-CO5	05	00	20
K3	**Apply**	CO3-CO5	04	00	10
K4	**Analyze**	CO3-CO5	03	00	10
K5	**Evaluate**	CO5	03	05	10
K6	**Create**	CO4-CO5	00	05	00
Total Marks 100 (Class attendance 10 + In-course 20+ Assignment 10+ Final examination 60)			20	10	60

Recommended References:

1. Bowen, D. Q. (1979). Geographical perspective on the Quaternary. *Progress in Physical Geography*, *3*(2), 167-186.
2. Bradley, R. S. (1999). *Paleoclimatology: reconstructing climates of the Quaternary* (Vol. 68). Elsevier.
3. Lowe, J. J., & Walker, M. (2014). *Reconstructing quaternary environments*. Routledge.
4. Monsur, H., (2020) *Quaternary Geology of Bangladesh*; Event Plus, Dhaka, 384p.
5. Ruddiman, W. F. (2008). Earth's Climate: Past and Future; W. H. Freeman and Company, New York.

GHT-3105 Economic Geology and Georesources

Credit Hour: 3

Course Type: General Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description: This course provides a comprehensive understanding of several principles and processes that govern the formation, localization, classification, and utilization of economic mineral deposits. It also encompasses the study of the distribution, occurrence, stratigraphy, reserves, exploration, and extraction of various mineral resources, with a focus on Bangladesh and the broader Subcontinent. Students will gain scientific and technical knowledge on the industrial applications of these minerals, their critical role in infrastructure development, and the importance of fossil fuels for energy security.

Course Learning Objectives (CLOs):

- Comprehensive knowledge of ore forming processes.
- Use of economic minerals in infrastructure development, industries and energy sector.
- Commitment to Sustainable exploration and utilization of mineral Resources
- Gain Insight into Mineral Resource Distribution in Bangladesh and the Subcontinent.

Course Learning Outcomes (COs):

Upon successful completion of this course, students will be able to:

CO1: Understand the formation processes and classifications of mineral and energy resources.

CO2: Identify and evaluate the geological settings of major ore deposits and fossil fuel reserves.

CO3: Apply exploration methods for locating and assessing georesources.

CO4: Analyze the economic, environmental, and societal implications of resource extraction and management.

Mapping CO vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓	✓	✓		
CO2	✓		✓		✓
CO3	✓	✓	✓	✓	✓
CO4			✓	✓	✓

No of lecture: 30 (1.5 hours each)

Course Content:

Lecture	Topic	Details	Homework/ Assignments
1	Introduction to Economic Geology	● Definition, scope, and important terminologies, ● Classification and importance of mineral resources. ● Mineral resource exploration.	
2	Ore localization and its controls	● Formation of ore deposit. ● Geospatial distribution of ores ● Factors controlling distribution and their importance.	
3	Magmatic mineral deposits	● Cooling and crystallization of magma. ● Formation of Magmatic ore minerals. ● Early and Late magmatic deposits.	
4	Genesis of	● Origin of Hydrothermal solution.	

	Hydrothermal deposits	● Hydrothermal processes ● Formation and classification of Hydrothermal Mineral Deposits.	
5	Metasomatism and associated mineral deposits	● Contact metamorphism and metasomatism. ● Metasomatic process and resulting mineral deposits. ● Cavity-filling and replacement deposits.	Assignment-1
6	Residual deposits	● Mode of formation ● Occurrences ● Classification	
7	Placer Deposits	● Mode of formation ● Occurrences ● Classification	
8	Coal Deposits	● Genesis of peat and coal deposit. ● Composition, properties and ranks of coal. ● Uses of coal.	
9	Supergene enrichment and Evaporation	● Weathering and supergene enrichment ● Formation of secondary ore minerals. ● Genesis, occurrence and significance of evaporite deposits.	
10	Mineral economics and resource sustainability.	● Market dynamics ● Geopolitics of Minerals ● Sustainable management of mineral resources.	Assignment-2
11	**In-course/Midterm-1**		
12	Introduction to mineral resources of Bangladesh	● Mineral resources of Bangladesh and their distribution. ● Energy Resources. ● Renewable and Non-renewable energy.	
13	Hydrocarbon resources of Bangladesh	● Geological controls on the occurrence of Natural Gas and Crude Oil. ● Genesis, properties and uses of various hydrocarbon resources.	

14	Hydrocarbon resources of Bangladesh	● Stratigraphy, exploration, history, reserve, production and consumption of hydrocarbon resources. ● Unconventional resources of hydrocarbon.	
15	Coal deposits of Bangladesh	● Origin, distribution, stratigraphic relationship, reserves and mining of coal deposits of Bangladesh	Assignment-3
16	Coal deposits of Bangladesh	● Major coalfields of Bangladesh ● Prospects and problems of coal mining in Bangladesh.	
17	Hard rock, deposits of Bangladesh	● Origin, distribution, stratigraphic relationship, reserves and mining of hard rock in Bangladesh.	
18	Limestone deposits of Bangladesh	● Origin, distribution, stratigraphic relationship, reserves and mining of limestone deposits in Bangladesh.	
19	China Clay deposits of Bangladesh	● Origin, distribution, stratigraphic relationship, reserves and mining of china clay deposits in Bangladesh.	
20	Glass Sand deposits of Bangladesh and Placer Deposits of Bangladesh	● Origin, distribution, stratigraphic relationship, reserves and mining of glass sand deposits in Bangladesh.	Assignment-4
21	**In-course-2**		
22	Petroleum resources of India.	● Occurrence of crude oil resource in India, reserve, production and consumption. ● Distribution of major oilfields in India.	
23	Petroleum resources of India.	● Oil fields of upper Assam Basin ● Oil fields of Gujrat Basin	
24	Coal resources of India	● Origin, distribution, stratigraphic relationship, reserves and mining of coal deposits of India.	
25	Coal resources of	● Major Coalfields of India	Assignment-5

	India	including Jharia coalfield and Raniganj coalfield.	
26	Iron ore deposits of India.	● Formation of Iron ore. ● Occurrence, distribution and use of Iron mineral in India.	
27-29	Copper ore deposit of India	● Mode of formation, occurrence and use of copper ore deposit. ● Distribution, reserve and production of copper minerals in India.	
29-30	Bauxite deposit of India	● Formation, mode of occurrence and types of Bauxite deposits. ● Distribution, production and use of Bauxite in India.	Assignment-6

Instructional Strategies: Lectures**,** Class discussions**,** Use of multimedia resources (videos, animations, images) and In-class exercises

Assessment Pattern:

Assessment Pattern level no.	Knowledge level	Level of CO	In-course	Assignment	Final Examination
K1	**Remember**	CO1-CO3	05	00	10
K2	**Understand**	CO2-CO4	05	00	20
K3	**Apply**	CO3-CO4	04	00	10
K4	**Analyze**	CO3-CO4	03	00	10
K5	**Evaluate**	CO3-CO4	03	05	10
K6	**Create**	CO2-CO4	00	05	00
Total Marks 100 (Class attendance 10 + In-course 20+ Assignment 10+ Final examination 60)			20	10	60

Recommended References:

Text Book:

1. Jensen, M.L., & Bateman, A.M. (1981) Economic mineral deposits (3rd Edition). John Wiley & Sons Inc.

Reference Books:

2. Pohl, W.L. (2011) Economic Geology: Principles and Practice. Wiley-Blackwell.

3. Smirnov, V.I. et al. (Eds.) (1983) Studies of mineral deposits. MIR Publishers.

4. Imam, B (2005) Energy Resources of Bangladesh - Natural Gas, Oil and Coal. University Grants Commission of Bangladesh.

5. Racey, A. & Ridd, M.F. (2015) Petroleum Geology of Myanmar. Geological Society of London.

6. Tyner, W.E. (2012) Energy resources and economic development in India. Springer Science & Business Media.

7. Banarjee, D.K. (1998) Mineral Resources of India. World Press Private Limited.

8. Sinha, R.K. and Sharma, N.L. (1970) Mineral Economics: A Text Book for University. Oxford & IBH Publishing Company.

9. Beyschlag, F.H.A., et al. (1914) The Deposits of the Useful Minerals and Rocks. Macmillan and co., limited.

GHL-3106 Structural Geology and Geological Map Lab

Credit Hour: 3

Course Type: Core Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description:

This course is designed in accordance with the theory Structural Geology and to develop a good background for geological field mapping courses. Laboratory exercises will be used in measuring and describing geological structures, including numerical problems, thickness and depth calculation, structural analysis with stereonet; tectonics and plate tectonic problems. The objective of this course will be to introduce the fundamentals of structural analysis including kinematic and dynamic analytical techniques. The lab period will be devoted to a review of previous assignments and demonstration on and hands-on practice of new problem material. All assignments are to be done as independent work. Understanding geological maps and deduction of subsurface geological information from surface outcrops is an essential skill for geologist. The map lab portion of this lab course involves studying geological maps, construction of geological cross sections based on outcrop and borehole data as well as topography, deduction of structural, structural, stratigraphic, and geological history from outcrop maps. This course also include stereoscopic interpretation of aerial photograph for obtaining geological information.

Course Learning Objectives (CLOs):

Structural geology part:

- Understand the 3-dimensional aspect of structural elements in complex geological set up.
- Solve different structural and tectonic problems.
- Determine the stratigraphic thickness and depth of the stratum in different field conditions.
- Apply knowledge in field geology.

- Explain the deformation process and determination of principal stress axes.
- recognize and classify geologic structures associated with folding and fracturing of the lithosphere

Map lab part:
- Read and understand geological maps
- Correlate outcrops to subsurface geology
- Identify and interpret the sequences of geological events in a mapped area
- Draw cross sections from both surface outcrop map and borehole information
- Deduce structural and stratigraphic information from geological maps
- Write report based on geological maps
- Visualize aerial photos in 3D using stereoscope and obtaining geological information from aerial

Course Learning Outcomes (COs):

Upon successful completion of this course, students will be able to:

CO1: Interpret geological structures such as folds, faults, and joints through field and map analysis.

CO2: Construct and analyze geological cross-sections and stereonet.

CO3: Apply structural data to solve geological problems and understand crustal deformation processes.

Mapping CO vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓

No of Lab Class: 30 (3 hours for each)

Course Content:

Lab	Topic	Details	Assignments
1	Introduction to course contents	Introduction to course contents	
2-4	Numerical problems	Numerical problems	
5-7	Thickness and Depth calculation	Thickness and Depth calculation	Assignment-1
8-11	Structural analyses with stereonet	Structural analyses with stereonet	
12-14	Problems related to tectonics, plate tectonics and Euler pole.	Problems related to tectonics, plate tectonics and Euler pole.	Assignment-2

15	**In-course/Lab Exam -1**		
16-20	Understanding Geological Maps	Determination of Bed attitude and identification of geological structure from surface exposure, deduction of geological history and ordering past geological events from the map	Assignment-3
21-25	Map Completion	Geological map completion from incomplete data on surface exposure and subsurface data in boreholes	Assignment-4
26-27	Map Interpretation	Interpretation of Geological Maps	Assignment-5
28-29	Aerial Photograph Interpretation	Visual interpretation and Stereoscopic interpretation, application in geology	Assignment-6
30	**In-course/Lab Exam -2**		

Instructional Strategies:
Laboratory work, Demonstration, Discussion, Question-Answer
Assessment Pattern:

Assessment Pattern level no.	Knowledge level	Level of CO	In-course	Assignment	Final Examination
K1	**Remember**	CO1-CO2	00	00	10
K2	**Understand**	CO2	00	00	10
K3	**Apply**	CO2-CO3	05	02	10
K4	**Analyze**	CO3	05	03	10
K5	**Evaluate**	CO2-CO3	05	02	10
K6	**Create**	CO3	05	03	10
Total Marks 100 (Class attendance 10 + In-course 20+ Assignment 10+ Final examination 60)			20	10	60

Recommended References:
Structural geology

Text books:

1. Billings, M. P. 1972. Structural geology. Prentice Hall College Div.

2. Ragan, D.M. 2009. Structural Geology and Introduction to Geometrical Techniques. Blackwell.

References:

3. Rowland, S.M; Duebendorfer, E.M. and Schiefelbein, I.M. (2007) Structural Analysis and Synnthesis: A Laboratory Course in Structural mGeology (3rd Edition). Elsevier.

4. Fossen, H. (2010) Structural Geology. Cambridge University Press.

5. Allison, D.T. (2015) Structural Geology Laboratory Manual (4th Edition). University of South Alabama

Map Lab

6. Bennison, G.M. (2012) An Introduction to Geological Structures and Maps. Springer Science & Business Media.
7. Miller, V.C (2003) Photogeology. Textbook Publishers.
8. Simpson, B. (2013) Geological Maps (Revised Edition). Elsevier.
9. Thomas, J.A.G. (1977) An Introduction to Geologic Maps (2nd Ediition). Allen and Unwin.
10. Blyth, F.G. (1965) Geological Maps and Their Interpretation. E. Arnold.

GHT -3201 Mining Geology

Credit Hour: 3

Course Type: Core Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description: This advanced course focuses on the practical aspects of mineral extraction, including mining methods, mine engineering, environmental management, and safety considerations. Building upon foundational knowledge of ore deposit geology and mineral economics, students will gain a comprehensive understanding of the technical and operational aspects of the mining industry.

Course Learning Objectives (CLOs):

Upon successful completion of this course, students will be able to:

- Describe and analyze various surface mining methods (e.g., open-pit mining, strip mining, quarrying).
- Describe and analyze various underground mining methods (e.g., room and pillar, longwall, sublevel caving).
- Evaluate the suitability of different mining methods for various ore deposit types and geological conditions.
- Understand the principles of mine planning and design, including mine layout, ventilation, drainage, and ground control.
- Analyze mine stability and rock mechanics considerations in mine design.
- Evaluate the role of technology in modern mining operations (e.g., automation, robotics).
- Describe the basic principles of mineral processing, including comminution, concentration,

and beneficiation.

- Understand the environmental impacts of mineral processing and waste disposal.
- Evaluate the environmental impacts of mining operations (e.g., water pollution, air pollution, land disturbance).
- Understand and apply environmental management strategies in mining (e.g., mine reclamation, water treatment, and dust suppression).
- Analyze the environmental regulations and permitting requirements for mining operations.
- Understand mine safety hazards and their mitigation.
- Analyze mine accidents and implement safety protocols.
- Discuss the importance of occupational health and safety in the mining industry.

Course Learning Outcomes (COs):

At the end of the course the students will be able to:

- **CO1:** Understand the fundamentals of Geology relevant to mining and apply the geological principles to the exploration, evaluation and development of the mineral resources
- **CO2:** Analyze and classify ore deposits based on their formation processes and geological settings, understand prospecting and exploration techniques and drilling equipments for exploration
- **CO3:** Assess the economic potential of the mineral deposits through geological data integration and analysis, opening up the mineral deposits, mine entry, choice of locations and different infrastructures associated to mining.
- **CO4:** Understand the environmental and sustainability aspects related to mining geology and resource extraction
- **CO5:** Analyze the rock pressure, physical and mechanical properties of rocks, effects of underground works on the surface, support for underground workings

Mapping CO vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓	✓	✓	✓	✓
CO2	✓		✓	✓	✓
CO3	✓	✓		✓	
CO4	✓		✓	✓	✓
CO5	✓		✓		✓

No of Lecture: 30 (1.5 hours each)

Course content:

Lecture	Topic	Details	Homework/ Assignments
1	Introduction to Mining Geology	Scope, importance, and evolution of mining practices	
2	Mining Methods	Different methods of mining and factors controlling the choice of mining methods	
3	Open-Pit Mining	Principles, equipment, and applications	
4	Strip Mining and Quarrying	Techniques, environmental impacts, and reclamation.	
5	Underground Mining	General principles and classifications of underground mining methods	Assignment-1
6	Room and Pillar Mining	Techniques, applications, and limitations.	
7	Long wall Mining	Techniques, equipment, and safety considerations.	
8	Sublevel Caving	Principles, applications, and environmental impacts	
9	Mine Planning and Design	Reserve Calculation, Resource estimation, mine layout	
10	Mine Planning and Design	infrastructure development for mining activities, and production planning	Assignment- 2
11	**In-course/Midterm-1**		
12	Rock Mechanics	Rock mass characterization, stress analysis, and ground control	
13	Drilling and Blasting	Drilling techniques, explosives, blasting equipment, and precautions	
14	Mine Ventilation	Principles of mine ventilation, ventilation systems, and air quality control	

15	Mine Drainage	Water management in mines, dewatering techniques, and water treatment	Assignment-3
16	Mineral Processing	Commination, concentration, mineral valuation, and beneficiation techniques	
17	Mine Waste Management	Tailings disposal, waste rock management, and mine reclamation	
18	Water Pollution from Mining	Sources of water pollution, water treatment technologies, and environmental regulations	
19-20	Air Pollution and Dust Control	Sources of air pollution, dust control measures, and air quality monitoring	
21	**In-course/Midterm-2**		
22	Mine Safety Hazards	Rock falls, explosions, fires, and other mine hazards	
23	Mine Safety Regulations and Practices	Occupational safety and health standards, emergency response plans, and social impacts of mining	
24	Mining Laws	Mineral Economics, mineral rights, and mining laws	
26 -30	Advance topics on Mining	Automation and robotics in mining, Mine sustainability and environmental management, Emerging technologies in mining (e.g., in-situ leaching, underground mining using robotics), Case studies of successful and unsuccessful mining projects-(Hard rock, Coal, mineral)	Assignment- 5

Instructional Strategies: Lectures**,** Class discussions**,** Use of multimedia resources (videos, animations, images) and In-class exercises

Assessment Pattern:

Assessment Pattern level no.	Knowledge level	Level of CO	In-course	Assignment	Final Examination
K1	Remember	CO1, CO2	04	02	10
K2	Understand	CO1-CO4	04	02	20
K3	Apply	CO3-CO5	08	04	15
K4	Analyze		00	00	00
K5	Evaluate	CO3 & CO5	04	02	15
K6	Create		00	00	00
Total Marks 100 (Class attendance 10 + In-course 20+ Assignment 10+ Final examination 60)			20	10	60

Recommended References:

Arogyaswamy, R.N.P.: Courses in mining geology.

Peters, W.C.: Exploration and mining geology.

Maximov et al.: Short course of geological prospecting and exploration.

Lewis, R.S. and Clark, G.B.: Elements of mining.

William Callier Peters; Exploration and Mining Geology

Banerjee P K and Ghosh Elements of Prospecting for Non-fuelMineral Deposits"

Erik Ronald, PG and Dawn Schippe, PG Mining Geology

GHT-3202 Geochemistry

Credit Hour: 3

Course Type: Core Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description: This course delves into the core principles of geochemistry, focusing on the chemical composition and behavior of materials that make up the Earth. It offers students a comprehensive understanding of the distribution and abundance of elements within the Earth's crust, mantle, and core. The course also emphasizes the chemical processes and reactions that drive various geological phenomena. Additionally, students will learn to apply geochemical data to address and solve complex geological challenges, providing them with essential knowledge for research and practical problem-solving skills in Earth sciences.

Course Learning Objectives (CLOs):

Upon successful completion of this course, students will be able to:

- Understand the fundamental concepts of Geochemistry
- Describe the major geochemical cycles (e.g., carbon, nitrogen, sulfur, water cycles)
- Comprehend the interactions between the major spheres (geosphere, hydrosphere, atmosphere, and biosphere)
- Know the principles of radiogenic and stable isotope geochemistry and their application to solve geological problems (e.g., geochronology, paleoclimatology).
- Understand the principles of igneous geochemistry, including magma genesis and differentiation.
- Understand the principles of weathering, soil formation, and water-rock interactions.
- Apply geochemical principles to the study of surface processes, identify environmental problems and find out the solutions.
- Learn the basic principles of modern analytical techniques used in geochemistry.

Course Learning Outcomes (COs):

At the end of the course the students will be able to:

- **CO1:** relate important elements to their occurrence in the Earth's crust , explain the distribution of elements in mantle and core and their geochemical classification
- **CO2:** Analyze the fundamentals of geochemistry and its relevance in earth's crust
- **CO3:** Evaluate processes such as weathering, sedimentation, magmatism and metamorphism using geochemical signature.
- **CO4:** Understand the role of geochemistry in exploration geology, environmental studies and resource management

- **CO5:** Anticipate the procedures of geochemical sampling and different methods of analysis

Mapping CO vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓		✓	✓	✓
CO2	✓		✓	✓	✓
CO3	✓	✓	✓	✓	
CO4	✓	✓	✓		✓
CO5	✓		✓	✓	✓

No of Lecture: 30 (1.5 hours for each)

Course Content:

Lecture	Topic	Details	Homework/ Assignments
1	Introduction to Geochemistry	Scope, history, importance of geochemistry, major branches of geochemistry and relative position and interrelationship of geochemistry with other branches of geoscience	
2	Atomic Structure and Chemical Bonding	Atomic structure, periodic table, types of chemical bonds, Cosmo chemistry and Origin of elements	
3	Geochemical classification of Elements	Various geochemical classification schemes and their bases, description of individual classification schemes and their implication in geochemistry	
4	Thermodynamics	Basic thermodynamic concepts (Gibbs free energy, entropy, enthalpy), Equilibrium and disequilibrium in geochemical systems, Reaction	

		kinetics and rate laws in geochemistry	
5	Magma Genesis and Differentiation	Magma differentiation, mixing, and contamination	Assignment-1
6	Igneous Rock Geochemistry: Major elements	Definition & classification of major elements, major elements variation in igneous rock composition, Processes controlling major element distribution, Major element based classification of igneous rocks	
7	Igneous Rock Geochemistry: Trace elements	Definition & classification of trace elements, Role of trace elements in petrogenesis, Behavior of Trace Elements in Magmatic Systems (Partition coefficients (Kd values) and their significance, Bulk distribution and Rayleigh fractionation, Trace Element Classification and Geochemical Groups, Rare Earth Element (REE) Geochemistry (REE fractionation patterns, Chondrite-normalized REE plots and their interpretation, Europium anomalies and plagioclase fractionation)	
8	Geochemical signatures of different tectonic settings	Major element signatures of different tectonic settings: Mid-ocean ridge basalts (MORB) vs. island arc basalts (IAB), Continental vs. oceanic igneous rocks, Trace Element Signatures of different	

		Tectonic Settings: MORB, OIB, IAB, and continental crust signatures Discrimination diagrams (e.g., Th/Yb vs. Ta/Yb, Nb/Yb vs. Th/Yb)	
9	Geochemical Differentiation	Definition and importance of geochemical differentiation, Early Earth differentiation processes, Role of planetary accretion and core, Magma ocean hypothesis and metal-silicate segregation, Density-driven differentiation and elemental partitioning, Geochemical composition of the core and mantle,	
10	Geochemical Differentiation	Seismological evidence of chemical heterogeneity, Geodynamic and geochemical evolution over geological time, Influence of geochemical differentiation on magnetic field generation and mantle convection, Comparisons with other planetary bodies.	Assignment -2
11	**In course-1**		
12 & 13	Fundamentals of Low Temperature Geochemistry	Definition and scope, Importance in surface and near-surface environments, Key processes and applications, Chemical Weathering and Soil Formation, Thermodynamic Principles in Low-Temperature Geochemistry (Solubility of minerals in natural waters, Eh-pH diagrams and their	

		applications.	
14	Aqueous Geochemistry and Solute Transport	Composition of natural waters (rainwater, river water, groundwater), Sources of dissolved ions, Factors controlling water chemistry, Speciation and Complexation of Elements in Natural Waters, Major chemical reactions and transport of solute in aqueous system.	
15	Introduction to Environmental Geochemistry	Definition and Scope of Environmental Geochemistry, Importance of Geochemistry in Environmental Studies, Earth's Chemical Reservoirs cycling of elements in the environment; Chemical Equilibrium and Solubility in Natural Systems, Kinetics of Geochemical Reactions, Redox Reactions and Their Environmental Significance	Assignment-3
16 & 17	Environmental Pollution and Remediation Techniques	Sources, Transport, and Fate of toxic elements; Heavy Metal Pollution: Lead, Mercury, Arsenic, Cadmium, Organic Contaminants Pesticides, Hydrocarbons, and Emerging Pollutants, Microplastic Contamination in Soil and Water Systems, Case Studies of Major Environmental Pollution Events, Natural attenuation and engineered remediation strategies.	
18-19	Biogeochemistry and Ecotoxicology	Interactions Between Biological and Geochemical Processes,	

		Biogeochemical Cycles of Carbon, Hydrogen, Oxygen, Nitrogen, Sulfur (CHONS), and Phosphorus, Bioavailability and Toxicity of Heavy Metals, Microbial Mediation of Geochemical Reaction, Medical geochemistry.	
20	Fundamentals of Isotope Geochemistry	Definition and Scope, Overview of radiogenic and stable isotopes; Radioactive decay, half-life, and geochronology; Fractionation and isotope ratio in stable isotopes.	Assignment-4
21	**In-course-2**		
22	Applications of isotope geochemistry	Applications of stable isotope geochemistry (e.g., paleoclimatology, paleoceanography), Principles of Stable and Radiogenic Isotopes in the Environment, Isotopic Tracers in Hydrology, Climate, and Pollution Studies, Applications of Carbon, Hydrogen, Oxygen, Nitrogen and Sulphur Isotopes.	
23	Geochemical Exploration and Resources	Geochemical methods in mineral exploration, Geochemical signatures of ore deposits, Hydrocarbon geochemistry	
24-27	Analytical Techniques in Geochemistry and interpretation	Methods and instrumentation for geochemical analysis of soil, rock and aqueous samples.	Lab work and assignment-5

28-30	Geochemical data	Interpretation of geochemical data.	Assignment-6

Instructional Strategies: Lectures**,** Class discussions**,** Use of multimedia resources (videos, animations, images) and In-class exercises

Assessment Pattern:

Assessment Pattern level no.	Knowledge level	Level of CO	In-course	Assignment	Final Examination
K1	**Remember**	**CO1, CO3**	05	04	20
K2	**Understand**	**CO2-CO4**	04	04	10
K3	**Apply**	**CO4-CO5**	08	00	15
K4	**Analyze**		00	00	00
K5	**Evaluate**	**CO1 & CO4**	03	02	15
K6	**Create**		00	00	00
Total Marks 100 (Class attendance 10 + In-course 20+ Assignment 10+ Final examination 60)			20	10	60

Recommended References:

1. Introduction to Geochemistry: Principles and Applications by Kula C. Misra

2. Principles of Igneous and Metamorphic Petrology by John D. Winter (Second Edition)

3. Igneous Petrogenesis: A Global Tectonic Approach by M. Wilson

4. Developments in Environmental Science, Volume 5 by D. Sarkar, R. Datta and R. Hannigan (Editors)r 2007 Published by Elsevier Ltd.

5. Handbook of Exploration and Environmental Geochemistry by M. Hale

6. Environmental Geochemistry by Barbara Sherwood Lollar

7. Isotope Geochemistry (2nd Edition) by William M. White

8. Isotopes: Principles and Applications (3rd Edition) by Gunter Faure and Teresa M. Mensing

9. Principles of Stable Isotope Geochemistry Zachary Sharp

10. Environmental Geochemistry by Barbara Sherwood Lollar

11. Modern Analytical geochemistry by Robin Gill

12. Environmental Geochemistry: Site Characterization, Data Analysis and Case Histories by B. De Vivo, H. E. Belkin & A. Lima

GHT 3203 Remote Sensing and GIS

Credit Hour: 3

Course Type: General Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description: This course introduces students to the fundamental principles and applications of remote sensing and Geographic Information Systems (GIS). Students will learn about the principles of remote sensing data acquisition, processing, and analysis, and the core concepts and applications of GIS.

Course Learning Objectives (CLOs):

Upon successful completion of this course, students will be able to:

- Understand the principles of electromagnetic radiation and its interaction with Earth's surface.
- Describe different types of remote sensing platforms (aerial, satellite, airborne).[1]
- Analyze different types of remote sensing data (e.g., aerial photographs, satellite imagery, radar).
- Apply basic image processing techniques (e.g., image enhancement, classification, change detection).
- Understand the components of a GIS and its basic functions.
- Work with different types of spatial data (raster, vector).[2]
- Perform basic GIS operations (e.g., data entry, editing, query, analysis).
- Create and interpret maps using GIS software.
- Application of remote sensing and GIS techniques to solve real-world problems in geology (e.g., geological mapping, mineral exploration, natural hazard assessment).[3]
- Understand the applications of remote sensing and GIS in environmental monitoring and management.
- Explore the use of remote sensing and GIS in other fields (e.g., agriculture, forestry, urban planning).

Course Learning Outcomes (COs):

At the end of the course the students will be able to:

- **CO1:** Understand the basic principles of remote sensing including electromagnetic radiation, sensor types and satellite systems
- **CO2:** Interpret and analyze remotely sensed imagery to extract meaningful geospatial information
- **CO3:** Understand the fundamentals of Geographic Information System (GIS) and spatial data structures (raster and vector)
- **CO4:** Apply image processing techniques such as classification, enhancement and filtering ,

perform spatial analysis and modeling using GIS tools to solve real world problems

- **CO5:** Apply basic procedure of thematic mapping and effectively communicate geospatial findings through maps

Mapping CO vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓	✓	✓		✓
CO2	✓	✓	✓	✓	✓
CO3		✓		✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	

No of Lecture: 30 (1.5 hours each)

Course Content:

Lecture	Topic	Details	Homework/ Assignments
1	Introduction to Remote Sensing	Principles of remote sensing, Electromagnetic spectrum	
2	Remote Sensor and Platform	Remote Sensing Platforms, Scanner, Types of remote sensor, satellite remote sensing	
3	Remote Sensing Data Acquisition	Data Acquisition system of Active, Passive and Hyper spectral remote sensing; Geometric and Radiometric distortion of image	
4	Image Enhancement	Contrast enhancement, filtering, noise reduction, band rationing etc.	
5	Image Interpretation Techniques	Visual Image interpretation, digital image processing	Assignment-1
6	Image Classification	Supervised and unsupervised classification techniques	
7	Change Detection	Techniques for detecting changes in land cover and land use, land surface temperature	
8	Aerial	Principles of aerial photography; Acquisition	

	photography	aerial photograph and interpretation techniques	
9	Photogrammetry	Principles of photogrammetry; Acquisition of Photogrammetry image and interpretation techniques	
10	LiDAR (Light Detection and Ranging)	Principles of LIDAR; Acquisition LIDAR image and interpretation techniques	Assignment-2
11	**In-course-1**		
12	Microwave Remote Sensing	Concept, microwave EMR system, RADAR and InSAR sensor resolution, application of microwave remote sensing	
13	Remote Sensing of rocks, minerals and vegetation	Spectral mapping of rocks, minerals and vegetation	
14	Introduction to GIS	- Definition and evolution of GIS - Components: Hardware, Software, Data, People, Methods - Key functions: Data capture, storage, analysis, visualization - Applications in urban planning, disaster management, environmental monitoring	
15	Current Trends and Approaches	- Evolution from traditional GIS to modern GIS platforms - Cloud GIS and Web GIS - Integration with AI, Big Data, and IoT - Mobile GIS and real-time data analytics - Role of Open Source GIS	Assignment-3
16-17	Map Projection and Coordinate Systems	- Basics of map projections and distortions (shape, area, distance, direction) - Types of projections: Cylindrical, Conical, Azimuthal - Coordinate systems: Geographic (lat/long), Projected (UTM)	

		- Datum concepts and transformation techniques	
18	Vector Data Model	- Concepts: Points, Lines, Polygons and their real-world representations - Topology rules: Connectivity, Contiguity, Adjacency - Georelational Data Model: Linking spatial and attribute data through unique IDs (e.g., Shapefiles) - Object-Based Data Model: Treating spatial features as objects with properties and behaviors (e.g., Geodatabases) - Comparison of Georelational vs. Object-Based Models: Structure, storage, performance - Advantages and limitations of vector data for spatial analysis	
19	Raster Data Model	- Definition and characteristics of raster data - Cell size, resolution, and data storage formats - Raster vs. Vector comparison - Common raster data: Satellite images, DEMs, Land cover maps	
20	Geometric Transformation	- Importance of geometric corrections - Transformation methods: Affine, Polynomial, Projective - Root Mean Square (RMS) error analysis - Image registration and resampling techniques	Assignment-4
21	**In-course- 2**		
22	Attribute Data Management	- Attribute tables: Fields, records, data types (text, number, date) - Database management: Joins, relates, normalization - Querying data: SQL basics, selection by attributes - Data visualization through attribute-driven symbology	

23	GIS Data Acquisition	- Primary and secondary data sources - Remote sensing and GPS data collection - Public GIS data portals and open-source datasets - Data quality considerations: Accuracy, precision, metadata	
24	Data Input	- Methods: Manual digitizing, scanning, importing shapefiles, geocoding - Error checking, data cleaning, and validation - Coordinate systems and data alignment during input - Best practices for efficient data entry	
25	Cartography and Map Design	- Principles of effective cartography - Map elements: Title, legend, scale, north arrow, grid, labels - Symbolization, color theory, and visual hierarchy - Map layout design for different purposes (thematic, topographic)	Assignment-5
26	Vector Data Analysis	- Spatial analysis techniques: Buffering, overlay (union, intersect), Dissolve - Proximity analysis and spatial queries - Network analysis basics: Shortest path, service area - Real-world applications: Site selection, risk mapping	
27	Raster Data Analysis	- Raster operations: Reclassification, Raster calculator, Map algebra - Overlay analysis with raster data - Zonal statistics for summarizing spatial data - Applications: Land use change detection, environmental modeling	
28-29	Terrain and Watershed	- Digital Elevation Models (DEM): Slope, aspect, hillshade analysis	

	Analysis	- Watershed delineation: Flow direction, accumulation, stream network extraction - Hydrological modeling concepts and flood risk analysis	
30	Neighborhood Analysis	- Concept of neighborhood operations in raster GIS - Focal statistics: Mean, median, maximum, etc. - Moving window analysis for spatial smoothing - Applications: Hotspot detection, land suitability modeling	Assignment-6

Instructional Strategies: Lectures**,** Class discussions**,** Use of multimedia resources (videos, animations, images) and In-class exercises

Assessment Pattern:

Assessment Pattern level no.	**Knowledge level**	**Level of CO**	**In-course**	**Assignment**	**Final Examination**
K1	**Remember**	**CO1, CO2**	02	00	05
K2	**Understand**	**CO1-CO4**	06	02	10
K3	**Apply**	**CO3-CO5**	04	02	10
K4	**Analyze**		04	02	15
K5	**Evaluate**	**CO3 & CO5**	02	02	10
K6	**Create**		02	02	10
Total Marks 100 (Class attendance 10 + In-course 20+ Assignment 10+ Final examination 60)			20	10	60

Recommended References:

1. Jensen, J.R. (2014) Remote Sensing of the Environment: An Earth Resource Perspective (Pearson New International Edition). Pearson.

2. Longley, P.A., Goodchild, M.F., Maguire, D.J., Rhind, D.W. (2015) Geographic Information Science

& System (4th Ediiton). Wiley.
3. Kennedy, M. (2013) Introducing Geographic Information Systems with ArcGIS. A Workbook Approach to Learning GIS (3rd Edition). Wiley.
4. Heywood, I., Cornelius, S., Carver, S. (2006) An Introduction to Geographical Information Systems (3rd Edition). Pearson Prentice Hall.
5. Jensen, J.R. (2004) Introductory Digital Image Processing: A Remote Sensing Perspective (3rd Edition). Prentice Hall.
6. Lillesand, T.M., Kiefer, R.W. and Chipman, J.W. (2004) Remote Sensing and Image Interpretation (5th Edition). John Wiley and Sons.
7. Clarke, K.C., (2003) Getting Started with Geographic Information System (4th Edition). Prentice Hall.
8. Bonham-Carter, G.F. (1994) Geographic Information Systems for Geoscientists: Modeling with GIS. Elsevier Science Publications.

GHT-3204 Geohazard and Risk Analysis

Credit Hour: 3

Course Type: General Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description: The course *Geohazard and Risk Analysis* provides an in-depth understanding of natural geological hazards such as earthquakes, landslides, volcanoes, floods, and coastal hazards. It emphasizes the processes behind these hazards, their spatial and temporal patterns, and methods for assessing associated risks. Students will learn to apply geospatial tools, statistical models, and risk assessment frameworks to evaluate hazard susceptibility and vulnerability. The course integrates case studies from both global and regional contexts, with a special focus on hazard-prone areas. Students will also explore strategies for risk mitigation, disaster preparedness, and resilience building. Interdisciplinary approaches combining geology, engineering, and socio-economic perspectives are highlighted. Practical exercises and projects will enhance students' abilities to analyze and communicate geohazard risks effectively.

Course Learning Objectives (CLOs):

- Identify and explain the physical processes responsible for major geohazards and their environmental impacts.
- Apply hazard assessment techniques using geospatial tools and quantitative methods.
- Evaluate the vulnerability and risk levels of communities and infrastructure in hazard-prone areas.
- Design and recommend appropriate mitigation and adaptation strategies for geohazard risk reduction.

- Interpret and communicate geohazard risk assessments to support informed decision-making in planning and disaster man

Course Learning Outcomes (COs):

At the end of the course the students will be able to:

- **CO1:** Understand the types, causes and characteristics of geo-hazards including earthquakes, landslides, floods, tsunamis and volcanoes
- **CO2:** Analyze physical processes behind geo-hazard events and their spatial and temporal patterns
- **CO3:** Evaluate vulnerability and exposure of human populations, infrastructures and environments to geo-hazards
- **CO4:** Develop strategies for geo-hazard mitigation, early warning systems and community based risk reduction
- **CO5:** Critically analyze case studies of past geo-hazard events to understand risk management plans effectively to understand risk management successes and failures

Mapping CO vs PLO:

CO	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**
CO1	✓	✓	✓		✓
CO2		✓	✓	✓	✓
CO3	✓		✓	✓	✓
CO4	✓	✓	✓		✓
CO5	✓	✓		✓	✓

No of Lecture: 30 (1.5 hours for each)

Course Content:

Lecture No.	**Topic Name**	**Details**	**Assignment**
1-2	Introduction to Geohazards and Risk Analysis	Definition of geohazards, significance, classification, and their impact on society and the environment.	
3-4	Tectonic Hazards: Earthquakes, Tsunamis, and Volcanic	Causes and effects of earthquakes, tsunami generation, volcanic	

	Eruptions	hazards, and mitigation strategies.	
5-6	Mass Movement Hazards: Landslides, Erosion, and Subsidence	Types of landslides, causes of soil erosion, mining-induced subsidence, and monitoring techniques.	Assignment-1
7-8	Hydro meteorological Hazards: Floods, Cyclones, and Storm Surges	Flooding mechanisms, impacts of cyclones, storm surges, and disaster management approaches.	
9-10	Climate Change-Induced Geohazards	How climate change influences geohazards, sea-level rise, glacier retreat, and extreme weather events.	Assignment-2
11	**In-course-1**		
12-13	Anthropogenic and Environmental Hazards	Impact of human activities on geohazards, land degradation, mining-induced hazards, and urbanization risks.	
14-15	Geohazard Risk Assessment: Concepts and Frameworks	Concepts of risk, hazard, vulnerability, exposure, probabilistic vs. deterministic assessments, and hazard zonation.	Assignment-3
16-18	Machine learning and geoinformatics based Applications in Geohazard Analysis	Present stat of art ML and DL techniques together with the Use of satellite data and GIS for hazard mapping, real-time monitoring, and risk analysis.	
19-20	Numerical Modeling and Early Warning Systems for Geohazards	Simulation techniques for earthquakes, tsunamis, landslides, and the role of early warning systems in disaster prevention.	Assignment-4
21	**In-course-2**		
22-23	Geohazard Mitigation Strategies: Engineering and Policy Interventions	Engineering solutions for geohazard mitigation, policy frameworks, and land-use planning.	
24-25	Disaster Risk Reduction (DRR) and Community-Based Hazard	Community-based risk reduction, emergency response planning, and	Assignment-5

	Management	resilience-building strategies.	
26-27	Case Studies: Bangladeshi Geohazard Challenges and Solutions	Analysis of Bangladesh's vulnerability to cyclones, floods, landslides, and earthquake risks.	
28-29	Case Studies: Lessons from Major Geohazard Events in Bangladesh	Global case studies including the 2007 cyclone, 2024 flash flood and 1988 flood in Bangladesh,	
30	Future Perspectives: Innovations and Multi-Hazard Risk Assessment	Emerging technologies, AI in hazard prediction, and integrating multi-hazard approaches for future resilience.	Assignment-6

Instructional Strategies: Lectures**,** Class discussions**,** Use of multimedia resources (videos, animations, images) and In-class exercises

Assessment Pattern:

Assessment Pattern level no.	Knowledge level	Level of CO	In-course	Assignment	Final Examination
K1	**Remember**	**CO1-CO3**	02	04	10
K2	**Understand**	**CO2-CO4**	06	00	15
K3	**Apply**	**CO4-CO5**	06	02	20
K4	**Analyze**		02	00	00
K5	**Evaluate**	**CO1,CO2 & CO5**	04	04	15
K6	**Create**		00	00	00
Total Marks 100 (Class attendance 10 + In-course 20+ Assignment 10+ Final examination 60)			20	10	60

Recommended References:

1. Keller, E.A. and DeVecchio, D.E., 2019. *Natural hazards: earth's processes as hazards, disasters, and catastrophes*. Routledge.

2. Bryant, E., 2005. *Natural hazards*. Cambridge university press.

3. Wisner, B., Gaillard, J.C. and Kelman, I., 2012. *Handbook of hazards and disaster risk reduction*. Routledge.

GHL-3205 Remote sensing and GIS Lab

Credit Hour: 3

Course Type: General Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description: This advanced laboratory course focuses on the application of remote sensing and GIS techniques to solve complex geological problems. Students will gain hands-on experience with image processing, spatial analysis, and geospatial modeling using industry-standard software.

Course Learning Objectives (CLOs):

Upon successful completion of this course, students will be able to:

- Image Processing:
  - Understand the fundamental principles of remote sensing and GIS.
  - Develop proficiency in using remote sensing and GIS software (e.g., ArcGIS, ERDAS Imagine, and Google Earth Engine).
  - Apply remote sensing and GIS techniques to solve geological problems.
  - Interpret and analyze remote sensing imagery and spatial data.
  - Create thematic maps and spatial models relevant to geological applications.
  - Perform advanced image processing techniques (e.g., image classification, object-based image analysis, change detection).
  - Apply image rectification and orthorectification techniques.
  - Utilize spectral indices and other image enhancement methods.
- GIS Analysis:
  - Perform spatial interpolation techniques to predict unknown values
  - Perform various geoprocessing to be able to execute spatial analysis
  - Perform advanced spatial analysis operations (e.g., network analysis, surface analysis, 3D modeling).
  - Integrate remote sensing data with other geospatial datasets (e.g., DEMs, geological maps).
  - Develop and implement geospatial databases.
- Geospatial Modeling:
  - Develop and implement simple geospatial models (e.g., slope stability models, groundwater models).

    - Integrate remote sensing and GIS data into geospatial models.
- Applications in Geology:
    - Apply remote sensing and GIS techniques to solve geological problems (e.g., mineral exploration, natural hazard assessment, environmental monitoring).
    - Analyze and interpret geospatial data for geological mapping and terrain analysis.
    - Develop and present research-quality geospatial analyses.

Course Learning Outcomes (COs):

At the end of the course the students will be able to:

CO1: Understand basic concepts of Remote Sensing and GIS technologies- recognize satellite image types, sensors and resolutions

CO2: Perform image processing and enhancement techniques- applying filtering, classification of remotely sensed images

CO3: Analyzing spatial data using GIS tools and conduct spatial analysis like buffering, overlaying and spatial queries

CO4: Prepare thematic maps and reports- design maps with appropriate symboloby, scales and legends

CO5: Interpret satellite imagery for real world applications- identify land use/land cover, vegetation indices, water bodies etc.

Mapping CO vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓	✓		✓	✓
CO2		✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓		✓	
CO5		✓	✓	✓	✓

No of Lab Classes: 30 (3 hours each)

Course Content:

Lab	Topic	Details	Homework/ Assignments
1-2	Introduction to Image	Introduction to ArcGIS/ERDAS Imagine remote sensing modules. Image display and basic	

	Processing Software	manipulation. Image statistics and histograms.	
3	Satellite Image Acquisition and visualization in Software.	Learning the acquisition of satellite image from specific satellite sensor's website.	
4	Spectral Properties of Earth Materials	Spectral reflectance curves of rocks, minerals, soils, and vegetation. Spectral libraries and their applications. Introduction to spectral indices	
5-6	Geometric Correction and Image Registration	Geometric distortions and their sources. Ground control points (GCPs) and rectification. Image registration and mosaicking	Assignment-1
7-8	Image Enhancement Techniques	Contrast stretching and histogram equalization. Spatial filtering and edge enhancement. Color composites and band combinations	
9-10	Image Classification (Unsupervised) and accuracy assessment	Principles of unsupervised classification (e.g., k-means). Accuracy assessment methods (e.g., confusion matrix).	Assignment-2
11-12	Image Classification (Supervised)	Principles of supervised classification. Training sample selection and signature generation. Classification algorithms (e.g., maximum likelihood).	
13-14	Applications of RS in Geology	Lithological Mapping using Remote Sensing based on spectral analysis. Lineament extraction from remote sensing imagery. Spectral remote sensing for mineral identification.	Assignment-3
15	Introduction to GIS and Spatial Data	GIS concepts and applications. Vector and raster data models. Coordinate systems and projections	

16	GIS Software and Data Input	Introduction to ArcGIS. Familiarization of various component of ArcGIS software Digitizing vector data. Georeferencing raster data.	
17	Spatial Data Editing and Manipulation	Vector editing tools. Attribute data management. Topology and spatial relationships	
18	Spatial Analysis (Vector)	Buffering and overlay analysis. Network analysis. Spatial queries and selections.	Assignment-7
19	Spatial Analysis (Raster)	Raster algebra and map algebra. Distance and proximity analysis. Terrain analysis (slope, aspect, elevation),	
20	Digital Elevation Models (DEMs) and Applications	Sources of DEM data (SRTM, LiDAR). DEM processing and analysis. Applications in geomorphology and hydrology.	Assignment-4
21	**In-course/Midterm-2**		
22	Map Design and Cartography	Principles of map design. Creating thematic maps. Map layout and export.	
23	Introduction to GPS and Field Data Collection	GPS principles and applications. Field data collection using GPS. Integration of GPS data with GIS.	Assignment-9
24	Landslide Hazard Assessment using Remote Sensing and GIS	Identifying landslide-prone areas. Creating landslide susceptibility maps. Integration of remote sensing and GIS data.	
25	Hydrological	Watershed delineation and analysis.	

	Applications in Geology	Groundwater potential mapping. Flood modeling.	
26	Environmental Geology, GIS and Remote Sensing	Monitoring environmental changes. Land use/land cover change detection. Environmental impact assessment.	Assignment-9
27-30	Introduction to Google Earth Engine	Cloud based remote sensing. Accessing and processing large datasets. Scripting in Google Earth Engine.	

Instructional Strategies:

Laboratory work, Demonstration, Discussion, Question-Answer

Assessment Pattern

Assessment Pattern level no.	Knowledge level	Level of CO	In-course	Assignment	Final Examination
K1	**Remember**	**CO1-CO3**	00	00	10
K2	**Understand**	**CO2-CO5**	00	00	15
K3	**Apply**	**CO3**	06	03	15
K4	**Analyze**	**CO2-CO5**	04	02	10
K5	**Evaluate**	**CO3-CO5**	00	05	10
K6	**Create**	**CO4-CO5**	10	00	00
Total Marks 100 (Class attendance 10 + In-course 20+ Assignment 10+ Final examination 60)			20	10	60

Recommended References:

Jensen, J.R. (2014) Remote Sensing of the Environment: An Earth Resource Perspective (Pearson New International Edition). Pearson.

Longley, P.A., Goodchild, M.F., Maguire, D.J., Rhind, D.W. (2015) Geographic Information Science &

System (4th Ediiton). Wiley.
Kennedy, M. (2013) Introducing Geographic Information Systems with ArcGIS. A Workbook Approach to Learning GIS (3rd Edition). Wiley.
Heywood, I., Cornelius, S., Carver, S. (2006) An Introduction to Geographical Information Systems (3rd Edition). Pearson Prentice Hall.
Jensen, J.R. (2004) Introductory Digital Image Processing: A Remote Sensing Perspective (3rd Edition). Prentice Hall.
Lillesand, T.M., Kiefer, R.W. and Chipman, J.W. (2004) Remote Sensing and Image Interpretation (5th Edition). John Wiley and Sons.
Clarke, K.C., (2003) Getting Started with Geographic Information System (4th Edition). Prentice Hall.
Bonham-Carter, G.F. (1994) Geographic Information Systems for Geoscientists: Modeling with GIS. Elsevier Science Publications.

GHF-3206 Geological Field Mapping

Credit Hours: 3

Course Type: Capstone Course

Total Marks: 100 (Attendance-10, Field Performance- 15, Field Viva-15 and Field Report-60)

Course Description:

This course provides students with foundational training in geological field techniques through a combination of classroom preparation and an immersive seven-day fieldwork program in the hill tracts of Bangladesh. The course focuses on developing practical skills for geological mapping, sedimentary logging, structural measurements, and field interpretation. Emphasis is placed on understanding and documenting large-scale geological features such as folds, faults, and unconformities, as well as the identification and analysis of stratigraphic units and sedimentary structures. Students are trained to collect and synthesize field data, construct lithological columns, correlate stratigraphic sections, and produce geological maps and reports based on field observations. The course integrates hands-on exercises, field lectures, and laboratory work to reinforce geological reasoning and reporting.

Course Learning Objectives (CLOs):

By completing this course students will be able to –

i) Identify and locate geological exposures in the field using topographic maps and field navigation techniques.

j) Accurately measure and record bed attitudes (strike and dip) and other structural features such as folds and faults.

k) Construct lithological columns and stratigraphic logs to represent vertical rock successions.
l) Correlate stratigraphic sections across different outcrops and interpret facies changes.
m) Interpret sedimentary structures and depositional environments based on field observations.
n) Prepare geological maps that incorporate lithological boundaries, structural elements, and stratigraphic units.
o) Document field data systematically using field notebooks, sketches, photographs, and standardized note-taking techniques.
p) Write a comprehensive geological field report, including maps, sections, interpretations, and summaries of field data.

Course Learning Outcomes (COs):

At the end of the course the students will be able to:

CO1: Analyze sedimentary facies- identify and interpret sedimentary facies and depositional environment from field observation

CO2: Correlate stratigraphic units across measured sections using lithologic, fossil or structural markers

CO3: Apply basic sequence stratigraphic concepts in the field such as recognizing transgressive-regressive cycles

CO4: Interpret the geological history and paleoenvironment of a region based on stratigraphic evidence

CO5: Prepare detailed field logs, stratigraphic columns and a report summarizing observations, interpretations and conclusions.

Mapping CO vs PLO:

CO	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**
CO1	✓	✓		✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4		✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓

No of Lectures: 30 (1.5 Hours for each)

Course contents:

Lec.	Topic	Details	Assignment
1–10	Preparation for fieldwork	• Introduction to geological fieldwork • Field equipment and safety • Field observation at different scales • Field notebook: sketches, written notes, correlation with other data, etc. • Recording features of sedimentary logs and constructing graphic logs • Recording palaeontological data • Recording structural information • Making a geological map • Photography, sampling, etc. • Laboratory analysis of samples and interpretation • Field report writing	
11	**In-course/Midterm-1**		
12-28	Geological Fieldwork	Conduct a seven-day geological fieldwork program (comprising five days of fieldwork and two days of travel) in a well-exposed outcrop section to study the general geology of the area. The program focuses on developing essential field skills, including geological observation, documentation, and mesoscopic-scale mapping. Activities include observing exposed rock facies, mapping exercises, maintaining standardized field notes, constructing lithological columns, collecting rock samples, correlating lithological sections from different locations, interpreting the depositional environment and summarizing and plotting field data on a map at the end of each field day.	
29-30	Sequence Stratigraphy	Recognize or detection of sequence stratigraphic surfaces, system tracts and sequences, identifying	

		petroleum system elements and processes.	

Instructional strategies: Classroom lecture and discussion**,** Hands-on exercise, on-site lectures, and discussions.

Assessment Pattern:

Assessment Pattern level no.	**Knowledge level**	**Level of CO**	**Field Performance**	**Field Viva**	**Field Report**
K1	**Remember**	**CO1, CO2**	00	02	05
K2	**Understand**	**CO1-CO4**	04	03	15
K3	**Apply**	**CO3-CO5**	04	03	10
K4	**Analyze**		03	03	15
K5	**Evaluate**	**CO3 & CO5**	02	02	10
K6	**Create**		02	02	05
Total Marks 100 (Field attendance 10 + Field Performance 15+ Field Viva 15+ Field Report 60)			15	15	60

Recommended References:

Lisle, R.J., Brabham, P.J., Barnes, J.W. (2011) Basic Geological Mapping (5th Edition). Wiley-Blackwell.

Coe, A.L. (2010) Geological Field Techniques. John Wiley & Sons.

Collinson, J., Mounney, J.N. and Thompson, D. (2006) Sedimentary Structures. 3rd Edition. Terra Publishing, England, 292 p. https://www.amazon.com/Sedimentary-Structures-Third-John-Collinson/dp/190354419X

Barnes, J.W. & Lisle, R.J. (2004) Basic Geological Mapping (4th Edition). John Wiley & Sons.

McClay, K.R. (1987) The Mapping of Geological Structures (Reprinted 2007). John Wiley & Sons.

Compton, R.R. (1962) Manual of Field Geology. Wiley.

Lahee, F.H. (1961) Field Geology (6th Edition). McGraw-Hill Book Co.

Low, J.W. (1957) Geological Field Methods. Harper & Bros.

Pettijohn, F.J. (2004) Sedimentary Rocks (3rd edition). CBS Publisher.

Catuneanu, O. (2006). Principles of Sequence Stratigraphy. Elsevier.

Van Wagoner, J. C., Mitchum, R. M., Campion, K. M., &Rahmanian, V. D. (1990). Siliciclastic Sequence Stratigraphy in Well Logs, Cores, and Outcrops: Concepts for High-Resolution Correlation of Time and Facies. AAPG.

Embry, A. F., & Johannessen, E. P. (1992). Tethyan and Boreal Sequence Stratigraphy. SEPM Special Publication.

Allen, P. A., & Allen, J. R. (2005). Basin Analysis: Principles and Application to Petroleum Play Assessment. Wiley-Blackwell.

GHV-3207 Viva Voce

Credit Hour: Non-Credit Course

Course Type: Capstone Course

Total Marks: Satisfactory / Unsatisfactory

Course Description:

Viva voce will be conducted towards the end of the academic year which will be covering the complete syllabus. This will assess the student's knowledge and understanding during the course of their graduate programme. In doing so, the main objective of this course is to prepare the students to face interview both at the academic and the professional arenas.

Course Learning Objectives (CLOs):

The primary aim of the course is to develop students' confidence in oral assessments and to evaluate the conceptual understanding gained during their third year of undergraduate education.

Course Learning Outcomes (COs):

Upon successful completion of the course the students will be able to

CO1: To describe and explain their understanding of the theoretical and practical geology courses
CO2: Get prepared to face the interview both at the academic and the professional arenas

Mapping Co vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓	✓	✓		
CO2				✓	✓

Assessment Pattern:
Oral Examination

GHT-4101 Hydrogeology

Credit Hour: 3

Course Type: Core Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description:
The course Hydrogeology explores the occurrence, movement, and distribution of groundwater in geological formations. It introduces fundamental principles of groundwater flow, aquifer properties, and the hydrogeological characteristics of different rock types. Students will learn methods for groundwater exploration, monitoring, and modeling, as well as the interactions between surface water and groundwater systems. The course emphasizes both theoretical concepts and practical applications, including groundwater contamination, recharge assessment, and sustainable management. Real-world case studies, with a focus on both local and global water issues, will be used to contextualize learning. Laboratory sessions and field-based exercises will develop students' skills in data collection, analysis, and interpretation. The course is suitable for students interested in careers in environmental science, water resource management, and geosciences.

Course Learning Objectives (CLOs):

- Understand the physical and chemical principles governing groundwater occurrence and movement.
- Characterize aquifer systems and evaluate their hydraulic properties using field and analytical methods.
- Analyze groundwater flow patterns and interactions with surface water through conceptual and numerical models.
- Identify sources and pathways of groundwater contamination and assess mitigation strategies.
- Apply hydrogeological knowledge to address water resource challenges and support sustainable groundwater management.

Course Learning Outcomes (COs):
Upon successful completion of this course, students will be able to:

CO1: Understand the principles of groundwater flow, aquifer properties, and the hydrologic cycle.

CO2: Analyze groundwater recharge, discharge, and contamination processes.

CO3: Apply hydrogeological methods for groundwater exploration, monitoring, and sustainable management.

Mapping CO vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓	✓	✓		
CO2	✓	✓	✓	✓	
CO3			✓	✓	✓

No of Lecture: 30 (1.5 hours each)

Course Content:

Lecture	Module/Topic	Details	Assignment
1	Hydrogeology Overview	Introduction to Hydrogeology: Exploring the interconnectedness of water resources. The hydrologic cycle and the crucial role of groundwater. Career paths and applications of hydrogeology in the 21st century.	Assignment-1
2	”	Groundwater Occurrence and Distribution: Understanding porosity, permeability, specific yield, and specific storage. Visualizing saturated and unsaturated zones. The dynamic water table: factors influencing its fluctuations.	Assignment-2
3	”	Aquifer Types and Characteristics: Delving into the characteristics of confined, unconfined, perched, and fractured aquifers. Mapping and interpreting hydrogeological units	Assignment-3

4	Fundamental concepts of groundwater flow	Darcy's Law: Unveiling the principles of groundwater flow. Calculating specific discharge and seepage velocity. Understanding hydraulic head and gradient.	Assignment-4
5	”	Groundwater Flow in Confined and Unconfined Aquifers: Comparing and contrasting flow behavior. Exploring the concept of storage coefficients and their practical implications.	Assignment-5
6	”	Measuring Hydraulic Conductivity: From Theory to Practice: Review of Darcy's Law and its relationship to hydraulic conductivity. Discussion of factors affecting K. Hands-on activity: Analyzing slug test data using an online calculator or spreadsheet software. Introduction to pumping test design and analysis (briefly).	Assignment-6
7	”	Flow Nets: Visualizing Groundwater Flow: Constructing and interpreting flow nets in two dimensions. Applying flow net analysis to simple hydrogeological scenarios.	Assignment-7
8-10	GW-SW interactions	River-Aquifer Interactions: Exploring the dynamic connections between surface water and groundwater. Understanding gaining and losing streams. The vital role of the hyporheic zone.	Assignment-8
11	**In-course/midterm-1**		
12	Groundwater flow equation and its applications	Fundamentals of Groundwater Flow Equations: Deriving (simplified) and applying the groundwater flow equation. Understanding its assumptions and	Assignment-9

		limitations.	
13	”	Analytical Solutions (Well Hydraulics): Applying the Theis and Theim equations to analyze flow to wells in confined and unconfined aquifers.	Assignment-10
14	”	Aquifer Testing: Designing and conducting pumping tests and slug tests. Mastering data interpretation methods to estimate aquifer parameters.	Assignment-11
15	”	Image Well Theory: Applying the image well theory to analyze flow near boundaries and understand its practical applications.	Assignment-12
16	Groundwater Modeling	Introduction to Numerical Modeling: Exploring the power of numerical models in hydrogeology. Conceptualizing a simple groundwater model and understanding the steps involved.	Assignment-13
17	”	Groundwater Modeling with MODFLOW: Getting hands-on with MODFLOW. Setting up and running a simple model. Interpreting model results and visualizing groundwater flow.	Assignment-14
18	Groundwater Chemistry and contaminant Hydrology	Basic Groundwater Chemistry: Understanding major ions, pH, Eh, and key water quality parameters.	Assignment-15

19	”	Geochemical Processes in Groundwater: Exploring the complex world of weathering, dissolution, precipitation, and ion exchange.	Assignment-16
20	”	Contaminant Transport: Understanding advection, dispersion, diffusion, and hydrodynamic dispersion. Analyzing the fate and transport of contaminants. Introduction to isotope hydrology.	Assignment-17
21	**In-course/Midterm-2**		
22	Groundwater Resources exploration, assessment and management	Groundwater Exploration: Exploring various techniques for locating groundwater resources, including remote sensing, geophysics, and hydrogeological mapping.	Assignment-18.
23	”	Groundwater Resources Assessment: Estimating groundwater availability and understanding the concept of sustainable yield.	Assignment-19
24	”	Groundwater Management Strategies: Exploring artificial recharge, conjunctive use, and demand management. Case studies of successful implementation.	Assignment-20
25	Groundwater Abstraction	Fundamentals of Well Design: Designing wells for optimal performance, considering hydrogeological conditions, water demand, and well construction materials.	Assignment-21

26	”	Well Completion and Well Development: Mastering the techniques of well completion and development to ensure long-term well productivity.	Assignment-22
27	Groundwater resources of Bangladesh	Groundwater Resources of Bangladesh: Hydrogeological Background; Regional Groundwater Conditions: Understanding the unique hydrogeological setting of Bangladesh and exploring regional variations in groundwater availability and quality.	Assignment-23
28	”	Present Groundwater Utilization; Groundwater Development Potential; Planning and Management: Analyzing current groundwater use patterns, assessing future development potential, and discussing planning and management challenges.	Assignment-24
29-30	”	Groundwater Withdrawal Technologies. Groundwater Law and Policy: Exploring different groundwater withdrawal technologies and understanding the legal and policy framework governing groundwater management in Bangladesh.	Assignment-25

Instructional Strategies: Lectures**,** Class discussions**,** Use of multimedia resources (videos, animations, images) and In-class exercises

Assessment pattern:

Assessment Pattern level no.	Knowledge level	Level of CO	In-course	Assignment	Final Examination
K1	**Remember**	**CO1-CO3**	00	00	10
K2	**Understand**	**CO1-CO3**	03	00	15
K3	**Apply**	**CO1-CO3**	03	02	15
K4	**Analyze**	**CO1-CO3**	04	02	10
K5	**Evaluate**	**CO1-CO3**	05	03	10
K6	**Create**	**CO1-CO3**	05	03	00

Total Marks 100 (Class attendance 10 + In-course 20+ Assignment 10+ Final examination 60)		20	10	60

Recommended References:

1. Fetter, C.W. (2014) Applied Hydrogeology (4th International Edition). Pearson.
2. Kevin M. Hiscock, Victor F. Bense (2014) Hydrogeology: Principles and Practice (2nd Edition). Wiley.
3. Freeze, R.A. & Cherry, J.A. (1979) Groundwater. Prentice Hall.
4. Todd, D.K. (2006) Groundwater Hydrology (2nd Edition). Wiley.
5. Rahman and Ravenscroft (2003) Groundwater Resources and Development in Bangladesh. The University Press Ltd.
6. Hounslow, A., 2018. Water quality data: analysis and interpretation. CRC press.
7. Sterrett, R.J., 2007. Groundwater and wells. Smyth Co Inc, (3rd edition)

GHT-4102 Seismology and Geodesy

Credit Hour: 3

Course Type: Core Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description:

This course provides a comprehensive overview of seismology and geodesy, focusing on the physical principles, measurement techniques, and applications related to Earth's dynamic processes. Students will explore the generation, propagation, and recording of seismic waves, earthquake source mechanisms, and seismic hazard assessment. The geodetic component covers the Earth's shape, gravity field, and the use of modern geodetic techniques such as GPS, InSAR, and LiDAR to monitor crustal deformation and tectonic activity. Emphasis is placed on the integration of seismic and geodetic data to understand plate tectonics, fault mechanics, and natural hazards. Case studies and real-world data analysis are incorporated to build practical skills. This course is ideal for students interested in geophysics, geodynamics, and hazard mitigation.

Course Learning Objectives (CLOs):

- Understand the fundamental principles of seismology, including wave propagation, earthquake mechanics, and seismic data interpretation.

- Gain knowledge of geodetic concepts such as Earth's shape, coordinate systems, and reference frames.
- Apply modern geodetic techniques (e.g., GPS, InSAR) to monitor and analyze crustal deformation and tectonic processes.
- Integrate seismic and geodetic observations to assess earthquake hazards and crustal dynamics.
- Develop the ability to interpret and analyze real seismic and geodetic datasets for scientific and applied geoscience purposes.

Course Learning Outcomes (COs):

CO1: Upon successful completion of this course, students will be able to:
CO2: Understand the principles of seismic wave generation, propagation, and detection.
CO3: Analyze earthquake data to determine source parameters and assess seismic hazards.
CO4: Interpret geodetic measurements for crustal deformation and tectonic movement.
CO5: Apply GPS and remote sensing techniques in geodetic studies.
CO6: Evaluate the integration of seismological and geodetic data for earthquake risk assessment and geodynamic research.

Mapping CO vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓	✓	✓		
CO2	✓	✓	✓		✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓
CO6	✓	✓	✓	✓	✓

No of Lecture: 30 (1.5 hours each)

Lecture Plan:

Lecture No.	Topic Name	Details	Assignment
1	Introduction to Seismology	Scope, history, significance, and applications of seismology in geoscience and hazard mitigation.	
2	Earthquake Source Physics	Elastic rebound theory, fault types, stress and strain accumulation, and earthquake rupture dynamics.	
3	Seismic Waves	P-waves, S-waves, surface waves, wave propagation, velocity variations, attenuation, and dispersion.	

4	Seismograph Networks	Types of seismometers, seismograph stations, global and regional networks, data acquisition systems.	
5	Earthquake Location Techniques	Triangulation, travel-time curves, hypocenter and epicenter location methods using real-time and historical data.	Assignment-1
6	Earthquake Magnitude Scales	Richter, moment magnitude, energy release concepts, comparison of scales and when to use each.	
7	Earthquake Focal Mechanisms	Fault plane solutions, beach ball diagrams, strike-slip, normal, reverse faults, stress tensor analysis.	
8	Earthquake Early Warning Systems	Working principles, real-time detection, system design, regional and global applications, limitations.	
9	Introduction to Geodesy	History, importance in Earth sciences, basic principles of measurement and Earth shape (ellipsoid vs. geoid).	
10	Global Positioning System (GPS)	GPS principles, data collection and correction, crustal movement monitoring, plate tectonic applications.	Assignment-2
11	**In-course/midterm-1**		
12	Interferometric Synthetic Aperture Radar (InSAR)	Basics of radar, interferometry, displacement mapping, volcano and earthquake deformation detection.	
13	Geodetic Techniques for Monitoring	Combining GPS, InSAR, tiltmeters, strainmeters for monitoring tectonic deformation and volcanic activity.	
14	Earth's Internal Structure	Seismic tomography, crust, mantle, core structure, discontinuities (Moho, Gutenberg, Lehmann), global models.	
15	Plate Tectonics and Seismicity	Global seismic zones, earthquake types at plate boundaries, Wadati-Benioff zones, subduction-related quakes.	Assignment-3
16	Earthquake Hazards and Risk Assessment	Ground shaking, liquefaction, landslides, probabilistic seismic hazard assessment (PSHA), risk mitigation.	
17	Tsunami Hazards	Earthquake-triggered tsunamis, generation, propagation, coastal impacts, early warning systems.	
18	Strong Ground Motion and Earthquake Engineering	Seismic wave amplification, building response, seismic design, ground motion prediction equations.	
19	Seismology of Active Faults	Mapping faults, paleoseismology, fault slip rates, recurrence intervals, fault segmentation.	
20	Geodetic Monitoring of Volcanoes	Surface deformation, inflation/deflation cycles, magma movement detection using GPS and InSAR.	Assignment-4

21	**In-course/Midterm-2**		
22	Space Geodesy Techniques	Overview of VLBI (Very Long Baseline Interferometry), SLR (Satellite Laser Ranging), DORIS systems.	
23	Seismic Microzonation	Local site effects, mapping of seismic amplification zones, case studies of urban seismic risk zoning.	
24-25	Earthquake Forecasting and Probabilistic Models	Foreshocks, aftershocks, recurrence models, time-dependent hazard assessment models.	Assignment-5
26	Induced Seismicity	Earthquakes caused by human activities: reservoirs, mining, fluid injection/extraction, geothermal energy.	
27	Seismotectonics of South Asia	Regional fault systems, seismicity patterns, historical earthquakes, risk zones in the Indian subcontinent.	
28	Geodesy and Sea-Level Change	Vertical land motion, relative vs. absolute sea-level rise, GPS/InSAR contributions to sea-level studies.	
29	Earthquake Case Study I: 2004 Sumatra-Andaman Earthquake	Seismological and geodetic analysis, tectonic setting, tsunami generation, regional impact.	
30	Earthquake Case Study II: 2015 Gorkha Earthquake (Nepal)	Seismic and geodetic data interpretation, fault slip, tectonic implications for the Himalayas.	Assignment-6

Instructional Strategies: Lectures**,** Class discussions**,** Use of multimedia resources (videos, animations, images) and In-class exercises

Assessment Pattern:

Assessment Pattern level no.	Knowledge level	Level of CO	In-course	Assignment	Final Examination
K1	**Remember**	CO1-CO3	05	00	10
K2	**Understand**	CO2-CO5	05	00	20
K3	**Apply**	CO3-CO5	04	00	10
K4	**Analyze**	CO3-CO6	03	00	10
K5	**Evaluate**	CO5-CO6	03	05	10
K6	**Create**	CO5-CO6	00	05	00
Total Marks 100 (Class attendance 10 + In-course 20+ Assignment 10+ Final examination 60)			20	10	60

Recommended References:

Text Book:

1. Stein, S., & Wysession, M. (2003). *An Introduction to Seismology, Earthquakes, and Earth Structure*. Blackwell Publishing.

Reference Book:

1. Aki, K., & Richards, P. G. (2002). Quantitative Seismology (2nd ed.). University Science Books.

2. Segall, P. (2010). Earthquake and Volcano Deformation. Princeton University Press.
3. Torge, W., & Müller, J. (2012). Geodesy (4th ed.). De Gruyter.
4. Hofmann-Wellenhof, B., & Moritz, H. (2006). Physical Geodesy. Springer.
5. Smith, J. R. (1997). Introduction to Geodesy: The History and Concepts of Modern Geodesy. Wiley.
6. El-Rabbany, A. (2002). Introduction to GPS: The Global Positioning System. Artech House.
7. Gupta, H. K. (2002). Understanding Earthquakes and Seismic Hazards. Allied Publishers.
8. Prost, G. L. (2013). Remote Sensing for Geoscientists: Image Analysis and Integration (3rd ed.). CRC Press.

GHT- 4103 Geotechnical Engineering and Urban Geology

Credit Hour: 3

Course Type: Core Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description: This advanced course explores the geological factors that influence engineering projects and Geohazards. Students will gain a comprehensive understanding of soil mechanics, rock mechanics, and their applications in the design and construction of civil infrastructure and geohazards mitigation.

Course Learning Objectives (CLOs): Upon successful completion of this course, students will be able to:

- Describe the physical and mechanical properties of soils (e.g., particle size distribution, plasticity, shear strength).
- Analyze soil behavior under different loading conditions (e.g., settlement, bearing capacity).
- Understand the principles of soil consolidation and its implications for foundation design.
- Describe the mechanical behavior of rocks under different stress conditions.
- Analyze rock mass properties (e.g., rock strength, joint systems, in-situ stresses).
- Evaluate rock mass stability and its implications for underground excavations.
- Describe and interpret geotechnical investigations (e.g., boreholes, geophysical surveys, laboratory tests).
- Analyze geotechnical data to assess site suitability for engineering projects.

- Apply geotechnical principles to the design and construction of foundations, tunnels, and other civil infrastructure and nature-based solutions (Nbs).
- Evaluate the geological hazards associated with urban areas (e.g., earthquakes, landslides, subsidence).
- Analyze the environmental impacts of urban development on geological environments.

Course Learning Outcomes (COs):
Upon successful completion of this course, students will be able to

CO1: Understand soil and rock mechanics principles relevant to engineering and construction.

CO2: Analyze subsurface conditions through site investigation and geotechnical testing methods.

CO3: Evaluate the stability of slopes, foundations, and earth structures.

CO4: Assess geological hazards in urban environments, such as land subsidence and soil liquefaction.

CO5: Apply geotechnical data in urban planning and infrastructure development.

CO6: Integrate geological and engineering knowledge to support sustainable urban growth and hazard mitigation.

Mapping CO vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓	✓	✓		
CO2	✓	✓	✓		✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓
CO6	✓	✓	✓	✓	✓

No of Lecture: 30 (1.5 hours each)

Course Content:

Lecture	Topic	Details	Homework/ Assignments
1	Introduction to Geotechnical Engineering	Scope, importance, and applications.	
2	Soil Properties/Mechanics	Soil consistency test, Atterberg limit test, Soil classification, particle size distribution, and index properties.	
3	Soil Properties/Mechanics	Soil consistency test, Atterberg limit test, Soil classification, particle size distribution, and index properties.	

4	Soil Properties/Mechanics	Soil consistency test, Atterberg limit test, Soil classification, particle size distribution, and index properties.	
5	Soil-Water Relationship	Soil-water relationships, pore water pressure, and effective stress.	Assignment- 1
6–7	Shear Strength of Soils	Shear strength parameters, Mohr-Coulomb failure criterion.	
8–9	Soil Consolidation	Settlement and time-dependent deformation analysis.	
10	Rock Mechanics	Rock properties, stress-strain behavior, and rock mass classification.	
11	Rock Failure Mechanisms	Rock slope stability, rockfalls, and rock bursts.	
12		Rock slope stability, rockfalls, and rock bursts.	Assignment-2
13	**In-course-1**		
14	Tunneling in Rock	Rock support systems, ground control measures, and tunnel stability.	
15-16	Geotechnical Investigations	Site investigation methods (boreholes, geophysical surveys, field tests).	
17	Foundation Engineering	Shallow foundations (footings, rafts), deep foundations (piles, piers).	
18		Shallow foundations (footings, rafts), deep foundations (piles, piers).	Assignment-3
19	Slope Stability Analysis	Methods of slope stability analysis, landslide hazards in urban areas.	
20	Urban Geology/Geohazards	Geological hazards in urban areas (earthquakes).	
21		Geological hazards in urban areas (landslides).	
22		Geological hazards in urban areas (subsidence).	Assignment-4
23	**In-course-2**		
24	Urban Geology/Geohazard	Geological hazards in Coastal and Offshore Environment.	
25	Construction Materials	Geological Aspects of Construction Materials.	
26	Sustainable Urban Development	Geological considerations for sustainable urban planning and development.	
27		Geological considerations for sustainable urban planning and development.	Assignment-5
28	Advance Topics and Case Studies	Geotechnical earthquake engineering.	
29		Geoenvironmental engineering.	
30		Case studies of geotechnical engineering project.	Assignment-6

Instructional Strategies: Lectures**,** Class discussions**,** Use of multimedia resources (videos, animations, images) and In-class exercises

Assessment Pattern:

Assessment Pattern level no.	Knowledge level	Level of CO	In-course	Assignment	Final Examination
K1	**Remember**	CO1-CO3	05	00	10
K2	**Understand**	CO2-CO5	05	00	20
K3	**Apply**	CO3-CO5	04	00	10
K4	**Analyze**	CO3-CO6	03	00	10
K5	**Evaluate**	CO5-CO6	03	05	10
K6	**Create**	CO5-CO6	00	05	00
Total Marks 100 (Class attendance 10 + In-course 20+ Assignment 10+ Final examination 60)			20	10	60

Recommended References:
Text Book:

1. V.N.S Murthy (2002): Geotechnical Engineering: Principles and Practices of Soil Mechanics and Foundation Engineering

Reference Book:

2. Das, B. M., & Sobhan, K. (2016). Principles of geotechnical engineering.

3. Hudson, J. A., & Harrison, J. P. (2000). Engineering rock mechanics: an introduction to the principles. Elsevier.

4. Hoek, E., (2008). Practical rock engineering.

5. Obert, Land Danvall, W.L. Rock mechanics and the design of structures in rock.

6. Ries, Hand Watson, T.L. Engineering geology

7. Schultz, J.R. and Cleaves, A.B. Geology in engineering

GHT-4104 Petroleum Geology and Reservoir Characterization

Credit Hour: 3

Course Type: Core Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description:

This course provides a comprehensive understanding of petroleum geology and reservoir characterization, encompassing both conventional and unconventional hydrocarbon resources. Students will explore the processes of hydrocarbon generation, migration, and entrapment, along with advanced exploration and reservoir evaluation techniques. Emphasis is placed on traditional and modern exploration methods, including seismic interpretation well log analysis, and reservoir characterization techniques. The course also examines unconventional resources such as shale gas, tight oil, coalbed methane (CBM), gas hydrates, and oil sands, highlighting their unique geological characteristics and extraction challenges. Additionally, sustainability considerations—such as carbon capture and storage (CCS), geothermal energy applications, and environmental impact assessments in hydrocarbon exploration—are integrated into the curriculum. Through case studies and practical exercises, students will develop analytical and problem-solving skills, equipping them to address contemporary challenges in petroleum geosciences.

Course Learning Objectives (CLOs):

By the end of this course, students will be able to:

- Explain the origin, generation, migration, and entrapment of hydrocarbons.
- Understand the petroleum system concept and apply it to exploration.
- Identify and analyze reservoir rock properties, traps, and seals.
- Utilize seismic interpretation, well logging, and petrophysical analysis for reservoir characterization.
- Apply AI, big data, and machine learning in petroleum exploration and reservoir modelling.
- Evaluate sustainability and environmental impact in petroleum exploration.
- Understand geophysical exploration techniques (seismic, gravity, magnetic, and remote sensing).
- Differentiate between conventional and unconventional resources and apply exploration techniques for each.

Course Learning Outcomes (COs):
At the end of the course, the students will be able to:

CO1: Understand the origin, migration, and accumulation of hydrocarbons in sedimentary basins.

CO2: Identify and evaluate different types of petroleum reservoirs and their structural and stratigraphic traps.

CO3: Analyze reservoir rock properties such as porosity, permeability, and fluid saturation.

CO4: Interpret well logs, seismic data, and core samples for reservoir characterization.

CO5: Apply reservoir modeling techniques for estimating hydrocarbon reserves.

CO6: Assess the impact of geological factors on reservoir performance and production strategies.

Mapping CO vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓				
CO2	✓		✓		
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓		✓
CO6	✓	✓	✓	✓	✓

No of Lecture: 30 (1.5 hours each)

Course Content:

Lecture	Topic	Details	Homework/ Assignments
1	Introduction to Petroleum Geology	● Scope, aims and objectives ● Historical review ● Context of Petroleum Geology: Relationship to other branches of science ● Subsurface environment: subsurface water, temperature, pressure and fluid dynamics	
2–3	Origin of petroleum	● Physical and chemical properties: natural gas, gas hydrates, crude oil ● Types and preservation of organic matter, bio- and geochemical degradation of organic matter into kerogen, Generation of hydrocarbons; hydrocarbon kitchen (gas and oil window);generative/depression	
4	Petroleum system concept	● Petroleum System Concept ● An overview of the geological elements and processes of a petroleum system ● Identifying a Petroleum System	
5–6	Source rocks	● Depositional environments of source rocks ● Total organic carbon (TOC), source rock maturity and evaluation	Assignment-1
7	Hydrocarbon migration	● Primary, secondary, and tertiary migration ● Expulsion mechanisms: expulsion of hydrocarbons as proto-petroleum, expulsion of hydrocarbons in aqueous solution, expulsion of oil in gaseous solution	
8–10	Reservoir rocks and characterization	● Porosity and permeability, capillary pressure ● Depositional and diagenetic factors controlling reservoir porosity and permeability ● Reservoir geometry and depositional environments ● Reservoir characterisation ● Reserve estimation – volumetric method ● Reservoir drive mechanism	Assignment-2
11	**In-course-1**		
12-13	Petroleum traps	● Structural, stratigraphic and combination	

	and seals	traps ● Detail evaluation of different trap types ● Relationship between trap and depositional environments	
14	Sedimentary basins and hydrocarbon distribution	● Petroleum prospect evaluation ● Distribution of hydrocarbons in different types of basins and within a basin	
15	Introduction to petroleum exploration	● Key concepts: Exploration, appraisal, development, production ● Tools: Satellite images and other remote sensing data, seismic data, wireline log data, core and cuttings, fluid samples from well, outcrop data, seepage of petroleum	Assignment-3
16	Magnetic and Gravity methods in petroleum Geology	● Magnetic surveying: data acquisition and interpretation ● Gravity surveying: data acquisition and interpretation ● Basin boundary analysis	
17–18	Seismic method in Petroleum Exploration	● Seismic surveying: data acquisition (2D & 3D), interpretation—seismic sequence analysis, seismic facies analysis, seismic attribute analysis	
19–20	Advanced exploration methods	● Visual remote sensing ● Radar data ● Multispectral scanning ● Virtual outcrop analysis (VOA) ● Lidar data ● AI, machine learning, and big data analysis	Assignment-4
21	**In-course-2**		
22-23	Unconventional Resources and their Exploration Techniques	● Unconventional resources: shale gas, tight oil, coalbed methane (CBM), gas hydrates, and oil sands ● Hydraulic fracturing, horizontal drilling, geo-steering, CO_2-enhanced recovery ● Geophysical and Geochemical Methods: microseismic monitoring, geochemical fingerprinting	
24	Drilling and mud logging	● Fundamentals of petroleum exploration drillings ● Drilling rigs – component systems of drilling rig, rotating system, hoisting system, mud circulation system, BOP	

		system. ● Mud logging ● Logging-while-drilling (LWD) ● Duties of well-site geologist	
25	Wireline logging and formation evaluation	● Wireline logging and formation evaluation ● Caliper log, resistivity log, SP log, Gamma-ray log, Sonic log, density log, neutron log, nuclear magnetic resonance (NMR) log ● Wireline log interpretation and hydrocarbon detection	Assignment-5
26	DST test & well completion	● DST ● Completion Equipment ● Completion mode selection ● Factors Influencing Well Completion Selection ● Completion and Workover Fluids, Packer Fluids, ● Perforation, Perforating Fluid, perforating methods	
27	Environmental & sustainability considerations	● Water usage in fracking ● Induced seismicity ● CCS ● Methane emissions	
28	Blowout accident in petroleum exploration drilling	● Causes of blowout. ● Tackling blowout ● Case study	
29-30	Petroleum Geology of Bangladesh and surrounding areas	● Petroleum provinces in Bangladesh ● Petroleum plays and prospects in Bangladesh – conventional and unconventional plays ● Petroliferous basins in the Bay of Bengal – offshore Bangladesh, offshore Rakhine Basin, Myanmar, offshore Krishna Godavari Basin, India	Assignment-6

Instructional Strategies: Lectures**,** Class discussions**,** Use of multimedia resources (videos, animations, images) and In-class exercises

Assessment Pattern:

Assessment Pattern level no.	Knowledge level	Level of CO	In-course	Assignment	Final Examination
K1	**Remember**	CO1-CO2	03	00	10
K2	**Understand**	CO3-CO5	05	00	20
K3	**Apply**	CO4-CO6	03	00	10
K4	**Analyze**	CO4-CO5	05	00	10
K5	**Evaluate**	CO4-CO6	04	05	10
K6	**Create**	CO5-CO6	00	05	00
Total Marks 100 (Class attendance 10 + In-course 20+ Assignment 10+ Final examination 60)			20	10	60

Recommended References:

1. Allain, O., Dyson, M., Jing, X., Pentland, C., Polikar, M. and Suicmez, V.S., 2018. The Imperial College Lectures in Petroleum Engineering: Volume 4: Drilling and Reservoir Appraisal. World Scientific Publishing.
2. Bellarby, J., 2009, Well Completion Design, Elsevier, Oxford.
3. Gluyas, J. & Swarbrick, R. (2004) Petroleum Geoscience. Oxford: Blackwell Publishing.
4. Jackson, R.B. et al. (2014) The Environmental Costs and Benefits of Fracking.
5. Imam, B., 2013, Energy Resources of Bangladesh. 2nd edn. University Grants Commission of Bangladesh.
6. Liu H. 2017, Innovation Model Analysis of New Energy Vehicles: Taking Toyota, Tesla and BYD as an Example. Procedia Engineering, (Chapters 1–7)
7. Montgomery, C.T. (2013) Hydraulic Fracturing. Littleton, CO: Society of Petroleum Engineers.
8. Rider, M., 2007, Wireline Log Interpretation, Whittles Publishing, UK.
9. Shah M, Kshirsagar A. & Panchal J., 2022, Applications of Artificial Intelligence (AI) and Machine Learning (ML) in the Petroleum Industry, CRS Press, London.
10. Selley, R.C. & Sonnenberg, S.A. (2014) Elements of Petroleum Geology. 3rd edn. Amsterdam: Elsevier.
11. Suarez-Rivera, R. et al. (2019) Unconventional Reservoir Geomechanics.
12. Tissot, B. & Welte, D. (1984) Petroleum Formation and Occurrence. 2nd edn. Berlin: Springer-Verlag.
13. Turner, S. J., & Freitas, M. 2020. Remote Sensing in Applied Geosciences: Exploration, Resource and Environmental Management. CRC Press.

GHL-4105 Hydrogeology and Engineering Geology Lab

Credit Hour: 3

Course Type: Core Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description:
This practical-based course is designed to complement theoretical knowledge in hydrogeology and engineering geology through hands-on laboratory exercises. Students will engage in activities such as aquifer property determination, groundwater flow modeling, soil and rock identification, and geotechnical testing. Emphasis is placed on the interpretation of hydrogeological data, construction of water table maps, and understanding subsurface conditions relevant to engineering projects. The lab sessions introduce essential tools and techniques used in field hydrogeology and geotechnical investigations. Students will also analyze real-world case studies and develop skills in data recording, analysis, and report writing. The course prepares students for applied work in water resource management, environmental geology, and civil engineering projects.

Course Learning Objectives (CLOs):

- Develop practical skills in measuring and interpreting hydrogeological parameters such as porosity, permeability, and hydraulic conductivity.
- Conduct standard laboratory tests for soil and rock classification and understand their engineering significance.
- Apply techniques for analyzing groundwater flow, aquifer behavior, and contamination transport.
- Interpret geotechnical data to assess site suitability for construction and infrastructure development.
- Strengthen abilities in data analysis, mapping, and technical reporting relevant to hydrogeological and engineering geological investigations.

Course Learning Outcomes (COs):
Upon successful completion of this course, students will be able to:

CO1: Develop practical skills in measuring and analyzing groundwater properties and flow parameters.

CO2: Conduct laboratory and field tests to evaluate the geotechnical properties of soils and rocks.

CO3: Interpret hydrogeological and engineering geological data for site investigation and groundwater assessment.

Mapping CO vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓

No of Lab Class: 30 (3 hours for each)

Course Content:

Lab	Topic	Activities	Assignments
1	Hydrological data analysis	Watershed delineation, Catchment water budget analysis- understanding climatic surplus and stress and solving numerical problems.	
2		Interpretation of rainfall, evapotranspiration, runoff, river discharge, surface water level and groundwater level data. Construction of Theissen polygons for raingauge distribution.	
3		Understanding flood situation from danger level. Rainfall-Runoff calculation, rainfall, surface water level and groundwater level interaction. Construction and interpretation of unit hydrograph	
4	Groundwater level monitoring data analysis	Hands on training for measuring groundwater level. Construction of groundwater level hydrograph, calculation of hydraulic gradient, contouring of groundwater elevation data and identify flow direction	
5	Darcy's law, groundwater flow, and transport equation	Application of Darcy's law, and groundwater flow, and transport equation for solving problems in hydrogeology. Permeability test	Assignment-1
6	Flow nets	Construct flow nets for various hydrogeological settings. Interpret flow nets to determine flow direction, seepage rates, and potential contaminant pathways.	
7	Borelog data analysis and well design	Hands on training of litholog preparation. Interpretation of borehole data to construct hydrostratigraphy (panel diagram), delineation of aquifer type and designing a pumping well	
8	Slug test and aquifer test data analysis	Design a slug test for a specific location, analyze provided slug test data, and calculate hydraulic conductivity. Design a pumping test for a specific location. Pump test data analysis to determine aquifer properties and type of the aquifer by time drawdown and distance drawdown methods. Analysis of pumping recovery data.	
9	Groundwater modeling	Groundwater Modeling with MODFLOW: Getting hands-on with MODFLOW. Setting up and running a simple model. Interpreting model results and visualizing groundwater flow.	
10	Well performance data analysis	Determination of the specific capacity and specific drawdown from Hantush – Bierschenk method by analysis of step drawdown test data. Determination of well loss and aquifer loss	Assignment-2
11	**In-course/Midterm-1**		
12	Grain size data analysis	Grain size data analysis for determination of hydraulic conductivity and comparing with pump test analysis, sorting and screen slot opening; pumping test.	

13	Groundwater sampling	Hands on training on groundwater sampling methods, sample preservation techniques, and measurement methods of field parameters.	
14	Laboratory analysis of water samples	Laboratory instrumentation in water analysis; analytical methods; determination of major and minor ions, and trace elements; QA/QC procedures.	Assignment-3
15	Water quality data analysis	Water quality data- data organization, conversion, And analytical accuracy checks. Visualization and graphical presentation (pie diagram, bar diagram, stiff pattern, piper diagram, finger print diagram, schoeller diagram) and interpretation. Statistical (regression, box and whisker and other) and spatial analysis of Water quality data	
16	Water quality data analysis	Calculation of hardness and SAR. Mass balance and source rock deduction	
17	Hydrogeological report writing	Integrated Hydrogeological report writing.	
18-19	Basic Soil Properties	Water Content (ASTM D2216) – Oven drying, Specific Gravity (ASTM D854) – Pycnometer method, Organic Content (ASTM D2974) – Loss on ignition.	
20-21	Grain Size Distribution & Atterberg Limits	Sieve Analysis (ASTM D6913) – Coarse soils, Hydrometer Analysis (ASTM D7928) – Fine soils, Liquid Limit (Casagrande/Cone Penetrometer, ASTM D4318), Plastic Limit (ASTM D4318).	Assignment-4
22	**In-course/Midterm-2**		
23-24	Laboratory Permeability	Constant Head Permeability (ASTM D2434) – Sand/gravel, Falling Head Permeability (ASTM D5856) – Clay/silt.	
25-26	Consolidation (Oedometer Test)	1D Consolidation Test (ASTM D2435) – Load increments, time-settlement data.	
27-28	Soil Strength Testing	Direct Shear Test (ASTM D3080) – c and φ under different normal stresses, Unconfined Compression Test (UCS) (ASTM D2166), Triaxial tests (UU/CU/CD)	
29-30	Rock Parameter Testing	Rock Density & Porosity, Point Load Strength Test, Schmidt Hammer Rebound Test, Slake Durability Test, Rock Triaxial Test, Rock UCS Test, etc.	Assignment-5

Instructional Strategies:
Laboratory work, Demonstration, Discussion, Question-Answer

Assessment Pattern:

Assessment Pattern level no.	Knowledge level	Level of CO	In-course	Assignment	Final Examination
K1	**Remember**	CO1-CO3	00	00	10
K2	**Understand**	CO2	00	00	10
K3	**Apply**	CO3	05	02	10
K4	**Analyze**	CO2-CO3	05	03	10
K5	**Evaluate**	CO2	05	02	10
K6	**Create**	CO3	05	03	10
Total Marks 100 (Class attendance 10 + In-course 20+ Assignment 10+ Final examination 60)			20	10	60

Recommended References:
Hydrogeology
Reference Books:

1. Dingman, L. (2014) Physical Hydrology (3rd Edition). Waveland Press, Inc.
2. Fetter, C.W. (2014) Applied Hydrogeology (4th International Edition). Pearson.
3. Kruseman, G. P., Ridder, N. A. (1990) Analysis and evaluation of pumping test data (2nd Edition). IILRI.
4. Hounslow, A. (2018) Water quality data: analysis and interpretation. CRC press.

Engineering Geology
Textbook:

1. Bell, F.G. (2007) Engineering Geology (2nd Edition). Butterworth-Heinemann.

Reference Books:

2. Graig R.F. (2004) Soil Mechanics (7th Edition). CRC Press.
3. Bowles, J.E. (1988) Foundation Analysis and Design (4th Edition). McGraw Hill.
4. Blyth, F.G.H. and De Freitas, M.H. (1984) A Geology for Engineers (7th Edition). Taylor & Francis.
5. Das, B.M. (1983) Introduction to Soil Mechanics. Galgorita publishers.
6. Obert, Land Danvall, W.L. (1967) Rock mechanics and the design of structures in rock. Wiley.
7. Legget, R.F. (1962) Geology and engineering (International Student Edition). McGraw-Hill.
8. Schultz, J.R. and Cleaves, A.B. (1955) Geology in engineering. Chapman & Hall

GHL-4106 Geophysics and Petroleum Geology Lab

Credit Hour: 3

Course Type: Core Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description: The first part of the course is designed to give hands-on experience in the interpretation of geophysical methods including seismic and wireline logs for petroleum, groundwater exploration and other mineral deposits and integrate them with log data to calculate in place volumes. The second provides practical training in petroleum system analysis and reservoir characterization through lab-based exercises. Students evaluate source rock potential using palynofacies, geochemical data, and burial history modeling. They build reservoir models from well logs and seismic data, identify hydrocarbon traps, and estimate reserves volumetrically. It also includes interpretation of subsurface structures, construction of structural and stratigraphic maps, and preparation of paleontological range charts. Students analyze thin sections to identify depositional and diagenetic features, assess porosity and permeability, and evaluate overall reservoir quality using both microscopic analysis and wireline log data, gaining essential skills for subsurface geological interpretation and hydrocarbon exploration.

Course Learning Objectives (CLOs): Upon successful completion of this course, students will be able to:

- Geophysical Data Analysis:
- Process and interpret seismic reflection data, including seismic sections and time-depth conversions.
- Analyze and interpret gravity and magnetic data.
- Utilize well log data to characterize subsurface formations.
- Petroleum Systems Analysis: Integrate geophysical data with geological data (e.g., well logs, core data, seismic data) to characterize the petroleum system.
- Evaluate source rock potential, reservoir quality, and trap geometries using geophysical data.
- Prospect Evaluation: Identify and evaluate potential hydrocarbon prospects using geophysical and geological data.
- Construct and interpret subsurface maps and cross-sections.
- Assess the risks and uncertainties associated with hydrocarbon exploration and development.
- Reservoir Characterization: Utilize geophysical data for reservoir characterization, including porosity, permeability, and fluid saturation.
- Apply petrophysical concepts to interpret well log data.
- Depositional features and reservoir quality of reservoir rocks
- Framework grains, matrix, cement, porosity, sorting)
- Diagenetic features (compaction, cementation, pressure solution, replacement, and dissolution)
- Determination of overall reservoir quality.
- Laboratory Skills: Utilize industry-standard software for seismic interpretation, well log analysis, and geological modeling.
- Develop and present technical reports and presentations.

Course Learning Outcomes (COs):

- A student who completes this course should be able to:

CO1: Construct litho-facies maps, structural maps, and depth

CO2: Prepare isopach, isolith maps, clastic and non-clastic percentages, and litological summaries

CO3: Construct stratigraphic panel diagrams from well information and interpret depositional environments.

CO4: Select the location of oil and gas wells from depth contours and their patterns

CO5: Relate contour patterns with geological features (e.g., fault)

CO6: Determine diagenetic changes of the rock and identify their effects on the rocks

CO7: Infer overall reservoir characters

Mapping CO vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓
CO6	✓	✓	✓	✓	✓
CO7	✓	✓	✓	✓	✓

No of Lab classes: 30 (3 hours each)

Course Content:

Lab	Topic	Details	Assignments
1-2	Resistivity data processing and interpretation	CST, VES and ERT data processing and interpretation for subsurface geology, groundwater aquifer, and hydrocarbon potentials	
3	Seismic Interpretation Fundamentals	Basic seismic interpretation techniques and identifying key seismic horizons.	
4	Structural Interpretation:	Mapping faults, folds, and other structural features on seismic data	

5	Seismic Attribute Analysis	Extracting and Interpreting Seismic Attributes (Amplitude, Frequency, etc.).	Assignment-1
6	Seismic data inversion	Apply inversion algorithms to seismic data to generate subsurface property models (e.g., velocity, impedance).	
7-8	Magnetic and Electromagnetic data processing and Interpretation	Process and interpret magnetic or EM data to identify potential mineral deposits and subsurface structures.	
9	GPR data processing and interpretation	Process and interpret GPR data to identify shallow geological features such as voids, fractures, or soil layering.	
10	Shallow seismic data processing and interpretation	Process and interpret shallow seismic data to map subsurface features and provide geological insights.	Assignment-2
11	Interpretation of SP and IP data.	Analyze SP and IP curves to interpret subsurface lithology, mineralization, and fluid content.	
12	Introduction to Well Logs	Types of well logs (gamma ray, resistivity, density, and neutron).	
13	Well Log Interpretation	Analyzing well log data to determine lithology, porosity, and fluid saturation.	
14	Correlating Well Logs	Correlating well logs across different wells	Assignment-3
15	Petrophysical Analysis	Calculating petrophysical parameters from well log data.	
16	Source Rock Evaluation	Analyzing palynofacies and geochemical data to assess source rock potential.	
17	Burial History of Source Rock	Thermal maturity indication using Burial History Method (Application of Lopatin's Method)	
18	Reservoir Characterization	Building Reservoir Models Using Well Logs and Seismic Data.	
19	Trap Analysis	Identifying and Evaluating Hydrocarbon Traps on Seismic Data.	
20	Petroleum Reserve Estimation and Prospect Evaluation	Assessing the volumetric reserve and the Prospectivity of Exploration Targets.	Assignment-4
21	Subsurface geological structures and structural contour map from borehole data:	Interpretation of subsurface geological structure and preparation of structural contour map from well data.	

22	Construction of isopach, isolith, and per cent map and stratigraphic Panel diagram:	preparation of these maps and panel diagram based on the lithofacies data of wells.	
23	Construction of paleontological range chart	Preparation of paleontological range chart based on supplied species table.	
24-26	Recognize depositional and diagenetic features of reservoir rocks	Study thin-section slides of reservoir rocks under microscope for depositional features of sedimentary rocks (framework grains, matrix, cement, porosity, sorting) and diagenetic features (compaction, cementation, pressure solution, replacement and dissolution) and determination of overall reservoir quality.	
27-28	Reservoir Quality	Recognition of primary and secondary types of porosity, determination of total and effective porosity of thin sections under the microscope and calculation from wireline logs. Estimation of permeability from thin section, correlation of porosity and permeability.	
29-30	Petrographic Studies	Petrographic analysis, heavy mineral identification, and geochemical fingerprinting will be used to reconstruct sedimentary environments, tectonic settings, and basin evolution	Assignment-5

Instructional Strategies:
Laboratory work, Demonstration, Discussion, Question-Answer

Assessment Pattern:

Assessment Pattern level no.	Knowledge level	Level of CO	In-course	Assignment	Final Examination
K1	**Remember**	CO1-CO2	00	00	10
K2	**Understand**	CO2	00	00	10
K3	**Apply**	CO2-CO7	05	02	10
K4	**Analyze**	CO4-CO5	05	03	10
K5	**Evaluate**	CO2-CO7	05	02	10
K6	**Create**	CO3-CO7	05	03	10
Total Marks 100 (Class attendance 10 + In-course 20+ Assignment 10+ Final examination 60)			20	10	60

Recommended References:

Reading Materials

Textbooks:

Badeley, M.E. (1985) Practical Seismic Interpretation. Intl Red Cross

References :

Rider, M.H. & Kennedy, M. (2011) The geological interpretation of well logs (3rd Edition). Rider-French.

Gadallah, M.R. & Ray, F. (2009) Exploration Geophysics (1st Edition). Springer.

Krygowski, D. et al. (2004) Basic Well log analysis for Geologists (2nd edition). AAPG memoir 4.

Sheriff, R.E. & Geldert, L.P. (1995) Exploration Seismology (2nd Edition). Cambridge University Press.

Schlumberger Ltd. (1991) Log interpretation, I, Principles. Schlumberger Educational Services.

Schlumberger Ltd. (1991) Log interpretation II, application. Schlumberger Educational Services.

Telford, W.M. et al. (1990) Applied Geophysics (2nd Edition). Cambridge University Press.

GHT-4201 Data Science and Numerical Methods

Credit Hour: 3

Course Type: General Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description:

This course introduces the fundamental concepts and practical applications of data science alongside key numerical methods used for data analysis and scientific computing. Students will gain hands-on experience in data acquisition, cleaning, visualization, and interpretation using modern programming tools. The numerical methods portion covers topics such as root-finding algorithms, numerical integration, interpolation, and solving differential equations. Emphasis is placed on algorithmic thinking, accuracy, stability, and error analysis in computational methods. Real-world problems from various scientific and engineering disciplines will be addressed to bridge theory and application. By the end of the course, students will be equipped to handle data-driven problem-solving and apply numerical techniques effectively in a variety of domains.

Course Learning Objectives (CLOs):

- Understand the foundational concepts of data science and its role in real-world problem solving.
- Apply numerical methods for solving mathematical problems, including root-finding, integration, and differential equations.

- Develop and implement data processing pipelines using programming tools such as Python or MATLAB.
- Analyze and visualize data using statistical and computational techniques.
- Evaluate the accuracy and efficiency of numerical algorithms and interpret their results in practical contexts.

Course Learning Outcomes (COs)

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

CO1: Apply numerical techniques to solve differential equations and linear algebra problems.

CO2: Use statistical methods for data analysis and interpretation.

CO3: Implement data processing and visualization using programming tools like Python or MATLAB.

CO4: Develop predictive models using machine learning algorithms.

CO5: Interpret and communicate data-driven insights for scientific and engineering applications.

Mapping CO vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓				
CO2	✓		✓		
CO3		✓	✓	✓	✓
CO4		✓	✓	✓	✓
CO5		✓	✓		✓

No of Lecture: 30 (1.5 hours each)

Course Content:

Lecture No.	Topic	Details	Assignment
1	Introduction to Data Science	Definition, applications, example on data science application in geoscience	
2	Data Collection and Pre-processing	Data sources, cleaning, handling missing values, outliers	
3	Introduction to Python for Data Science	Python basics, Pandas, NumPy, Matplotlib, Seaborn etc	Assignment 1
4	Data Exploration and Visualization	Descriptive statistics, visualization with Matplotlib & GIS	
5	Time-Series Analysis for Environmental Data	Central tendency, correlation, regression, rainfall analysis	Assignment 2
6	Introduction to Machine Learning	Supervised vs. Unsupervised learning, classification techniques	
7	Supervised Learning for Geoscience	Regression, Decision Trees, random forest, SVM and their application	Assignment 3

8	Unsupervised Learning and Clustering	K-Means clustering, PCA, DB scane and their applications	Assignment 4
9	Deep Learning and Generative artificial intelligence	ANN, CNN, RNN, LSTM, GAN, Encoder etc models in geoscience	Assignment 5
10	Geospatial Data Science	Handling geospatial data, Python libraries for spatial data analysis like rasterio, geopandas, Shapely and Fiona for vector data processing	
11	**In-course/Midterm-1**		
11	Big Data Technologies for Geoscience	Big Data tools (Hadoop, Spark), Google Earth Engine	
12	Data Ethics and Privacy in Geoscience	Ethical considerations in geoscience data analysis	
13	Case Studies in Data Science and Geoscience	Students work on real-world projects (flood risk mapping, climate analysis) which will provide them the practical implication of data science in geoscience discipline	Assignment 6
14	Same task student will work on data science project	Same work	
15	Introduction to Mathematical Models	● What is a model? Why do we model? ● Types of models: Conceptual, physical, mathematical. ● Focus on mathematical models in geology. ● Model development process: Conceptualization, formulation, implementation, validation. ● Examples of geological models.	
16	Types of Mathematical Models	● Box models (lumped parameter models): Strengths, limitations, applications. ● Distributed parameter models: Partial differential equations (PDEs). ● Process-based models: Coupling of multiple physical/chemical processes. ● Data-driven models (brief introduction, link to data science part of the course). ● Hybrid models. ● Examples of each type in geology.	
17	Introduction to stochastic models	● Deterministic vs. stochastic models	Assignment 7

		• Key concept in Stochastic modelling • Common types of Stochastic Models • Geological applications	
18	Introduction to Numerical Methods	• Discretization: The concept of grids and nodes. • Approximation: Interpolation, Taylor series expansion (review). • Numerical error: Truncation error, round-off error, convergence. • Stability and consistency (brief introduction).	Assignment 8
19-20	Initial and boundary conditions	• The importance of BCs and ICs • ICs • BSc types	
21	**In-course-2**		
22	Finite Difference Method I	• Forward, backward, and central difference approximations. • Discretization of simple ODEs. • Example: Radioactive decay.	Assignment 9
23	Finite Difference Method II	• Discretization of PDEs (e.g., 1D heat equation). • Explicit and implicit schemes. • Stability analysis (brief).	Assignment 10
24	Applications of FDM: Diffusion Equation	• Derivation of the diffusion equation. • FDM solution of diffusion equation in 1D and 2D. • Geological applications: Groundwater flow, heat transport in the Earth. • Hands-on exercise: Modeling groundwater diffusion.	
25	Applications of FDM: Advection Equation	• Derivation of the advection equation. • FDM solution of the advection equation. • Upwind schemes (brief discussion of stability issues). • Geological applications: Solute transport, contaminant migration. • Hands-on exercise: Modeling contaminant transport.	Assignment 11

26	Applications of FDM: Wave Equation	• Derivation of the wave equation. • FDM solution of the wave equation. • Geological applications: Seismic wave propagation (simplified). • Hands-on exercise: Modeling seismic waves in 1D.	
27	Application of FDM for Petroleum Reservoir Simulation	• Understanding of the equations involved • 1D, 2 phase reservoir simulation problem	Assigment 12
28	Introduction to the Finite Element Method	• Weak formulation of PDEs. • Galerkin method. • Basis functions (linear, quadratic). • 1D example: Heat equation.	
29-30	Advanced Topics in Numerical Modeling	• Mesh generation (brief overview, available tools). • Model calibration and validation. • Uncertainty quantification. • Introduction to inverse modeling	Assignment 13

Instructional Strategies: Lectures, Class discussions, Use of multimedia resources (videos, animations, images) and In-class exercises

Assessment Pattern:

Assessment Pattern level no.	Knowledge level	Level of CO	In-course	Assignment	Final Examination
K1	**Remember**	CO1-CO2	03	00	10
K2	**Understand**	CO3-CO5	05	00	20
K3	**Apply**	CO4-CO5	03	00	10
K4	**Analyze**	CO4-CO5	05	00	10
K5	**Evaluate**	CO4-CO5	04	05	10
K6	**Create**	CO4-CO5	00	05	00
Total Marks 100 (Class attendance 10 + In-course 20+ Assignment 10+ Final examination 60)			20	10	60

Recommended References:

1. Grus, J., 2019. Data science from scratch: first principles with python. O'Reilly Media.
2. Wang, L., Yin, D.Z. and Caers, J., 2023. Data science for the geosciences. Cambridge University Press.
3. Ferguson, J., 1988. Mathematics in geology. London: Allen & Unwin.
4. Olsen-Kettle, L., Numerical solution of partial differential equations, Lecture Notes, The University of Queensland, School of Earth Sciences, Centre for Geoscience Computing, http://researchers.uq.edu.au/researcher/768
5. Pelletier, J.D., 2008. Quantitative modeling of earth surface processes.

GHS-4202 Research Methodology and Scientific Writing

Credit Hour: 3

Course Type: General Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description: This course is structured in two parts. The first part introduces students to fundamental research concepts and methodologies commonly used in various branches of earth sciences. Students will learn to design research projects, identify relevant data sources, and develop appropriate methods for data collection, analysis, and interpretation. The second part focuses on scientific writing, guiding students through the process of drafting research articles, reports, and theses. Additionally, the course will cover essential topics such as research ethics and plagiarism, ensuring adherence to academic integrity and best practices in scholarly communication.

Course Learning Objectives (CLOs):

- Describe and compare major quantitative and qualitative methods.
- Identify research topics, define problems, and select appropriate parameters.
- Develop proposals, organize, and conduct advanced research effectively.
- Write research articles, reports, and theses.

Course Learning Outcomes (COs):

At the end of the course, the students will be able to

CO1: Understand the principles and processes of scientific research design.

CO2: Formulate research questions, hypotheses, and objectives effectively.

CO3: Apply appropriate methods for data collection, analysis, and interpretation.

CO4: Develop skills in academic writing, referencing, and plagiarism avoidance.

CO5: Prepare structured research proposals, reports, and scientific manuscripts.

Mapping CO vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓				
CO2	✓		✓		
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓		✓

No of Lectures: 30 (1.5 hours each)

Lecture Plan:

Lecture	Topic	Details	Homework/ Assignments
1	Introduction to Research	Introduction, Objectives of Research, Motivation behind Research, Important Ingredients for Research, Types of Research, Phases of Research/Research Process	
2	Research Problem	What is a Research Problem? Selecting the Problem, Necessity of Defining the Problem, Technique Involved in Defining a Problem	
3	Research Design	What Is Research Design? Approaches of Research Design, Qualitative versus Quantitative Research, Testing Research Design, Principles of Experimental Design , Design of Experiments, Sampling Concepts, Methods of Sampling	
4-6	Sampling Design	Census and Sample Survey, Implications of a Sample Design, Steps in Sampling Design, Criteria of Selecting a Sampling Procedure, Characteristics of a Good Sample Design, Different Types of Sample Designs, How to Select a Random Sample?, Random Sample from an Infinite Universe, Complex Random Sampling Designs	
7-8	Variables and Formulation of Hypothesis	Types of Variables and objectivity; Nature and Function of Hypothesis; Fundamental Basis of Hypothesis	Assignment-1

9	Interpretation of Data	Processing and Analysis of Data Processing Operations, Some Problems in Processing, Elements/Types of Analysis, Statistics in Research, Measures of Central Tendency, Measures of Dispersion, Measures of Asymmetry (Skewness), Measures of Relationship, Simple Regression Analysis, Multiple Correlation and Regression, Partial Correlation, Association in Case of Attributes, Other Measures,	
10	Applied Statistics	Introduction, Regression Analysis, Parameter Estimation, Inferential Statistics (Chi-SquareTest, T-Test Analysis), Univariate, Bivariate and Multivariate Data Analysis, Principal Component Analysis, State Vector Machines, Uncertainty Analysis, Modelling and Prediction of Performance, Scale Modelling, Sensitivity Analysis, Statistical Software Tool	Assignment-2
11	**Incourse-1**		
12	Introduction to scientific writing	● Importance and purpose of scientific writing in earth sciences. ● Differences between scientific and general writing styles.	
13	Structure and Components of Scientific Documents	● Formatting and structuring research articles, reports, and theses. ● Key sections: Abstract, Introduction, Methodology, Results, Discussion, Conclusion, and References	
14	Structure and Components of Scientific Documents	● Proper use of figures, tables, and scientific data representation ● Citation styles (APA, Harvard, etc.) and reference management	
15	Literature review techniques and procedure	● Purpose of a Literature Review ● Using academic databases (Google Scholar, Web of Science, Scopus) for literature search. ● Boolean operators (AND, OR, NOT) to refine search queries.	Assignment-3
16	Literature review techniques and	● Evaluating and Organizing Literature	

	procedure	● Synthesizing Information and Identifying Research Gaps	
17	Research Ethics and Integrity	● Ethical considerations in data presentation and authorship ● Responsible scientific communication and peer review process	
18	Plagiarism and Self-Plagiarism	● Definition and types of plagiarism ● Self-Plagiarism and Duplicate Publication.	
19	Proper Citation and Attribution Practices	● Common citation styles and their applications (APA, MLA, Harvard, IEEE, Chicago) ● Techniques for correct attribution	
20	Software for detection of Plagiarism	● Introduction to plagiarism detection software (Turnitin, iThenticate, Grammarly, Plagscan) ● Strategies to reduce plagiarism	Assignment-4
21	**Incourse-2**		
22	Instructions for Conducting a Literature-Based Scientific Study.		
23-30	Literature-Based Scientific Study.	● Define the Research Topic and Objectives ● Conduct a Systematic Literature Search ● Evaluate and Organize the Literature ● Analyze and Synthesize Information ● Structuring the Scientific Study while maintaining academic integrity.	Assignment-5

Instructional Strategies: Lectures, Class discussions, Use of multimedia resources (videos, animations, images) and In-class exercises

Assessment Pattern:

Assessment Pattern level no.	Knowledge level	Level of CO	In-course	Assignment	Paper Presentation
K1	**Remember**	CO1-CO2	03	00	10
K2	**Understand**	CO3-CO5	05	00	20
K3	**Apply**	CO4-CO5	03	00	10
K4	**Analyze**	CO3-CO5	05	00	10
K5	**Evaluate**	CO3-CO5	04	05	10
K6	**Create**	CO3-CO5	00	05	00
Total Marks 100 (Class attendance 10 + In-course 20+ Assignment 10+ Final examination 60)			20	10	60

Recommended References:

Cargill, M. & O'Connor, P. (2009) Writing Scientific Research Articles: Strategy and Steps. Wiley.

Walliman, N. (2011) Research Methods - The Basics. Routledge.

Reference Books:

Kumar R. (2010) Research Methodology: A Step-by-Step Guide for Beginners (3rd Edition). SAGE Publications Ltd.

Kothari, C R (2004) Research Methodology: Methods and Techniques (2nd Edition). New Age International.

Katz M.Z. (2006) From research to manuscript: A guide to scientific writing. Springer.

Day, R.A. & Gastel, B. (2006) How to write and publish a scientific paper. Cambridge University Press.

GHT-4203 Geosciences for Sustainable Development

Credit Hours: 3

Course Type: General Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description:

Sustainable Resource Management deals with the protection of all-natural resources. By taking this course, students will learn about various natural resources, their management issues, and the best practices that can protect and preserve these resources. Discussions will be made on different sectors that play a role in the abuse and preservation of natural resources, for example, how social systems affect the environment—how people and organizations interact with natural resources, how values affect people's views of the environment, and how various societies differ in their treatment of it. Much of the coursework will be based on research and field study, giving the students a first-hand experience in this exciting and endlessly important field.

Course Learning Objectives (CLOs):

By completing this course, students will be able to -

a. Describe issues concerning the availability and sustainability of resources
b. Recognize theories, paradigms, concepts, and principles in resources management
c. Recognize the moral and ethical issues of investigations and appreciate the need for professional codes of conduct
d. Plan and conduct environmental investigations including the use of secondary data and and reporting the results of such investigation
e. Collect, record, and analyze data using appropriate techniques in the field and the laboratory

Course Learning Outcomes (COs):

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

CO1: Understand the role of geosciences in addressing sustainability challenges.

CO2: Analyze natural resources and environmental processes in the context of sustainable use.

CO3: Evaluate geohazards and their impact on communities and infrastructure.

CO4: Apply geoscientific knowledge to support sustainable development goals (SDGs).

Mapping CO vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓	✓	✓		✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

No of Lecture: 30 (1.5 hours each)

Course Content:

Lecture	Topic	Details	Homework/ Assignments
1-2	Introduction to sustainable development	Aims, scope and application; Population, Poverty and Inequality; Unplanned Urbanization; Energy Security; Inefficient Water Resource Management; Natural Disasters and Climate Change	

3-4	The concepts of Sustainable Development	Carrying capacity, Precautionary principle, Gaia hypothesis and triple bottom line; Tools for ESD, indicators, and new economics; MDG and SDG goals of United Nations, Status of Bangladesh; Sustainable Development as a value system	Assignment 1
5-6	Introduction to natural resources	Types, consumption, demand, supply, availability, and their sustainability	
7-8	Principles of Natural Resource Conservation and Management	Theory and approach, Origin and types of natural resources, Resource and development, Concept of sustainable development of resources	
9-10	The policy instruments for natural resource management and Accounting	Classical issues of growth, welfare reform, market failure, and externalities, the design of policy instruments for industrial pollution, Valuation methods for economic damage to the ecosystem, taxonomy of the valuation methods, guidelines for financial valuation, issues in the incorporation of environmental values into cost-benefit analysis, methods for economic valuation of environmental impacts	
11	**In-course/Midterm-1**		
12-14	Introduction to climate change and global warning	Greenhouse gas emission: Sources, Cycles, Problems and Emission Controls; Current Understanding of Key Climate Issues and its impacts; Global Temperature and Greenhouse Effects; Detection of the global warming signal and climate impacts.	
15-16	Sustainable management of Groundwater resources	Introduction, Groundwater devlopment challenges in Bangladesh, GW monitoring and Governance, GW management tools,	

17-18	Sustainability Solutions: Urbanization and Land Management	Understanding Urban Sprawl, Drivers and Consequences, Environmental Impact, and Opportunities for Sustainable Urbanization	
19-20	Environmental Economics and Policy Measuring Sustainability	Indicators of environmental sustainability: from concept to applications, Measuring Bangladesh environmental policy performance, Evolution of sustainability indicator worldwide	Assignment 2
21	**In-course/Midterm-2**		
22-23	Problems and Management of Mineral, Energy, Soil, Water, and Coastal and Marine	Targeting unexplored plays of Natural gas and coal resources, Marine geo-resources and prospects, Marine pollution detection, Sustainable Ganges-Brahmaputra-Meghna river Delta	
24-25	Institutional Framework	Review of Existing Organizational Arrangement for Environmental Management; Recent Discourse on Institutional Arrangement for Environmental Management; Proposed Institutional Framework for NSDS; Overall Role of Sustainable Development Monitoring Council; Sustainable Development Board (SDB); Institutional Support to Sustainable Development; Monitoring Indicators for Sustainable Development	
26-28	Good Governance	Present Status; Key Challenges; Strategies	Assignment 3
29-30	Environmental Management Plan	Implementing an EMP, The ISO 9000; The ISO 14000; Integration of Environmental and Quality Management System	

Instructional Strategies:

Lecture, discussion, question-answer and assignment.

Assessment Pattern:

Assessment Pattern level no.	Knowledge level	Level of CO	In-course	Assignment	Final Examination
K1	**Remember**	CO1-CO2	03	00	10
K2	**Understand**	CO3-CO4	05	00	20
K3	**Apply**	CO4	03	00	10
K4	**Analyze**	CO2-CO4	05	00	10
K5	**Evaluate**	CO3-CO4	04	05	10
K6	**Create**	CO2-CO4	00	05	00
Total Marks 100 (Class attendance 10 + In-course 20+ Assignment 10+ Final examination 60)			20	10	60

Recommended References:

Textbook:

Cargill, M. & O'Connor, P. (2009) Writing Scientific Research Articles: Strategy and Steps. Wiley.
Walliman, N. (2011) Research Methods - The Basics. Routledge.

Reference Books:

Kumar R. (2010) Research Methodology: A Step-by-Step Guide for Beginners (3rd Edition). SAGE Publications Ltd.
Saha, S.K. (2009) Research planning & proposal writing skill. AHDPH, Dhaka.
Kothari, C R (2004) Research Methodology: Methods and Techniques (2nd Edition). New Age International.
Katz M.Z. (2006) From research to manuscript: A guide to scientific writing. Springer.
Day, R.A. & Gastel, B. (2006) How to write and publish a scientific paper. Cambridge University Press.

GHL-4204 Data Science and Numerical Modeling Lab

Credit Hour: 3

Course Type: General Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description: This lab course provides hands-on experience in applying data science techniques and numerical modeling methods to real-world problems, particularly in the geosciences. Students will learn to use programming tools like Python and relevant libraries to analyze data, build models, and interpret results. This course complements the theoretical concepts covered in the Data Science and

Numerical Modeling lecture course.
Prerequisites: Concurrent enrollment or completion of the Data Science and Numerical Modeling lecture course. Basic programming knowledge (ideally Python) is recommended.
Lab Schedule (Weekly): One 3-hour lab session per week.
Lab Breakdown (Matching Lecture Topics):

Course Learning Objectives (CLOs):

- Develop proficiency in using programming languages such as Python or MATLAB for data science tasks.
- Perform data cleaning, transformation, and visualization for geoscientific analysis.
- Apply numerical methods to model physical processes in geosciences.
- Build and evaluate predictive models using machine learning techniques.
- Interpret and communicate modeling results through reports and visual presentations.

Course Learning Outcomes (COs):

Upon successful completion of this course, students will be able to:

CO1: Gain hands-on experience in data analysis, visualization, and preprocessing using programming tools.

CO2: Implement numerical modeling techniques to solve geoscientific problems.

CO3: Develop and validate predictive models using real-world datasets.

Mapping CO vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓

No of Lectures: 30 (3 hours each)

Lecture Plan:

Lecture	Topic	Details	Assignment
1 to 3	Lab 1: Python for Data Science Refresher	Review of Python basics, Pandas, NumPy, Matplotlib, and Seaborn. Focus on practical exercises using these libraries	
4	Lab 2: Data Exploration and Visualization	Hands-on practice with descriptive statistics, creating informative visualizations	

		(histograms, scatter plots, maps) using Matplotlib and potentially GIS software. Working with real-world datasets	
5	Lab 3: Time-Series Analysis	Implementing time-series analysis techniques (e.g., moving averages, trend analysis, correlation) on environmental datasets (e.g., rainfall, temperature)	
6-7	Lab 4: Supervised Learning	Implementing regression and classification algorithms (Decision Trees, Random Forests, SVM) using scikit-learn. Applying these to geoscience problems (e.g., land cover classification, mineral Prospectivity mapping	
8	Lab 5: Unsupervised Learning	Applying clustering algorithms (K-Means, DBSCAN) and PCA to explore and analyze geoscience datasets	
10	Lab 6: Geospatial Data Science	Working with geospatial data using libraries like GeoPandas, Rasterio, Shapely, and Fiona. Performing spatial analysis operations (e.g., overlay analysis, buffer creation).	
11	**In-course/Midterm-1**		
12	Lab 7: Big Data Technologies (Introduction)	Introduction to cloud-based geospatial platforms like Google Earth Engine (if feasible). Simple exercises on data access and visualization	
13-14	Lab 8: Data Science Project Work (Part 1)	Students begin working on their chosen data science project. Focus on data collection, cleaning, and initial exploration	
15-16	Lab 9: Data Science Project Work (Part 2)	Continued project work. Focus on model development, evaluation, and visualization	
17	Lab 10: Introduction to Numerical Methods in Python	Implementing basic numerical methods (e.g., forward/backward difference) in Python. Focus on understanding numerical error and convergence	
18	Lab 11: Finite Difference Method I:)	Solving simple ODEs using finite difference methods	
19	Lab 12: Finite Difference Method II	Solving the 1D heat equation using explicit and implicit schemes. Analyzing stability	

20-22	Lab 14: Applications of FDM	Advection Equation: Modeling contaminant transport using the advection equation.	
23-26	Lab 15: Introduction to Finite Element Methods	Simple example of the finite element method	
27-30	Lab 16: Numerical Modeling Project Work:	Students work on a numerical modeling project related to a geoscience problem. This could involve modifying existing code or developing a new model.	

Instructional Strategies:
Laboratory work, Demonstration, Discussion, Question-Answer

Assessment Pattern:

Assessment Pattern level no.	Knowledge level	Level of CO	In-course	Assignment	Final Examination
K1	**Remember**	CO1-CO3	00	00	10
K2	**Understand**	CO1-CO3	00	00	10
K3	**Apply**	CO1-CO3	05	02	10
K4	**Analyze**	CO1-CO3	05	03	10
K5	**Evaluate**	CO1-CO3	05	02	10
K6	**Create**	CO1-CO3	05	03	10
Total Marks 100 (Class attendance 10 + In-course 20+ Assignment 10+ Final examination 60)			20	10	60

Recommended References:

Guus, S., & Fred, V. (2023). *Numerical methods in scientific computing*. TU Delft Open.

Manual, A. B. S. (2013). An introduction to statistical learning with applications in R.

Press, W. H. (2007). Numerical recipes 3rd edition: The art of scientific computing. Cambridge university press.

Ruppert, D. (2004). The elements of statistical learning: data mining, inference, and prediction.

GHF-4205 Comprehensive multidisciplinary Geological Field Work

Credit hour: 3

Course Type: Capstone Course

Total Marks: 100 (Attendance-10, In-course-20, Assignment-10 and Final Examination-60)

Course Description:
A mufti-disciplinary field work/project work in a suitable location in Bangladesh. Emphasis will be given on the study of all major branches of geology such as stratigraphy, sedimentology, Quaternary geology, hydrogeology, environmental geology, geophysics, and petroleum geology. Students will apply various geological, and geophysical tools in assessing the prospect for petroleum and groundwater in a region and to identify potential environmental risks and hazards

Course Learning Objectives (CLOs):
By completing this course students will be a able to –

- Use the principles and knowledge of geology in the exploration of groundwater, Petroleum, and other geological resources.
- Collect, analyse, and interpret geological and geophysical data.
- Collect, analyse, and interpret hydrogeological data
- Perform environmental risks and hazard analysis
- Write a comprehensive scientific reports

Course Learning Outcomes (COs):

At the end of the course the students will be able to:

CO1: Analyze sedimentary facies- identify and interpret sedimentary facies and depositional environment from field observation

CO2: Correlate stratigraphic units across measured sections using lithologic, fossil or structural markers

CO3: Apply basic sequence stratigraphic concepts in the field such as recognizing transgressive-regressive cycles

CO4: Interpret the geological history and paleoenvironment of a region based on stratigraphic evidence

CO5: Prepare detailed field logs, stratigraphic columns and a report summarizing observations, interpretations and conclusions.

Mapping CO vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓	✓		✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4		✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓

Course contents:

Lec.	Topic	Details	Assignment
1–8	Preparation for fieldwork	● Introduction to geological fieldwork ● Field equipment and safety ● Field observation at different scales ● Field notebook: sketches, written notes, correlation with other data, etc. ● Recording features of sedimentary logs and constructing graphic logs ● Recording palaeontological data ● Recording structural information ● Making a geological map ● Photography, sampling, etc. ● Laboratory analysis of samples and interpretation ● Field report writing	
9	**Discussion**		
10	**In-course Examination/Class test**		
11-30	Geological Fieldwork	Visit selected areas to view the general geology and to learn field observation, documentation, and mapping skills; standard procedure in using geophysical tools in the field, collection of sediments, rocks and water samples for laboratory analysis, identification and mapping of potential environmental risks and hazards	

Instructional strategies: Classroom lecture and discussion**,** Hands-on exercise, on-site lectures, and discussions.

Assessment pattern:

Assessment Pattern level no.	Knowledge level	Level of CO	Field Performance	Field Viva	Field Report
K1	**Remember**	**CO1, CO2**	00	02	05
K2	**Understand**	**CO1-CO4**	04	03	15
K3	**Apply**	**CO3-CO5**	04	03	10
K4	**Analyze**		03	03	15
K5	**Evaluate**	**CO3 & CO5**	02	02	10
K6	**Create**		02	02	05

Total Marks 100 (Field attendance 10 + Field Performance 15+ Field Viva 15+ Field Report 60)		15	15	60

Recommended References:

Lisle, R.J., Brabham, P.J., Barnes, J.W. & (2011) Basic Geological Mapping (5th Edition). Wiley-Blackwell.
Coe, A.L. (2010) Geological Field Techniques. John Wiley & Sons.
Barnes, J.W. & Lisle, R.J. (2004) Basic Geological Mapping (4th Edition). John Wiley & Sons.

McClay, K.R. (1987) The Mapping of Geological Structures (Reprinted 2007). John Wiley & Sons.
Compton, R.R. (1962) Manual of Field Geology. Wiley. Lahee, F.H. (1961) Field Geology (6th Edition). McGraw-Hill Book Co.
Low, J.W. (1957) Geological Field Methods. Harper & Bros.

GHI-4206 Internship/Project

Credit Hour: 3

Course Type: Capstone Course

Total Marks: 100 (Attendance-10, Performance-30 and Report-60)

Course Description:

The Undergraduate Internship course provides students with practical experience in a professional environment relevant to their field of study. It bridges academic knowledge with real-world application, enabling students to gain insights into workplace dynamics, technical procedures, and organizational operations. The internship fosters professional growth, enhances employability, and encourages the development of essential soft and technical skills.

Course Learning Objectives (CLOs):

- To provide hands-on experience in a relevant industry or research setting.
- To develop practical skills and professional competencies.
- To enhance understanding of real-world challenges and problem-solving approaches.
- To promote career awareness and readiness for the job market.
- To encourage reflection on professional experiences and academic learning integration.

Course Learning Outcomes (COs):

CO1: Gain practical experience and apply academic knowledge in real-world settings.

CO2: Develop professional skills such as communication, teamwork, and problem-solving.

CO3: Build industry connections and enhance career readiness through hands-on exposure.

Mapping CO vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓

Assessment Pattern:

Assessment Component	Wt%	Detail Description
Internship proposal /Plan	10	Outline of objectives, tasks and expected outcomes prior to the start of internship
Mid-Term Progress Report	15	A brief report detailing tasks completed, challenges faced, and key learnings
Supervisor Evaluation	25	Evaluation by the workplace supervisor based on performance, punctuality, initiative, teamwork, and professionalism
Final Internship Report	30	A comprehensive written report summarizing internship experience, key responsibilities, outcomes, and reflections
Presentation/Viva Voce	20	Oral presentation to faculty panel covering the work performed and lessons learned. Includes Q&A

GHV-4207 Viva Voce

Credit Hour: Non-Credit Course

Course Type: Capstone Course

Total Marks: Satisfactory / Unsatisfactory

Course Description:

Viva voce will be conducted towards the end of the academic year which will be covering the complete syllabus. This will assess the student's knowledge and understanding during the course of their graduate programme. In doing so, the main objective of this course is to prepare the students to face interview both at the academic and the professional arenas.

Course Learning Objectives (CLOs):

The primary aim of the course is to develop students' confidence in oral assessments and to evaluate the conceptual understanding gained during their fourth year of undergraduate education.

Course Learning Outcomes (COs):

Upon successful completion of the course the students will be able to

CO1: To describe and explain their understanding of the theoretical and practical geology courses
CO2: Get prepared to face the interview both at the academic and the professional arenas

Mapping Co vs PLO:

CO	PLO1	PLO2	PLO3	PLO4	PLO5
CO1	✓	✓	✓		
CO2				✓	✓

Assessment Pattern:
Oral Examination