CURRICULUM

for MPhil Programme in Geology

Academic Sessions: 2019-2020, 2020-2021 and 2021-2022

DEPARTMENT OF GEOLOGY
FACULTY OF EARTH AND ENVRONMENTAL SCIENCES
UNIVERSITY OF DHAKA
DHAKA 1000
BANGLADESH

Prologue

I am pleased to write this prologue for the curriculum of the Master of Philosophy (MPhil) programme in Geology under the Faculty of Earth and Environmental Sciences, University of Dhaka for the academic sessions 2019-2020, 2020-2021 and 2021-2022.

The Department Geology offers 4-Year BS Honours in Geology, 1-Year MS in Geology (with specialization in different fields of Geology), MPhil and PhD programmes in specialised fields of Geology.

The MPhil curriculum is prepared as part of the plan to develop course curriculum for all the degree programmes of the department to enhance the overall quality of higher education that started under the Higher Education Quality Enhancement Project (HEQEP) of the University of Dhaka. In the curriculum, the objectives and learning outcomes of each of the courses offered under the programme are well explained to enable the students to have a complete sense of the programme and its outcome.

The MPhil is a two-year programme of course work and research. The programme is designed to provide advanced knowledge in the applied and specialised fields of Geology and to train students in carrying out original research work. The advanced theoretical courses and one-year supervised research under the MPhil programme enhances the ability of the students undertaking higher degree research programme like PhD research as well as contribute to the field of knowledge and research in geosciences.

Finally, I would like to thank the Syllabus/Curriculum Committee and all members of the Academic Committee of Geology Department for making this effort successful.

Dr. M. Aziz Hasan
Professor and Chairman

About 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 asthe 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 Centres. The number of students and teachers has risen to about 37018 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 enrols 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 Programme, the University also trains up a large number of researchers in different disciplines. More than 1262 PhD and 1217 MPhil Researchers have obtained their degrees from this University.

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 to foster the transformation processes of the individual students and the country as a whole 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.

About the Faculty of Earth and 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 new hub of teaching and research in various fields of earth and environmental sciences to face the major environmental challenges of 21st Century and achieving 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 programmes includes all the major branches of earth and environmental sciences encompassing aspects covering space to the centre of the Earth. The Faculty is led by a Dean, elected by all the teachers of constituting departments once in 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 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 attendance record of 75% or more during the course of study.

About the Department

Introduction

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 programme (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 country's natural/mineral resources. To fulfill the increasing demand of professional geoscientists, curricula 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.

Photograph: Department of Geology, University of Dhaka.

Degree Programmes

The Department currently offers degrees in Bachelor of Science (BS) with Honours, Master of Science (MS), Master of Philosophy (MPhil) and Doctor of Philosophy (PhD) in Geology. The Department also offers minor courses for Honours students of other disciplines.

The BS (Hons) is a four-year integrated programme consisting 126 credit hours of theory, practical, field mapping, project and viva voce (oral) courses as majors and 20 credit hours of physics, chemistry and mathematics courses as minors. The MS degree is a one-year programme based either on course work (Group A) or on course work along with research (Group B). The MPhil is a two-year programme of course work and research. The PhD programme essentially involves research work. The Department enrolls 50 students in each academic year as first-year honours students.

Research Facilities

The Department presently has 27 academic staff with a wide range of research interest 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 programmes 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.

Museum

The Department has a geological museum, named after Shaheed Md. Abdul Muktadir, a martyr of 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.

Library

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

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).

Photographs: Various activities during field work

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.

Remote Sensing and GIS Laboratory

This laboratory was established in 2006 with significant funding support from Columbia University, NY and Geology Department of Dhaka University. The lab houses 20 high performance Desktop PCs build into a Local Area Network through a Server that hosts the floating licenses of ArcGIS software. Both ArcGIS and Erdas Imagine software are used to teach the 3rd year students fundamental courses in Remote Sensing and GIS. The MS students engaged in thesis research also uses this lab to facilitate spatial data interpretation relevant to their research topics. Faculty members also make good uses of the lab facilities in their research projects creating and analyzing GIS data and digital processing of satellite imagery. This laboratory will be housed in a dedicated room in the new 1st floor wing of the department once the construction is completed.

Cartographic Facilities

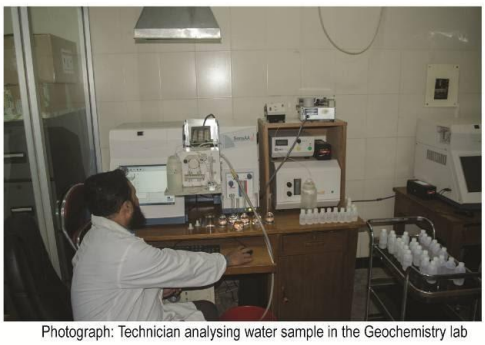
The department has a drafting section equipped with necessary cartographic and drafting gears. The section provides necessary support to the students in preparing base maps and geological maps for field work. The section also provides cartographic services in research activities of the department.

Hydrogeology and Environmental Geology Lab

The lab is equipped with Atomic Absorption Spectrometer (AAS), Ion Chromatograph (IC) UV-Visible Spectrometer, Flame photometer, Total Organic Carbon (TOC) analyser 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.

Photograph: Multi disciplinary computer laboratory with GIS and RS facilities

Photograph: Triaxial test aparatus



Photograph: Technician analysing water sample in the Geochemistry lab

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. All these equipment have been donated by the European Commission (EC) through United Nations Development Programme (UNDP) under the Earthquake and Tsunami Preparedness Component of the Comprehensive Disaster Management Programme (CDMP).

TheCyclic 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 the civil engineering structures, such as building, road, bridge, tunnel, etc. These parameters are also necessary for slope stability analysis of mines and road cut in hilly region. 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 upto the depth of engineering bed rock. The shear wave velocity is important for the preparation of engineering geological map which is used in seismic (earthquake) hazard and vulnerability assessment.

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.

The Department of Geology has also an informal research group known as Geohazard Research Group (GRG) consisting of faculty members to promote advance research pertaining to the Geoenvironmental Hazards.

Dhaka University Earth Observatory

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

The Department of Geology of Dhaka University has initiated an 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 know as ‘Dhaka University Earth Observatory (DUEO)’ established in February 2003. The observatory is equipped with 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 co-operation with Rajshahi University, Khulna University, Chittagong University, Chittagong University of Engineering and Technology (CUET), Patuakhali Science and Technology University (PSTU), Shajalal University of Science and Technology (SUST).

Dhaka University Earth Observatory operates network of 6 permanent seismic stations, 6 portable seismographs and 18 continuous geodetic GPS stations in the country. The objectives of the Observatory is to carryout 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 scientific community.

Numerical Simulation 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 modelling, Reservation characterization and Reservoir Simulation.

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 career in Industry and Research. Faculty members also make good use of the lab facilities in their research projects.

Photograph: Dhaka University Earth Observatory

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 a number of 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 a cultural club and a photographic club responsible for the arrangement of various cultural activities in the department.

Photographs: Extracurricular activities by the students of the Geology Department

Scholarship

The department has a number of 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 offering a monthly award of Tk 350 an MS student who secured the highest CGPA at the BS final examination. '**Prof. Abdul Hai and Prof. Manzoor Hasan Scholarship'** has been 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'** has been 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'** has been 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.

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.

1. Introduction to the Programme

Title: MPhil in Geology

Duration: Duration of MPhil Programme is 2 years. First year is for course work and the second year is for research and thesis writing. However, in accordance with DU regulations, a student's MPhil registration will be valid for a maximum of 4 years, i.e. a student has to complete MPhil course within maximum four years from the date of admission.

2. Rules and Guidelines[1]:

2.1 Admission Requirement:

a) Four years honours degree with 1-year master degree, or

b) Three years honours degree and 1-year master degree, or

c) Two years bachelor degree and two years master degree with at least 1 year of teaching/research/job experience in reputed organizations or 1 research publication in recognised journal.

d) Candidate should have at least second class (minimum 50% marks) in all examination, or CGPA 3.5 on a scale of 5 or 3 on a scale of 4.

2.3 Admission Procedure:

Students interested to undertake MPhil courses under the Department of Geology shall have to apply in response to admission circulars published by University of Dhaka. The following steps must be followed for completing the admission procedure:

- The student must contact an eligible, as set by university regulations, faculty member of the Department of Geology who is willing to supervise him/her for the MPhil course.
- The student will have to prepare a research proposal with an appropriate title in any field of Geology in accordance with the expertise of the chosen supervisor.
- One co-supervisor can be included from other university/institute/organisation if needed, particularly for multi-disciplinary research.
- The candidate will have to deposit Tk 500.00 at the Janata Bank, TSC Branch for collecting the admission form. Second, an application form will have to be collected from the registered office showing the money receipt.
- Properly filled application form will have to be submitted with original copies of all certificates of required degrees, professional experiences, NOC from employer in case the candidate is working at any government/nongovernment/private organization, etc along with the research proposal agreed by the supervisor and co-supervisor.
- Student will be enrolled upon approval by the Departmental Academic Committee, Faculty of Earth and Environmental Sciences, and the Board of Advanced Studies of University of Dhaka.
- On approval from all required committees, the student will have to complete the admission procedure by paying required fees.

- Students will have to take leave of absence from their institution/organisation if applicable.

3. Structure of the course:

a. MPhil Course is a combination of taught courses and supervised research. Students must successfully complete the taught part to qualify for undertaking the supervised research.

b. Students will have to take two Theory and one Viva Voce course during Year 1, equivalent to 12 credits/3 units from the list of courses given below.

c. The two theory courses shall be chosen by the student, with advice from the supervisor, considering relevance to his/her proposed research topic.

d. On successful completion of Year 1, students will be allowed to complete a supervised thesis work during Year 2 equivalent to 12 credits/3 units.

List of Courses for 1st Year MPhil:

Course No.	Course Name	Unit	Credit	Marks
GEOL601T	Advanced Sedimentology	1	4	100
GEOL602T	Advanced Stratigraphy	1	4	100
GEOL603T	Structural Geology and Tectonics	1	4	100
GEOL604T	Seismology and Earthquake Geology	1	4	100
GEOL605T	Advanced Environmental Geology	1	4	100
GEOL606T	Advanced Hydrogeology	1	4	100
GEOL607T	Advanced Exploration Geophysics	1	4	100
GEOL608T	Advanced Petroleum Geology	1	4	100
GEOL609T	Advanced Quaternary Geology	1	4	100
GEOL610T	Advanced Economic Geology	1	4	100
GEOL611T	Applied Micropaleontology	1	4	100
GEOL612T	Research Methods in Geosciences	1	4	100
GEOL613V	Viva Voce (Compulsory)	1	4	100

List of Courses for 2nd Year:

Course No.	Course Name	Unit	Credit	Marks
GEOL614R	Thesis	2	8	200
GEOL615V	Viva Voce (Thesis Defence)	1	4	100

4. Student assessment and evaluation:

a. On completion of the admission procedure, the student will have attend theory classes as per routine approved by the Departmental academic committee.

b. Departmental Academic Committee shall form an Examination Committee for all students of the same academic year as per university guidelines for conducting theory examinations and viva voce.

c. Written examination shall be held at the end of year 1 for the theory courses. Duration of the written examination for each course shall be four hours. Pass Mark for each course is 50% and students must pass each course individually.

d. A viva voce shall be held for the students successfully passing the theory courses. Pass mark for the viva voce course is 50%.

e. The examination committee shall publish the result of First Year MPhil course and student shall be allowed to enrol for Second Year on payment of required fees.

f. The student shall have to complete research work within one year from the date of admission into the second year. However, the student can apply for extension of time through Departmental Academic Committee if recommended by the supervisor with valid reasons.

g. The student will have to give two presentations in front of the Departmental faculty members and any other invited experts: one at the beginning of second year for validating research methodology; and one towards the end of second year for presenting research findings.

h. Student shall start writing thesis, according to guidelines of Department/Faculty/University as soon as agreed by the supervisor on successful completion of the planned field/experimental work and interpretations.

i. Departmental academic committee shall form separate Evaluation Committee for each student as per university guidelines. The thesis will be evaluated by two external members of the Evaluation Committee. Viva (Thesis Defence) shall be conducted by the Evaluation Committee upon recommendations of the Examiners.

j. Students will be recommended for MPhil Degree by the Evaluation Committee based on reports of the examiners and performance at the Thesis Defence.

[1]*Prepared following the existing rules and guidelines of the University of Dhaka (vide A.c.-29-4-2013 and S.m.-30-4-2013). The rules and guidelines are subject to change/modified by the university authority.*

Details of Courses:

1. Course Number and Title: GEOL601T Advanced Sedimentology

2. Credit Hours/Unit: 4 credit hours/1 Unit

3. Course Description: This course examines the study on sedimentary rocks and basins and the methods used to understand them. Among the topics to be covered are the concept of facies, depositional environments both in clastic and non-clastic settings, interpretation of ancient deposits from all continental and marine environments by facies analysis, reconstruction of the basin and its evolution interpreting paleocurrent analysis, the factors control the sedimentation record, sequence stratigraphy of siliciclastic and carbonate successions and the application of sedimentological knowledge in decoding the earth history and exploring economic resources.

4. Learning outcomes: At the end of the course the learners will be able to –

- Accurately describe and interpret sedimentary successions
- Describe and interpret facies; construct facies models
- Understand the concept of depositional sedimentary environments; their types and classifications;
- Interpret from sedimentary records the environments of deposition that were operating, identifying all reasonable alternative explanation and extract information that might indicate past climatic conditions; construct depositional/facies models for respective environments
- Make regional predictions of the lateral extent, geometry and lithological characteristics of a sedimentary succession from limited sets of sedimentary logs
- Utilize many different data types in order to understand sedimentary deposits, such as outcrops, landscapes, aerial imagery, seismic data and cores
- Discern paleocurrent properties and attributes, procedures for paleocurrent analysis and application of paleocurrent data to basin analysis and assessment of its mineral-resource potential
- Acquire basic knowledge about sequence stratigraphic concepts and methods for both siliciclastic and carbonate rocks

- Know the processes behind and the effects of sea-level changes, tectonics and sediment supply on the build-up of stratigraphic successions
- Know the application of sedimentology in decoding the earth's history and exploring economic resources.

5. Course content: (Total 56 Classes)

Section	No. of Classes
Section-1: Recent advantages in sedimentology Lecture 1-2: Virtual Outcrop (VO), behind outcrop borehole Lecture 3-4: GPR	4
Section-2: Concept of facies and facies models Lecture 5-6: Facies analysis in the outcrop Lecture 7-8: Facies analysis in the subsurface—seismic facies borehole Lecture 9-10: Geophysical log facies	6
Section-3: Environments of deposition (clastic) and facies model Lecture 11-12: Continental: Alluvial fans and coarse braided systems-sandy fluvial system—single-channel meandering, multi-channel braided and anastomosing Lecture 13-20: Transitional: Deltaic systems– River dominated, wave- dominated and tide-dominated deltas, non-deltaic siliciclastic systems—beach-ridges, strand plains, tidal flats, barrier-island/lagoons, estuaries Lecture 21-24: Marine: Deep-sea fans/turbidites	14
Section-4: Environments of deposition (non-clastic) and facies model Lecture 25-26: Carbonate facies models-continental and supratidal (Sabkha) evaporates; Lecture 27-28: Marginal-marine carbonates, Shallowing upward carbonate fancies	4
Section-5: Paleocurrents and basin analysis Lecture 29-30: Hydrodynamic conditions of depositions of sedimentary agents such as fluvial, Aeolian, glacial, oceanic agents Lecture 31-32: Resultant fabrics and sedimentary structures analysis Lecture 33-34: Basin analysis and the sedimentary model	6
Section-6: Controls on the sedimentary rock record Lecture 35-37: Climate, tectonics and sea-level change Lecture 38: Milankovitch processes, and orbital forcing Lecture 39-40: Intrinsic sedimentary processes	6

Section-7: Sequence stratigraphy of siliciclastic and carbonate successions: Lecture 41-42: Concepts and principles Lecture 43-46: Sequence stratigraphic tools Lecture 47-50: Applications to various depositional systems	10
Section-8: Application of Sedimentology: Lecture 51-53: In decoding earth history and Lecture 54-56: In exploring economic deposits (oil, gas, coal, aggregates, building materials and certain minerals)	6

6. Instructional Strategies:

Lecture, Discussion, Question-Answer, Presentation

7. Assessment:

Summative (100%): Course Final Examination

8. Reading Materials:

1. Reading, H.G. (1996). *Sedimentary Environments: Processes, Facies and Stratigraphy*. 3rd Edition, Blackwell.
2. Lewis, D.W. and McConchie D. (1994). *Analytical Sedimentology (1st edition)*. Springer US.
3. Walker, R.G. and James N.P. (1992). *Facies Models: Response to Sea-level Change*. Geological Association of Canada.
4. James, N.P. and Dalrymple, R.W. (2010). *Facies Models 4*. Geological Association of Canada.
5. Emery, D. and Myers, K. (1996). *Sequence Stratigraphy*. Blackwell.
6. Catunaenu, O. (2006). *Principle of sequence stratigraphy* (1st edition). Elsevier.
7. Pettijhon, F.J. (1973). *Sedimentary rocks* (3rd edition). Hamper & Row, N.T., London.
8. Pettijohn, F.J., Pottern, P.E. and Siever R. (1973). *Sand and Sandstone*.Springer-Verlag, New York, Heidelberg, Berlin.
9. Potter, P.E. and Pettijohn, F.J. (1963). *Paleocurrent and Basin Analysis*.Springer Berlin Heidelberg.
10. Potter, P.E. and Pettijohn, F.J. (1977). *Paleocurrent and Basin Analysis* (2nd edition). Springer-Verlag Berlin Heidelberg.
11. Selley, R.C. (1976). *Introduction to Sedimentology*. Academic Press, London.
12. Reinck, HE and Singh, L.B. (1980). *Depositional sedimentary environments* (2nd edition). springer-verlag, N.Z.
13. Friedman, G.F. and Sanders, J.E. (1978). *Principles of sedimentology*. John Well and Son Inc. N.Y.

1. Course Number and Title: GEOL602T Advanced Stratigraphy

2. Credit Hours/Unit: 4 credit hours/1 Unit

3. Course Description: This course focuses on the concepts, methods and applications of modern stratigraphy. It includes traditional techniques and state of the art concepts and methods like sequence-stratigraphic principles and applications, predictive stratigraphic modelling, quantifying stratigraphy in a mass-balance framework, qualitative and quantitative paleoenvironmental reconstructions, estimation of the temporal completeness of the stratigraphic record and an understanding of autogenic dynamics in sedimentary systems. Analysing clastic and nonclastic deposits based on their internal facies architectures, case studies and exercises from field analogues will get special emphasis. Well-log data and observations from cores, well correlation and seismic sequence stratigraphy will support the learning. Ultimate goal of this course is to characterise the sedimentary basins and evaluate their economic potential through the integration of different disciplines.

4. Learning outcomes: At the end of the course, the learners will be able to –

- Transform a stratigraphic cross section into a historical summary that expresses environmental states and changes
- Understand the principles of facies analysis and be able to apply these principles to specific regional examples in order to reconstruct paleoenvironments
- Manipulate multiple variables that contribute to the accumulation of strata (e.g., tectonic subsidence, sediment supply, sea level change) in deducing plausible scenarios
- Apply an understanding of stratigraphic sequence mapping and interpretation to a variety of data types typical to surface geological and subsurface geological analysis
- Consider the degree to which geologic times is not preserved as physical material when proposing interpretations of strata and when designing tests of hypotheses about Earth phenomena which will be tested using proxies preserved in strata

- Reason at multiple spatial and temporal scales and can combine pieces of historical information appropriate to those various scales into a coherent overview of the formation of a package of strata
- Develop advanced techniques of stratigraphic correlation, including predictive models of subsurface stratigraphy, use of geotechnical data in stratigraphy
- Understand the spatial and temporal development in sedimentary basins, with a predictive perspective on determining facies distribution

5. Course content: (Total 56 Classes)

Section	No. of Classes
Section-1: Introduction Lecture 1-3: Recent advances in stratigraphy, principles of stratigraphy, stratigraphic sequences and depositional framework, comparison between the stratigraphic scales in marine and continental successions, stratigraphy in relationship with other branches of geology Lecture 4-6: The Stratigraphic Section, Facies Analysis, the time in stratigraphy; geological chronology (relative and absolute), the temporal sequence of events; standard global chronostratigraphical scale Lecture 7-8: Relative Dating Techniques, absolute Dating Techniques, statistical analysis, quantifying stratigraphy in a mass-balance framework. Lecture 9-10: Need for stratigraphic correlation, different correlation techniques and related methodologies Lecture 11-12: The sedimentary Cyclicity and paleogeographic reconstructions	12
Section-2: Sequence stratigraphy Lecture 13-15: Introduction to sequence stratigraphy, Walther's Law and facies belts, Stratal stacking patterns, Shoreline trajectories, historical developments, workflow of sequence stratigraphic analysis Lecture 16-18: Identification of Subaerial Unconformities (Sequence Boundaries), Maximum Flooding Surfaces, Wave and Tidal Ravinement Surfaces, Maximum Regressive Surfaces in sub-surface datasets such as seismic, well-log and core data, Sequence Stratigraphy of Shallow Marine Siliciclastic Systems	12

Section	No. of Classes
Lecture 19-20: Systems tracts in downstream-controlled settings, Systems tracts in upstream-controlled settings, Economic potential of all types of systems tract Lecture 21-22: Depositional sequences, Genetic stratigraphic sequences, Transgressive-regressive sequences, Parasequences Lecture 23-24: The importance of scale, sequence stratigraphic hierarchy, moving forward to a standard application of sequence stratigraphy	
Section-3: Sedimentary Basin Lecture 25-27: Understanding basin forming processes and basin architecture Lecture 28-32: Autocyclic and Allocyclic processes and their controls on stratigraphic signatures of basins Lecture 33-36: Depositional facies, seismic facies, seismic expression & configuration, log-based sequence, correlation of sequences, predictive stratigraphic models	12
Section-4: Stratigraphic principles Lecture 37-39: Stratigraphic principles and facies tracts of carbonate sequence stratigraphy, recognition of key surfaces in surface and subsurface data Lecture 40-43: Highstand shedding of carbonate platforms, effects of karstification, dissolution and leaching along subaerial unconformities, drowning unconformities (Type-3 sequence boundaries) Lecture 44-46: Variations in cycle-style in carbonates, the start-up, catch-up and keep-up phases in carbonate platform development	10
Section-5: Stratigraphic evidences Lecture 47-50 Geology and stratigraphy of some important sections of Archaean-Precambrian, Palaeozoic, Gondwana, Mesozoic and Cenozoic deposits in Bangladesh, India, Pakistan and Myanmar Lecture 51-53 Stratigraphic boundaries and their significances Lecture 54-56 Tectonic evolution and Paleogeographic reconstruction of this region based on stratigraphic evidences	10

6. Instructional Strategies:

Lecture, Discussion, Question-Answer, Presentation

7. Assessment:

Summative (100%): Course Final Examination

8. Reading Materials:

1. Principles of sedimentology & stratigraphy by Sam Boggs Jr., 5th edition, 2011, Prentice Hall, ISBN-13: 978-0321643186.
2. Basin Analysis: Principles and Application to Petroleum Play Assessment by Allen, Philip & R., Allen, 2nd edition, 2013
3. Facies Models Revisited by Roger Walker, 2006, SEPM Special Publication 84. 1-17. 10.2110/pec.06.84.0001.
4. Principle of sequence stratigraphy by Catuneanu O., 1st edition, 2006. Elsevier.
5. Carbonate Sedimentology by Tucker M.E. and Wright V.P., 1991, Publisher Wiley, ISBN 0632014725, 9780632014729.
6. Sedimentology and stratigraphy by Gary Nichols, 2nd edition, 2009, Wiley-Blackwell, ISBN: 978-1-4051-3592-4.
7. Sedimentary Geology by Donald R. Prothero, Fred Schwab,3rdedition, 2013, W. H. Freeman, ISBN-13: 978-1429231558.
8. Sedimentary Rocks in the Field: A Practical Guide (Geological Field Guide) by Maurice E. Tucker, 4th edition, 2011, Wiley-Blackwell, ISBN-13: 978-0470689165.
9. Principles of Sedimentary Basin Analysis by Miall A.D., 2000, Springer-Verlag.
10. Geology of India and Burma by Krishnan, M.S., 1982, C.B.S. Publishers & Distributors, Delhi.
11. Siliciclastic Sequence Stratigraphy—Concepts and Applications by Posamentier, H. W. and Allen G. P., 1999, SEPM Concepts in Sedimentology and Paleontology #7, 204 p.

1. Course Number and Title: GEOL603T Structural Geology and Tectonics

2. Credit Hours/Unit: 4 credit hours/1 Unit

3. Course Description: This course is intended to introduce MPhil students to the advanced knowledge in specific topics related to structural geology and tectonics. The course includes a quantitative approach of stress and strain in various tectonic setting, advanced aspects of rock deformation and complex deformation geometries of tectonically significant structural elements. The course will focus on both field and laboratory-based studies, data collection, analysis, and mathematical modelling procedure in the respective field.

4. Learning outcomes: At the end of the course the learners will be able to -

- Discuss about the major structural elements and the processes through which they formed
- Plot the linear and planar structural elements using advanced technology
- Deduce stress strain relationship both in 2D and 3D
- Infer stress trajectory and deformation pathways through statistical tools
- Draw a complete picture of regional tectonic evolution of Bengal basin
- Formulate geodynamic model in a local scale and solve it numerically

5. Course content: (Total 60 Classes)

Sections	No. of Classes
Section-1: Introduction to rock deformation Lecture 1: Type of rock deformations – brittle and ductile, continuous and discontinuous and the factors responsible for the deformation. Lecture 2: Deformation of the Earth's lithosphere, scale of deformation, progressive deformation, kinematics of deformation. Lecture 3: Linear and planer structural elements, concept of superposed structures and its relation to regional tectonics, grouping of structural elements Lecture 4-5: Introduction to common types of structures, viz., fold, fault, joint, unconformity, rock cleavage Lecture 6: Rock fabric – its development mechanisms and rheological properties of rocks, classification of fabrics, fabrics in analysis of histories of polydeformed terrains	6
Section-2: Stress and Strain in Earth's crust Lecture 7-8: Force and stress, stress ellipsoid, Mohr circle, stress tensor, stress fields and history, stress trajectories Lecture 9: Rock behaviour under stress and principles of rock mechanics, state of stress in upper crust, lower crust and upper mantle Lecture 10-11: Strain introduction, pure and simple shear, strain tensor, strain ellipse, strain heterogeneity, displacement fields, strain from circles, lines and angles Lecture 12-14: Strain partitioning, strain path dependencies, measurement of strain in deformed rock, strain modelling of transpressional and transtensional deformation	8

Sections	No. of Classes
Section-3: Faults and faulting Lecture 15-17: Fault-slip analysis, friction of rock interfaces, sense of shear Lecture 18-20: Faults and stress regimes, mechanical theories of faulting, sense of slip in relation to fault geometry Lecture 21-22: Detachment fault, splay fault, anthethetic and synthetic faults, shear zone.	8
Section-4: Folds and folding Lecture 23-24: Mechanics of folding, significance of Z-fold, M-fold and S-fold Lecture 25-26: Study of superposed folds –mechanism of formation and its significance Lecture 27-30: Duplex structures: layer-parallel shortening, fault propagation fold and fault bend fold, detachment folding, fold amplification and diapirism in thrust belt and its kinematics, determination of geological shortening rates of fold and thrust belt	8
Section-5: Tectonics Lecture 31-32: Fundamental concepts: Wilson cycle, Orogenesis, epeirogenesis and their characteristic features Lecture 33-34: Development of modern concept and mechanism of plate movement Lecture 35: Tectonics of crust; lithosphere and asthenosphere	5
Section-6: Geodynamic set up of Bangladesh and sorroundings Lecture 36: Major tectonic elements of Southeast Asia Lecture 37-41: Evolution of the Himalayan & Indo-Burmese hill ranges; Ninety East Ridge and Bengal Basin, Bay of Bengal Lecture 42-47 : Geodynamics of Bangladesh	12
Section-7: Detailed analysis of tectonically significant structures Lecture 48-53: Stress transfer and uplift of Shillong Plateau, impacts of Shillong Plateau on Brahmaputra avulsion and sedimentation. Fold: Genesis, Classification, morphology and kinematics interpretation Lecture 54-60: Convergent tectonics, Subduction of Indo-Burma fold and thrust belt, tectonic history of Paleogene and Neogenge deformation of Indo-Burma fold and thrust belt	13

6. Instructional Strategies:

Lecture, Discussion, Question-Answer, Presentation

7. Assessment:

Summative (100%): Course Final Examination

8. Reading Materials:

1. Bell, F.G. (1992). *Fundamentals of Engineering Geology (Indian Edition)*. Aditya Books Pvt. Ltd.
2. Condie, K. C. *Plate tectonics and crustal development*.
3. D. H. & Judd, W.R. (1998). *Principles of Engineering Geology*
4. Ghosh, S. K. (1993). *Structural Geology: Fundamental and Modern Developments*. Pergamon Press.
5. Hobbs, B. E., Means, W. D., and Wiliams, P. F. *An outline of Structural geology*.
6. Marshak S. & Mitra, G. (1988). *Basic Methods of Structural Geology*. Prentice Hal.
7. Price, N. J. and Casgrove; J. W. *Analysis of Geological structures*.
8. Ramsay, J. G. *Folding and Fracturing of Rocks*
9. Schultz, J.R. & Cleaves, A.B. (1951). *Geology in Engineering*. John Willey & Sons, NY.
10. Turner, F. J. & Weiss, L. E. (1963). *Structural analysis of Metamorphic Tectonites*. McGraw Hill.
11. Valdiya, K. S. *Aspects of Tectonics*

1. Course Number and Title: GEOL604T Seismology and Earthquake Geology

2. Credit Hours/Unit: 4 credit hours/1 Unit

3. Course Description: The course will cover the history, scope, and recent developments in seismology, especially in seismograph and seismic networks. The students will learn about the earthquake source mechanism, strain build-up and release mechanism, earthquake focal mechanism, and paleoseismology and its importance in analyzing earthquakes' recurrence. Interseismic, coseismic, and postseismic ground deformation analysis through geomorphology, GPS, and InSAR will be taught. The formation of tsunamis and their impacts will also be discussed.

Emphasis will be given to studying the relationship of seismic waves with local geology, and their effects on infrastructures, landforms and river systems. Neo-tectonics, monitoring active tectonic activities in Bangladesh, studying active faults, and understanding seismicity in Bangladesh and surroundings related to the geodynamic set-up are the key components of this course. The course is designed for the students who have sound background of structural geology, tectonics and geophysics.

4. Learning outcomes: At the end of the course the learners will be able to -

- Develop a critical understanding of advanced seismology and the range of techniques employed in this field
- Use principles of seismic instrumentation to select suitable equipment for various applications
- Understand the use and significance of GPS geodesy and InSAR in studying interseismic, coseismic and postseismic ground deformations
- Interpret various types of seismograms and to apply them in suitable fields
- Understand the relationship between prevailing tectonic activities and their impacts on rivers, landforms
- Asses the risk of earthquake, tsunami and their impacts in Bangladesh

5. Course content: (Total 60 Classes)

Section	No. of Classes
Section-1: General Seismology Lecture 1-2: History of seismology, its development and scope; branch of seismology Lecture 3-5: Seismograph, its principle & instrumental development including short period, long period & broad band seismometers Lecture 6-8: Installation of seismometers: permanent and portable, close aperture and wide aperture seismic network; strong motion accelerometer	8
Section-2: Earthquake basic Lecture 9-10: Elastic wave propagation, seismic ray theory, interpretation of travel times, finite frequency effects, and surface wave dispersion	14

Section	No. of Classes
Lecture 11-14: Seismic data processing, interpretation and archiving Lecture 15: Earthquake catalogue: global and local Lecture 16-18: Earthquake classification; global distribution of earthquakes; earthquake source parameters Lecture 19-22: Strain buildup and release mechanism; earthquake cycle; focal mechanism	
Section-3: Seismic data processing and analysis Lecture 23-27: Seismic data processing, analysis, interpretation and archiving Lecture 28-29: Earthquake catalogue: global and local	7
Section-4: Earthquake geology Lecture 30-31: Paleoseismology and its significance to earthquake recurrence study Lecture 32-33: Study of interseismic, coseismic & post seismic deformations using geomorphology, geodetic GPS and InSAR Lecture 34-36: Earthquake velocity and acceleration; effects of high and low frequency seismic waves to local geology and infrastructures; soil liquefactions and sand/mud eruptions Lecture 37-41: Subduction earthquakes: characterization of subduction zone based on seismicity pattern, coupling and decoupling mechanism, décollement and splay faults, global occurrences of subduction earthquakes and its effects on landforms and river course, slow slip earthquakes – case history from Cascadian subduction zone	12
Section-5: Earthquakes in Bangladesh Lecture 42-43: Concept of tectonics: neo-tectonics and active tectonics; monitoring active tectonic activities in Bangladesh Lecture 44-46: Active fault: seismic and aseismic; geodynamic setup of Bangladesh, potential sources of earthquakes in and around Bangladesh Lecture 47-52: Seismicity in Bangladesh and surroundings; case studies of historical earthquakes in and around Bangladesh and its effects on the landforms, river avulsions and society Lecture 53: Tsunami sources in Bay of Bengal and its impacts in Bangladesh	12

Section	No. of Classes
Section-6: Earthquake hazards and risk analysis Lecture 54: Historical development of earthquake zone map of Bangladesh and India Lecture 55-56: Concept of deterministic and probabilistic hazard map of Bangladesh Lecture 57-60: Assessment of seismic hazard, risk and vulnerability in Bangladesh; earthquake risk assessment and resilience	7

6. Instructional Strategies:

Lecture, Discussion, Question-Answer, Presentation

7. Assessment:

Summative (100%): Course Final Examination

8. Reading Materials:

1. Müller, J., and Torge, W. (2012) Geodesy (4th Edition). De Gruyter
2. Shearer, P.M. (2009) Introduction to Seismology (2nd Edition). Cambridge University Press.
3. Yeats, R.S; Sieh, K. and Allen, C.R. (1997): The Geology of Earthquakes. Oxford University Press.
4. Havskov, J. and Alguacil, G. (2016): Instrumentation in Earthquake Seismology (2nd Edition). Springer
5. Havskov, J. and Ottemollere, L. (2010): Routine Data Processing in Earthquake Seismology: With Sample Data, Exercises and Software. Springer.
6. Khan, A.A. (2010): Earthquake, Tsunami and Geology of Bangladesh. University Grants Commission of Bangladesh.
7. Kramer, S.T. (1996): Geotechnical Earthquake Engineering. Prentice Hall.
8. Scholoz, C.H. (2002): The Mechanics of Earthquakes and Faulting (2nd Edition). Cambridge University Press.
9. Stein, S. and Wysession, M.M. (2003) An Introduction to Seismology, Earthquakes, and Earth Structure.
10. Udías, A.; Madariaga, R. and Buforn, E. (2014): Source Mechanisms of Earthquakes: Theory and Practice. Cambridge University Press.
11. Vanicek, P. and Krakiwsky, E.J. (1987) Geodesy: The Concepts (2nd Edition). Elsevier Science.
12. Wiley-Blackwell.Hofmann-Wellenhof, B. and Moritz, H. (2006) Physical Geodesy (2nd Correction Edition). Springer.

1. Course Number and Title: GEOL605T Advanced Environmental Geology

2. Credit Hours/Unit: 4 credit hours/1 Unit

3. Course Description: This course is intended to introduce MPhil students to the interactions between human activities and natural systems, in terms of natural resources, environmental impacts, geological hazards and sustainable land use planning and management. The course will focus on both field and laboratory-based studies, data collection, analysis and mathematical modelling procedure in the field of environmental geology.

4. Learning outcomes: At the end of the course the learners will be able to -

- Identify burning environmental issues
- Assess the adverse environmental impact of various development projects
- Play leading rules in suitable site selections for development projects
- Conduct qualitative and quantitative examination of the application of geology to environmental problems including natural hazards and their remediation
- Formulate mathematical model to monitor and control various environmental problems
- Introduce environmental problems that were previously invisible and figure out possible solutions in both national and international level

5. Course content: (Total 60 Classes)

Section	No. of Classes
Section-1: Introduction to Environmental Geology: Lecture 1: The Earth System and Living with Earth Lecture 2: Origin of the Earth, Earth systems and its interaction – Lithosphere, atmosphere, hydrosphere and biosphere Lecture 3: Living with Earth, Earth Systems Lecture 4: Earth's Materials – Minerals and their definition Lecture 5: Distribution and abundance of elements in the Earth's crust Lecture 6: Formation and classification of Rocks; Soil characteristics, formation of soil erosion and conservation	6

Section	No. of Classes
Section-2: Urbanization and environment Lecture 7: Natural Resource Flows and Sustainability in Urban Areas Lecture 8: Land Subsidence in Urban Environment Lecture 9: Geochemical Modelling in Environmental and Geological Studies Lecture 10: Groundwater Salinity Due to Urban Growth Lecture 11: Fresh Water Geochemistry: Overview; Nutrients in Rivers and Lakes: Minor and Trace Elements Isotopes in Fresh Waters Lecture 12: Water treatment and Impact on Sustainability of Human Systems	6
Section-3: Geoengineering and Geoenvironment Lecture 13: Earthquake Faulting: Ground Motions and Deformations, Induced Seismicity Lecture 14: Dredging Practices and Environmental Considerations Lecture 15: Dam Engineering and Its Environmental Aspects; Construction Planning Lecture 16: Environmental Impact of Foundation Studies and Earthquake Issues Lecture 17-18: Infrared Thermographic Imaging in Geoengineering and Geoscience	6

Section	No. of Classes
Section-4: Mining and Environment Lecture 19: Mining and Its Environmental Impacts Lecture 20: Mine Wastes Characterization, Treatment and Environmental Impacts; Mine Water Inrush Lecture 21: Groundwater Impacts of Radioactive Wastes and Associated Environmental Modelling Assessment Lecture 22: River Sand Mining, Mining Methods and environmental impacts Lecture 23-24: Marine Life Associated with Offshore Drilling, pipelines and Platforms	6
Section-5: Energy and Environment Lecture 25: Perspectives on Energy Resources; Renewable Energy Conversion, Transmission and Storage; Life-cycle analysis of energy systems Lecture 26-27: Fundamentals of Energy Storage Lecture 28-29: Geologic Carbon Sequestration: Sustainability and Environmental Risk	5
Section-6: Climate change and Environment Lecture 30: Climate, climate forcing, climate sensitivity and transient climate change Lecture 31: Natural climate variations, Human caused forcing Lecture 32: Climate system models Lecture 33-35: Observed climate change during Industrial area and future climate change, assessing progress in climate science Lecture 36: Global temperature impacts and other climate impacts	7
Section -7: Environmental Impact and Sustainability Lecture 37: Assessing and Measuring Environmental Impact and Sustainability	7

Section	No. of Classes
Lecture 38: Sustainability Impact Assessment: concepts and approaches Lecture 39: Scenario modelling of land use changes Lecture 40: Sustainability Indicator framework, Regional and local evaluation; the meaning of value and use of economic valuation in the environmental policy decision making process Lecture 41: Ecosystem functions to the value of ecosystem services Lecture 42: Implementing an EMP, Strategic environmental assessment; The ISO 9000; The ISO 14000 Lecture 43: Integration of Environmental and Quality management System	
Section -8: Hydro-Meteorological Hazards, Risks, and Disasters Lecture 44-49: Flood Processes and Hazards, Measuring and Mapping Flood Processes Lecture 50-52: Vulnerability and Exposure in landslides Lecture 53-56: Integrated Risk Assessment of Water-Related Disasters and coastal processes Lecture 57-60: Drought Monitoring and Assessment: Remote Sensing and Modelling Approaches	17

6. Instructional Strategies:

Lecture, Discussion, Question-Answer, Presentation

7. Assessment:

Summative (100%): Course Final Examination

8. Reading Materials:

1. Sharma, K. (1982). *The State of India's Environment: The First Citizens' Report, 1982*. A. Agarwal, & R. Chopra (Eds.). Delhi: Centre for Science and Environment.
2. Betz Jr, F. (1975). Environmental Geology. Stroudsburg, Dowden. Hutchinson and Ross. *Inc.—1975.—390 p*.
3. Coates, D. R. *Environmental Geology*

4. Down, C. G., & Stocks, J. (1977). *Environmental impact of mining.*
5. Davis, S. N., Reitan, P. H., & Pestrong, R. (1976). Geology: Our physical environment.
6. Keller, E. A. (1979). Environmental Geology, Charles E. *MerrilPublishing Company*.
7. Valdiya, K. S. (1987). *Environmental geology, Indian context*. Tata McGraw-Hill Pub. Co.

1. Course Number and Title: GEOL606T Advanced Hydrogeology

2. Credit Hours/Unit: 4 credit hours/1 Unit

3. Course Description: The course covers theory relevant for advanced studies and research within the field of hydrogeology and groundwater resources. The goal of the course is to strengthen the knowledge base of students beyond introductory level by investigating the scientific research frontier regarding various themes of research in hydrogeology. The teaching focuses on a physical understanding of key processes in the hydrological cycle that control the state and movement of water in the subsurface. The knowledge that is the basis for addressing practical aspects such as: how to apply common and advanced techniques in hydrogeology, how to solve practical problems and which tools can be used in each case. Analytical and numerical models are applied and benchmarked software will be used to model groundwater flow and transport of solutes.

4. Learning outcomes: At the end of the course the learners will be able to –

- Equip themselves with discipline-specific knowledge and expertise appropriate for post-graduate research, discipline-specific knowledge and expertise enabling them to take their place as professional hydrogeologists in academia, industry or government organizations;
- Determine the distribution, movement and quality of groundwater using conventional and emerging approaches/technologies;
- Evaluate groundwater flow, storage, recharge and discharge, in the context of resource management, by applying appropriate tests;
- Assess chemical and isotopic factors affecting the composition and evolution of groundwater chemistry;
- Become independent users of existing software modelling groundwater;
- Apply knowledge obtained from the course to address problems of sustainable groundwater management.

5. Course content: (Total 55 Classes)

Section	No. of Classes
Section-1: Physical Hydrogeology Lecture 1-2: Groundwater Hydraulics Lecture 3-4: Quantitative Analysis of Hydrological Processes Lecture 5-6: Groundwater Flow Modelling Lecture 7-8: Contaminant Transport Modelling Lecture 9-10: Borehole Design, Construction and Maintenance	10
Section-2: Chemical Hydrogeology Lecture 11-13: Inorganic Chemistry and Groundwater Lecture 14-16: Groundwater Pollution and Remediation Lecture 17-18: Applications of Isotopes in Hydrogeology Lecture 19-20: Groundwater and Public Health	10
Section-3: Regional Hydrogeology Lecture 21-22 Bangladesh Lecture 23-25 Indo-Gangetic Basin Lecture 26-28 Major Aquifer Systems of the World	8
Section-4: Management of Groundwater (12 hours) Lecture 29-30: Human Impacts on Groundwater Lecture 31-33: Monitoring of Groundwater Lecture 34-35: Managed Aquifer Recharge Lecture 36-37: Groundwater Governance Lecture 38-40: Climate Change and Groundwater Lecture 41-43: Sustainable Management of Groundwater	12
Section-5: Assignments/presentations/discussions on all topics covered in lectures	Equivalent to 12 classes

6. Instructional Strategies:

Lecture, Assignment, Discussion, Presentation

7. Assessment:

Summative (100%): Course Final Examination

8. Reading Materials:

1. C.W. Fetter Jr., 2001. Applied Hydrogeology (4th Edition). Prentice-Hall, Inc.
2. Anderson, M.P. and Woessener, W.W.: Applied Groundwater Modelling, Scientific soft wave group, USA.
3. Driscoll, F. G., 1986. Groundwater and wells. Second Edition, Johnson Division. USA.
4. US Bureau of Reclamation, 1995. Groundwater Manual, 2nd Edition. US Bureau of Reclamation, Department of Interior.
5. G. P. Kruseman and N. A. De Ridder, 1994. Analysis and Evaluation of Pumping Test Data, 2nd Revised Edition 2nd Revised Edition. International Institute for Land Reclamation and Improvement, Wageningen, The Netherlands.
6. Garg, S. P. 1978. Groundwater and Tube Wells. Oxford and IBH Publishing Company, New Delhi.
7. Hassan, M.Q.,1992. Saline Water Intrusion and Hydrogeological Modelling in SW Bangladesh. Schelzky & Jeep, Berlin, Germany.
8. K. R. Karanth**,** 1987. Ground Water Assessment: Development and Management**.** Tata McGraw-Hill Education, New Delhi.
9. James W. Mercer and Charles R. Faust,1981. Groundwater Modelling, National Water Well Association, USA.
10. Rahman, A A and Ravenscroft, P, 2003. Groundwater Resources and Development in Bangladesh. Background to The Arsenic Crisis, Agriculture Potential and the Environment. The University Press Ltd, Dhaka.
11. UNDP 1982. Groundwater Survey: The Hydrogeological Conditions of Bangladesh. UNDP Technical Report DP/UN/BGD-74-009/1, 113p.
12. Walton, W.C. (1970): Groundwater Resource Evaluation, Mc-Graw-Hill Book Company.
13. W. D. Weight, 2008. Hydrogeology Field Manual, Second Edition, The McGraw-Hill Companies, Inc., ISBN**:** 9780071477499.

1. Course Number and Title: GEOL607T Advanced Exploration Geophysics

2. Credit Hours/Unit: 4 credit hours/1 Unit

3. Course Description: This course is designed for the MPhil students to explain the concepts and application of geophysical methods (Seismology, Gravity, Magnetic, Electric, and Electromagnetic) in subsurface exploration. It covers the principles and acquisition of the methods as well as processing, modelling, inversion, interpretation, and integration of the acquired data for oil, gas, and mineral exploration,

environmental, archaeological and engineering site investigation. This course will provide students with a broad theoretical background as well as the practical skills to develop their career in the geophysical arena.

4. **Learning Outcomes: At the end of the course, the learners will be able to -**

- Explain the theory and practice of gravity and magnetic methods, Earth's gravity and magnetic fields, instrumentation- survey design- and data acquisition techniques, processing and interpretation of gravity and magnetic data;
- Explain the principle and practice of Electromagnetic (MT, GPR, and CSEM) methods, the field procedures of EM survey, data acquisition and processing, modelling and inversion, application in subsurface interpretation, and geo-resources exploration;
- Explain the concept of the seismic method, the field procedures of seismic survey, data acquisition and processing, modelling and inversion, subsurface interpretation, seismic sequence stratigraphy, and hydrocarbon detection;
- Explain the principle of electrical methods (resistivity, SP, IP), electrode configurations and field procedures of electrical surveys, data processing, interpretation of resistivity data and their application in geo-resources exploration, geotechnical and environmental studies;
- Discuss the principles of wireline logging methods and their application in the identification of lithology, minerals, hydrocarbon, groundwater and subsurface interpretations;
- Discuss the basic principles of the radioactive method, radioactivity of rocks and minerals and measuring instruments, processing, and interpretation of radiometric data and
- Explain the logic behind the integration of geophysical data for the exploration of geo-resources and subsurface interpretation

5. **Course Contents (Total 60 Classes)**

Section	No. of Classes
Section-1: Gravity and Magnetic Methods Lecture 1-2: Principles of gravity and magnetic methods Lecture 3: Instruments Lecture 4-5: Survey design and data acquisition Lecture 6-7: Data corrections and calibration Lecture 8-9: Processing of gravity and magnetic data Lecture 10-11: Qualitative and quantitative interpretation Lecture 12: Anomaly maps and profile	12
Section-2: Electromagnetic Methods Lecture 13: Principles of EM methods Lecture 14-15: Types of EM methods& instrumentation Lecture 16-17: Survey design and EM data acquisition Lecture 18: Processing of EM data Lecture 19-20: Modelling and inversion of EM data Lecture 21-22: Interpretation of EM data	10
Section-3: Seismic Method Lecture 23-24: Principles of seismic method Lecture 25: Seismic instruments Lecture 26-28: Survey design and acquisition of seismic data Lecture 29-33: Processing of seismic data Lecture 34-36: Interpretation of seismic data Lecture 37: AVO/AVAanalysis of seismic data Lecture 38: Seismic inversion	16

Section	No. of Classes
Section-4: Electrical Methods Lecture 39: Principles of electrical methods Lecture 40: Instruments, survey design and data acquisition Lecture 41: Processing of electrical data Lecture 42-43: Resistivity profiling, mapping, and tomography Lecture 44: Interpretation of electrical data	6
Section-5: Wireline logs Lecture 45-46: Principles of wireline logging Lecture 47-48: Instruments of wireline logging Lecture 49-54: Application of wireline logs	10
Section-6: Radioactive Methods Lecture 55: Principles of radioactive methods Lecture 56: Instruments, survey design, and data acquisition Lecture 57: Processing of radioactive data Lecture 58: Interpretation of radioactive data	4
Section-7: Integration of geophysical data Lecture 59: Integration procedure Lecture 60: Data examples	2

6. Instructional Strategies:

Lecture, Discussion, Question-Answer, Presentation

7. Assessment:

Summative (100%): Course Final Examination

8. Reading Materials:

1. Paransis, D.S. (1997) Principles of Applied Geophysics (5th Edition). Chapman & Hall. Page 82 of 124.
2. Keller, G. V. & Frischnesht, F. C., (1966): Electrical methods in geophysical prospecting. Pergamon, Oxford.
3. Telford, W.M. et al. (1990) Applied Geophysics (2nd Edition). Cambridge University Press.
4. Hart, B (2012) Introduction to Seismic Interpretation (1st Edition). AAPG.
5. Reynolds, J.M. (2011) An introduction to Applied and Environmental Geophysics (2nd Edition). Wiley-Blackwell.
6. Brown, A (2011) Interpretation of Three-Dimensional Seismic Data (7th Edition). AAPG memoir 42.
7. M. Bacon, R. Simm, T. Redshaw (2007) 3D seismic interpretation (2nd edition). Cambridge.
8. Stacey, F.D. & Davis, P. (2008) Physics of the earth (4th Edition). Cambridge University Press.
9. Kearey, P., Brooks, M., & Hill, I. (2002) An introduction to geophysical exploration (3rd Edition). Wiley-Blackwell.
10. Sheriff, R.E. & Geldert, L.P. (1995) Exploration Seismology Vol. 1 & 2 (2nd Edition). Cambridge University Press.
11. Sharma, P. V. (1986) Geophysical methods in geology (2nd Edition). Elsevier Science Ltd.Howell, B.F. (1959) Introduction to Geophysics. McGraw-Hill.
12. Badley, M.E. (1988) Practical seismic interpretation. Publisher. Englewood Cliffs (N.J.), Prentice Hall, company.
13. McQuillin, R. Bacon, M & Barclay, W. (1985) An introduction to Seismic Interpretation. 2nd ed. 287 pp. Houston, London, Paris, Tokyo: Gulf Publishing Company.

1. Course Number and Title: GEOL608T Advanced Petroleum Geology

2. Credit Hours/Unit: 4 credit hours/1 Unit

3. Course Description: This course provides a working knowledge of the main qualitative and quantitative techniques used by petroleum geoscientists in finding and evaluating subsurface resources. Basic techniques utilised in geological and geophysical analyses of the subsurface are discussed.

The first part of this course will introduce the concepts and procedures of petroleum exploration, including the acquisition of acreage, play development and prospect assessment. Topics include geological and geophysical attributes of the various elements of a petroleum system: source rock potential, migration pathways, reservoir characterisation; identification and mapping of structural and stratigraphic traps from seismic data, prediction of trap integrity and volume estimation of hydrocarbon accumulations. The principles of sequence stratigraphy will be used to estimate the reservoir geometry and quality; determining occurrence of source rock and migration pathways; integration of technical data with economic principles and risk assessment in making exploration decisions, developing exploration strategies are the other key topics of discussion.

The second part will focus on the application of seismic and well log data and sequence stratigraphic understandings for simulating reservoir model and petroleum engineering. Topics of discussion include recovery factors in hydrocarbon reservoirs; capillary pressure principles as a basic concept for understanding vertical and lateral distribution of fluids in a reservoir; seal capacity and recovery efficiency; petrophysics in the oil field environment and scaling to appropriate earth models. Linking rock physics, well logs and borehole seismic data to extend borehole rock properties measurements to 3D seismic data volumes is another key component of this course. Other topics are seismic facies modelling, Geostatistical modelling, seismic amplitude interpretation, seismic inversion, AVO analysis, seismic attributes application, 4D seismic application and reservoir monitoring. Geological sequestration of CO_2 will also be discussed in this course.

4. Learning outcomes: At the end of the course, the learners will be able to –

- Understand the state-of-the-art methods and techniques in petroleum Geology
- Apply concepts from petroleum geology (petroleum systems elements, source rock and reservoir characterization, mass and energy transport in sedimentary basins, fluid flow systematics and in-reservoir alteration processes) to design and implement the critical phases of an exploration, appraisal and production strategy
- Learn details on how to begin evaluating a hydrocarbon play and developing a prospect
- Analyse exploration risk, prospect evaluation and production in the petroleum industry
- Apply sequence stratigraphic techniques for reservoir characterization
- Learn how to apply geophysical data and techniques for petroleum exploration, development and production
- Understand the process of reservoir model building and fluid flow in subsurface
- Illustrate basic principles of Carbon Capture and Storage (CCS) and how the principles of petroleum geology can be applied to geological sequestration of CO_2

5. Course content: (Total 60 Classes)

Section	**No. of Classes**
Section-1: Petroleum System elements Lecture 1-2: Source rock and its evaluation: total organic content, kerogen type and thermal maturity; spore coloration, vitrinite reflection, pyrolysis, chemical indicators of maturity Lecture 3-4: Petroleum migration and accumulation; traps and trapping mechanism; structural, stratigraphic and other types of traps Lecture 5-8: Reservoir rock - basic properties, factors controlling reservoir properties - primary depositional factors, secondary diagenetic factors, diagenesis and its implication on reservoir qualities, secondary porosity - type, recognition and origin; effect	**12**

Section	No. of Classes
of clay minerals on reservoir performances; reservoir geometry, heterogeneity, facies analysis for depositional environment Lecture 9-10: Subsurface reservoir conditions; overpressure - its occurrences and origin, implications of overpressure in petroleum drillings Lecture 11-12: Unconventional resources: concept, global distribution, potential of unconventional HC resources in Bangladesh	
Section-2: Petroleum Exploration Lecture 13-14: Petroleum exploration techniques; geophysical, geochemical, wireline logs etc. Lecture 15-16: Procedures of Petroleum Exploration - Land acreage - Play development - Prospect Assessment - Decision tree analysis - Lecture 17-20: Quantitative use of well logs in petroleum geology Lecture 21-22: Formation evaluation	**10**
Section-3: Sequence Stratigraphy and Subsurface Mapping Lecture 23-26: Sequence stratigraphic reservoir characterization - Sequence stratigraphic surfaces, models - Reservoir connectivity and geometry - Lecture 27-30: Subsurface mapping - Structural mapping - Thickness mapping - Hydrocarbon Pore Volume (HCPV) mapping	**8**
Section-4: Reservoir Modelling and Engineering Lecture 31-33: Facies modelling Lecture 34-35: Petrophysical modelling Lecture 36-38: Upscaling of well log properties Lecture 39-40: Static Earth Modelling Lecture 41-42: Fluid flow in reservoirs	**12**

Section	No. of Classes
Section-5: Reservoir Geophysics Lecture 43-44: AVO Lecture 45-46: Seismic Inversion Lecture 47-49: Seismic Amplitude Interpretation Lecture 50-52: Rock physics Lecture 53-54: 4DSeismic	**12**
Section-6: Reservoir Geophysics Lecture 55-57: Reservoir monitoring Lecture 58-60: Applications of petroleum geology related techniques in CO_2 sequestration	**6**

6. Instructional Strategies:

Lecture, Discussion, Question-Answer, Presentation

7. Assessment:

Summative (100%): Course Final Examination

8. Reading Materials:

1. Methods and Applications in Reservoir Geophysics by David H. Johnston, 2010, SEG
2. Development Geology Reference Manual by Morton-Thompson, D., and Woods, A.M., 1987, American Association of Petroleum Geologists.
3. Basin Analysis: Principles and Application to Petroleum Play Assessment by Allen, Philip & R., Allen, 2nd edition, 2013
4. Facies Models Revisited by Roger Walker, 2006, SEPM Special Publication 84. 1-17. 10.2110/pec.06.84.0001.
5. Principle of sequence stratigraphy by Catuneanu O., 1st edition, 2006. Elsevier.
6. Reservoir Model Design: A Practitioner's Guide by Ringrose P., and Bentley M., 2014. Springer.
7. Reservoir Geophysics by Sheriff, R., 1992, Investigations in Geophysics No. 7, SEG Principles of Sedimentary Basin Analysis by Miall A.D., 2000, Springer-Verlag.

8. Siliciclastic Sequence Stratigraphy—Concepts and Applications by Posamentier, H. W. and Allen G. P., 1999, SEPM Concepts in Sedimentology and Palaeontology #7, 204 p.
9. Sequence Stratigraphy by Emery, D., and Myers, K.F., 1996. Blackwell Science (Considering the uniformity of referencing style)

1. Course Number and Title: GEOL609T Advanced Quaternary Geology

2. Credit Hours/Unit: 4 credit hours/1 Unit

3. Course Description: The course is designed to make the students acquainted with the characteristics, climate change, glacial Geology, classical models, geological history, stratigraphy, structure, sedimentology 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 Geology of Bengal Basin.

4. Learning outcomes: At the end of the course the learners will be able to -

- Introduce themselves to the scope and general characteristics of the Quaternary Geology
- Explain Alpine, North American, Siwalik and other classical models
- Describe climate and sea-level changes, glacial and periglacial processes
- Compare and contrast between the Pleistocene and Holocene landscape evolution of the Bengal Basin
- Analyse the types of Quaternary sediments, stratigraphy and depositional environments
- Explain the concepts, criteria and implication of neotectonics activity to the Quaternary landform development in the Bengal Basin
- Explain paleomagnetic dating and Oxygen isotope analysis and their implications in stratigraphy
- Describe Soil profiles, Micromorphology and Paleosols in relation to climate and landform changes
- Analyse the impacts of Quaternary sea-level changes along the coasts of Bengal Basin

5. Course content: (Total 55 Classes)

Section	No. of Classes
Section-1: Introduction Lecture 1: Introduction to Quaternary Geology Lecture 2: Implication of Quaternary Environment Lecture 3: Scope of the subject	3
Section-2: Quaternary Glaciations Lecture 4-5: Extent and chronology: Ideas about Quaternary glaciations; Evidence of glaciations; Quaternary Cryosphere reconstruction Lecture 6-7: Causes and the feedback mechanism of the glacial and deglacial episodes; The mechanism of atmospheric CO2 change; Methane and its role in glacial cycles; the role of the tropics and the tropical climate change Lecture 8-9: The Milankovitch Hypothesis and Quaternary Environment	6
Section-3: Quaternary Sea-level Changes Lecture 10-11: Nature, description and causes of sea-level fluctuation: Quaternary sea levels; the Holocene transgression; recent and historic changes in sea level. Implications of sea level changes in the Bengal delta Lecture12-13: Evidence from the ocean: Microfossils, palaeo-chemistry, pollen and coral as records of environmental change Lecture14-15: Quaternary rivers, lakes and groundwater; factors influencing Quaternary riverine environmental changes; features of Quaternary lakes Lecture 16-17: Quaternary deserts: Causes of aridity and distributions of deserts; glacial and interglacial desert environment; the loess of China	8
Section-4: Quaternary plate tectonics Lecture 18-19: Effects of Plate Tectonics on the Quaternary landforms, oceans and atmosphere	8

Section	No. of Classes
Lecture 20-21: Onset of Ice Age in the Quaternary; The nature and possible causes of the Quaternary instability Lecture 22-23: Criteria for Neotectonics studies Lecture 24-25: Neotectonics activity in the Bengal Basin and Implications of neotectonics on Quaternary landform development, upliftment and subsidence of landforms, river shifting, evolution of Bengal delta, change in relief and soil morphology	
Section-5: Quaternary Geology of Bengal Basin Lecture 26-27: Quaternary depositional and erosional history of the Bengal Basin Lecture 28-29: Upper Pleistocene monsoon climate Lecture 30-31: Mid- Holocene sea-level rise, Holocene sea-level changes along Maheshkhali, Cox's Bazar Coast Lecture 32-33: Quaternary Stratigraphy of Holocene Floodplains, Barind, Madhupur and Lalmai areas	8
Section-6: Quaternary Life Forms-Part A Lecture 34-35: Quaternary Terrestrial flora and fauna Lecture 36-37: Quaternary palynomorphs and fossil database Lecture 38-39: The late Tertiary/ Quaternary transition; glacial/interglacial cycles Lecture 40-41: The development of the present vegetation pattern: Biome Models	8
Section-7: Quaternary Life Forms-Part B Lecture 42-43: Human origin, innovations and migrations: From Homo erectus to Homo sapiens; Stone Age Lecture 44-45: Pleistocene faunal extinctions Lecture 46-47: Neolithic plant and animal domestication	6

Section	No. of Classes
Section-8: Quaternary Atmosphere and Environment Lecture 48-49: Atmospheric circulation during the Quaternary: Present day circulation pattern; Global palaeohydrology and links between oceanic and atmospheric circulation Lecture 50-51: Environmental Changes- Past, Present and Future Lecture 52-53: The human population in the context of Late Quaternary; Biota in the Quaternary; Drought, Overgrazing, Desertification, Irrigation and Salinization Lecture 54-55: Human effects on the atmosphere; Future actions	8

6. Instructional Strategies:

Lecture, Discussion, Question-Answer, Presentation

7. Assessment:

Summative (100%): Course Final Examination

8. Reading Materials:

1. Bennet, K.D. (1997). *Evolution and Ecology: The pace of life*. Cambridge University Press, Cambridge.

2. Birks, H.J.B. and Rivks, H.H. (1981). *Quaternary Palaeoecology*. Edward Arnold, London.

3. Ho, S. and Yasuda, Y. (1995). *Nature and Humankind in the Age of Environmental Crisis*. International Research Centre for Japanese studies, Kyoto.

4. Millinan, J.D. and Haq, B.U. (1996). *Sea level rise and Coastal Subsidence*.

5. Williams, M., Dunkerley, D., De Deckker P., Kershaw P., and Chappell J. (1998). *Quaternary Environment* (second edition). Arnold, London.

1. Course Number and Title: GEOL610T Advanced Economic Geology

2. Credit Hours/Unit: 4 credit hours/1 Unit

3. Course Description: The objective of the course is to introduce the fundamentals of Economic Geology. It will acquaint the learners with the various processes and principals involved for the formation of different metallic and non-metallic mineral deposits and their uses in the industries for the benefits of mankind. The course is designed for understanding localization, classification, genesis, conservation, mining, beneficiation and economic implications of ore deposits that are needed for the progress and prosperity of any country. The course includes the development of scientific knowledge on the uses of economic minerals in the construction of many infrastructures like roads, buildings, skyscrapers, bridges, ports etc. The course will also impart knowledge on the importance of fossil fuels in transportation and power sectors which cannot run for a single day without their uses.

4. Learning outcomes: At the end of the course the learners will be able to -

- Introduce themselves to the scope and significance of mineral resources.
- Describe the various processes, occurrences, stratigraphy, reserves and localization of mineral deposits.
- Explain the origin, localization, reserves, petrography, uses and detrimental effects of coal.
- Understand the utilization, conservation, mineral economics and worldwide distribution of mineral deposits.
- Realize the importance of mineral resources in modern society,

5. Course content: (Total 60 Classes)

Section	No. of Classes
Section-1: Introduction Lecture 1-2: Processes of formation and classification of mineral deposits Lecture 3-4: Plate tectonic control on the distribution of ores Lecture 5-6: Major theories of ore genesis Lecture 7-8: Morphology, texture and structure of ore deposits	8

Section	No. of Classes
Section-2: Formation of mineral deposits through fluid exchange Lecture 9-10: Migration of fluids and deposition of economic minerals Lecture 11-12: Fluid inclusions in ores, geo-thermometry, geobarometry, paragenetic sequences Lecture13-14: Zoning and dating of ore deposits Lecture 15-16: Microscopic study of ores and coal	8
Section-3: Formation of mineral deposits through magmatic and crystallization processes Lecture 17-18: Crystallization of magma and resultant ore deposits Lecture 19-20: Hydrothermal deposits Lecture21-22: Deposition of manganese and iron ores Lecture 23-24: Mechanical and chemical weathering and resultant mineral deposits	8
Section -4: Mineral resources Lecture 25-26: Mineral resources of ocean basins Lecture 27-28: Various controls of ore localization Lecture 29-30: Metallogenetic Epochs and Provinces	6
Section-5: Coal as a natural resource Lecture 31-33: Origin, occurrence, classification, properties and petrography of coal, gasification and liquefaction of coal Lecture 34-35: Economics and environmental impacts of coal utilization Lecture 36: Coal resources of major countries of the world	6

Section	No. of Classes
Section-6: Exploration of economic mineral deposits Lecture 37-38: The design of exploration programmes Lecture 39-40: Methods of estimation of reserves Lecture 41-42: Geological, geophysical and geochemical exploration Lecture 43-44: Mineral economics and mineral processing	8
Section-7: Environmental impacts of mineral exploration Lecture 45-46: Environmental impacts of mining Lecture 47-48: Detrimental effects of fossil fuels and greenhouse gases	4
Section-8: Geography and uses of mineral deposits Lecture 49-50: Worldwide distribution of important mineral deposits Lecture 51- 52: Worldwide uses of iron ore, bauxite, gold, diamond and placer deposits Lecture 53-54: Worldwide uses of energy resources	6
Section-9: Renewable energy: A new horizon Lecture 55-56: Importance of renewable energy Lecture 57-58: Development of renewable energy resources and Lecture59-60: Adoption strategies to get rid of fossil fuels in the future	6

6. Instructional Strategies:

Lecture, Discussion, Question-Answer, Presentation

7. Assessment:

Summative (100%): Course Final Examination

8. Reading Materials:

1. Beyschlag, F. H. A. (1916). *The deposits of the useful minerals and rocks: their origin, form and content* (Vol. 2). Macmillan and Co.
2. Edwards, R. (2012). *Ore deposit geology and its influence on mineral exploration*. Springer Science & Business Media.
3. Evans, A. M. (2009). *An introduction to economic geology and its environmental impact*. John Wiley & Sons.
4. Gokhale, K. V. G. K., & Rao, T. C. (1978). *Ore deposits of India: their distribution and processing*. Thomson Press (India).
5. Hurlbut, C. S. (1968). *Minerals and man*. Random House.
6. Guilbert, J. M., & Park Jr, C. F. (2007). *The geology of ore deposits*. Waveland Press.
7. Kent, P. (1980). Minerals from the marine environment.
8. Lindgren, W. (1913). *Mineral deposits*. McGraw-Hill Book Company, Incorporated.
9. Rahmani, R. A., & Flores, R. M. (Eds.). (2009). *Sedimentology of coal and coal-bearing sequences*. John Wiley & Sons.
10. Sinha, R. K., & Sharma, N. L. (1988). *Mineral economics*. Oxford & IBH Publishing Company.
11. Shackleton, W. G. (2020). *Economic and applied geology: an introduction* (Vol. 6). Routledge.
12. Smirnov, V. I., & Beus, A. A. (Eds.). (1983). *Studies of mineral deposits*. Mir publishers.

1. Course Number and Title: GEOL611T Applied Micropaleontology

2. Credit Hours/Unit: 4 credit hours/1 Unit

3. Course Description:

This course is intended to introduce MPhil students to the major marine microfossil groups, terrestrial pollen and spore communities; their implication on reconstructing Paleoclimate and sea level fluctuation, revealing depositional history and monitoring geo-environmental changes. The course will focus on applying advanced analytical, instrumental, microscopic and field technique in the field of micropaleontology.

4. Learning outcomes: At the end of the course the learners will be able to -

- Introduce the scope and general characteristics of the Quaternary periods
- Explain classical models like Alpine, North American, Siwalik etc.
- Describe climatic and sea-level change, glacial and periglacial geology.
- Compare and contrast between the Pleistocene and Holocene geological history of the Bengal basin
- Analyse the types of Quaternary sediments, landforms, stratigraphy and depositional environment of the Bengal basin.
- Explain the concepts, criteria and implication of neotectonics activity to the Quaternary landform development
- Explain the principal paleo-magnetic dating and Oxygen isotope analysis and their implications in Stratigraphy
- Describe the soil profiles and Paleosols with emphasis on their micromorphology
- Analyse the impacts of Pleistocene-Holocene sea level changes along the coast of Bengal Basin

5. Course content: (Total 60 Classes)

Section	Number of Classes
Section-1: Basic considerations Lecture 1-2: Introduction to microfossils Lecture 3-4: Major developments of ecological studies over the past decade	8

Lecture 5-6: Taxonomy and shell construction in modern calcareous Foraminifera Lecture7-8: Quantitative methods of data analysis in foraminiferal ecology	
Section-2: Features of Distribution Lecture 9-10: Biogeography of benthic and planktonic Foraminifera Lecture 11-12: Foraminiferal microhabitats in marginal marine environments Lecture 13-14: Foraminiferal microhabitats below the sediment-water interface Lecture 15-16: Benthic Foraminifera and the flux of organic carbon to the seabed Lecture 17-18: Effects of marine pollution on Foraminifera	10
Section-3: Geochemistry of shells Lecture 19-20: Stable oxygen and carbon isotopes in foraminiferal shells Lecture 21-22: Stable carbon isotopes in foraminiferal shells Lecture 23-24: Trace elements in foraminiferal shells	6
Section-4: Preservation of records Lecture 25-26: Taphonomy and temporal resolution of foraminiferal assemblages Lecture 27-28: Life processes influencing the contribution of tests to the sediment Lecture 29-30: Characteristics microhabitats of warm and cool-temperate carbonate shelf environments	6
Section-5: Paleoenvironmental interpretation Lecture 31-32: Basic principles and implication of paleoenvironmental, paleoclimatic and palaeoceanographic interpretation	6

Lecture 33-24: Microfossils as natural proxies of paleoenvironmental interpretation Lecture 35-36: Paleoenvironmental interpretation and associated modern visualization technologies	
Section-6: The Application of Microfossils to Environmental Geology Lecture 37-38: Importance of monitoring environmental change Lecture 39-40: Foraminifera as indicators of environmental pollution Lecture 41-42: Ostracoda in detection of sewage Discharge and river Pollution Lecture 43-44: Ostracoda as Indicators of Conditions and Dynamics of Water Ecosystems	8
Section-7: Application of Micropaleontology to hydrocarbon exploration Lecture 45-46: Applications in petroleum exploration Lecture 47-48; Applications in reservoir exploitation Lecture 49-50: Applications in well-site operations Lecture 51-52: Unconventional petroleum geology	8
Section-8: Palynofacies analysis Lecture 53-54: Introduction to palynofacies analysis Lecture 55-56: Implication of palynofacies in hydrocarbon exploration Lecture 57-58: Implication of palynofacies in Paleoenvironmental analysis Lecture 59-60: Interpretation and diagrammatic representation of palynofacies data	8

6. Instructional Strategies:

Lecture, Discussion, Question-Answer, Presentation

7. Assessment:

Summative (100%): Course Final Examination

8. Reading Materials:

1. Armstrong, H. & Brasier, M. (2005). *Microfossils*. Wiley. Shukla,
2. Cushman, J.A. (2013). *Foraminifera: Their Classification and Economic Use*, 4th Revised and Enlarged Edition. Harvard University Press.
3. Bignott, G. (1985). *Elements of Micropaleontology*. Springer Science & Business Media.
4. Brasier, M.D. (1980). *Microfossils*. Chapman & Hall.
5. 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. Pokomy,
6. V. (1963). *Principles of Zoological Micropaleontology* (Vol 1 & 2). University of California. Markhovan, F.P. C.M.V. (1962). *Post Paleozoic Ostracods* (Vol 1 & 2). Elsevier.

1. Course Number and Title: GEOL612T Research Methods in Geosciences

2. Credit Hours/Unit: 4 credit hours/1 Unit

3. Course Description: This course is intended to introduce MPhil students to the processes of scientific research and the design of research projects as applied to modern earth science. The course will focus on both field and laboratory-based studies, data collection, analysis, and mathematical modelling procedure in geosciences.

4. Learning outcomes: At the end of the course the learners will be able to -

- Discuss the scientific method, including hypothesis testing, as applied to modern earth science research
- Identify and avoid unethical issues in doing research
- Conduct literature searches
- Design a scientific research project
- Collect samples and analyse sample data
- Formulate mathematical model and solve it numerically
- Write scripts in R/Matlab for statistical data analysis and model simulation.

5. Course content: (Total 60 Classes)

Section	No. of Classes
Section-1: Introduction to research and research methods Lecture 1-3: Research basics: research design and research theory Lecture 4-5: Formulation of research hypothesis Lecture 6-7: Research Ethics Lecture 8-10: Procedure for literature review	10
Section-2: Field procedure in geosciences Lecture 11-13: Field procedure for geological mapping Lecture 14-16: Hydrogeological and environmental field data collection Lecture 17-19: Geophysical field data collection	9
Section-3: Basics of data and data collection Lecture 20-22: Basics of data Lecture 23-25: Collection and validation of secondary data Lecture 26-30: Collection of primary data (sampling methods and experimental design)	11
Section-4: Qualitative and quantitative data analysis Lecture 31-38: Introduction to common statistical methods including univariate, bivariate and multivariate analysis Lecture 39-45: Basics of spatial data and spatial interpolation Lecture 46-47: Qualitative data analysis	17
Section-5: Introduction to mathematical modelling in geosciences using example datasets in R/Matlab Lecture 48-51: Basics of R/Matlab Lecture 52-56: Basics of analytical and numerical methods (finite difference and finite element methods) Lecture 57-60: Application of analytical and numerical models in geosciences (using example dataset and/or student's research dataset)	13

6. Instructional Strategies:

Lecture, Discussion, Question-Answer, Presentation

7. Assessment:

Summative (100%): Course Final Examination

8. Reading Materials:

1. Walliman, N. (2011) Research Methods - The Basics. Routledge
2. Mann, P. S. (2013). Introductory statistics (8th Edition). John Wiley & Sons
3. Pelletier, J. D. (2008). Quantitative modelling of earth surface processes. Cambridge University Press.
4. Hijmans, R. J. (2020) Spatial Data Science with R. https://rspatial.org/index.html#
5. Kothari, C R (2004) Research Methodology: Methods and Techniques (2nd Edition). New Age International
6. Yau, C. (nd) R Tutorial with Bayesian Statistics Using Stan. http://www.r-tutor.com/content/r-tutorial-ebook