CURRICULUM

Master of Science

Degree in Geology

(With specialisation in different branches of geoscience)

For Academic Sessions
2020-2021, 2021-2022 and 2022-2023

DEPARTMENT OF GEOLOGY
FACULTY OF EARTH AND ENVIRONMENTAL SCIENCES
UNIVERSITY OF DHAKA
DHAKA-1000
BANGLADESH

PROLOGUE

This is a great pleasure for me to write this prologue for the curriculum of the Master of Science (MS) programme in Geology under the Faculty of Earth and Environmental Sciences, University of Dhaka for the academic sessions 2020-2021, 2021-2022 and 2022-2023.

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

The MS 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. The curriculum is designed keeping the need and current research trends in mind. 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 MS programme aims to provide updated knowledge in the applied and specialised fields of Geology and to train students in carrying out research/project work. I believe that combination of theoretical courses, laboratory courses and individual research/project work under the programme will make the students competent for the job market and enable them to contribute to the field of knowledge and research in geosciences.

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

Dr. M. Aziz Hasan
Professor and Chairman

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Department of Geology

Faculty of Earth and Environmental Sciences
University of Dhaka

MS Degree in Geology (with specialisation in different branches of geoscience)

1. Title of the Programme: Master of Science in Geology (with specialisation in different branches)

2. Duration of the Programme: One (1) Academic Session

3. Eligibility for Admission: BS (Honours) degree in Geology from Department of Geology, University of Dhaka

4. Objectives of the Programme:
The major objectives of this MS programme with specialisation in different fields of Geology are to -

- provide advanced and applied knowledge and skills in geosciences;
- provide practical training to be engaged in the profession of geological mapping, surveying, exploration, extraction/production and management of the country's natural and mineral resources;
- train for identification and mitigation of geohazards;
- make familiar with the modelling and other software in different field of geosciences.

5. Degree Requirements:

- There will be two groups in MS in Geology: ***(i) General Group (Group-A)*** and ***(ii) Thesis Group (Group-B)***. Both groups shall have to complete 33 credit hours. There will be compulsory courses of 18 credit hours comprising four theory courses, one lab course, and a viva voce. The remaining 15 credit hours will comprise 03 theory courses, 01 lab course, and project work for Group-A, and 03 theory courses and thesis work for Group-B of the optional specialised branches. All the theory and lab courses, and project work will be of 03 credit hours and the thesis work will be of 06 credit hours.
- Obtaining of minimum grade point average (GPA) of 2.5 on a scale of 4.0 without any F grade in any of the courses.
- Completion of all requirements of the degree within 3 (three) academic years from first enrolment/admission.

6. Academic Session:
Under the Letter-Grading System, the MS Degree in Geology with specialisation in different branches at the University of Dhaka is a programme of one academic session corresponding to 12 calendar months/52 calendar weeks i.e., 22 weeks for teaching; 4 weeks for preparation prior course final examination; 6 weeks for course final examination; 12 weeks for submission and presentation of project work (after completion of course final examination) –

for Group A; 12 weeks for submission and defence of thesis (after completion of course final examination) – for Group B; and 8 weeks of vacation and holidays.

7. Contact Hours:

There will be 45 hours of classroom teaching for each 3 credit hour theory courses and 90 hours laboratory work including assignments for each 3 credit hour laboratory courses.

Assessment and Evaluation of the Courses

1. Distribution of Marks and Evaluation System

1.1 Distribution of marks for 3 credit hour theory courses:

Continuous assessment (30%)	
Attendance	10
In-course examination/Assignment	20
Course final examination (70%)	70
Total	100

1.2 Distribution of marks for 3 credit hour laboratory courses:

Continuous assessment (40%)	
Attendance	10
Class performance and lab assignment/report	30
Practical examination (60%)	60
Total	100

1.3 Distribution of marks for 3 credit hour Project/Geological Field Mapping course for Group-A:

Project report (60%)	60
Project presentation (40%)	40
Total	100

1.4 Distribution of marks for 6 credit hour Thesis course for Group-B:

Thesis/Dissertation (60%)	120
Thesis defence (40%)	80
Total	200

1.5 Awarding marks for attendance in a theory/lab course:

Attendance (%)	Percentage Total Marks (%)
95-100	10
90-94	9
85-89	8
80-84	7
75-79	6
70-74	5
65-69	4
60-64	3
< 60	0

1.6 The duration of each in-course examination is 50 minutes. The nature of the test items will be determined by the course instructor. The instructor will conduct at least one in-course examination. Additionally, assignments can be evaluated by the instructor as part of the continuous assessment. Moreover, the instructor may take more in-courses than specified without increasing ratio of marks.

1.7 The academic committee will appoint a course coordinator at the beginning of the academic session.

1.8 An examination committee will be formed for the course final examination by the departmental academic committee. The examination committee will be consisted of 4 (four) members including a chairperson, two internal members from the department and one external member from outside the department.

1.9 The duration of course final examination is 3 hours for each three credit-hour theory course and 4 hours for three credit-hour lab course.

1.10 Question paper of the course final examination for the theory courses will include a total of 7 (seven) sets of questions, each set carrying equal marks. Students can choose to answer a maximum of any 5 (five) sets (either partial or full set) out of the seven. Each set of the question should include at least two questions but no more than 4 questions. If a student answer more than 5 (five) sets (either partial or full set) of question, the last set answered will not be considered for evaluation. The questions in the course final examination should cover all the categories of cognitive domain, including a few items which requires thinking.

1.11 For each theory course, the exam committee will appoint two separate question setters' usually among the course instructors. In case of a single instructor for a course, the exam committee may appoint any faculty from the department as the second question setter.

1.12 The examination committee will set up the final question paper based on the two question papers from the two examiners. However, the exam committee may add or drop any questions or modify any questions set by the examiners. During the moderation the exam committee will ensure the following-

a) Questions covering topics of the course content;
b) Questions fulfil the conditions as mentioned in sections 1.9 and 1.10.

1.13 Answer scripts of the in-course examination will be evaluated by the respective course instructor.

1.14 Answer script for the course final examination will be evaluated separately by two examiners, usually the question setters. In case, any of the question setter is unable to examine the answer script the exam committee can appoint any faulty from the department as the answer script examiner.

1.15 During the tabulation process if the difference between the marks of course final examination from the two examiners for a course be more than 20%, the answer script will be

evaluated by a third examiner appointed by the exam committee. Average of the nearest two marks will be considered as final score.

1.16 For laboratory courses, the course instructor(s) will set the questions/lab exam items and evaluate the answer scripts of practical examination preferably in the presence of the external member of the examination committee.

1.17 For the research or project works, a supervisor from the respective specialised branches of the department will provide advice and guidance throughout the research/project works until the thesis/project report submission.

1.18 The Viva-Voce will be conducted by the examination committee on completion of all theory and lab courses. In the viva voce, the committee members will assess the student's knowledge in geology based on the courses completed during the MS programme.

2. The Grading System:

2.1 Credit Hours (CH): Each three credit-hour course will be evaluated on a numerical scale of 100 marks. Total marks obtained by a student in a particular course will be converted to letter grade & grade points using the following conversion table in 2.2.

2.2 Letter Grade (LG) and Grade Point (GP): Letter Grades, corresponding Grade Points will be assigned in accordance with marks obtained in a course as shown below:

Marks Obtained (%)	Letter Grade	Grade Point
80-100	A+	4.00
75-79	A	3.75
70-74	A-	3.50
65-69	B+	3.25
60-64	B	3.00
55-59	B-	2.75
50-54	C+	2.50
45-49	C	2.25
40-44	D	2.00
<40	F	0.00
	I	Incomplete
	W	Withdrawn

2.3 Grade Point Average (GPA): The weighted average of the grade points obtained in all the courses in an academic session by a student shall be calculated from the following equations:

$$GPA = \frac{\sum_{i=1}^{N} GP_i \times CH_i}{\sum_{i=1}^{N} CH_i}$$

Where GP_i = grade point obtained in individual courses, CH_i = credit-hours for respective courses. GPA will be rounded off up to 2 (two) places after decimal as in the following example. GPA = 2.112 shall be rounded off as GPA = 2.11 and GPA = 2.115 will be rounded off as 2.12.

3. Examinations:

3.1 General Outline:

The MS Examinations will consist of course final examination based on the taught theory courses at the end of the academic session followed by lab course examinations, viva-voce, and a final thesis/dissertation submission and defence or final project report submission and presentation.

3.2 Eligibility for Appearing in Examinations:

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

% of Class Attendance	**Category**	**Eligibility**
75% and above	Collegiate	Eligible
<75 to 60%	Non-collegiate	Eligible with payment of penalty fee
<60%	Dis-collegiate	Not eligible

4. Publication of Results:

Results will be prepared by the respective Examination Committee at the end of examinations showing the obtained GPA. The transcript will show the course number, course title, credit-hour, letter-grade and grade points of individual courses, and GPA obtained in the final examination.

4.1 Award of Degree

The Degree of Master of Science in Geology (with specialisation) will be awarded on the basis of GPA obtained by a candidate. In order to qualify for the degree, a candidate must obtain:

i) A minimum GPA of 2.50, and

ii) A minimum GP of 2.00 in all courses.

Result of the students with letter grade "F" in any course will remain incomplete (I) and the degree will be awarded after improving the grade.

Distribution of Courses

Distribution of credit-hours is given below:

Course distribution	General Group (Group-A) Credit Hours	Thesis Group (Group-B) Credit Hours
Compulsory courses:		
Four theory courses	12	12
One lab course	03	03
A viva voce	03	03
Courses from optional specialised branch:		
Three theory courses	09	09
One lab course	03	NA
Project/Geological Field Mapping	03	NA
Thesis	NA	06
Total Credit Hours	**33**	**33**

Distribution of compulsory and optional specialised courses is given below:

Course Number	Course Name	Credit Hours
Compulsory courses:		
GMT 501	Sequence Stratigraphy	3
GMT 502	Exploration Geology	3
GMT 503	Delta Processes and Management	3
GMT 504	Computational Geology	3
GML 505	Computational Geology Lab	3
GMV 506	Viva Voce	3
Courses from optional specialised branches:		
Applied Geophysics (AG)		
GMT 507 AG	Geophysical Data Processing and Inversion	3
GMT 508 AG	Environmental and Engineering Geophysics	3
GMT 509 AG	Geophysical Data Interpretation	3
GML 510 AG	Geophysical Prospecting Lab	3
GMP 511 AG	Project/Geological Field Mapping	3
GMR 512 AG	Supervised Individual Research/Thesis	6
Environmental Geology and Geohazards (EG)		
GMT 507 EG	Environmental Geology and Natural Hazards	3
GMT 508 EG	Disaster Risk Reduction	3
GMT 509 EG	Environmental Impact Assessment and Auditing	3
GML 510 EG	Environmental Geology and Geohazards Lab	3
GMP 511 EG	Project/Geological Field Mapping	3

GMR 512 EG	Supervised Individual Research/Thesis	6
Geoinformatics (GI)		
GMT 507 GI	Spatial Data Science	3
GMT 508 GI	Photogrammetry and Advanced Remote Sensing	3
GMT 509 GI	Application of Geoinformatics in Geosciences	3
GML 510 GI	Geoinformatics Lab	3
GMP 511 GI	Project/Geological Field Mapping	3
GMR 512 GI	Supervised Individual Research/Thesis	6
Hydrogeology and Water Resources Management (HG)		
GMT 507 HG	Water Resources Planning and Management	3
GMT 508 HG	Hydrochemistry and Contamination of Groundwater	3
GMT 509 HG	Groundwater Resource Evaluation and Modelling	3
GML 510 HG	Field and Laboratory Techniques in Hydrogeology	3
GMP 511 HG	Project/Geological Field Mapping	3
GMR 512 HG	Supervised Individual Research/Thesis	6
Mining Geology (MG)		
GMT 507 MG	Mine Planning and Design	3
GMT 508 MG	Mine Operations	3
GMT 509 MG	Mine Safety Management	3
GML 510 MG	Mining Geology Lab	3
GMP 511 MG	Project/Geological Field Mapping	3
GMR 512 MG	Supervised Individual Research/Thesis	6
Paleogeoscience and Biostratigraphy (PB)		
GMT 507 PB	Environmental Micropaleontology	3
GMT 508 PB	Biostratigraphy and Paleoenvironment Reconstruction	3
GMT 509 PB	Applied and Industrial Micropalaeontology	3
GML 510 PB	Micropaleontology and Biostratigraphy Lab	3
GMP 511 PB	Project/Geological Field Mapping	3
GMR 512 PB	Supervised Individual Research/Thesis	6
Petroleum Geoscience and Engineering (PG)		
GMT 507 PG	Basin Analysis and Reservoir Geology	3
GMT 508 PG	Petroleum Exploration Techniques	3
GMT 509 PG	Petroleum Engineering	3
GML 510 PG	Subsurface Characterisation and Reservoir Modelling Lab	3
GMP 511 PG	Project/Geological Field Mapping	3
GMR 512 PG	Supervised Individual Research/Thesis	6
*[Note: The courses are denoted by three-letter code as **GMT** for Geology Masters Theory; **GHL** for Geology Masters Lab/practical; **GHV** for Geology Masters Viva voce; **GMP** for Geology Masters Project; and **GMR** for Geology Masters Research/Thesis followed by a three-digit number in Arabic numeral along with the short form of specialised branches.* *Both **Group A** - General Group and **Group B** - Thesis Group will complete total 33 credit hours.]*		

Course Details

Compulsory Courses:

1. Course Number and Title: GMT 501 - Sequence Stratigraphy

2. Credit Hours: 3

3. Course Description: The goal of this course is to introduce the basic principles in sequence stratigraphy and show how these principles can be applied to better understand how the sedimentary successions are structured in a temporal-spatial perspective. The course will discuss the basic concepts of surfaces, systems tracts, parasequence, sequence sets and stratigraphic hierarchy, and their definitions. All these concepts will be explained with field examples from seismic, well-log, core, and outcrop data of fluvial, shallow marine, and deep marine depositional settings. In-class exercises will emphasize on the recognition of sequence stratigraphic surfaces and systems tracts on well-log cross-sections, seismic lines, and outcrop profiles. The points of agreement and difference between the various sequence stratigraphic approaches (models) will be discussed, and guidelines for a standardized process-based workflow of sequence stratigraphic analysis will be provided. This will enable students to apply sequence stratigraphy effectively for facies predictions in exploration and production.

4. Learning outcomes: On completion of the course the learners will be able to –

- understand the basic concepts and methods in sequence stratigraphy
- explain the formation of key discontinuity surfaces and break down sedimentary successions into sequences
- understand the processes behind, and the effects of tectonics, climate, sediment supply and sea-level changes on the routing of sediments from source to sink and the build-up of stratigraphic successions
- use the concept of facies, facies stacking and shoreline trajectory to define parasequences, surfaces, and systems tracts
- describe and analyse a sedimentary succession with focus on interpretation of internal and external controls, sedimentary environments and sequence stratigraphy
- identify genetically related units and their intervening discontinuity surfaces
- use the method of sequence stratigraphy to define play, prospects and predict play elements presence and quality in seismic data
- use the above knowledge and skills in practical works related to reservoir characterization and basin fill evaluation for petroleum, CO_2 repositories, aquifers etc.

5. Course content:

Unit/Chapter	No. of Lectures
Unit 1: Sequence stratigraphy - concept, historical development, order and duration, application and significance	3
Unit 2: Fundamentals of Sequence Stratigraphy: eustatic sea level changes, allogenic controls on sedimentation, base level, fluvial graded profiles, sediment supply, accommodation space, shoreline trajectories (transgression, forced regression, normal regression)	5

Unit 3: Depositional sequence, Genetic stratigraphic sequences, Transgressive-Regressive sequences, Parasequences, Sequence architecture	5
Unit 4: Sequence Stratigraphic Surfaces: Subaerial Unconformity (SB); Correlative Conformity (CC); Basal Surface of Forced Regression; Regressive Surface of Marine Erosion; Maximum Regressive Surface; Flooding surface (FS)/ Transgressive Surface (TS); Maximum flooding surface (MFS); Marine flooding surface; Transgressive Ravinement surface; Tidal and Wave Ravinement surface	7
Unit 5: Systems tracts: Definition, stacking pattern, economic potential, and petroleum plays; Highstand Systems Tract (HST); Falling Stage Systems Tract (FSST); Lowstand systems tract (LST); Transgressive systems tract (TST)	6
Unit 6: Recognition criteria for the identification of sequence stratigraphic surfaces, depositional sequences, systems tracts, and parasequences in Outcrops, Cores, Well Logs, and Seismic	7
Unit 7: Sequence Models: Sequences in Fluvial Systems; Sequences in Coastal to Shallow-Water (paralic) Clastic Systems; Sequences in Deep-Water Clastic Systems	5
Unit 8: Sequence stratigraphic approach in basin analysis, and case studies on the application of sequence stratigraphy in hydrocarbon exploration and development in different petroliferous basins	7

6. Instructional Strategies:

Lecture, Discussion, Question-Answer, Presentation

7. Assessment:

Formative (30%): Attendance, In-course Examination/Assignment

Summative (70%): Course Final Examination

8. Reading Materials:

Textbook:

1. *Catuneanu, O. (2006). Principles of sequence stratigraphy. Elsevier.*
2. *Emery, D., & Myers, K. (2009). Sequence stratigraphy. John Wiley & Sons.*

References:

1. *Posamentier, H. W., & Allen, G. P. (1999). Siliciclastic sequence stratigraphy: concepts and applications (Vol. 7). SEPM (Society for Sedimentary Geology) Tulsa, Oklahoma.*
2. *Van Wagoner, J. C., Mitchum, R., Campion, K., & Rahmanian, V. (1990). Siliciclastic sequence stratigraphy in well logs, cores, and outcrops: concepts for high-resolution correlation of time and facies.*
3. *Angela, L., Bosence, D. W., Church, K. D., Dan, W., Flint, S. S., Kevin, D., Howell, J. A., Wilson, R. C. L., & John, A. (2003). The sedimentary record of sea-level change. Cambridge University Press.*
4. *Boggs Jr, S. (2014). Principles of sedimentology and stratigraphy. Pearson Education.*

1. Course Number and Title: GMT 502 - Exploration Geology

2. Credit Hours: 3

3. Course Description: The objective of the course is to introduce the students with the different aspects of exploration techniques and their advantages in locating subsurface natural resources. They would gather knowledge on mineral resources and reserves, mineralization in space and time, mining methods, mineral processing stages and economic analysis of the mineral Commodity (Mineral Economics); environmental concerns related with mineral production, taxation and royalty of minerals, application of exploration and exploitation rules & regulations for subsurface natural resource development.

4. Learning outcomes: On completion of the course the learners will be able to –

- develop significant background regarding exploration procedures, processing and development of natural resources, opportunities and challenges of the mineral exploration and development industries
- understand how mineral grade, price and technology influence the minerals industries

5. Course content:

Unit/Chapter	No. of Lectures
Unit 1: Different techniques and aspects of geological exploration for locating various subsurface natural resources	4
Unit 2: Geographical distribution of mineral resource, production, consumption, prices of minerals, mineral commodity market structures of selected minerals	7
Unit 3: Economic evaluation of minerals, grade-tonnage considerations, capital budgeting techniques, capital and operating costs estimation, assessment of mineral market conditions, estimation of revenues, taxation.	8
Unit 4: Risk analysis in mining industry, SWOT (Strength, Weakness, Opportunity, and Threat) analysis, economic optimization of mine development and extraction	7
Unit 5: Fundamental principles of geophysical exploration through surface methods of gravity, magnetic, seismic, electrical, electromagnetic and radioactive methods	6
Unit 6: Surveying procedures of different geophysical methods for locating subsurface natural resources	6
Unit 7: Application and challenges of different geophysical methods for exploring various kinds of subsurface natural resources, case studies	7

6. Instructional Strategies:

Lecture, Discussion, Question-Answer, Presentation

7. Assessment:

Formative (30%): Attendance, In-course Examination/Assignment

Summative (70%): Course Final Examination

8. Reading Materials:

References:

1. *Evans, A. M., 1993, Ore Geology and Industrial Minerals- An Introduction, Blackwell Science, Australia.*
2. *Peters, W. C., 1978, Exploration and Mining Geology; John Wiley & Sons, USA.*
3. *Dentith M. and Mudge S.T., 2014, Geophysics for the Mineral Exploration Geoscientist.Cambridge University Press.*
4. *Dobrin, M.B. and Savit, C.H., 1988, Introduction to Geophysical Prospecting; McGraw- Hill Book Co., N.Y.*
5. *Kearey, P., Brooks, M. and Hill, I., 2002, An Introduction to Geophysical Exploration; 3rd Edition, Blackwell Scientific Publication, Oxford.*
6. *Marine Mineral Resources: Scientific Advances and Economic Perspectives; By United Nations. Divi sion for Ocean Affairs and the Law of the Sea, United Nations. Office of Legal Affairs, International Seabed Authority, 2004.*
7. *Ministry of Energy and Mineral Resources, GoB, Mines and Minerals Rules, 1968 (amended).*
8. *Mines and Minerals Rules, 2012, Ministry of Power, Energy and Mineral Resources; People's Republic of Bangladesh.*
9. *National Board of Revenue, GoB, Income Tax Ordinance, 1984 (amended).*
10. *Ministry of Forest and Environment, GoB, Environment Conservation Rules, 1997.*
11. *Global Energy Perspectives, Edited by Nebojsa Nakicenovic, Arnulf Grubler and Alan McDonald, Cambridge University Press, U.K., 1998.*
12. *Energy for the Future, Edited by Sir Denis Rooke, Ian Fells and John Horlock, E & FN Spon for The Royal Society, London, 1995.*
13. *Field, B. C., 2001, Natural Resource Economics, An introduction, McGrew Hill., New York.*
14. *Torries, T. F., 1998, Evaluating Mineral Projects: Applications and Misconceptions, society for Mining, Metallurgy and Exploration, Inc., USA.*

Selected publications

1. Course Number and Title: GMT 503 - Delta Processes and Management

2. Credit Hours: 3

3. Course Description: This course provides students with insight in physical processes of coastal environments and geological processes governing delta evolution. The course commences with an overview of coastal and shoreline processes, and the geological processes leading to delta development. It describes the morphology, facies sequences and lobe shifting of deltas. The dynamics and vulnerability of delta systems along with challenges in modern delta systems. A major part of this course will focus on the Delta Processes, Delta Plan and Delta Management of Bangladesh.

4. Learning outcomes: On completion of the course the learners will be able to –

- understand the delta building processes along with their facies sequences.
- learn the dynamics, vulnerability, and challenges of delta systems.
- understand the evaluation of and challenges of the Ganges-Brahmaputra-Meghna (GBM) Delta and its challenges.
- know how the understanding obtained during the course can be used for sustainable delta management.

5. Course content:

Unit/Chapter	No. of Lectures
Unit 1: Coastal and shoreline processes: sediment supply, sediment delivery to the basin, zonation of the shoreline profile, wave processes, wave-induced nearshore currents, fair-weather vs. storm conditions; Tides- wind, gravitational processes; Coastal models and classifications.	6
Unit 2: Delta evolution: Characteristics of delta and its significance; History of delta studies; Delta building processes; Delta morphology and environments; Classification; Facies sequences- progradational sequences, transgressive sequences and Delta abandonment, lobe shifting; World major deltas.	6
Unit 3: Dynamics and vulnerability of delta systems: Change in and Vulnerability of Deltas; Conceptual Framework of Scale and Function of Deltas; Strategies for Understanding and Managing Change and Vulnerability of Deltas.	5
Unit 4: Challenges: Sinking of modern deltas, Climate change, sea level rise, flood, droughts, riverbank erosion, cyclone and storm surge; management strategies.	5
Unit 5: Ganges-Brahmaputra-Meghna (GBM) Delta: Morphological Evolution of the Delta; Delta development during the Anthropocene; Challenges in GBM.	6
Unit 6: Delta Planning: Objectives of Delta Planning; Stakeholders and activities of Delta Planning; Bangladesh Delta Plan 2100 (BDP 2100); International Delta Plans.	6
Unit 7: Adaptive Delta Management: Objectives of ADM; Protecting coastal areas of Bangladesh against cyclone, floods, storm surge and ensure the availability of fresh water; Uncertainties and dependencies in decision-making on ADM; Expertise and skills, relationships and policy framework of ADM; Socio economic characteristics, culture and governance for ADM. Land-use and Resource management; Integrated Coastal Zone Management (ICZM)	6
Unit 8: Management of Polder System in Bangladesh: History and Background of Polder System Development in Bangladesh; Geomorphology and Infrastructures around the Polders; Influence of Delta Processes on Polders; Geological and environmental impacts of Polders; Manage the Polder System.	5

6. Instructional Strategies:

Lecture, Discussion, Question-Answer, Presentation

7. Assessment:

Formative (30%): Attendance, In-course Examination/Assignment

Summative (70%): Course Final Examination

8. Reading Materials:

Textbook:

1. *Reading, H. G. 1996. Sedimentary Environments: Processes, Facies and Stratigraphy, 3rd Edition, Wiley-Blackwell, ISBN: 978-0-632-03627-1.*

References:

1. *Brown, S. and Nicholls, R.J. 2015. Subsidence and human influences in mega deltas: The case of the Ganges-Brahmaputra-Meghna. Science of the Total Environment, 527–528, 362–374, https://doi.org/10.1016/j.scitotenv.2015.04.124.*
2. *Coleman, J.M. and Rouge, B. 1973. Variations in Morphology of Major River Deltas as Functions of Ocean Wave and River Discharge Regimes.*
3. *Nicholls, R.J. and Goodbred, S.L. 2004. Towards integrated assessment of the Ganges–Brahmaputra delta. Mega-deltas of Asia: geological evolution and human impact, 168–181.*
4. *Overeem, I. and Syvitski, J.P.M. n.d. Dynamics and Vulnerability of Delta Systems.*
5. *Overeem, I., Syvitski, J.P.M. and Hutton, E.W.H. 2011. Three-Dimensional Numerical Modeling of Deltas. River Deltas-Concepts, Models, and Examples, 11–30, https://doi.org/10.2110/pec.05.83.0011.*
6. *Rahman, M., Dustegir, M., et al. 2018. Recent sediment flux to the Ganges-Brahmaputra-Meghna delta system. Science of the Total Environment, 643, 1054–1064, https://doi.org/10.1016/j.scitotenv.2018.06.147.*
7. *Syvitski, J.P.M., Kettner, A.J., et al. 2009. sinking deltas due to human activities. Nature Geoscience, 2, 681–686, https://doi.org/10.1038/ngeo629.*
8. *Bangladesh Delta Plan 2100. https://plandiv.gov.bd/site/files/e295dab0-145f-48bf-bd9a-8738c3947953/Bangladesh-Delta-Plan-2100*
9. *Selective papers on ADP and Polders of Bangladesh.*

1. Course Number and Title: GMT 504 - Computational Geology

2. Credit Hours: 3

3. Course Description: The goal of this course is to introduce numerical modelling methods in geosciences and show how mathematical models can be developed and applied to solve and better understand various problems in geology.

4. Learning outcomes: On completion of the course the learners will be able to –

- understand the basic concepts and methods of mathematical modelling
- explain the differences among various models
- understand various methods of solving a mathematical problem
- use the concept of models for solving practical problems in geosciences
- describe physical system using mathematical equations
- identify boundaries and parameters of geological/natural systems

5. Course content:

Unit/Chapter	No. of Lectures
Unit 1: Introduction to Mathematical Modelling in Geosciences, model and their types; A short overview of differential equations	2
Unit 2: Box Model: Analytical methods, Numerical methods	4

Unit 3: The diffusion and convection equations and their application in geosciences	4
Unit 4: Stochastic processes	3
Unit 5: Time series analysis	3
Unit 6: Parameter estimation/Empirical models/curve fitting	3
Unit 7: Rule-based models	2
Unit 8: Introduction to laws for wave propagation, Finite-difference and Finite-element methods for wave propagation and diffusion	4
Unit 9: Introduction to numerical formulations applied in reservoir simulators; Difference methods, Control-volume method, Time integration	4
Unit 10: Spatial Analysis and Modelling in GIS: Concept of spatial data model; Vector spatial data model; Raster-based cartographic modelling, 3-D visualization, Geostatistics and network analysis, Relational spatial model; Spatial data structure; Spatial Data analysis and modelling; Geostatistical tools for spatial analysis.	5
Unit 11: Models for Remote Sensing Image Processing: Introduction to Models and Methods for Remote Sensing Image Pre-processing and Analysis; Models for Multispectral Image Analysis; Models for Hyperspectral Image Analysis; Models for InSAR/RADAR images; Remote Sensing data fusion; Understanding the mathematical model for satellite image classification; Model for thermal infrared remote sensing; Application of Models in Remote Sensing data for retrieving the geoscience/geohazards information.	5
Unit 12: Close-range (UAV) Photogrammetric Image processing: Analytical methods, Digital image processing – fundamentals, processing steps, geometric image transformation, digital processing of single images, image matching and 3D object reconstruction, Digital Elevation Models (DEM), and Orthoimage Generation.	3
Unit 13: Machine Learning and Data Science: Big Data, Data Analytics, and Machine Learning; Types of Data Analytics; Geoscience Databases; Common Types of Geologic Data Analysis; Basic Steps in Machine Learning-Based Modelling; Popular Machine Learning Algorithms in Geosciences.	3

6. Instructional Strategies:

Lecture, Discussion, Question-Answer, Presentation

7. Assessment:

Formative (30%): Attendance, In-course Examination/Assignment

Summative (70%): Course Final Examination

8. Reading Materials:

References:

1. *Ferguson, J. (1988). Mathematics in geology (No. 551: 51 FER). London: Allen & Unwin.*
2. *Nazaikinskii, V. E. (2015). Handbook of Linear Partial Differential Equations for Engineers and Scientists (2nd Edition). CRC Press.*
3. *Skidmore, A. (2017). Environmental modelling with GIS and remote sensing. CRC Press.*
4. *Pelletier, J. D. (2008). Quantitative modeling of earth surface processes. Cambridge University Press.*
5. *Zhao, C., Hobbs, B. E., & Ord, A. (2009). Fundamentals of computational geoscience: numerical methods and algorithms (Vol. 122). Springer Science & Business Media.*
6. *Paradis, E. (2005). R for Beginners (pp. 37-71). Institut des Sciences de l'Evolution. Université Montpellier II.*
7. *Bivand, R. S., Pebesma, E. J., Gómez-Rubio, V., & Pebesma, E. J. (2008). Applied spatial data analysis with R (Vol. 747248717, pp. 237-268). New York: Springer.*
8. *Barnichon, J. D. (1998). Finite element modelling in structural and petroleum geology (Doctoral dissertation, Universite de Liege).*
9. *Kasser, M. and Egels, Y. 2002. Digital photogrammetry, Taylor & Francis.*
10. *Kraus, K. 2007, Photogrammetry: Geometry from Images and Laser Scans, Volume 1, De Gruyter.*
11. *Linder, W. 2016. Digital Photogrammetry 2016: A practical course, Springer (4th Edition).*
12. *Luhmann, T, Robson, S., Kyle, S., Boehm, J. 2014. Close-Range Photogrammetry and 3D imaging, De Gruyter.*
13. *E. Alpaydin. 2014. Introduction to Machine Learning, Adaptive Computation and Machine Learning MIT Press (3rd Edition), Cambridge.*

1. Course Number and Title: GML 505 - Computational Geology Lab

2. Credit Hours: 3

3. Course Description: This course covers problems solving with different software, e.g., Matlab/R programming, Petrel, Eclipse, Teclog, and Kingdom, SGeMS, Agisoft PhotoScan, LIME, RS and GIS in different fields of geoscience.

4. Learning outcomes: On completion of the course the learners will be able to –

- applications of GIS and Remote Sensing in geosciences fields
- interpretation of spatial data and their uses in geosciences fields
- application of R in geosciences fields
- application of Petrel, Eclipse, Teclog, and Kingdom in geosciences fields
- application of sGeMS in geoscience fields
- application of Agisoft PhotoScan and LIME in geoscience fields

5. Course content:

Unit/Chapter	No. of Lab Classes
Unit 1: Introduction to Matlab/R; Exercises to get familiarized with Matlab/R, data manipulation, data plotting etc.	4
Unit 2: Box model analytical solution programming in Matlab/R	2
Unit 3: Box model numerical solution programming in Matlab/R	2
Unit 4: Time series analysis exercise in Matlab/R	2
Unit 5: Geostatistical simulation of subsurface heterogeneity using SGeMS	1
Unit 6: 3D facies and reservoir modelling using Petrel and Eclipse	2
Unit 7: Seismic & well data processing and interpretation using Petrel, Teclog and Kingdom	2
Unit 8: Resistivity and IP inversion using RES2DINV/RES3DINV	1
Unit 9: Multi-Criteria Decision Analysis, DRASTIC, TIN Model; Watershed Modelling	3
Unit 10: Model based Image Analysis exercises in ERDAS/ ENVI/ ArcGIS	3
Unit 11: 3D outcrop modelling and interpretation using Agisoft PhotoScan and LIME	1

6. Instructional Strategies:

Computational tasks and problem solving based on different software.

7. Assessment:

Formative (40%): Attendance, Submission of assignment/report/lab note-book

Summative (60%): Practical Examination

8. Practical Materials:

1. *Cotton, R. (2013). Learning R: a step-by-step function guide to data analysis. " O'Reilly Media, Inc.".*
2. *Problems will be supplied based on the theory courses designed for this course.*
3. *Ringrose, P. and Bentley, M. (2015). Reservoir Model Design, Springer.*

1. Course Number and Title: GMV 506 - Viva Voce

2. Credit Hours: 3

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

Specialised Branch: Applied Geophysics (AG)

1. Course Number and Title: GMT 507 AG - Geophysical Data Processing and Inversion

2. Credit Hours: 3

3. Course Description:

4. Learning outcomes: On completion of the course the learners will be able to –

- Develop understanding of the concepts of geophysical field surveying
- Enable to select proper methodology and investigation tool/s for solving some geological problem
- Enable to operate some geophysical instruments
- Develop confidence and ability to work alone and solving geological problems using geophysical data
- Enable to grasp core-level mathematics in geophysical data processing,
- Develop competency to process real data using simple rules
- Enable to use computer for numerical purposes
- Gain an understanding of possible applications of geophysical methods
- Evaluate formulation of inverse problem and methods of solving it

5. Course content:

Unit/Chapter	No. of Lectures
Unit 1: Introduction to Geophysical problems, Types of problems and their solution	5
Unit 2: Time series analysis in seismology: transforms (integral transforms; Fourier analysis and Fourier synthesis; Fourier transforms; multidimensional Fourier transforms; Radon (τ - p) transforms; implementation of transforms); convolution; correlation; phase considerations; deconvolution and frequency filtering	12
Unit 3: Reflection data processing: automatic statics determination; velocity analysis; preservation of amplitude information; apparent-velocity (2-D) filtering; stacking; other processing techniques; migration; data-processing procedures; AVO analysis	14
Unit 4: Introduction; The inverse problem and its formulation; Linear inverse problems and methods of solution - the Fourier method of linear inversion and the matrix method applied to linear problems; Non-linear problems and methods of solution - linearization of the non-linear problem and unconstrained and constrained iterative solutions, Sample applications to non-linear problems - inversion of gravity and magnetic data; vertical electric sounding data and electromagnetic data.	14

6. Instructional Strategies:

Lecture, Discussion, Question-Answer, Presentation

7. Assessment:

Formative (30%): Attendance, In-course Examination/Assignment

Summative (70%): Course Final Examination

8. Reading Materials:

References:

1. *Parasnis, D.S., 1997, Principles of Applied Geophysics; Chapman and Hall, N.Y.*
2. *Reynolds, J.M., 2011, An Introduction to Applied and Environmental Geophysics, John Wiley & Sons. Chicester.*
3. *Robinson, E.S. and Coruh, C., 1988, Basic Exploration Geophysics; John Wiley & Sons., New York.*
4. *Sheriff, R.E. and Geldart, L.P., 1995, Exploration Seismology; Cambridge University Press, Cambridge, Vol. 1 & 2.*
5. *Telford, W.M., Geldard L.P. and Sheriff R.E., 1990, Applied Geophysics; Cambridge University Press, Cambridge.*
6. *Yilmaz, O., 1987, Seismic Data Processing; Society of Exploration Geophysicists, Tulsa, Oklahoma*

Selected publications

1. Course Number and Title: GMT 508 AG - Environmental and Engineering Geophysics

2. Credit Hours: 3

3. Course Description: This course provides an introduction to geophysical methods for mapping and monitoring the physical properties of the shallow ground materials with a specific focus on environmental, water resources, geohazards and engineering applications. Includes discussion on various geo-environmental and geo-engineering problems and geophysical techniques to address them. Secondary data analysis, processing and interpretation are included to provide experience on geophysical data interpretation and software uses.

4. Learning outcomes: On completion of the course the learners will be able to –

- know the most common geophysical methods applied in environmental, geohazard, water resources and engineering studies
- planning, design, and conduct a geophysical survey
- evaluate the differences in field methodology of shallow and deep Geophysics
- select proper methodology and geophysical techniques to solve various geo-environmental and geo-engineering problems
- develop theoretical knowledge and skill and self-reliant in carrying out field investigations.

5. Course content:

Unit/Chapter	No. of Lectures
Unit 1: The role of geophysical investigations in environmental and engineering studies, the main methods of environmental and engineering geophysics, specifics of near-surface geophysical investigations, resolution of geophysical data, planning and design a geophysical survey	6
Unit 2: Brief review of Geophysical imaging: Microgravimetry, Magnetometry, Geoelectrical methods (self-potential, resistivity methods, electric tomography, electromagnetic methods, induced polarisation), Ground Penetrating Radar (GPR), High-resolution	6

reflection seismics; Seismic refraction method, Seismic surface waves methods (Multichannel Analysis of Surface Waves (MASW), Microtremor and passive studies), Seismic measurements in boreholes	
Unit 3: Traditional geophysical methods VS evolving and emerging technologies in environmental and engineering investigations; Emerging techniques: Surface nuclear magnetic resonance, Time-lapse microgravity, Induced-seismicity studies, Landmine discrimination, Passive GPR interferometry, Seismoelectric coupling	6
Unit 4: Application of geophysical methods in solving hydrogeological, and other geoenvironmental problems, potential fields and environmental issues, Non-invasive geophysics and the environmental issues, ground-penetrating radar and the environmental issues	7
Unit 5: Engineering Geophysical investigations for soil and rock, planned transport route, engineering bed-rock for excavation planning and highway and pipeline cuts, abandoned waste dumps	5
Unit 6: Application of microgravity studies of rockburst in mines, detection of subsurface voids and cavities, magnetic investigations over landfills, detection of buried metal drums and casings, mapping of cavities voids and dykes blocking groundwater flow, detection of archaeological ruins and artifacts, location of permafrost zones, site investigation for foundation studies of large structures, landslides and slope stability	6
Unit 7: Seismic hazard assessment: ground motion parameters, down-hole seismic survey and surface wave analysis for ground response, amplification and liquefaction, Micro-tremor Array Measurements (MAM) for site classification and building code	5
Unit 8: Secondary field data processing and analysis to address specific geo-environmental and geo-engineering problems	4

6. Instructional Strategies:

Lecture, Discussion, Question-Answer, Presentation

7. Assessment:

Formative (30%): Attendance, In-course Examination/Assignment

Summative (70%): Course Final Examination

8. Reading Materials:

References:

1. *Parasnis, D.S., 1997, Principles of Applied Geophysics; Chapman and Hall, N.Y.*
2. *Reynolds, J.M., 2011, An Introduction to Applied and Environmental Geophysics, John Wiley & Sons. Chicester.*
3. *Robinson, E.S. and Coruh, C., 1988, Basic Exploration Geophysics; John Wiley & Sons., New York.*
4. *Telford, W.M., Geldard L.P. and Sheriff R.E., 1990, Applied Geophysics; Cambridge University Press, Cambridge.*
5. *Everett, M.E., 2013, Near-Surface Applied Geophysics; Cambridge University Press, Cambridge.*

Selected publications

1. Course Number and Title: GMT 509 AG – Geophysical Data Interpretation

2. Credit Hours: 3

3. Course Description:

4. Learning outcomes: On completion of the course the learners will be able to –

- Demonstrate understanding of the ambiguity in geophysical data interpretation
- Enable to interpret field geophysical data and handle computations both manually and using
- computer to have an understanding into situations where geology is complex
- Equip with a range of appropriate analytical skills for solving problems
- Enhance ability to apply theoretical knowledge in order to arrive at realistic judgments
- Develop geophysical mapping skills, self-reliance and ability to work alone
- Motivate for exposure to in depth applied geophysics ideas
- Explore scientific basis for applying geophysics in geology

5. Course content:

Unit/Chapter	No. of Lectures
Unit 1: Introduction to Interpretation of Geophysical data	4
Unit 2: Magnetic effects of buried bodies; Effect of demagnetization. Magnetic data interpretation: qualitative and quantitative; Typical magnetic anomalies for geological features. Geologic factors affecting density; density estimates; Gravity effects of simple and complex shapes; Gravity data interpretation: qualitative and quantitative; Gravity anomalies and geological structures.	7
Unit 3: Self-potential (SP) method: Measurement and origin of self-potentials; interpretation of SP data. Resistivity methods: elementary theory – potential distribution, effect of inhomogeneous ground; resistivity sounding interpretation and ambiguity in interpretation; electrical resistivity imaging (ERI); lateral profiling, Induced polarization (IP) method: sources of IP effects; IP measurements; interpretation of IP data – forms of displaying data and interpretation.	8
Unit 4: EM applications, and basic EM data interpretation; ground penetrating radar (GPR) – principles, data interpretation.	6
Unit 5: Gamma-ray spectrometer; Measurement of radioactivity in the field and Interpretation of radioactivity data.	4
Unit 6: Geologic interpretation of reflection data: seismic interpretation procedures; outline of the seismic evidences of geologic features; lateral variations in seismic velocity. Seismic stratigraphy: reflection parameters; seismic sequence analysis; seismic facies analysis. Seismic indicators of hydrocarbons	8

Unit 7: Qualitative interpretation of well logs. Fundamental relationships of well log interpretation: borehole environment; invasion and resistivity profiles; basic information needed in log interpretation; formation temperature calculation; fundamental equations, Archie Equation Sw and Sxo; ratio method; bulk volume water; quicklook methods; different cross plots	8

6. Instructional Strategies:

Lecture, Discussion, Question-Answer, Presentation

7. Assessment:

Formative (30%): Attendance, In-course Examination/Assignment

Summative (70%): Course Final Examination

8. Reading Materials:

References:

1. *Parasnis, D.S., 1997, Principles of Applied Geophysics; Chapman and Hall, N.Y.*
2. *Reynolds, J.M., 2011, An Introduction to Applied and Environmental Geophysics, John Wiley & Sons. Chicester.*
3. *Robinson, E.S. and Coruh, C., 1988, Basic Exploration Geophysics; John Wiley & Sons., New York.*
4. *Sheriff, R.E. and Geldart, L.P., 1995, Exploration Seismology; Cambridge University Press, Cambridge, Vol. 1 & 2.*
5. *Telford, W.M., Geldard L.P. and Sheriff R.E., 1990, Applied Geophysics; Cambridge University Press, Cambridge.*
6. *Yilmaz, O., 1987, Seismic Data Processing; Society of Exploration Geophysicists, Tulsa, Oklahoma.*

Selected publications

1. Course Number and Title: GML 510 AG - Geophysical Prospecting Lab

2. Credit Hours: 3

3. Course Rationale: This course is designed to introduce students to proper geophysical surveying for solving some specific geological problem and provides students with an in-depth practical knowledge in handling and interpreting geophysical data.

4. Learning outcomes: On completion of the course the learners will be able to –

- Develop understanding of the concepts of geophysical field surveying.
- Enable to select proper investigation tool(s) and methodologies for solving some geological problem
- Enable to operate available geophysical instruments individually
- Enable to interpret field geophysical data and handle computations both manually and using available software
- Enhance ability to apply theoretical knowledge in order to arrive at realistic judgments
- Develop individual geophysical mapping skills and exposure to in depth professional insights into handling geophysical data.

5. Course content:

Unit/Chapter	No. of Lab Classes
Unit 1: Acquiring/collecting geophysical data using existing facilities in the department and geological data.	4
Unit 2: Processing geophysical data both manually and using computer (involving different methods of filtering)	4
Unit 3: Interpretation of magnetic (land and aeromagnetic) data: simple rules, characteristic curves and computer modelling for location and dimension; Interpretation of gravity data: simple rules, characteristic curves and computer modelling for location, dimension and total anomalous mass; Interpreting seismic reflection (including variable-velocity layering) and refraction data manually and using computer; Inverting and interpreting VES data using curve matching and computer interpretation techniques; Inverting and interpreting ERT (2D and 3D) data using computer techniques; Interpretation of EM data.	9
Unit 4: Fundamental of quantitative log interpretation of spontaneous - potential (SP) curve, conventional resistivity logs and induction loggings. Determination of lithology, porosity, Rw, Determination of saturation of clean formation and shaly formations.	5

6. Instructional Strategies:

Laboratory investigation and interpretation

7. Assessment:

Formative (40%): Attendance, Submission of assignment/report/lab note-book

Summative (60%): Practical Examination

8. Practical Materials:

Materials will be supplied based on the theory courses designed for this branch.

1. Course Number and Title: GMP 511 AG - Project/Geological Field Mapping
(Supervised individual research project on any aspect of Geophysics or relevant field).

2. Credit Hours: 3

3. Course Description: The aims of this course are to assess the student's ability to provide a critical synthesis of a scientific problem; to enable a student to derive original laboratory or field data, and/or to seek and utilize published/secondary data; to train a student to assess those data and draw appropriate conclusions; to learn how to communicate the experimental strategy, results and conclusions effectively with appropriate citations.

4. Learning outcomes:

- ability to formulate and execute a research project
- ability to analyse, synthesise, summarise and evaluate critically information from literature
- ability of data handling and evaluation
- ability to define problems, devise and evaluate possible solutions

- ability to communicate effectively through the report and a poster presentation
- ability to consider issues from a wide range of perspectives
- an in-depth understanding of the student's field of specialisation
- appreciation of the use and limitations of data in testing a hypothesis
- ethics and integrity in research

5. Course Content: The Project Report should contain high level of practical work and has to be submitted within allocated time which has to have the following

- Clearly stated aims/objectives
- Thoroughly researched background
- Data presentation and analysis in a clear and concise manner.
- Cogent interpretation of discussion.
- Perceptive conclusions and broader scientific significance.
- Appropriate of references

Evidence of considerable application of numerical/computing techniques and or laboratory techniques as appropriate and excellent presentation in terms both of English and of layout (e.g., appropriate headings, consistent reference style and reference list, sizing and clarity of figures, etc.) is expected. Project report submission will be followed by Project defence/Poster presentation.

6. Instructional Strategies:

Consultations, literature review with appropriate citations, attending recommended courses, workshops/seminars and appropriate training in data handling and analysis etc.

7. References: Supervisor will guide the students in going through the relevant literatures during the course of the work.

1. Course Number and Title: GMR 512 AG – Thesis (Supervised individual original research on any aspect of Geophysics or relevant field)

2. Credit Hours: 6

3. Course Description: The aims of this course are to assess the student's ability to provide a critical synthesis of a scientific problem; to enable a student to derive original laboratory or field data, and/or to seek and utilize published data; to train a student to assess those data and draw appropriate conclusions; to learn how to communicate the experimental strategy, results and conclusions effectively with appropriate citations; to provide training in how to formulate a research problem. Therefore, this course would enable students to put their specialist skills, knowledge, and understanding into practice through the medium of a significant individual research project and written dissertation. Thesis/project might involve students working within one of the Department's established research groups or can work in collaboration with another industrial or academic partner. Wherever is the work, the students will be supervised, throughout the project/thesis duration by a supervisor assigned by the Department. The supervisor will provide advice on the approaches and methods that are best suited to the research problem and on collection/analysis of data and will guide in producing a well-written dissertation.

4. Learning outcomes:

Knowledge and Understanding:

- an in-depth understanding of a specialised area
- the principles and methodology of experimental techniques and
- data handling and evaluation.

Intellectual Outcomes:

- ability to define problems, devise and evaluate possible solutions
- ability to solve routine and unfamiliar problems elegantly
- ability to consider issues from a wide range of perspectives

Practical and Transferable Outcomes:

- ability to formulate and execute a research project individually
- ability to analyse, synthesise, summarise and evaluate critically information from literature
- ability to communicate effectively through the research report and oral presentation.
- ability to present research findings to technical audiences as well as generalized audiences
- ability to publish papers in peer reviewed journals
- ability to work in a professional organization in the specialised field of expertise.

Ethical Outcomes:

- clear understanding of data protection issues and appreciation of the use secondary data
- clear understanding of plagiarism
- honesty and transparency in developing, undertaking, reporting and communicating research
- research ethics and integrity

5. Course Content: The work has to be completed within allocated time by completing the following steps:

- Proposal development and synopsis presentation
- Literature review
- Methodology selection
- Secondary Data Collection
- Carrying out field studies
- Carrying out laboratory analysis
- Data analysis and interpretations
- Preparation of draft of dissertation/thesis following given guidelines
- Submission of Dissertation/Thesis
- Thesis defence

A good thesis requires to have

- Clearly stated aims/objectives
- Thoroughly researched background

- Data presentation and analysis in a clear and concise manner.
- Cogent interpretation of discussion.
- Perceptive Conclusions and broader scientific significance.
- Appropriate references

Evidence of following skills should be reflected in it

Intellectual skills: considerable evidence of independence and initiative beyond the instructions

Numeracy and IT skills: application of numerical/computing techniques using relevant software

Laboratory skills: use of well-defined laboratory techniques as appropriate

Writing Skills: relevant, logical, concise and succinct writing

Presentation skills: both in terms of English and of layout (e.g., appropriate headings, consistent reference style and reference list, sizing and clarity of figures, etc.).

6. Instructional Strategies:

Consultations, literature review with appropriate citations, attending recommended courses, workshops/seminars and appropriate training in data handling and analysis etc.

7. References: Supervisor will guide the students in going through the relevant literatures during the course of the work.

Specialised Branch: Environmental Geology and Geohazards (EG)

1. Course Number and Title: GMT 507 EG - Environmental Geology and Natural Hazards

2. Credit Hours: 3

3. Course Description: This course is designed to provide knowledge of environmental and geohazard issues. Clear understanding of the natural and anthropogenic causes of environmental pollution and geohazards. Application of geologic knowledge to identify, remediate, and prevent environmental problems and geohazards.

4. Learning outcomes: On completion of the course the learners will be able to –

- introduce the study of interrelationship between the earth and environment, environmental pollutions, different manmade and natural hazards and precautionary and mitigation measures.
- study the behavior of anthropogenic pollutants in the environment and how remedial measures may be applied to cover their harmful effects.
- train and help the students in spreading the awareness on geological and environmental issues and the tactics of cropping the disastrous scenario, mitigation on hazards and related anticipatory policy measures which will be helpful to protect populations at risk.

5. Course content:

Unit/Chapter	No. of Lectures
Unit 1: Fundamentals of Environmental Geology Introduction to Environmental Geology: Fundamental concepts of environmental geosciences, its scope and necessity; Definition, structure, composition and general characteristics of lithosphere, hydrosphere, atmosphere and biosphere; Concept of ecology, ecosystem, its structure and functions, types of ecosystem; Biogeochemical cycles of carbon, nitrogen, phosphorus and sulfur; Physiography, drainage, climate, soils and natural resources of Bangladesh.	6
Unit 2: Environmental issues and management Environmental issues: Water pollution: types of water pollution, groundwater pollution sources, pathways and mechanism, attenuation processes, case histories of natural (arsenic and fluoride poisoning) and man-made water pollution; water logging, causes, effects and remedial measures, aquifers; declining groundwater tables, subsidence and compaction of aquifers; Soil pollution- sources, causes and effects; Soil pollution control measures; Air pollution: definition, terminology, sources and classification of air pollutants; effects of air pollution- acid rain, green house effects and ozone layer depletion; Air pollution control and management.	12
Unit 3: Natural hazards Natural hazards: an introduction, Natural hazards and environmental change, Natural hazard impacts: a historical perspective, A natural hazards primer, Recent environmental change.	6
Unit 4: Climatic hazards Weather-related natural hazards and climate change, Observing and predicting trends in weather-related hazards, Windstorms in a warmer world, Mid-latitude storminess in a warmer world, Tropical cyclones, tornadoes, derechos and dust storms as the climate changes; Global warming and greenhouse effect: the temperature record, Global warming and the future. Air pressure and winds, Air masses and cyclones, Thunderstorms. Floods and other weather-related hazards in a changing climate, River flooding and environmental change, Trends in rainfall extremes that can cause river flooding, Coastal floods and climate change, Changes in other hydrological and temperature extremes; Indian monsoons: Components of Monsoon, Synoptic systems of Monsoon, Indian Monsoon Rainfall and its variability.	8
Unit 5: Geogenic hazards Earthquake and seismic hazards Distribution, magnitude and intensity of earthquakes; Seismic hazard zones; Neotectonics in seismic hazard assessment; Earthquake hazards their causes and control. Landslides and environmental change	10

Impact of landslides, Types of landslide, Sluggish deformation, Catastrophic deformation, Intermediate deformation, Water and slope failure, Water and landslide run-out, Effect of environmental change on global rates of land-sliding, The future. Volcanoes and environmental change Volcanism and environmental change: a brief history of research, Eruption characteristics and environmental impact, Contribution of volcanic eruptions to the atmosphere, Physical and chemical effects of volcanogenic aerosols on the atmosphere, Volcanoes and climate, Volcanoes as initiators of past environmental change: notes of caution, Volcanic super-eruptions and environmental change, Volcanoes and Ice Age, Volcanoes and mass extinctions. Sea-level change as a trigger of natural hazards Changing sea levels and natural hazards, Perspectives on future sea-level change, Sea-level change as an initiator of seismicity and volcanism, Changing sea levels, submarine landslides and collapsing ocean islands.	
Unit 6: Environmental change and natural hazards: prospects for the future Environmental change and natural hazards: the impact in the twenty-first century, Natural hazards: the human dimension, Forecast for the future; Problems of urbanization, human population and their impact on environment; Alternative sources of energy; Waste disposal and related problems; Environmental legislations.	3

6. Instructional Strategies:

Lecture, Discussion, Question-Answer, Presentation

7. Assessment:

Formative (30%): Attendance, In-course Examination/Assignment

Summative (70%): Course Final Examination

8. Reading Materials:

References:

1. *Bell, F.G. (1999): Geological Hazards, Routledge, London. 190 p.*
2. *Bryant, E. (1985): Natural Hazards, Cambridge Univ. Press.*
3. *Keller, E.A. (1978): Environmental Geology, Bell and Howell, USA.*
4. *Lal, D. S. (2007): Climatology, Sharda Pustak Bhawan, Allahabad.*
5. *Patwardhan, A.M. (1999): The Dynamic Earth System, Prentice Hall.*
6. *Smith, K. (1992): Environmental Hazards, Routledge, London.*
7. *Subramaniam, V. (2001): Textbook in Environmental Science, Narosa International.*
8. *Valdiya, K.S. (1987): Environmental Geology – Indian Context, Tata McGraw Hi*

Selected publications

1. Course Number and Title: GMT 508 EG - Disaster Risk Reduction

2. Credit Hours: 3

3. Course Description: Disaster risk reduction is a systematic approach to identifying, assessing and reducing the risks of disaster. It aims to reduce socio-economic vulnerabilities to disaster as well as dealing with the environmental and other hazards that trigger them. Here it has been strongly influenced by the mass of research on vulnerability that has appeared in print since the mid-1970s as well as the mapping of natural disaster risks. Disaster risk reduction is the responsibility of development and relief agencies alike. It should be an integral part of the way such organizations do their work, not an add-on or one-off action. Disaster risk reduction is very wide-ranging: Its scope is much broader and deeper than conventional emergency management. There is potential for Disaster risk reduction initiatives in just about every sector of development and humanitarian work. Disaster risk is an indicator of poor development, so reducing disaster risk requires integrating DRR policy and DRM practice into the sustainable development goals. We need to manage risks, not just disasters.

4. Learning outcomes: DRR is a part of sustainable development, so it must involve every part of society, government, non-governmental organizations and the professional and private sector. It therefore requires a people-centred and multi-sector approach, building resilience to multiple, cascading and interacting hazards and creating a culture of prevention and resilience. Consequently, DRM includes strategies designed to:

- avoid the construction of new risks
- address pre-existing risks
- share and spread risk to prevent disaster losses being absorbed by other development outcomes and creating additional poverty

5. Course content:

Unit/Chapter	No. of Lectures
Unit 1: Hazards, Disasters, and Risks Hazards: Classification of Hazards by Causes, Classification of Hazards by Occurrences, Intensity Classification of Hazards Disasters: Classification of Disasters, Classification of Disaster Scale Risks: Disaster, Risk and Evolution of the Concept, Risk Classification System of Davos World Economic Forum, Risk Classification of International Risk Governance Council, Classification Criteria for Risk Levels. Understanding Vulnerability and Risks	6
Unit 2: Disaster Risk Management The Basis for Disaster Risk Management, Risk Society and Disaster Risk Management, Academic Schools of Disaster Risk Management, The Disaster Risk Management System National Perspectives of Disaster Risk Reduction in Bangladesh, Flood Risks and Reduction Approaches in Bangladesh, Cyclone and Tornado Risk and Reduction Approaches in Bangladesh, Earthquake Risk and Reduction Approaches in Bangladesh, Drought Risk and Reduction Approaches in Bangladesh, Landslide and Flashflood in Bangladesh, Sea-Level Rise Along the Coast of Bangladesh, Urban Risk Reduction	10

Approaches in Bangladesh, Community-Based Disaster Risk Reduction Approaches in Bangladesh.	
Unit 3: Disaster Risk Management Mechanism Disaster Emergency Management and Response, Disaster Emergency Management, Disaster Emergency Management Principle, Disaster Emergency Management Mechanism, Disaster Emergency Management Legal System	8
Unit 4: Risk Assessment and Preparedness Pre-Disaster Management activities; Hazard and vulnerability analysis; Hazard zonation maps: preparation and utilization; capability assessment; emergency/contingency planning and post-disaster management activities; Development planning, planning environment, types of plans, MBO, SWOT analysis; Mitigation strategy : Relief measures, community health, casualty management, Role of Government, Non-Governmental and media agencies, Reconstruction and Rehabilitation; Awareness through print and electronic media, involving youth in field observations.	6
Unit 5: Disaster Resilience The Nation's Agenda for Disaster Resilience, Foundation for Building a Resilient Nation: Understanding, Managing, and Reducing Disaster Risks, Making the Case for Resilience Investments: The Scope of the Challenge, Measuring Progress Toward Resilience, Building Local Capacity and Accelerating Progress, Resilience from the Bottom-Up, The Landscape of Resilience Policy, Resilience from the Top-Down, Putting the Pieces Together: Linking Communities and Governance to Guide National Resilience, Building a More Resilient Nation: The Path Forward.	5
Unit 6: Disaster Management in Bangladesh perspective Evolution of approaches to disaster preparedness, Government initiatives for the improvement of Meteorological Service in Bangladesh; Disaster development linkages: National and International drivers for change - Millennium Development Goals (MDG); Sustainable Development Goals (SDG); The Poverty Reduction Strategy Paper (PRSP), Bangladesh; Hyogo Framework for Action (HFA) 2005-2015; United Nations Framework Convention on Climate Change (UNFCCC); National Adaptation Programs of Action (NAPA); SAARC Framework for Action (SFA) 2006-2015; Bangladesh Climate Change Strategy and Action Plan 2009; Conceptualizing Disaster Management in Bangladesh, Mainstreaming Risk reduction-the strategies; Disaster Management Regulatory Framework - Disaster Management Act; National Disaster Management Policy; Disaster Management Plans; Standing Orders on Disaster; Guidelines for Government at all Levels (Best Practice Models)	10

6. Instructional Strategies:

Lecture, Discussion, Question-Answer, Presentation

7. Assessment:

Formative (30%): Attendance, In-course Examination/Assignment

Summative (70%): Course Final Examination

8. Reading Materials:

References:

1. *Barbar W. Murk et al., 1996, Environmental Geology, John Wiley & Sons, New York.*
2. *Edward A. Keller, 2011, Introduction to Environmental Geology, Pearson Education publisher.*
3. *K. S. Valdiya, 2013, Environmental Geology, McGraw-Hill Education (India)*
4. *Collins Larry R. and Schneid Thomas D., 2000, Disaster Management and Preparedness, Taylor and Francis.*
5. *Graham Thompson and Jon Turk, 2007, Earth Science and the Environment, Thomson and Brooks/cole.*
6. *Goel S.L. and Kumar Ram, 2001, Disaster Management, Deep and Deep Publications.*
7. *A global review of disaster reduction initiatives, 2004 Vision, Living with Risk: United Nations.*

Selected publications

1. Course Number and Title: GMT 509 EG - Environmental Impact Assessment and Auditing

2. Credit Hours: 3

3. Course Description: Environmental assessment (EA) is the assessment of the environmental consequences of a plan, policy, program, or actual projects prior to the decision to move forward with the proposed action. In this context, the term "environmental impact assessment" (EIA) is usually used when applied to actual projects by individuals or companies and the term "strategic environmental assessment" (SEA) applies to policies, plans and programmes most often proposed by organs of state. It is a tool of environmental management forming a part of project approval and decision-making. Environmental assessments may be governed by rules of administrative procedure regarding public participation and documentation of decision making and may be subject to judicial review.

4. Learning outcomes: On completion of the course the learners will be able to –

- ensure that Environmental considerations are addressed properly and incorporated into decision making process.
- avoid, minimize or balance the adverse significant bio-physical, social and other relevant effects of developmental projects.
- protect the productivity and capacity of natural system and ecological processes with maintain their function.
- promote development that is sustainable and optimize resources use and management opportunities.

5. Course content:

Unit/Chapter	No. of Lectures
Unit 1: Fundamentals of Impact Assessment International study of the effectiveness of Environmental assessment-Historical background of EIA, NEPA and its implementation, Council on Environmental Quality (CEQ regulations), Challenges to contemporary practice; Foundations of Assessment, Purpose and Aims of EA, Principles of EIA, EIA procedures; Environmental Assessment in prospective (Legal Mandate, EIA process roles and responsibilities of National and international bodies involved in the EIA system).	4
Unit 2: Methods on Environment and Disaster Impact Assessment Methods for EIA (Categorizing methodologies: Adhoc, Checklists, Matrices, Network diagrams, Overlays, Mathematical modelling); Vulnerability Assessment Methods - Determinants of Vulnerability on existing vulnerability assessment tools; Social vulnerability assessment; Physical vulnerability assessment; HAZUS-MH Methodology; Loss criteria methodology; Participatory Vulnerability Analysis (PVA) analytical steps Disaster Assessment Tools and methods - Information on elements exposed to disaster risk; Tools and Techniques of Disaster Management; Disaster impacts model; Complex Humanitarian Emergencies (CHE) Model	10
Unit 3: Economic and Social Assessment Economic analysis (valuation methods for economic damage to ecosystem, Role of economics in EIA, steps in Economic valuation of EIA, taxonomy of the valuation methods, guidelines for economic valuation of EIA, issues in the incorporation of environmental values into cost benefit analysis, methods for economic valuation of environmental impacts); Social Impact Assessment, Basic model for SIA, Identification of SIA variables, steps in SIA; Vulnerable groups. Environmental monitoring program (Implementing an environmental monitoring program, designing environmental monitoring program, examples of monitoring from developing country EIAs, post audit and evaluation); Risks and uncertainties in EIA (The nature of uncertainty, performing ERA	10
Unit 4: Climate change Impact Assessment Mitigation measures and adaptation techniques - Mitigation measures and carbon trading; Non-structural and structural adaptation; Adaptation techniques in the context of integrated water resource management. Policy, laws, international conventions and country program - Global awareness and IPCC interpretations; Kyoto protocol and other international conventions; Responses to climate change: global, national	10

and local; National Climate change strategies and activities; Institutional arrangements of climate change. Economic, social and Environmental implications of climate change - Economics of climate change; Social impact of climate change: vulnerable social groups and gender; Impact of climate change on deltaic ecosystem (arid, coastal and deltaic system); Implication of climate change on agriculture, food security and livelihood; Implication of climate change on water supply, sanitation and health (heat stress and vector born diseases). Vulnerability analysis, adaptive capacity and sensitivity	
Unit 5: Disaster Management Tools and Assessment Disaster preparedness tools, Overview of Assessment Methodology, Cost-benefit system, Emergency management; Flood risk assessment, Drought risk assessment, Sea level rise and salinity intrusion, River Erosion and livelihoods, Cyclone and storm surges.	5
Unit 6: Environmental Management Plan Environmental Management Plan (Implementing an EMP, preparing an EIA report, reviewing and evaluating EIA report, strategic environmental assessment); Case studies: Case studies related to the following sectors - Infrastructure - Mining – Industrial - Thermal Power - River valley and Hydroelectric - Nuclear Power; The ISO 9000; The ISO 14000; Integration of Environmental and Quality management system; Mining and environment - Legislations and control and case studies.	6

6. Instructional Strategies:

Lecture, Discussion, Question-Answer, Presentation

7. Assessment:

Formative (30%): Attendance, In-course Examination/Assignment

Summative (70%): Course Final Examination

8. Reading Materials:

References:

1. *Canter, L.W. 1996. Environmental Impact Assessment, McGraw Hill Inc. (2nd ed.).*
2. *Modak, P.C. & Biswas, AK. 1999. Conducting EIA for developing countries, OXFORD.*
3. *Lohani, B., J. W. Ekans, H. Ludwig, R.R. Everitt, Richard A. Carpenter & S.L. Tu. 1997. EIA for developing countries in Asia, Vol.1 (Overview).*
4. *Jain, RK etal. 1993. Environmental Assessment, McGraw-Hill, Inc.*
5. *Vanclay, F & Bronstein, DA. 1996. Environment & Social Impact Assessment, Joha Witey & sons, New York.*
6. *Ortolano, L, 1997. Environmental Regulations & Impact Assessment, John Wiley & Sons, Inc. New York*
7. *Treweek, Jo, 1999. Ecological Impact Assessment, Blackwell Science Ltd. UK*

8. *Saha, S. K. Environmental Impact Assessment for changing World, AHDPH, Dhaka.*
9. *Asian Development Bank, (1994): Climate Change in Asia: Bangladesh Country Report; Published by ADB.*
10. *Hug. S et al (1999): Vulnerability and Adaptation to Climate Change for Bangladesh, Kluwer Academic Publishers.*
11. *Washington W.M. and Parkinson C.L. (1986): An Introduction to Three-Dimensional Climate Modelling, USA.*
12. *Lockwood, J. G. -World Climatology: An Environmental Approach. Edulard Arnold.*
13. *Climate change in Asia: Bangladesh - Asian Development Bank.*

Selected Publications

1. Course Number and Title: GML 510 EG - Environmental Geology and Geohazards Lab

2. Credit Hours: 3

3. Course Description: This course is designed for the use of geo-scientists with an interest and need in developing the above courses.

4. Learning outcomes: On completion of the course the learners will be able to –

- avoid the construction of new risks
- address pre-existing risks
- share and spread risk to prevent disaster losses being absorbed by other development outcomes and creating additional poverty
- ensure that Environmental considerations are addressed properly and incorporated into decision making process.
- avoid, minimize or balance the adverse significant bio-physical, social and other relevant effects of developmental projects.
- protect the productivity and capacity of natural system and ecological processes with maintain their function.
- promote development that is sustainable and optimize resources use and management opportunities.

5. Course content:

Unit/Chapter	No. of Lab Classes
Unit 1: Introduction to varied social survey techniques, people-centered monitoring and evaluation, environmental analyses, and the application of appropriate methodologies to people-centered development issues.	2
Unit 2: New approaches and skills for coping with a variety of issues that may face a community after a disaster, using community-based, participatory, interactive, methods; vulnerability and capacities assessment.	2
Unit 3: Approaches to Impact Prediction (Predictive methods, models and modelling, predicting quantitative environmental changes);	2

Risks and uncertainties in EIA (The nature of uncertainty, performing ERA, Human health risk assessment methods, comparative risk analysis, ecological risk assessment (EcoRA).	
Unit 4: Economic valuation of EIA, taxonomy of the valuation methods, guidelines for economic valuation of EIA, issues in the incorporation of environmental values into cost benefit analysis, methods for economic valuation of environmental impacts) Environmental monitoring program (Implementing an environmental monitoring program, designing environmental monitoring program, examples of monitoring from developing country EIAs, post audit and evaluation).	6
Unit 5: Environmental Management Plan (Implementing an EMP, preparing an EIA report, reviewing and evaluating EIA report, strategic environmental assessment); The ISO 9000; The ISO 14000; Integration of Environmental and Quality management system.	5
Unit 6: Case studies (Padma Bridge, Bangladesh Gas Rehabilitation and expansion project, environmental issues related to Mega Hydroelectric Projects/Dams, resettlement and rehabilitation of people; its problems and concerns).	5

6. Instructional Strategies:

Laboratory investigation and interpretation

7. Assessment:

Formative (40%): Attendance, Submission of assignment/report/lab note-book

Summative (60%): Practical Examination

8. Reading Materials:

Reference:

1. *Canter, L.W. 1996. Environmental Impact Assessment, McGraw Hill Inc. (2nd ed.).*
2. *Modak, P.C. and Biswas, AK. 1999. Conducting EIA for developing countries, OXFORD. Lohani, B., J. W. Ekans, H. Ludwig, R.R. Everitt, Richard A. Carpenter and*
3. *S.L. Tu. 1997. EIA for developing countries in Asia, Vol.1 (Overview).*
4. *Jain, RK et al. 1993. Environmental Assessment, McGraw-Hill, Inc.*
5. *Vanclay, F and Bronstein, DA. 1996. Environment and Social Impact Assessment, John Wiley and sons, New York.*
6. *Ortolano, L, 1997. Environmental Regulations & Impact Assessment, John Wiley and Sons, Inc. New York*
7. *Treweek, Jo, 1999. Ecological Impact Assessment, Blackwell Science Ltd. UK*
8. *Gilpin, A, 1995. EIA cutting edge for the 21st century, Cambridge University Press.*

1. Course Number and Title: GMP 511 EG - Project/Geological Field Mapping
(Supervised individual research project on any aspect of Environmental Geology and Geohazards or relevant field).

2. Credit Hours: 3

3. Course Description: The aims of this course are to assess the student's ability to provide a critical synthesis of a scientific problem; to enable a student to derive original laboratory or field data, and/or to seek and utilize published/secondary data; to train a student to assess those data and draw appropriate conclusions; to learn how to communicate the experimental strategy, results and conclusions effectively with appropriate citations.

4. Learning outcomes:

- ability to formulate and execute a research project
- ability to analyse, synthesise, summarise and evaluate critically information from literature
- ability of data handling and evaluation
- ability to define problems, devise and evaluate possible solutions
- ability to communicate effectively through the report and a poster presentation
- ability to consider issues from a wide range of perspectives
- an in-depth understanding of the student's field of specialisation
- appreciation of the use and limitations of data in testing a hypothesis
- ethics and integrity in research

5. Course Content: The Project Report should contain high level of practical work and has to be submitted within allocated time which has to have the following

- Clearly stated aims/objectives
- Thoroughly researched background
- Data presentation and analysis in a clear and concise manner.
- Cogent interpretation of discussion.
- Perceptive Conclusions and broader scientific significance.
- Appropriate references

Evidence of considerable application of numerical/computing techniques and or laboratory techniques as appropriate and excellent presentation in terms both of English and of layout (e.g., appropriate headings, consistent reference style and reference list, sizing and clarity of figures, etc.) is expected. Project report submission will be followed by Project defence/Poster presentation.

6. Instructional Strategies:

Consultations, literature review with appropriate citations, attending recommended courses, workshops/seminars and appropriate training in data handling and analysis etc.

7. References: Supervisor will guide the students in going through the relevant literatures during the course of the work.

1. Course Number and Title: GMR 512 EG – Thesis (Supervised individual original research on any aspect of Environmental Geology and Geohazards or relevant field)

2. Credit Hours: 6

3. Course Description: The aims of this course are to assess the student's ability to provide a critical synthesis of a scientific problem; to enable a student to derive original laboratory or field data, and/or to seek and utilize published data; to train a student to assess those data and draw appropriate conclusions; to learn how to communicate the experimental strategy, results and conclusions effectively with appropriate citations; to provide training in how to formulate a research problem. Therefore, this course would enable students to put their specialist skills, knowledge, and understanding into practice through the medium of a significant individual research project and written dissertation. Thesis/project might involve students working within one of the Department's established research groups or can work in collaboration with another industrial or academic partner. Wherever is the work, the students will be supervised, throughout the project/thesis duration by a supervisor assigned by the Department. The supervisor will provide advice on the approaches and methods that are best suited to the research problem and on collection/analysis of data and will guide in producing a well-written dissertation.

4. Learning outcomes:

Knowledge and Understanding:

- an in-depth understanding of a specialised area
- the principles and methodology of experimental techniques and
- data handling and evaluation.

Intellectual Outcomes:

- ability to define problems, devise and evaluate possible solutions
- ability to solve routine and unfamiliar problems elegantly
- ability to consider issues from a wide range of perspectives

Practical and Transferable Outcomes:

- ability to formulate and execute a research project individually
- ability to analyse, synthesise, summarise and evaluate critically information from literature
- ability to communicate effectively through the research report and oral presentation.
- ability to present research findings to technical audiences as well as generalized audiences
- ability to publish papers in peer reviewed journals
- ability to work in a professional organization in the specialised field of expertise.

Ethical Outcomes:

- clear understanding of data protection issues and appreciation of the use secondary data
- clear understanding of plagiarism
- honesty and transparency in developing, undertaking, reporting and communicating research
- research ethics and integrity

5. Course Content: The work has to be completed within allocated time by completing the following steps:

- Proposal Development and synopsis presentation
- Literature review
- Methodology Selection
- Secondary Data Collection
- Carrying out field studies
- Carrying out laboratory analysis
- Data Analysis and Interpretations
- Preparation of draft of dissertation/thesis following given guidelines
- Submission of Dissertation/Thesis
- Thesis Defence

A good thesis requires to have

- Clearly stated aims/objectives
- Thoroughly researched background
- Data presentation and analysis in a clear and concise manner.
- Cogent interpretation of discussion.
- Perceptive Conclusions and broader scientific significance.
- Appropriate references

Evidence of following skills should be reflected in it

Intellectual skills: considerable evidence of independence and initiative beyond the instructions

Numeracy and IT skills: application of numerical/computing techniques using relevant software

Laboratory skills: use of well-defined laboratory techniques as appropriate

Writing Skills: relevant, logical, concise and succinct writing

Presentation skills: both in terms of English and of layout (e.g., appropriate headings, consistent reference style and reference list, sizing and clarity of figures, etc.).

6. Instructional Strategies:

Consultations, literature review with appropriate citations, attending recommended courses, workshops/seminars and appropriate training in data handling and analysis etc.

7. References: Supervisor will guide the students in going through the relevant literatures during the course of the work.

Specialised Branch: Geoinformatics (GI)

1. Course Number and Title: GMT 507 GI - Spatial Data Science

2. Credit Hours: 3

3. Course Description: Spatial data science lets analysts to extract deeper insight from data using a comprehensive set of analytical methods and spatial algorithms. This course explores the use of spatial data science to uncover hidden patterns and improve predictive modelling. It deals with powerful analytical tools in Esri's ArcGIS software and learn how to integrate popular open data science packages into different analyses.

4. Learning outcomes: On completion of the course the learners will be able to –

- Elucidate the distinctive characteristics of spatial data, as well as how spatial data are created, sensed, stored, manipulated, and represented distinctly compared to other data types
- Practice the science of spatial analysis and modelling, open geospatial data, and spatial thinking to develop reproducible workflows of different spatial problems
- Research and visually communicate spatial data quality and map spatial analysis results in support of analytical reasoning in a variety of data intensive spatial data science contexts

5. Course content:

Unit/Chapter	No. of Lectures
Unit 1: Spatial analysis and modelling (knowledge driven and data driven methods)	8
Unit 2: Geostatistical analysis and interpolation	8
Unit 3: 3-D analysis, DEM and surfacing	8
Unit 4: Topographic analysis using Lidar and TIN	6
Unit 5: Advanced analytical methods in geospatial intelligence	7
Unit 6: Spatial Decision Support System: concepts and applications	8

6. Instructional Strategies:

Lecture, Discussion, Question-Answer, Presentation

7. Assessment:

Formative (30%): Attendance, In-course Examination/Assignment

Summative (70%): Course Final Examination

8. Reading Materials:

Textbook:

1. *Ian, H. (2010). An introduction to geographical information systems. Pearson Education India.*
2. *Kennedy, M. D. (2013). Introducing geographic information systems with ARCGIS: a workbook approach to learning GIS. John Wiley & Sons.*

References:

1. *Longley, P. A., Goodchild, M. F., Maguire, D. J., & Rhind, D. W. (2005). Geographic information systems and science. John Wiley & Sons.*
2. *O'sullivan, D., & Unwin, D. (2003). Geographic information analysis. John Wiley & Sons.*

1. Course Number and Title: GMT 508 GI - Photogrammetry and Advanced Remote Sensing

2. Credit Hours: 3

3. Course Description: This course covers the advanced principles of photogrammetry and remote sensing systems, and their analysis and interpretation in the field of geosciences.

4. Learning outcomes: On completion of the course the learners will be able to know -

- Principles of photogrammetry
- Multi and hyper spectral remote sensing system (Optical)
- Thermal remote sensing system
- Airborne Remote Sensing System
- Analysis and interpretation of both photogrammetry and remote sensing images
- Application of photogrammetry and advanced remote sensing in geosciences

5. Course content:

Unit/Chapter	No. of Lectures
Unit 1: Principles of Photogrammetry	5
Unit 2: Analysis of Photogrammetry	4
Unit 3: Interpretation of Photogrammetry	4
Unit 4: Application of Photogrammetry	5
Unit 5: Satellite multispectral Remote Sensing	4
Unit 6: Satellite hyperspectral Remote Sensing	4
Unit 7: Thermal Remote Sensing System	4
Unit 8: Airborne Remote Sensing System	4
Unit 9: Analysis and Interpretation of Remote Sensing Images	5
Unit 10: Applications of photogrammetry and advanced remote sensing in Geosciences	6

6. Instructional Strategies:

Lecture, Discussion, Question-Answer, Presentation

7. Assessment:

Formative (30%): Attendance, In-course Examination/Assignment

Summative (70%): Course Final Examination

8. Reading Materials:

Textbook:

1. *Wilfried Linder (2003) Digital Photogrammetry, theory and application, Springer*
2. *Jensen, J.R. (2014) Remote Sensing of the Environment: An Earth Resource Perspective (Pearson New International Edition). Pearson.*

References:

1. *Jensen, J.R. (2004) Introductory Digital Image Processing: A Remote Sensing Perspective (3rd Edition). Prentice Hall.*
2. *Lillesand, T.M., Kiefer, R.W. and Chipman, J.W. (2015) Remote Sensing and Image Inter-pretation (7th Edition). John Wiley and Sons.*
3. *Wilfried Linder (2016) Digital Photogrammetry, A practical course, Springer (Fourth edi-tion)*
4. *Kuenzer C. and Dech S., (2013) Thermal Infrared Remote Sensing, sensors, methods and application, Springer*
5. *Richards J. A. and Jia X. (2006) Remote Sensing Digital Image Analysis, Fourth edition, Springer*
6. *Schowengerdt R. A. (2007) Remote Sensing: Models and Methods for Image Processing, third edition, ELSEVIER*
7. *Konecny G. (2003) Geoinformation: Remote sensing, photogrammetry and geographic information systems, Taylor & Francis*

1. Course Number and Title: GMT 509 GI - Application of Geoinformatics in Geosciences

2. Credit Hours: 3

3. Course Description: This course concerns the observations geo-hazards, mapping of geological structure, phenomenon, mineral resource mapping, and its changes over time through geospatial techniques. However, it is not always easy for geologists to visit a location for field observation. Through the application of remote sensing and GIS, geologists can collect detailed information from all over the world. The course specially involves the Interpretation and visualization of the data that comes from those remote sensors to solve specific geoscience related problems.

4. Learning outcomes: On completion of the course the learners will be able to –

- focus on methods of gathering and analysing remote sensing information and using those findings to solve geoscience related problems.
- explain complicated geographic-geologic patterns and relationships using the theoretical concepts.
- generate geographical and geological information by processing digital remotely sensed data and critically evaluating its use for special one-of-a-kind applications.

5. Course content:

Unit/Chapter	No. of Lectures
Unit 1: Advances and Current Trends of GIS in Geosciences	4
Unit 2: GIS for Environmental Modelling and Management System	5
Unit 3: GIS for Groundwater Hydrology and Management	4
Unit 4: GIS Data Modelling and Visualization	4
Unit 5: Mapping and Analysing Geology Data with GIS	4

Unit 6: Sharing GIS Data and Maps through the Internet	4
Unit 7: Current trends of RS for Geosciences	5
Unit 8: Applications of RS for Geo-environments	5
Unit 9: Applications of RS for Geo-resources	5
Unit 10: Applications of RS for Geo-hazards	5

6. Instructional Strategies:

Lecture, Discussion, Question-Answer, Presentation

7. Assessment:

Formative (30%): Attendance, In-course Examination/Assignment

Summative (70%): Course Final Examination

8. Reading Materials:

References:

1. *McEwen, J. W. (2017). GIS Technology Applications in Environmental and Earth Sciences.*
2. *Bonham-Carter, G. F. (2014). Geographic information systems for geoscientists: modelling with GIS (Vol. 13). Elsevier.*
3. *Tian, B. (2016). GIS technology applications in environmental and earth sciences. Crc Press.*
4. *Jensen, J.R. (2014) Remote Sensing of the Environment: An Earth Resource Perspective (Pearson New International Edition). Pearson.*
5. *Liu J. G. and Mason P. J. (2016). Image processing and GIS for Remote Sensing-Techniques and Application, Wiley Blackwell*
6. *Quattrochi, D.A.and Luvall, J.C. (2005). Thermal Remote Sensing in Land Surface Processes. CRC press*
7. *Weng Q. (2010). Remote Sensing and GIS integration, Theories, methods and application, Mc Graw Hill*

1. Course Number and Title: GML 510 GI - Geoinformatics Lab

2. Credit Hours: 3

3. Course Description: This course covers the problems solving with GIS, photogrammetry, UAV, satellite multispectral-hyperspectral- thermal remote sensing systems in the field of geosciences.

4. Learning outcomes: On completion of the course the learners will be able to know -

- Applications of GIS in geosciences fields
- Interpretation of Photogrammetric image and their uses in geosciences fields
- Application of multi and hyper spectral remote sensing images in geosciences fields
- Application thermal remote sensing images in geosciences fields
- Application of InSAR or RADAR images in geoscience fields

5. Course content:

Unit/Chapter	No. of Lab Classes
Unit 1: Problems related spatial data science or GIS (7 problems)	7
Unit 2: Analysis and Interpretation of Photogrammetric Images (4 problems)	4
Unit 3: Problems solving using multispectral satellite images (4 problems)	4
Unit 4: Problems solving using hyperspectral satellite images (3 problems)	3
Unit 5: Problems solving using thermal infrared satellite images (2 problems)	2
Unit 6: Problems solving using InSAR or RADAR images (2 problems)	2

6. Instructional Strategies:

Hands-on excersise

7. Assessment:

Formative (40%): Attendance, Submission of assignment/report/lab note-book

Summative (60%): Practical Examination

8. Practical Materials:

Materials will be supplied based on the theory courses designed for this branch in GIS and RS lab.

1. Course Number and Title: GMP 511 GI - Project/Geological Field Mapping
(Supervised individual research project on any aspect of Geoinformatics or relevant field).

2. Credit Hours: 3

3. Course Description: The aims of this course are to assess the student's ability to provide a critical synthesis of a scientific problem; to enable a student to derive original laboratory or field data, and/or to seek and utilize published/secondary data; to train a student to assess those data and draw appropriate conclusions; to learn how to communicate the experimental strategy, results and conclusions effectively with appropriate citations.

4. Learning outcomes:

- ability to formulate and execute a research project
- ability to analyse, synthesise, summarise and evaluate critically information from literature
- ability of data handling and evaluation
- ability to define problems, devise and evaluate possible solutions
- ability to communicate effectively through the report and a poster presentation
- ability to consider issues from a wide range of perspectives
- an in-depth understanding of the student's field of specialisation
- appreciation of the use and limitations of data in testing a hypothesis

- ethics and integrity in research

5. Course Content: The Project Report should contain high level of practical work and has to be submitted within allocated time which has to have the following

- Clearly stated aims/objectives
- Thoroughly researched background
- Data presentation and analysis in a clear and concise manner.
- Cogent interpretation of discussion.
- Perceptive Conclusions and broader scientific significance.
- Appropriate references

Evidence of considerable application of numerical/computing techniques and or laboratory techniques as appropriate and excellent presentation in terms both of English and of layout (e.g., appropriate headings, consistent reference style and reference list, sizing and clarity of figures, etc.) is expected. Project report submission will be followed by Project defence/Poster presentation.

6. Instructional Strategies:

Consultations, literature review with appropriate citations, attending recommended courses, workshops/seminars and appropriate training in data handling and analysis etc.

7. References: Supervisor will guide the students in going through the relevant literatures during the course of the work.

1. Course Number and Title: GMR 512 GI – Thesis (Supervised individual original research on any aspect of Geoinformatics or relevant field)

2. Credit Hours: 6

3. Course Description: The aims of this course are to assess the student's ability to provide a critical synthesis of a scientific problem; to enable a student to derive original laboratory or field data, and/or to seek and utilize published data; to train a student to assess those data and draw appropriate conclusions; to learn how to communicate the experimental strategy, results and conclusions effectively with appropriate citations; to provide training in how to formulate a research problem. Therefore, this course would enable students to put their specialist skills, knowledge, and understanding into practice through the medium of a significant individual research project and written dissertation. Thesis/project might involve students working within one of the Department's established research groups or can work in collaboration with another industrial or academic partner. Wherever is the work, the students will be supervised, throughout the project/thesis duration by a supervisor assigned by the Department. The supervisor will provide advice on the approaches and methods that are best suited to the research problem and on collection/analysis of data and will guide in producing a well-written dissertation.

4. Learning outcomes:

Knowledge and Understanding:

- an in-depth understanding of a specialised area

- the principles and methodology of experimental techniques and
- data handling and evaluation.

Intellectual Outcomes:

- ability to define problems, devise and evaluate possible solutions
- ability to solve routine and unfamiliar problems elegantly
- ability to consider issues from a wide range of perspectives

Practical and Transferable Outcomes:

- ability to formulate and execute a research project individually
- ability to analyse, synthesise, summarise and evaluate critically information from literature
- ability to communicate effectively through the research report and oral presentation.
- ability to present research findings to technical audiences as well as generalized audiences
- ability to publish papers in peer reviewed journals
- ability to work in a professional organization in the specialised field of expertise.

Ethical Outcomes:

- clear understanding of data protection issues and appreciation of the use secondary data
- clear understanding of plagiarism
- honesty and transparency in developing, undertaking, reporting and communicating research
- research ethics and integrity

5. Course Content: The work has to be completed within allocated time by completing the following steps:

- Proposal Development and synopsis presentation
- Literature review
- Methodology Selection
- Secondary Data Collection
- Carrying out field studies
- Carrying out laboratory analysis
- Data Analysis and Interpretations
- Preparation of draft of dissertation/thesis following given guidelines
- Submission of Dissertation/Thesis
- Thesis Defence

A good thesis requires to have

- Clearly stated aims/objectives
- Thoroughly researched background
- Data presentation and analysis in a clear and concise manner.
- Cogent interpretation of discussion.
- Perceptive Conclusions and broader scientific significance.

- Appropriate references

Evidence of following skills should be reflected in it

Intellectual skills: considerable evidence of independence and initiative beyond the instructions

Numeracy and IT skills: application of numerical/computing techniques using relevant software

Laboratory skills: use of well-defined laboratory techniques as appropriate

Writing Skills: relevant, logical, concise and succinct writing

Presentation skills: both in terms of English and of layout (e.g., appropriate headings, consistent reference style and reference list, sizing and clarity of figures, etc.).

6. Instructional Strategies:

Consultations, literature review with appropriate citations, attending recommended courses, workshops/seminars and appropriate training in data handling and analysis etc.

7. References: Supervisor will guide the students in going through the relevant literatures during the course of the work.

Specialised Branch: Hydrogeology and Water Resources Management (HG)

1. Course Number and Title: GMT 507 HG - Water Resources Planning and Management

2. Credit Hours: 3

3. Course Description: Water resources systems; Water resources planning and policy; Water conservation and demand management; Integrated water resources management; Water governance and water safety plans; Impacts of climate change on water resources; Water resources of Bangladesh and challenges.

4. Learning outcomes: On completion of the course the learners will be able to –

- assess the potential of groundwater and surface water resources;
- ability for developing master and strategic water resources planning;
- deal with water supply-demand issues including water demand management, reservoir storage and other structural and non-structural methods;
- know the concepts of water resources management, their implementation and challenges;
- evaluate the water resources of Bangladesh and mange future challenges.

5. Course content:

Unit/Chapter	No. of Lectures
Unit 1: Introduction to water resources and related issues; Water availability, uses and demand; Water resources data acquisition and processing; Water resources planning and policy.	6

Unit 2: Concepts of water resources management; Integrated water resources management; Adaptive water resources management; Risk and uncertainty in water resources management	7
Unit 3: River basin/watershed management; Transboundary water resources management; Urban water management; Agricultural water management; Wastewater and stormwater management; Water and wastewater treatment.	7
Unit 4: Environmental and social evaluation of water resources development projects; Impacts of climate variability and climate change on water resources; Impacts of human activities on water resources	6
Unit 5: Water governance, water conservation and water safety plans; Water quality and impacts of water quality on the environment and public health.	5
Unit 6: Surface water and groundwater resources of Bangladesh; Water uses and demand; Water resources panning and policy in Bangladesh; Water resources management practice and institutional framework in Bangladesh.	8
Unit 7: Challenges of water recourses development and management in Bangladesh; Scope of integrated water resources management.	6

6. Instructional Strategies:

Lecture, Discussion, Question-Answer, Presentation

7. Assessment:

Formative (30%): Attendance, In-course Examination/Assignment

Summative (70%): Course Final Examination

8. Reading Materials:

Textbook:

1. *Water Resources Systems Planning and Management. SK Jain and VP Singh. Elsevier, 2003.*

References:

1. *Water Resources Systems Planning and Management. M C Chaturvedi. Tata McGraw-Hill Publishing Company Limited, New Delhi, 1987.*
2. *Water Resources Systems Planning and Management: An Introduction to Methods, models and Applications. Daniel P Loucks and Eelco van Beek (Ed.), Dettares, UNESCO-IHE, Springer, 2017*
3. *Developing Groundwater-A Guide for Rural Water Supply – A MacDonald, J Davies, R Calow and J Chilton, ITDG Publishing, UK, 2005.*
4. *Water Supply and Pollution Control. Warren Viessman, Jr and Mark J Hammer, Person Prentice Hall, New Jersey, 2005.*

1. Course Number and Title: GMT 508 HG - Hydrochemistry and Contamination of Groundwater

2. Credit Hours: 3

3. Course Description: Geochemical processes and evolution of groundwater; Water sampling and analytical procedure; Water chemistry data presentation and interpretation; groundwater contamination and remediation, Solute transport; Isotope geochemistry; Quality and contamination of water resources of Bangladesh

4. Learning outcomes: On completion of the course the learners will be able to –

- practice standard protocols for water/soil sampling and analysis in laboratory;
- present and interpret hydrochemical data and understand the hydrogeochemical processes active in the aquifer system;
- assess quality of water for various uses;
- identify the sources and types of groundwater contamination and suggest appropriate remediation techniques;
- develop strategic plan for protection and monitoring of water quality for safe and sustainable uses.

5. Course content:

Unit/Chapter	No. of Lectures
Unit 1: Hydrogeochemistry: Groundwater and surface water chemistry; Solutions, minerals and equilibria; Geochemical processes in groundwater; Carbonate system and chemical weathering; Chemical constituents and evolution of groundwater.	7
Unit 2: Sampling and Analysis: Planning and procedure of soil/water sampling; Methods and instrumentation for sampling; Techniques and instrumentation for water analysis; Hydrochemical data presentation and interpretation by different graphical and numerical methods.	8
Unit 3: Groundwater Contamination: Sources of contamination, Types of contaminants; Mass transport in aquifers: Advection, Dispersion, Diffusion, Sorption, Retardation, Biodegradation.	6
Unit 4: Remediation of contaminated soil and groundwater.	4
Unit 5: Water quality criteria: Water quality assessment, monitoring and protection	4
Unit 6: Solute transport and Reaction modelling	4
Unit 7: Isotope Geochemistry: Environmental Isotopes: 2H, 18O, 13C, 15N, 32S; Dating of Modern and Old Groundwater	2
Unit 8: Quality and Contaminations of water resources in Bangladesh	10

6. Instructional Strategies:

Lecture, Discussion, Question-Answer, Presentation

7. Assessment:

Formative (30%): Attendance, In-course Examination/Assignment

Summative (70%): Course Final Examination

8. Reading Materials:

Textbook:

1. *Drever, J. I (1988): The Geochemistry of Natural Waters, Prentice Hall*
2. *Fetter, C.W (1999): Contaminant Hydrogeology, Macmillan Publishing Company*

References:

1. *Brassington, R. (1999); Field Hydrogeology (2nd ed.) John Wiley & Sons. N.Y.*
2. *Domenico, P.A. and Sehwartgz, F.W. (1990): Physical and Chemical Hydrogeology. John Wiley & Sons, N.Y.*
3. *Hern, J.D. (1989). Study and Interpretation of the Chemical Characteristics of Natural Water, (3rd ed.) USGS – WSP 2254.*
4. *Matthess, G (1982): The Properties of Groundwater. John Wiley & Sons, N.Y.*
5. *Saether, O.M. & Caritat, P (de) (1997): Geochemical Processes, Weathering and Groundwater Recharge in Catchments. A.A. Balkema Publ. Rotterdarn.*
6. *Geochemistry, groundwater and pollution. C A J Appelo and D Postma. A A Balkema, Rotter-dam, 1994.*
7. *Protecting Groundwater for Heath. Oliver Schmoll, Guy Howard, John Chilton, Ingrid Cho-rus. WHO and IWA, 2006.*
8. *Lloyd, J.W. and Heathcoat, J.A. (1985) Natural Inorganic Chemistry in Relation to Groundwater. Clarendon Press, Oxford.*

1. Course Number and Title: GMT 509 HG - Groundwater Resource Evaluation and Modelling

2. Credit Hours: 3

3. Course Description: This course provides students an advanced understanding of the methods of groundwater resources evaluation, resource abstraction techniques, as well as risk and vulnerability assessment with special emphasis on the development and use of groundwater model as a decision-making tool.

4. Learning outcomes: On completion of the course the learners will be able to –

- assess groundwater resources in an area;
- design appropriate technology for groundwater abstraction;
- assess risk and vulnerability of groundwater abstraction;
- develop conceptual model of a hydrogeological system;
- develop and use numerical models for resource estimation, sustainable development as well as risk and vulnerability characterization.

5. Course content:

Unit/Chapter	No. of Lectures
Unit 1: Review of Methods in Groundwater Resources Assessment	3
Unit 2: Groundwater recharge, discharge and balance: Recharge by Vertical Leakage, Artificial Recharge, Groundwater Mounds, Groundwater Runoff	3
Unit 3: Water wells: Design, Construction, Performance and Maintenance of Production Wells	4
Unit 4: Vulnerability of Aquifers to pollution and overexploitation	3

Unit 5: Environmental Impacts of groundwater development	2
Unit 6: Basics of Groundwater Modelling	3
Unit 7: Conceptual model	4
Unit 8: Basics of Groundwater Flow	3
Unit 9: Introduction to numerical methods	4
Unit 10: Introduction to MODFLOW and SUTRA	3
Unit 11: Introduction to solute transport	3
Unit 12: Modelling exercises using MODFLOW and SUTRA	10

6. Instructional Strategies:

Lecture, Discussion, Question-Answer, Presentation

7. Assessment:

Formative (30%): Attendance, In-course Examination/Assignment

Summative (70%): Course Final Examination

8. Reading Materials:

Textbook:

1. *Anderson, M.P., (2015) Applied groundwater Modeling, Simulation of Flow and Advective Transport (2nd Edition), Elsevier*
2. *Walton W.C. (1970): Groundwater Resources Evaluation. McGraw Hill Book Co.*

References:

1. *Lemer D.N. Issar, A.S. & Simmers I. (1990): Groundwater Recharge. Vol. 8 LAH.*
2. *Wang, H and Anderson M.P. (1982): Introduction to Groundwater Modeling: Finite Dif-ference and Finite Element Methods. W.H. Freeman. USA.*
3. *Neven Kresic, (2007): Hydrogeology and Groundwater Modeling, 2nd Edition. CRC Press.*
4. *Rushton, K R (2005): Groundwater Hydrology Conceptual and Computational Models. Wiley.*
5. *Harbaugh, A.W., 2005, MODFLOW-2005, the U.S. Geological Survey modular ground-water model -- the Ground-Water Flow Process: U.S. Geological Survey Techniques and Methods 6-A16.*
6. *Provost, A.M., and Voss, C.I., 2019, SUTRA, a model for saturated-unsaturated, variable-density groundwater flow with solute or energy transport—Documentation of generalized boundary conditions, a modified implementation of specified pressures and concentrations or temperatures, and the lake capability: U.S. Geological Survey Techniques and Methods, book 6, chap. A52, 62 p., https://doi.org/10.3133/tm6A52.*
7. *Pollock, D.W., 2016, User guide for MODPATH Version 7 -- A particle-tracking model for MODFLOW: U.S. Geological Survey Open-File Report 2016-1086, 35 p., http://dx.doi.org/10.3133/ofr20161086.*
8. *Bedekar, Vivek, Morway, E.D., Langevin, C.D., and Tonkin, Matt, 2016, MT3D-USGS ver-sion 1: A U.S. Geological Survey release of MT3DMS updated with new and expanded transport capabilities for use with MODFLOW: U.S. Geological Survey Techniques and Methods 6-A53, 69 p., http://dx.doi.org/10.3133/tm6A53.*

9. *Winston, R.B., 2019, ModelMuse version 4—A graphical user interface for MODFLOW 6: U.S. Geological Survey Scientific Investigations Report 2019–5036, 10 p.*
10. *Hassan M.Q. (2000). Three-dimensional Groundwater Modeling; A Study of Southwest Bangladesh Dhaka University Publication Section.*
11. *Hassan, M.Q. (1992): Saline Water Intrusion and Hydrogeological Modeling in South-west Bangladesh. Schelzky & Jeep Publ. Co. Berlin, Germany*

1. Course Number and Title: GML 510 HG - Field and Laboratory Techniques in Hydrogeology

2. Credit Hours: 3

3. Course Description: The course emphasizes state-of-the-art techniques for sediments and groundwater sampling, aquifer testing, and the evaluation of groundwater systems. Integration of a broad range of hydrologic, hydrogeologic, and geochemical methods by application of field and laboratory methods in order to introduce students to a broad range of skills and methods in surface and boreholes geophysics, hydrogeological mapping, water well design, aquifer testing, groundwater sampling and analysis and report writing.

4. Learning outcomes: On completion of the course the learners will be able to –

- acquire higher order of thinking, analytical and interpretational skills;
- learn several techniques of data acquisition and analysis;
- draw conclusions from and integrating multiple datasets;
- write Hydrogeological Report integrating various different types of data;
- evaluate which methods are suitable for the study in question and decide what kind of hydrogeological surveys are necessary for: groundwater extraction, management and protection of groundwater resources, and studies of contaminant spreading in groundwater.

5. Course content:

Unit/Chapter	No. of Lab Classes
Unit 1: Site selection for hydrogeological study using RS/GIS – Identification of water bodies, land-use pattern and potential site for GW development.	2
Unit 2: Site investigations – Surface geophysical methods; drilling; sampling and litholog preparation; wire-line logging, grain size analysis for determination of hydraulic conductivity, sorting and screen slot opening; pumping test.	5
Unit 3: Aquifer mapping and well design; groundwater monitoring system design; hydrograph analysis.	3
Unit 4: Groundwater sampling methods, sample preservation techniques, and measurement methods of field parameters.	2
Unit 5: Laboratory analysis - Laboratory instrumentation in water analysis; analytical methods; determination of major and minor ions, and trace elements; QA/QC procedures.	4

Unit 6: Water chemistry data analysis and interpretation - analytical accuracy check; graphical interpretation; statistical and spatial analysis; water quality parameters, Mass balance and source rock deduction; numerical problems.	4
Unit 7: Integrated Hydrogeological report writing.	2

6. Instructional Strategies:

Lecture, Field and Laboratory Analyses, Discussion, Question-Answer, Presentation, Report Writing

7. Assessment:

Formative (40%): Attendance, Submission of assignment/report/lab note-book

Summative (60%): Practical Examination

8. Reading Materials:

References:

1. *Brassington, Rick, 2007. Field Hydrogeology, Third Edition, Print ISBN:9780470018286, John Wiley & Sons, Ltd*
2. *Moore, John E., 2012, Field Hydrogeology A Guide for Site Investigations and Report Preparation, Second Edition, ISBN 9781138077140, CRC Press.*
3. *Weight, Willis D., 2001. Manual of Applied Field Hydrogeology, ISBN: 9780070696396, The McGraw-Hill Companies, Inc*
4. *David M. Nielsen, Gillian Nielsen, 2006. The Essential Handbook of Ground-Water Sampling, 1st Edition, ISBN 9781420042788, CRC Press.*
5. *John Milsom, Asger Eriksen, 2011. Field Geophysics, Fourth Edition. Print ISBN:9780470749845, Wiley.*
6. *P. K. Kitanidis, 1997. Introduction to Geostatistics: Applications in Hydrogeology, CUP.*
7. *IAHS, 2004. GIS and Remote Sensing in Hydrology, Water Resources and Environment, IAHS Publication 289.*
8. *Arthur W. Hounslow, 1995. Water Quality Data Analysis and Interpretation,1st Edition, Taylor and Francis Group.*
9. *JOHN D. HEM, 1985. Study and Interpretation of the Chemical Characteristics of Natural Water, Third Edition, U.S GEOLOGICAL SURVEY WATER-SUPPLY PAPER 2254*
10. *G.P. Kruseman and N.A. de Ridder, 1994. Analysis and Evaluation of Pumping Test Data, Second Edition (Completely Revised), Publication 47, International Institute for Land Reclamation and Improvement, The Netherlands.*

1. Course Number and Title: GMP 511 HG - Project/Geological Field Mapping

(Supervised individual research project on any aspect of Hydrogeology or relevant field).

2. Credit Hours: 3

3. Course Description: The aims of this course are to assess the student's ability to provide a critical synthesis of a scientific problem; to enable a student to derive original laboratory or field data, and/or to seek and utilize published/secondary data; to train a student to assess those data and draw appropriate conclusions; to learn how to communicate the experimental strategy, results and conclusions effectively with appropriate citations.

4. Learning outcomes:

- ability to formulate and execute a research project
- ability to analyse, synthesise, summarise and evaluate critically information from literature
- ability of data handling and evaluation
- ability to define problems, devise and evaluate possible solutions
- ability to communicate effectively through the report and a poster presentation
- ability to consider issues from a wide range of perspectives
- an in-depth understanding of the student's field of specialisation
- appreciation of the use and limitations of data in testing a hypothesis
- ethics and integrity in research

5. Course Content: The Project Report should contain high level of practical work and has to be submitted within allocated time which has to have the following

- Clearly stated aims/objectives
- Thoroughly researched background
- Data presentation and analysis in a clear and concise manner.
- Cogent interpretation of discussion.
- Perceptive Conclusions and broader scientific significance.
- Appropriate references

Evidence of considerable application of numerical/computing techniques and or laboratory techniques as appropriate and excellent presentation in terms both of English and of layout (e.g., appropriate headings, consistent reference style and reference list, sizing and clarity of figures, etc.) is expected. Project report submission will be followed by Project defence/Poster presentation.

6. Instructional Strategies:

Consultations, literature review with appropriate citations, attending recommended courses, workshops/seminars and appropriate training in data handling and analysis etc.

7. References: Supervisor will guide the students in going through the relevant literatures during the course of the work.

1. Course Number and Title: GMR 512 HG – Thesis (Supervised individual original research on any aspect of Hydrogeology or relevant field)

2. Credit Hours: 6

3. Course Description: The aims of this course are to assess the student's ability to provide a critical synthesis of a scientific problem; to enable a student to derive original laboratory or field data, and/or to seek and utilize published data; to train a student to assess those data and draw appropriate conclusions; to learn how to communicate the experimental strategy, results and conclusions effectively with appropriate citations; to provide training in how to formulate

a research problem. Therefore, this course would enable students to put their specialist skills, knowledge, and understanding into practice through the medium of a significant individual research project and written dissertation. Thesis/project might involve students working within one of the Department's established research groups or can work in collaboration with another industrial or academic partner. Wherever is the work, the students will be supervised, throughout the project/thesis duration by a supervisor assigned by the Department. The supervisor will provide advice on the approaches and methods that are best suited to the research problem and on collection/analysis of data and will guide in producing a well-written dissertation.

4. Learning outcomes:

Knowledge and Understanding:

- an in-depth understanding of a specialised area
- the principles and methodology of experimental techniques and
- data handling and evaluation.

Intellectual Outcomes:

- ability to define problems, devise and evaluate possible solutions
- ability to solve routine and unfamiliar problems elegantly
- ability to consider issues from a wide range of perspectives

Practical and Transferable Outcomes:

- ability to formulate and execute a research project individually
- ability to analyse, synthesise, summarise and evaluate critically information from literature
- ability to communicate effectively through the research report and oral presentation.
- ability to present research findings to technical audiences as well as generalized audiences
- ability to publish papers in peer reviewed journals
- ability to work in a professional organization in the specialised field of expertise.

Ethical Outcomes:

- clear understanding of data protection issues and appreciation of the use secondary data
- clear understanding of plagiarism
- honesty and transparency in developing, undertaking, reporting and communicating research
- research ethics and integrity

5. Course Content: The work has to be completed within allocated time by completing the following steps:

- Proposal Development and synopsis presentation
- Literature review
- Methodology Selection
- Secondary Data Collection
- Carrying out field studies

- Carrying out laboratory analysis
- Data Analysis and Interpretations
- Preparation of draft of dissertation/thesis following given guidelines
- Submission of Dissertation/Thesis
- Thesis Defence

A good thesis requires to have

- Clearly stated aims/objectives
- Thoroughly researched background
- Data presentation and analysis in a clear and concise manner.
- Cogent interpretation of discussion.
- Perceptive Conclusions and broader scientific significance.
- Appropriate references

Evidence of following skills should be reflected in it

Intellectual skills: considerable evidence of independence and initiative beyond the instructions

Numeracy and IT skills: application of numerical/computing techniques using relevant software

Laboratory skills: use of well-defined laboratory techniques as appropriate

Writing Skills: relevant, logical, concise and succinct writing

Presentation skills: both in terms of English and of layout (e.g., appropriate headings, consistent reference style and reference list, sizing and clarity of figures, etc.).

6. Instructional Strategies:

Consultations, literature review with appropriate citations, attending recommended courses, workshops/seminars and appropriate training in data handling and analysis etc.

7. References: Supervisor will guide the students in going through the relevant literatures during the course of the work.

Specialised Branch: Mining Geology (MG)

1. Course Number and Title: GMT 507 MG - Mine Planning and Design

2. Credit Hours: 3

3. Course Description: The course is designed to comprehend the principles and procedures to make a mine plane for a geologic deposit in a systematic manner.

4. Learning outcomes: On completion of the course the learners will be able to –

- to understand the principles and stages of mine planning.
- to understand the technical aspects of open-pit and underground mine.
- to prepare a mining model for a geologic deposit.

5. Course content:

Unit/Chapter	No. of Lectures
Unit 1: General Mine Planning and design principles; Principles of mine planning.	2
Unit 2: Stages of planning of new mines and mine renovation.	2
Unit 3: Exploration and reserve estimation, Methods of exploration and reserve estimation	2
Unit 4: Selection of a mine site, Division of a coalfield into mine areas.	2
Unit 5: Surface layout of a mine: Types of mines. Surface layouts. Surface mine (mountain-top layout and sub-surface layout)	2
Unit 6: Pit bottom and layout of an underground working: Pit-bottom layout. Layout of underground workings. Detail of production face	3
Unit 7: Mine phases: Mine development phases. The planning phase. Accuracy of estimates.	3
Unit 8: Critical path analysis: Critical path presentation. Mathematical representation of CPM, and Graphical representation CPM	3
Unit 9: Environmental planning: Environmental planning procedure. Environmental impact assessment. Environmental management planning.	3
Unit 10: Mining revenues and costs: Economic concepts. Cash flow. Estimating revenues, Estimating costs.	4
Unit 11: Production planning: Mine life rules. Mine and mill plant sizing. Lanes algorithm, Production scheduling, Push back design.	4
Unit 12: Open pit mine: Geometrical considerations. Pit expansion process. Final pit slope angle Road construction. Stripping ratios, geometric sequencing Pit limits. Dewatering system analysis. Equipment selection.	5
Unit 13: Underground mine: Underground mine lay out plan. Access design. Selection criterion of underground mine machinery. Mining methods. Ventilation and dewatering system analysis and equipment.	5
Unit 14: Mining method selection: UBC method, Entropy method, Vikor method, Mining Method Selection Tool (MMST).	3
Unit 15: Mine Reclamation: Detail mine reclamation plan.	2

6. Instructional Strategies:

Lecture, Discussion, Question-Answer, Presentation

7. Assessment:

Formative (30%): Attendance, In-course Examination/Assignment

Summative (70%): Course Final Examination

8. Reading Materials:

Textbook:

1. *Open pit Mine Planning and Design; WA Hustruid, M Kuchta, RK Martin. 2013, 1308 pp.*
2. *Underground Mining Methods: Engineering Funadamentals and International Case Studies; WA Hustrulid, WA Hustruid, R C Bullock. 2001, 728 pp.*
3. *Introduction to Mining Engineering; HL Hartman, JM Mutmansky. 2002, 592 pp. 4. Supplied materials.*

1. Course Number and Title: GMT 508 MG - Mine Operations

2. Credit Hours: 3

3. Course Description:

4. Learning outcomes: On completion of the course the learners will be able to know –

how to explore Mineral Resources: Regional and detail exploration, Resource and reserve; Relation between resource, reserve and exploration, Methods of reserve estimation. Basics of mining system: Unit operations; Rock breakage; Principles of rock penetration and application, Blasting; zones of detonation, Effective energy release, Blast geometry, Mechanical excavation. finally, to operate a mine skilfully.

5. Course content:

Unit/Chapter	No. of Lectures
Unit 1: Mineral exploration Regional ad detail exploration; Resource and reserve; Relation between resource, reserve; Mineral exploration and its technique.	4
Unit 2: Basics of mining operation Unit operations; Rock breakage; Principles of rock penetration and application.	4
Unit 3: Rock breakage in mining system Blasting; zones of detonation, Effective energy release; Blast geometry; Principles of Mechanical excavation	4
Unit 4: Open Pit Mining An overview of open pit mining methods; Bench geometry. Typical workings of an open pit mine; Pit limit and stripping ratio; Slope stability.	6
Unit 5: Mechanical excavations	3

Mechanical excavations: principles; Mechanical excavations: selection of machineries.	
Unit 6: Mining Methods Classification; Detail of the methods; Method selection.	5
Unit 7: Support systems Support components and accessories; Selection of supports; Support configurations and their effects.	3
Unit 8: Strata control in coal mine Theories of strata behaviour; Subsidence monitoring; Groundwater management.	3
Unit 9: Unconventional Mining Systems Coal Bed Methane (CBM), Underground Coal Gasification (UCG), Subsurface Cultivation and Gasification (SCG); Hydraulic mining; Sea Bed Mining; Borehole mining; Mining in space.	6
Unit 10: Basics of Mineral Processing Introduction, Acceptance into the mill; Crushing, Seizing and sorting; Methods of separation, Unit processes and machineries.	4
Unit 11: Basics of Reclamation Removal of plant and buildings; Reclamation of trailing dumps; Monitoring of discharges.	3

6. Instructional Strategies:

Lecture, Discussion, Question-Answer, Presentation

7. Assessment:

Formative (30%): Attendance, In-course Examination/Assignment

Summative (70%): Course Final Examination

8. Reading Materials:

Textbook:

1. *Rock Mechanics for Underground Mining; BHG Brady and ET Brown. 2004, 628 pp.*
2. *Mining Boky. 1967, 753 pp.*
3. *Introduction to Mining Engineering; HL Hartman, JM Mutmansky.2002, 592 pp.*
4. *Underground Mining Methods: Engineering Funadamentals and International Case Studies; WA Hustrulid, William A Hustruid, R C Bullock. 2001, 718 pp.*

References:

1. *Open pit Mine Planning and design; William A Hustruid, M Kuchta, RK Martin. 2013, 1308 pp.*
2. *Mineral Processing; BA Wills, JA Finch. 1987, 512 pp.*
3. *Assessment, Restoration and Reclamation of Mining Influenced Soils; J Bech, C Bini, M Pashkevich. 2017, 520 pp.*

1. Course Number and Title: GMT 509 MG - Mine Safety Management

2. Credit Hours: 3

3. Course Description: The course includes safety management; hazard and risk analyses, safety hazard identification, management techniques, safety audits; statistics; HAZOP management and maintenance of change risk analysis; cost benefit analysis; attitudes to safety in mining; effective training; accident and injury report/recovery; ergonomics and safety engineering; prevention of traumatic injury; work stress; environmental factors; monitoring and protection; personal protective equipment; safety policies and programs; action plans.

4. Learning outcomes: On completion of the course the learners will be able to –

- review a generic approach to loss control within mining operations together with identification of management strategies to deal with such losses.
- extend from simple hazard control management to full catastrophic management planning.
- draw on experience and techniques applied in non-mining industries in addition to a practical focus on mining risk management taught by specialist safety management personnel.

5. Course content:

Unit/Chapter	No. of Lectures
Unit 1: Safety management: Classification of safety management in mining; Different types of safety management; HAZOP management and maintenance of change risk analysis	5
Unit 2: Hazard and risk analyses: Risk and accident, Fire hazards, Water inrush hazards, Subsidence hazards.	5
Unit 3: Safety hazard identification: Classification of accident/injury, Open pit safety hazards identifications, Underground safety hazards identifications	5
Unit 4: Hazard management techniques: Hazard and Operative (HAZOP) Analysis, Failure Mode and Effect Analysis (FMEA), Failure Mode Effect and Critical Analysis (FMECA)	5
Unit 5: Risk Analysis Methods: Job Safety Analysis (JSA), Preliminary Hazard Analysis (PHA), Appraisal of advanced techniques - Fault Tree Analysis (FTA), Probability Tree Method, Markov Method.	7
Unit 6: System Safety Engineering Approach: System safety engineering definitions, System safety engineering approaches, Domino model, Souder behavioural accident model Normal accident theory; Human Factors Analysis and Classification System (HFACS) using the “Swiss Cheese” model	6
Unit 7: Risk assessment using different multivariate modelling:	6

Logit and Logistic model, Structural equation modelling, Fuzzy logic, Recent trends of development of safety engineering approaches.	
Unit 8: Risk Analysis: Maintenance of change risk analysis; Attitudes to safety in mining; effective training; Prevention of traumatic injury; work stress; environmental factors; Personal protective equipment; safety policies and programs.	6

6. Instructional Strategies:

Lecture, Discussion, Question-Answer, Presentation

7. Assessment:

Formative (30%): Attendance, In-course Examination/Assignment

Summative (70%): Course Final Examination

8. Reading Materials:

Textbook:

1. *Mine Safety Science and Engineering Health and Disaster Management, by Debi Prasad Tripathy, Published September 10, 2019 by CRC Press; 424 Pages*
2. *Managing Mining Hazards: Regulation, Safety and Trust; 2012 by Neil Gunningham and Darren Sinclair; Published October 2012; 272 Pages.*
3. *Mine Health and Safety Management; by Michael Karmis; Published Society for Mining, Metallurgy, and Exploration 2001; 435 Pages*

1. Course Number and Title: GML 510 MG - Mining Geology Lab

2. Credit Hours: 3

3. Course Description: Estimation of metallic non-metallic ore reserve based on borehole data of deposit. Engineering calculations of rock support system. Blasting design and calculation of number of boreholes. Calculation of required amount of explosive for production of rock and for development workings.

Calculation for amount of air, for total ventilation of mine. Selection of main fan, for ventilation purposes. Designing of haul road in underground mine. Problem related to ultimate slope in open pit mine. Designing of length of long wall face. Problem related to scheduling.

4. Learning outcomes: On completion of the course the learners will be able to –

learn and practice miner for total mine design and operational processes.

5. Course content:

Unit/Chapter	No. of Lab Classes
Unit 1: Estimation of metallic non-metallic ore reserve based on bore hole data of deposit	2
Unit 2: Engineering calculation of rock support system	2
Unit 3: Blasting design and calculation of number of boreholes	2
Unit 4: Calculation of required amount of explosive for production of rock and for development workings.	2

Unit 5: Calculation of amount of air for total ventilation of mine. Selection of main fan for ventilation purposes.	2
Unit 6: Design of haul road.	2
Unit 7: Problem related to ultimate slope in open pit mine.	2
Unit 8: Design of length of long wall face.	2
Unit 9: Problem related to scheduling: Manning scheduling, Working scheduling, Equipment scheduling	3
Unit 10: Optimum blast design for open pit mine and underground mine	3

6. Instructional Strategies:

Mathematical calculation, Problem solving, Designing

7. Assessment:

Formative (40%): Attendance, Submission of assignment/report/lab note-book

Summative (60%): Practical Examination

8. Reading Materials:

References:

1. *Rock Mechanics for Underground Mining; BHG Brady and ET Brown. 2004, 628 pp.*
2. *Mining. Boky. 1967, 753 pp*
3. *Introduction to Mining Engineering; HL Hartman, JM Mutmansky.2002, 592 pp*
4. *Underground Mining Methods: Engineering Funadamentals and International Case Studies; WA Hustrulid, William A Hustruid, R C Bullock. 2001, 718 pp.*
5. *Open pit Mine Planning and design;William A Hustruid, M Kuchta, RK Martin. 2013, 1308 pp.*
6. *Practical Shaft Sinking; F Donaldson. 2018, 160 pp.*

1. Course Number and Title: GMP 511 MG - Project/Geological Field Mapping
(Supervised individual research project on any aspect of Mining Geology or relevant field).

2. Credit Hours: 3

3. Course Description: The aims of this course are to assess the student's ability to provide a critical synthesis of a scientific problem; to enable a student to derive original laboratory or field data, and/or to seek and utilize published/secondary data; to train a student to assess those data and draw appropriate conclusions; to learn how to communicate the experimental strategy, results and conclusions effectively with appropriate citations.

4. Learning outcomes:

- ability to formulate and execute a research project
- ability to analyse, synthesise, summarise and evaluate critically information from literature
- ability of data handling and evaluation
- ability to define problems, devise and evaluate possible solutions
- ability to communicate effectively through the report and a poster presentation

- ability to consider issues from a wide range of perspectives
- an in-depth understanding of the student's field of specialisation
- appreciation of the use and limitations of data in testing a hypothesis
- ethics and integrity in research

5. Course Content: The Project Report should contain high level of practical work and has to be submitted within allocated time which has to have the following

- Clearly stated aims/objectives
- Thoroughly researched background
- Data presentation and analysis in a clear and concise manner.
- Cogent interpretation of discussion.
- Perceptive Conclusions and broader scientific significance.
- Appropriate references

Evidence of considerable application of numerical/computing techniques and or laboratory techniques as appropriate and excellent presentation in terms both of English and of layout (e.g., appropriate headings, consistent reference style and reference list, sizing and clarity of figures, etc.) is expected. Project report submission will be followed by Project defence/Poster presentation.

6. Instructional Strategies:

Consultations, literature review with appropriate citations, attending recommended courses, workshops/seminars and appropriate training in data handling and analysis etc.

7. References: Supervisor will guide the students in going through the relevant literatures during the course of the work.

1. Course Number and Title: GMR 512 MG – Thesis (Supervised individual original research on any aspect of Mining Geology or relevant field)

2. Credit Hours: 6

3. Course Description: The aims of this course are to assess the student's ability to provide a critical synthesis of a scientific problem; to enable a student to derive original laboratory or field data, and/or to seek and utilize published data; to train a student to assess those data and draw appropriate conclusions; to learn how to communicate the experimental strategy, results and conclusions effectively with appropriate citations; to provide training in how to formulate a research problem. Therefore, this course would enable students to put their specialist skills, knowledge, and understanding into practice through the medium of a significant individual research project and written dissertation. Thesis/project might involve students working within one of the Department's established research groups or can work in collaboration with another industrial or academic partner. Wherever is the work, the students will be supervised, throughout the project/thesis duration by a supervisor assigned by the Department. The supervisor will provide advice on the approaches and methods that are best suited to the research problem and on collection/analysis of data and will guide in producing a well-written dissertation.

4. Learning outcomes:

Knowledge and Understanding:

- an in-depth understanding of a specialised area
- the principles and methodology of experimental techniques and
- data handling and evaluation.

Intellectual Outcomes:

- ability to define problems, devise and evaluate possible solutions
- ability to solve routine and unfamiliar problems elegantly
- ability to consider issues from a wide range of perspectives

Practical and Transferable Outcomes:

- ability to formulate and execute a research project individually
- ability to analyse, synthesise, summarise and evaluate critically information from literature
- ability to communicate effectively through the research report and oral presentation.
- ability to present research findings to technical audiences as well as generalized audiences
- ability to publish papers in peer reviewed journals
- ability to work in a professional organization in the specialised field of expertise.

Ethical Outcomes:

- clear understanding of data protection issues and appreciation of the use secondary data
- clear understanding of plagiarism
- honesty and transparency in developing, undertaking, reporting and communicating research
- research ethics and integrity

5. Course Content: The work has to be completed within allocated time by completing the following steps:

- Proposal Development and synopsis presentation
- Literature review
- Methodology Selection
- Secondary Data Collection
- Carrying out field studies
- Carrying out laboratory analysis
- Data Analysis and Interpretations
- Preparation of draft of dissertation/thesis following given guidelines
- Submission of Dissertation/Thesis
- Thesis Defence

A good thesis requires to have

- Clearly stated aims/objectives
- Thoroughly researched background

- Data presentation and analysis in a clear and concise manner.
- Cogent interpretation of discussion.
- Perceptive Conclusions and broader scientific significance.
- Appropriate references

Evidence of following skills should be reflected in it

Intellectual skills: considerable evidence of independence and initiative beyond the instructions

Numeracy and IT skills: application of numerical/computing techniques using relevant software

Laboratory skills: use of well-defined laboratory techniques as appropriate

Writing Skills: relevant, logical, concise and succinct writing

Presentation skills: both in terms of English and of layout (e.g., appropriate headings, consistent reference style and reference list, sizing and clarity of figures, etc.).

6. Instructional Strategies:

Consultations, literature review with appropriate citations, attending recommended courses, workshops/seminars and appropriate training in data handling and analysis etc.

7. References: Supervisor will guide the students in going through the relevant literatures during the course of the work.

Specialised Branch: Paleogeoscience and Biostratigraphy (PB)

1. Course Number and Title: GMT 507 PB - Environmental Micropaleontology

2. Credit Hours: 3

3. Course Description: Modern micropaleontologists are as likely to be trained in the biological as in the geological sciences. As our studies of the Earth have diversified, so a much greater variety of geological problems needs to be addressed. Furthermore, micro paleontological approaches are now being utilized not only to study past events but also to solve present-day environmental problems. And these are not minor problems, of little import to humankind. The chapters in this subject address the difficult but immediately relevant topics of environmental quality, pollution, and remediation.

Four different groups of interest to deal with environmental issues, such as eutrophication, heavy metal pollution, storm frequency, and coral reef vitality, in a wide range of settings from rivers and lakes, through marshes and lagoons, to atolls and reefs. Thus, readers will be able to find much that is relevant to their own particular interests.

4. Learning outcomes: On completion of the course the learners will be able to learn and deals with microscopic life from the past and the present, and also about the future -

- to reconstruct long-term macro evolutionary patterns, short-term ecosystems perturbations and the relationship between climate, environments and life.
- to understand the Paleoceanography and Paleoclimatology and the evolution of the biosphere.

- an appreciation of the importance of fossils; how they are used in biostratigraphy, recognition of paleo environments and knowledge of patterns of evolution and extinction throughout the Paleozoic, Mesozoic and Cenozoic.
- to distinguish the various microfossil groups of botanical and zoological origin by discussing their morphology, taxonomy, mode of life, environments and stratigraphic distribution.
- to emphasize on groups of geological importance by elucidating their application for dating, correlation and facies interpretation of sedimentary successions.
- to increase evolutionary knowledge of Tertiary and Quaternary microfossils of Bangladesh during this course.

5. Course content:

Unit/Chapter	No. of Lectures
Unit 1: Basic considerations and shell geochemistry: Introduction to Foraminifera: A biological overview; Foraminifera as proxies of change and concept of environmental variability and change, Importance of baseline studies for monitoring environmental change, Environmental variation and Foraminiferal test abnormalities; Effects of marine pollution on Benthic Foraminifera, Foraminifera of oxygen depleted environments, Chemical ecology of Foraminifera, Benthic Foraminiferal distributions in analogues to historical changes; Palaeobiological or evolutionary history of the Foraminifera; Quantitative methods of data analysis in foraminiferal ecology.	6
Unit 2: The Proxy Record on Bioindicators and Biomonitoring of pollution: Distribution trends of Foraminiferal assemblages in paralic environments, Trace elements in foraminiferal calcite, Benthic Foraminifera as bioindicators of heavy metal pollution, Stable oxygen and carbon isotopes in foraminiferal carbonate shells; Sedimentary facies; Bio facies; Depth biotopes and estimation of paleodepth of the ocean using benthic foraminiferal assemblages; Identification of Benthic foraminifera characteristic of Low oxygen environment; Identification of Planktic foraminifera characteristic of warm and mixed layer, thermocline and deep surface water of the modern oceans; Study of modern surface water, mass assemblages of Planktic foraminifera from Indian ocean, Atlantic Ocean and Pacific Ocean. Identification of modern and ancient surface water mass with the help of Planktic foraminiferal assemblages.	10
Unit 3: Larger Foraminifera as Indicators of Coral-Reef Vitality: Taphonomy and temporal resolution of foraminiferal assemblages, Analogies and differences between Foraminifera and Corals, Potential application of Foraminifera to Reef Studies, Larger Foraminifera and Global change; Larger foraminiferal zones and resolution of the stratigraphic records; Impact of anthropogenic environmental change on larger Foraminifera; Quantitative approaches to palaeozonation and palaeobathymetry of corals and coralline algae in Cenozoic reefs.	8
Unit 4: Features of Distribution and application:	8

Cenozoic planktic biostratigraphy, Sequence biostratigraphy; Benthic foraminiferal microhabitats below the sediment-water interface, Environmental Stratigraphy: Reconstructing bottom water oxygen conditions; Biogeography of neritic benthic Foraminifera; Biogeography of Planktonic Foraminifera, Symbiont-bearing Foraminifera, Foraminifera in marginal marine environments; Palaeoecology-principles and methods; application of fossils in the study of palaeoecology, palaeobiogeography and palaeoclimate; Ichnology-classification of trace fossils and their utility in palaeoenvironmental reconstructions.	
Unit 5: Palynology and its applications: Microfossil indicators of ocean water masses, circulation and climate; Pollen analysis in the reconstruction of past vegetation; Relative sea-level rise and climate change over the Holocene Applications of Aerobiology: Pollen Analysis and Meteorology; Modern and fossil mangroves and mangals: their climatic and biogeographic variability; Inferring Environmental Change in Estuaries from Plant Macrofossils; Differential Sorting of Palynomorphs into Sediments: Palynofacies, Palynodebris, Discordant Palynomorphs; Production, Dispersal, Sedimentation and Taphonomy of Spores/Pollen in Relation to the Interpretation of Palynofloras.	8
Unit 6: Miscellaneous microfossils: Ostracoda in detection of sewage discharge and river water ecosystem, Ostracoda as proxies for Quaternary climate change; Recent coccolith sedimentation patterns and transport in the Sea: implications for palaeoceanographic studies of marginal and continental shelf seas; Diatoms as Indicators of Environmental Change in Estuaries; Dinoflagellate Cysts as Proxies for Holocene Environmental Change in Estuaries: Diversity, Abundance and Morphology; Corals in Estuarine Environments: Their Response to Environmental Changes and Application in Reconstructing Past Environmental Variability.	5

6. Instructional Strategies:

Lecture, Discussion, Question-Answer, Presentation

7. Assessment:

Formative (30%): Attendance, In-course Examination/Assignment

Summative (70%): Course Final Examination

8. Reading Materials:

References:

1. *Arnold (2002) Quaternary Environmental Micropaleontology (Ed. Simon K. Haslett), Oxford University Press, New York.*
2. *Bergland, B.E. (1986) Handbook of Holocene paleoecology and paleohydrology, John Wiley, New York.*
3. *Bilal Ulla Haq and Anne Boersma (eds), 1978. Introduction to Marine Micropaleontology, Elsevier, 358p.*

4. *Brechley, P. J., and Harper, D. A. T. 1998. Palaeoecology: Ecosystems, Environments and Evolution. By Chapman and Hall:*
5. *D. Emery, and K. Mayers, 1996. Sequence Stratigraphy: Blackwell Publishers.*
6. *Kathal, P.K. (2011) Applied Geological Micropaleontology, Scientific Publishers, Jodhpur.*
7. *Kundal, P. (2003) Recent Developments in Indian Micropaleontology, Gondwana Geological Society, Sp. Vol. 6.*
8. *Kundal, P. and Humane, S.K. (Eds.) (2010) Applied Micropaleontology, Gondwana Geological Society, V. 24 (1).*
9. *Michael Foote and Arnold I. Miller. 2006. Principles of paleontology (3rd edition)- W.H. Freeman*
10. *Jones, T.P. and Rowe, T.P. (1999) Fossil Plants and Spores Modern Techniques, Geological Society of London.*
11. *Pipero, Dologes, R. (1988) Phytolith analysis: An Archaeobiological and Geological perspective, Academic Press.*
12. *Willis, K.J. & McElwain, J.C. 2002. The evolution of plants Oxford University Press.*

1. Course Number and Title: GMT 508 PB - Biostratigraphy and Paleoenvironment Reconstruction

2. Credit Hours: 3

3. Course Description: Organic-walled microfossils such as pollen, spores, and various organic debris derived from terrestrial plants are especially useful when studying terrestrial deposits. The chapters present the many different groups of organic-walled microfossils, collectively called palynomorphs, and the different methods palynologists use to study and extract them from sediments and rocks. We present a biostratigraphic application, the use of the pollen and spore record across the Cretaceous-Paleogene boundary, which has proven to be one of the most precise and reliable means for pinpointing this major transition within terrestrial deposits. Whether used for biostratigraphy, paleo environmental analysis or characterization of organic contents of rock, palynology has proven to be an essential tool for the study of unoxidized terrestrial sediments and sedimentary rocks. Fossil pollen and spores can be used to reconstruct a picture of past vegetation and can provide information on ancient climates. Furthermore, palynological processing and analysis is cost effective and provides a fast turnaround, in comparison with other analytical techniques.

4. Learning outcomes: On completion of the course the learners will be able to learn and deals with microscopic life on the followings:

- reconstruct long-term macroevolutionary patterns, short-term ecosystems perturbations and the relationship between climate, environments and life.
- understand the Paleoceanography and Paleoclimatology and the evolution of the biosphere.
- recognition of paleo environments and knowledge of patterns of evolution and extinction throughout the Paleozoic, Mesozoic and Cenozoic.
- discuss on the various microfossil groups of botanical origin by their morphology, taxonomy, mode of life, environments and stratigraphic distribution and facies interpretation of sedimentary successions.
- increase evolutionary knowledge of Tertiary and Quaternary microfossils of Bangladesh.

5. Course content:

Unit/Chapter	No. of Lectures
Unit 1: Introduction to Biostratigraphy: Biostratigraphy: Historical developments. Controls on the development of the stratigraphic records; Lithostratigraphy, Biostratigraphy, Chronostratigraphy, Magnetostratigraphy, Cyclo-stratigraphy, Event stratigraphy; Pedostratigraphy, Seismic stratigraphy, Sequence stratigraphy and Isotope stratigraphy and Correlation; Foraminifera in biostratigraphy (Palaeozoic, Mesozoic, Cenozoic); Foraminifera in sequence stratigraphy	6
Unit 2: Approach to Paleopalynology: Apparoach to paleobotany; Classification and morphology of fossil plants, Taxonomy and Biology; Evolutionary trend in angiosperm plants, Pre-Gondwana and Paleogene flora, A brief idea about Indian subcontinent and surroundings; Palynostratigraphy: the use of Palynology for biostratigraphy, Data Management in Palynostratigraphy; Cenozoic flora of Bangladesh, Paleoenvironment and Paleoecological utility on biostratigraphy; Computer-based Programs for Palynostratigraphy and Other Paleopalynological Projects-Probabilistic Methods, Multivariate Techniques, Graphic Methods, Relational methods	8
Unit 3: Reconstruction of Palaeobiology, palaeoecology (or palaeoenvironmental interpretation): Reconstruction of palaeoenvironment and past sea level changes using microfossils, Microfossil assemblages and stable isotopes in calcareous microfossils for palaeoclimate interpretation; Palynofacies and paleoenvironmental interpretation, Organic geochemistry of palynomorphs, Vegetational analysis from pollen; Application of paleobotany in assessing paleoclimate and paleoenvironment; Dendrochronology and its application; Phytoliths and their application in understanding paleoecology; Biogeochemical proxies in palaeoenvironmental interpretation ; Palaeoenvironmental interpretation and associated visualisation technologies	6
Unit 4: Marine paleoenvironmental analysis from fossils: Palaeoecology-principles and methods; application of fossils in the study of palaeoecology, palaeobiogeography and palaeoclimate, Palaeoecological models, non-uniformitarianism and tracking the changing ecology of the past; An introduction to the techniques, limitations and landmarks of carbonate oxygen isotope palaeothermometry, Palaeo-oxygenation: effects and recognition, Organic carbon as a palaeoenvironmental indicator in the marine realm; Modern and fossil mangroves and mangals: their climatic and biogeographic variability; Microfossil indicators of ocean water masses, circulation and climate.	9
Unit 5: Palynofacies analysis and interpretation:	10

Marine palynomorphs and organic particles classification, Holocene palynology and its application; Application of palynology in geochronology, paleoclimate and paleoenvironment interpretation; Significance of palynology in source rock evaluation and organic matter maturation; Fluorescence palynology and its application; Application to geological problems-stratigraphy, environmental factors, sequence stratigraphy, Stratigraphic or Ecological discordance, Variation in Natural vs. Anthropogenic eutrophication of shelf areas in front of major rivers, establishing a hydrostratigraphic framework using Palynology, Pollen analysis and meteorology Dinoflagellate cysts as indicators of cultural eutrophication and industrial pollution in coastal sediments; Application of paleobotany in assessing paleoclimate and paleoenvironment; Fossil record applied to sequence stratigraphy and depositional environment; The relevance of hierarchy theory to biogeography and paleobiogeography: Introduction, Hierarchies and Biogeography, Climate change and biogeographic patterns, Geological change and biogeographic patterns over even longer time scales, Mass extinctions and biogeography.	
Unit 6: Reconstructing Sea Level Changes: Ostracod Taxa as Palaeoclimate Indicators in the Quaternary; Quantitative Transfer Function Approaches in Palaeoclimatic Reconstruction Using Quaternary Ostracods; The Chemical Composition of Ostracod Shells: Applications in Quaternary Palaeoclimatology; The Versatility of Quaternary Ostracods as Palaeoclimate Proxies: Comparative Testing of Geochemical, Ecological and Biogeographical Approaches; Paleo-Environmental Approaches to Reconstructing Sea Level Changes in Estuaries; Organic carbon as a palaeoenvironmental indicator in the marine realm; Paleo-oxygenation: effects and recognition; Fossil indicators of nutrient levels: Eutrophication and climate change; Fossil indicators of nutrient levels: Evolution and extinction in relation to oligotrophy	6

6. Instructional Strategies:

Lecture, Discussion, Question-Answer, Presentation

7. Assessment:

Formative (30%): Attendance, In-course Examination/Assignment

Summative (70%): Course Final Examination

8. Reading Materials:

References:

1. *Alfred Traverse, 1988. Paleopalynology, Unwin Hyman, USA.*
2. *Allison, P.A. and Briggs, D.E.G. 1991. Taphonomy. Releasing the data locked in the fossils record, Plenum Press.*
3. *Bergland, B.E. 1986. Handbook of Holocene paleoecology and paleohydrology, John Wiley, New York.*

4. *Dord, J.R. and Stanta, R.J. 1981. Palaeoecology concepts and applications, John Wiley and Sons.*
5. *Jones, T.P. and Rowe, T.P. 1999. Fossil Plants and Spores Modern Techniques, Geological Soc. of London.*
6. *Patnaik, R. 2003. Reconstruction of Upper Siwalik palaeoecology and palaeoclimatology using microfossil palaeocommunities, Palaeogeography, Palaeoclimatology, Palaeoecology, Vo. 197.*
7. *Pipero, Dologes, R. 1988. Phytolith analysis: an Archaeobiological and Geological perspective, Academic Press.*
8. *Seaward, A.C. 1991. Plant fossils, Today's and Tomorrow, New Delhi.*
9. *Shipad N. Agashe, 1995. Paleobotany, Oxford and IBH Publ., New Delhi.*
10. *Stewart, Wilson N. and Rothwell Gar W., 1993. Paleobotany and the Evolution of Plants, Cambridge Univ. Press.*

1. Course Number and Title: GMT 509 PB - Applied and Industrial Micropalaeontology

2. Credit Hours: 3

3. Course Description: Fossil fuels will provide most of that energy for at least the next 60 to 80 years. Biostratigraphy has been and will continue to be an integral tool in the search for and production of oil and gas. Thus, there are economic incentives to sustain current industrial paleontology staff and reinvigorate university training programs in stratigraphically oriented paleontology. As we plan for the 21st Century, the most critical role for industrial paleontologists is twofold: 1) to document the value-added to exploration and production projects through integration of paleontologic data in each study, and 2) to communicate effectively to the academic community that the future demand is real for industrial paleontologists. Item 2 can be backed up with industry providing the teaching community with support through materials illustrating application of biostratigraphy to solving geologic problems.

As exploration declines there will be increased demand for secondary and tertiary recovery from producing reservoirs. Delineation of reservoir architecture will require better depositional models. Mudstone intervals bounding and within the reservoirs are best calibrated using paleontology, so paleontologists will be needed for these reservoir studies as well as in more traditional roles in exploration of frontier areas.

4. Learning outcomes: On completion of the course the learners will be able to learn and deals with microscopic life on the followings:

- Looking at specimens under the microscope
- Comprehensive coverage of the key microfossil groups used in hydrocarbon exploration
- Focus on the role of microfossils in understanding major changes in global climate
- Opportunity to experience working with geological consultancies as well as an academic research environment
- Individual research project tailored to wrap up skills and goals

5. Course content:

Unit/Chapter	No. of Lectures
Unit 1: Scope of Micropaleontology: Scope of Applied Micropaleontology; Modern field and laboratory techniques in the study of microfossils (collection, sampling and processing techniques); Diatoms: Outline of morphology, classification and their significance in environmental study, paleolimnology, paleoceanography and economic geology; Brief introduction of Cyanobacteria; Calcareous nannofossils, Ostracoda, Radiolaria, Conodonts and their significance in geosciences	5
Unit 2: Application of animal and plant microfossils: Foraminifera: Outline morphology of foraminifera and their significance in paleoceanographic, paleoclimatic, paleobathymetric, biostratigraphy reconstructions; Calcareous algae (Rhodophyta and Chlorophyta): morphology and internal structure, broad classification and their significance; Spores/pollen: Morphology, classification, production, dispersal and sedimentation of palynomorphs and their applications in paleoclimate and paleoenvironment interpretation; Types of organic matters; Brief introduction of dinoflagellate, phytoliths and acritarchs and their significance in geosciences.	5
Unit 3: Ostracoda as Proxies for Quaternary Climate Change: Overview and Future Prospects: Mutual Climatic Range Methods for Quaternary Ostracods; The Biogeography and Physicochemical Characteristics of Aquatic Habitats of Freshwater Ostracods; Biological and Environmental Controls on Isotopes in Ostracod Shells; Ostracoda as Indicators of Climatic and Human-Influenced Changes in the Late Quaternary; Geochemical and Palaeoecological Analyses of Mid Pleistocene to Holocene Ostracod Assemblages; Climate Variability during the Medieval Climate Anomaly and Little Ice Age Based on Ostracod Faunas and Shell Geochemistry	10
Unit 4: Microfossils and climate delineation: Advances in environmental micropaleontology; oxygen and carbon isotopes study of microfossil tests and their applications; Benthic Foraminifera and the flux of organic carbon to the seabed Microfossils and Earth's orbital cycles (Milankovitch Cycles); Forecasting of monsoon using microfossils; Delineation of Oxygen Minimum Zones (OMZ) using microfossils; Interpreting freshwater and marine pollution using microfossils; Reconstruction of diatom inferred past water quality and paleosalinity from sediment cores; Problems of global warming and role of micropaleontologists; Recent coccolith sedimentation patterns and transport in the Bay of Bengal: implications for palaeoceanographic studies of marginal and continental shelf seas	10
Unit 5: Microfossils and Petroleum exploration:	10

Implications of micropalaeontology to petroleum exploration, Biosteering and reservoir characterisation with examples; Preliminary observations on benthonic foraminifera associated with biogenic gas seep; Application of micropalaeontology to hydrocarbon exploration; Significance of palynology in source rock evaluation and organic matter maturation; Significance of microfossils in coal exploration; increasing biostratigraphic resolution with Molecular Biology; Microfossils in the study of sedimentary ore deposits. Scope and application of palynology in petroleum industry; study of nano fossils. Paleobotany as fossil fuels; Qualitative estimation of palynodebris and evaluation of Hydrocarbon generation potential	
Unit 6: Organic maturation studies Organic matter type and classification, Organic matter facies; Thermal alteration index values and spectral analysis for maturation assessment; Application of palynodebris in the interpretation of paleoenvironment, Applicability to petroleum source rock evaluation; Microfossils as thermal metamorphic indicators; Microfossils, stable isotopes and ocean-atmosphere history	5

6. Instructional Strategies:

Lecture, Discussion, Question-Answer, Presentation

7. Assessment:

Formative (30%): Attendance, In-course Examination/Assignment

Summative (70%): Course Final Examination

8. Reading Materials:

References:

1. *Agashe, Shipad N. (1995) Paleobotany, Oxford and IBH Publ., New Delhi.*
2. *Arnold (2002) Quaternary Environmental Micropaleontology (Ed. Simon K. Haslett), Oxford University Press, New York.*
3. *Bergland, B.E. (1986) Handbook of Holocene paleoecology and paleohydrology, John Wiley, New York.*
4. *Jones, T.P. and Rowe, T.P. (1999) Fossil Plants and Spores Modern Techniques, Geological Society of London.*
5. *Kathal, P.K. (2011) Applied Geological Micropaleontology, Scientific Publishers, Jodhpur.*
6. *Kundal, P. (2003) Recent Developments in Indian Micropaleontology, Gondwana Geological Society, Sp. Vol. 6.*
7. *Kundal, P. and Humane, S.K. (Eds.) (2010) Applied Micropaleontology, Gondwana Geological Society, V. 24 (1).*
8. *Pipero, Dologes, R. (1988) Phytolith analysis: An Archaeobiological and Geological perspective, Academic Press.*
9. *Seaward, A.C. (1991) Plant fossils, Today's and Tomorrow, New Delhi.*
10. *Smol, J.P., Birks, H.J.B. And Last, W.M. (2003) Tracking Environmental change using lake sediments: Terrestrial, Algal and Siliceous Indicators. Paleoenvironmental Research Book Series, 371p.*
11. *Stewart, Wilson N. and Rothwell, Gar W. (1993) Paleobotany and the Evolution of Plants, Cambridge Univ. Press.*

12. *Stoermer, E.F. and Smol, J.P. (1999)(Eds.) The Diatoms: Applications for the Environmental and Earth Sciences,Cambridge University Press, 469p.*
13. *Traverse Alfred (1988) Paleopalynology, Unwin Hyman, USA.*
14. *Wray, J.L. (1977) Calcareous Algae, Elsevier*

1. Course Number and Title: GML 510 PB - Micropaleontology and Biostratigraphy Lab

2. Credit Hours: 3

3. Course Description: This course is designed for the use of geo-scientists with an interest and need in developing palaeobiological materials as a potential source of data. To meet this objective, practical procedures have been formatted for use by students with an initial understanding of palaeo biological research aims as a primary source of scientific data. The layout of this manual should be particularly beneficial in the instruction and training of geotechnologists and museum preparators. Graduate students and scientists requiring an outline of a preparation procedure will also be able to use the manual as a reference from which to assess the suitability of a procedure.

4. Learning outcomes: On completion of the course the learners will be able to learn and deals with microscopic life on the followings:

- to assist in recent approaches to morphological and taphonomical studies, procedures for the collection and preservation of live zoological material are also included.
- to study the fossil fuel study.

5. Course content:

Unit/Chapter	No. of Lab Classes
Unit 1: Palaeontological Techniques - an introduction to practical procedures. Microscopic study of the selected taxa of Foraminifera, Ostracodes, Calcareous Algae, Diatoms.	4
Unit 2: Extraction techniques for palaeobotanical and palynological material; Pollens and Spores (Cretaceous and Cenozoic), dinoflagellates, Conodonts; SEM applications in microfossils.	6
Unit 3: Micropaleontology; Study of the polluted and unpolluted environments using diatoms; Processing techniques used in separation of diatoms and palynomorphs; Biofacies map using microfossils.	6
Unit 4: Real time well site micropalaeontology and techniques used in industrial micropaleontology for petroleum exploration discovery: Bio-Sequence stratigraphy; Building a reservoir zonation using microfossils. Palynofacies analysis-Introduction, The uses of palynofacies, Kerogen - particulate organic matter in sedimentary rocks, Simple classifications for rapid assessment of hydrocarbon potential, More detailed classifications for palaeoenvironmental analysis, Palynofacies parameters for palaeoenvironmental analysis, Bulk kerogen parameters, Palynomorph parameters, Comments on data interpretation, Diagrammatic representation of palynofacies data,	6

Total kerogen plots, Total palynomorph plots, Phytoplankton palynomorph plots.	

6. Instructional Strategies:

Laboratory investigation and interpretation

7. Assessment:

Formative (40%): Attendance, Submission of assignment/report/lab note-book

Summative (60%): Practical Examination

8. Reading Materials:

References:

1. *Boardman, R.S., Cheethan, A.M. and Rowell, A.J. 1988. Fossil Invertebrates, Blackwell.*
2. *Clarksons, E.N.K. 1998. Invertebrate Paleontology and Evolution, Allen and Unwin, London.*
3. *Dobzhansky, Ayala, Stebbins and Valentine, 1977. Evolution, Freeman.*
4. *Horowitz, A.S. and Potter, E.D. 1971, Introductory Petrography of Fossils, Springer Verlag.*
5. *Mayr, E. 1971, Population, Species and Evolution, Harvard.*
6. *Smith, A.B. 1994. Systematics and Fossil Record – Documenting Evolutionary Patterns, Blackwell.*
7. *Strean, C.W. and Carroll, R.L. 1989. Paleontology – the record of life, John Wiley.*

1. Course Number and Title: GMP 511 PB - Project/Geological Field Mapping
(Supervised individual research project on any aspect of Paleogeoscience and Biostratigraphy or relevant field).

2. Credit Hours: 3

3. Course Description: The aims of this course are to assess the student's ability to provide a critical synthesis of a scientific problem; to enable a student to derive original laboratory or field data, and/or to seek and utilize published/secondary data; to train a student to assess those data and draw appropriate conclusions; to learn how to communicate the experimental strategy, results and conclusions effectively with appropriate citations.

4. Learning outcomes:

- ability to formulate and execute a research project
- ability to analyse, synthesise, summarise and evaluate critically information from literature
- ability of data handling and evaluation
- ability to define problems, devise and evaluate possible solutions
- ability to communicate effectively through the report and a poster presentation
- ability to consider issues from a wide range of perspectives
- an in-depth understanding of the student's field of specialisation
- appreciation of the use and limitations of data in testing a hypothesis
- ethics and integrity in research

5. Course Content: The Project Report should contain high level of practical work and has to be submitted within allocated time which has to have the following

- Clearly stated aims/objectives
- Thoroughly researched background
- Data presentation and analysis in a clear and concise manner.
- Cogent interpretation of discussion.
- Perceptive Conclusions and broader scientific significance.
- Appropriate references

Evidence of considerable application of numerical/computing techniques and or laboratory techniques as appropriate and excellent presentation in terms both of English and of layout (e.g., appropriate headings, consistent reference style and reference list, sizing and clarity of figures, etc.) is expected. Project report submission will be followed by Project defence/Poster presentation.

6. Instructional Strategies:

Consultations, literature review with appropriate citations, attending recommended courses, workshops/seminars and appropriate training in data handling and analysis etc.

7. References: Supervisor will guide the students in going through the relevant literatures during the course of the work.

1. Course Number and Title: GMR 512 PB – Thesis (Supervised individual original research on any aspect of Paleogeoscience and Biostratigraphy or relevant field)

2. Credit Hours: 6

3. Course Description: The aims of this course are to assess the student's ability to provide a critical synthesis of a scientific problem; to enable a student to derive original laboratory or field data, and/or to seek and utilize published data; to train a student to assess those data and draw appropriate conclusions; to learn how to communicate the experimental strategy, results and conclusions effectively with appropriate citations; to provide training in how to formulate a research problem. Therefore, this course would enable students to put their specialist skills, knowledge, and understanding into practice through the medium of a significant individual research project and written dissertation. Thesis/project might involve students working within one of the Department's established research groups or can work in collaboration with another industrial or academic partner. Wherever is the work, the students will be supervised, throughout the project/thesis duration by a supervisor assigned by the Department. The supervisor will provide advice on the approaches and methods that are best suited to the research problem and on collection/analysis of data and will guide in producing a well-written dissertation.

4. Learning outcomes:

Knowledge and Understanding:

- an in-depth understanding of a specialised area
- the principles and methodology of experimental techniques and

- data handling and evaluation.

Intellectual Outcomes:

- ability to define problems, devise and evaluate possible solutions
- ability to solve routine and unfamiliar problems elegantly
- ability to consider issues from a wide range of perspectives

Practical and Transferable Outcomes:

- ability to formulate and execute a research project individually
- ability to analyse, synthesise, summarise and evaluate critically information from literature
- ability to communicate effectively through the research report and oral presentation.
- ability to present research findings to technical audiences as well as generalized audiences
- ability to publish papers in peer reviewed journals
- ability to work in a professional organization in the specialised field of expertise.

Ethical Outcomes:

- clear understanding of data protection issues and appreciation of the use secondary data
- clear understanding of plagiarism
- honesty and transparency in developing, undertaking, reporting and communicating research
- research ethics and integrity

5. Course Content: The work has to be completed within allocated time by completing the following steps:

- Proposal Development and synopsis presentation
- Literature review
- Methodology Selection
- Secondary Data Collection
- Carrying out field studies
- Carrying out laboratory analysis
- Data Analysis and Interpretations
- Preparation of draft of dissertation/thesis following given guidelines
- Submission of Dissertation/Thesis
- Thesis Defence

A good thesis requires to have

- Clearly stated aims/objectives
- Thoroughly researched background
- Data presentation and analysis in a clear and concise manner.
- Cogent interpretation of discussion.
- Perceptive Conclusions and broader scientific significance.
- Appropriate references

Evidence of following skills should be reflected in it

Intellectual skills: considerable evidence of independence and initiative beyond the instructions

Numeracy and IT skills: application of numerical/computing techniques using relevant software

Laboratory skills: use of well-defined laboratory techniques as appropriate

Writing Skills: relevant, logical, concise and succinct writing

Presentation skills: both in terms of English and of layout (e.g., appropriate headings, consistent reference style and reference list, sizing and clarity of figures, etc.).

6. Instructional Strategies:

Consultations, literature review with appropriate citations, attending recommended courses, workshops/seminars and appropriate training in data handling and analysis etc.

7. References: Supervisor will guide the students in going through the relevant literatures during the course of the work.

Specialised Branch: Petroleum Geoscience and Engineering (PG)

1. Course Number and Title: GMT 507 PG - Basin Analysis and Reservoir Geology

2. Credit Hours: 3

3. Course Description: The course is divided into two parts. The basin analysis part will discuss the theories of basin formation in various types of geotectonic setting, basin infill dynamics, subsidence history and consequences for reservoir and source rock development and the petroleum system. Subjects to be discussed include physical state of lithosphere, mechanisms of sedimentary basin formation by stretching, strike-slip, flexure and compression, effects of mantle dynamics, basin infill mechanisms, changes of reservoir and petrophysical parameters during burial and tectonic processes, and application to the petroleum system, leading towards the play concept. Reservoir geology part will discuss the geologic controls on reservoirs, how textural properties and post depositional diagenesis affect reservoirs. Lectures focusing on various depositional environments will explain the depositional processes, their resultant deposits, and their reservoir quality. Other topics to be covered are impact of reservoir geometry, heterogeneity, and compartmentalization on hydrocarbon production, unconventional resources and their extraction methods.

4. Learning outcomes: On completion of the course the learners will be able to –

- Understand the major mechanisms involved in subsidence and filling of sedimentary basins
- Apply theoretical knowledge to interpret the basin history, the character of the sedimentary fill, and assess the possible locations of petroleum system elements
- Understand the processes of petroleum system modelling, developing hydrocarbon plays and prospects
- Compare the different petroleum systems in the Bengal basin and evaluate their potential
- Understand the geologic controls on reservoir quality
- Understand the type of reservoirs form in different depositional environments

- Compare the reservoir qualities of different clastic reservoirs based on their depositional environments, reservoir geometry
- Understand the types of reservoir heterogeneity and their impacts on hydrocarbon production
- Develop plan for extracting hydrocarbons from unconventional reservoirs

5. Course content:

Unit/Chapter	No. of Lectures
Unit 1: The Foundations of Sedimentary Basins: Basins in their plate tectonic environment; The physical state of the lithosphere	3
Unit 2: The Mechanics of Sedimentary Basin Formation: Basins due to lithospheric stretching; Basins due to flexure; Basins in subduction zones; Basins associated with strike-slip deformation; Fundamental types of petroliferous basins; Thermal history	8
Unit 3: Application in Petroleum Geology: Quantitative modelling of maturity, techniques of source rock evaluation; Hydrocarbon expulsion and migration; Basin and Petroleum System Modelling – burial history, thermal history, Oil and Gas generation and migration; Petroleum plays and prospects analysis and classification; Overpressure in sedimentary basin - occurrence and origin; Petroleum systems - petroleum systems in the Bengal Basin	10
Unit 4: Geologic Controls on Reservoir Quality: Examination and Measurement of Porosity and Permeability; Textural and Diagenetic Controls on Reservoir Quality; Flow-Unit Characterization for Correlation; Capillary Pressure and Its Applications to Reservoir Characterization	4
Unit 5: Fluvial Deposits and Reservoirs: Introduction; Braided Fluvial (River) Deposits and Reservoirs; Meandering-River Deposits and Reservoirs; Incised-Valley-Fill Deposits and Reservoirs; Stratigraphy and Stacking Patterns of Fluvial Reservoirs	2
Unit 6: Deltaic Deposits and Reservoirs: Introduction; General Deltaic Processes, Environments (Physiographic Zones), and Types; River-Dominated Delta Deposits and Reservoirs; Wave-Dominated Deltas; Tide-Dominated Deltas	2
Unit 7: Deepwater Deposits and Reservoirs: Introduction; Sedimentary Processes and Deposits Operative in Deep Water; Depositional Models; Architectural Elements of Deepwater Deposits	2
Unit 8: Eolian Deposits and Reservoirs: Introduction; Processes and Deposits; Sandstone Reservoir Examples; Loess (Eolian Siltstone) Deposits and Reservoirs	1

Unit 9: Alluvial Fan deposits and Reservoirs: Introduction; Processes and Deposits; Sandstone Reservoir Examples	1
Unit 10: Tidal and Shallow marine deposits: Tidal flats deposits and reservoirs; Barrier Island deposits and reservoirs; Estuarine deposits and reservoirs	2
Unit 11: Reservoir Heterogeneity and Compartmentalization: Types of Reservoir Geometry; Scales of Reservoir Heterogeneity; Reservoir Compartmentalization	3
Unit 12: Unconventional reservoirs: Introduction; Shale Depositional Processes and Environments; Shale Porosity, Permeability, and Pore Types; Oil and Gas Shale; Tight sand; Thin bed reservoirs; Gas hydrates; Coal Bed Methane (CBM)	5

6. Instructional Strategies:

Lecture, Discussion, Question-Answer, Presentation

7. Assessment:

Formative (30%): Attendance, In-course Examination/Assignment

Summative (70%): Course Final Examination

8. Reading Materials:

Textbook:

1. *Allen, P. A. & J. R. Allen, 2005, Basin analysis: principles & applications: Blackwell Science., Oxford, UK, 549 pp.*
2. *Busby, C. J. & R. V. Ingersoll, 1995, Tectonics of sedimentary basins: Blackwell Science, Oxford, UK, 579 pp.*
3. *Slatt, Roger. (2013). Stratigraphic reservoir characterization for petroleum geologists, geophysicists, and engineers.*
4. *Boggs Jr, S. (2014). Principles of sedimentology and stratigraphy. Pearson Education.*

References:

1. *Barwis, J.H., McPherson, J.G. and Studlick, R.J. (eds), 1990, Sandstone Petroleum Reservoir, Springer Verlag.*
2. *Tissot, B.P. and Welte, D.H., 1984, Petroleum Formation and Occurrence (2nd edition), Springer-Verlag.*
3. *Watts, A. B., 2001, Isostasy and flexure of the lithosphere: Cambridge University Press, Cambridge, UK, 458 pp.*

1. Course Number and Title: GMT 508 PG - Petroleum Exploration Techniques

2. Credit Hours: 3

3. Course Description: The purpose of this course is to provide students with information and skills necessary to understand the oil and gas exploration. The course will give students insight into theory and applications of field discovery. The course lectures will introduce the concepts and procedures of petroleum exploration, including the surface and subsurface methods, play development, and prospect assessment. Multiple exercises aiming at the application of these

concepts to specific exploration problems will be performed during the coursework. Identification and mapping of structural and stratigraphic traps from seismic data, determination of petrophysical properties from wireline logs, prediction of trap integrity and volume estimation of hydrocarbon accumulations, application of facies models and seismic stratigraphy to the estimation of reservoir geometry and quality are the key components of this course. This course will also introduce the participants to the application of microfossil biostratigraphy to the petroleum industry. Topics for discussion are palynomorphs, spores and pollen, dinoflagellates, benthic and planktonic foraminifera, calcareous nannofossils, biozonation and the role of biostratigraphy in hydrocarbon exploration. Integration of technical data with economic principles and risk assessment in making exploration decisions and developing exploration strategies will also be covered in this course.

4. Learning outcomes: On completion of the course the learners will be able to –

- learn the basic notions of petroleum exploration
- describe the main workflows used in oil and gas industry for exploration
- utilize different geophysical and geochemical methods for petroleum exploration
- work with the borehole geophysical logs and determine the stratigraphic, sedimentological, and reservoir parameters
- analyse a case history, explain which methods should be used and what decisions could be made based on the available data
- understand the fundamentals of petroleum economics

5. Course content:

Unit/Chapter	No. of Lectures
Unit 1: Surface Geology and Regional Geologic Analysis: Fieldwork – structure, rock types, seepage; Aerial and Satellite Imagery Analysis	2
Unit 2: Tectonics and structural methods for exploration: Comparative structural style analysis; Structural Inversion and Reactivation; Structural models and methods; Fault geometry, mechanism and seal analysis	3
Unit 3: Gravity and Magnetic method in Petroleum Exploration	3
Unit 4: Electrical methods in Petroleum Exploration	2
Unit 5: Seismic Method: Acquisition and Processing; Structural and Stratigraphic interpretation; Direct Hydrocarbon Indicators; Seismic attribute Analysis; Seismic geomorphology & Stratigraphic Analysis; Seismic Inversion; Amplitude versus offset (AVO); 4D/Time lapse Seismic	12
Unit 6: Electromagnetic Method: Fundamentals; Acquisition and Processing; Inversion; Interpretation & Integration	3
Unit 7: Drilling, Mudlogging, DST, Coring: Drilling types; Fracking; Coring techniques; Drill Stem Test, Mudlogging	4
Unit 8: LWD & Wireline logging:	5

Lithology and Fluid identification; Formation Evaluation; Rock Physics	
Unit 9: Well testing: Formation pressure measurement; Permeability and Skin testing; Formation fluid characterization	2
Unit 10: Geochemical exploration: Surface geochemical techniques: Micro seepage surveys, Gas logging, Organo - Hydrochemical survey, Asphaltines survey	2
Unit 11: Micropaleontology and Palynology in Exploration: Microfossils in Petroleum geology; Nannofossils; Palynology; Applied Biostratigraphy	2
Unit 12: Prospect Evaluation and Risk Analysis: Geological Uncertainty; Exploration Economics; Reserves and Resources; Ranking of Prospects	3

6. Instructional Strategies:

Lecture, Discussion, Question-Answer, Presentation

7. Assessment:

Formative (30%): Attendance, In-course Examination/Assignment

Summative (70%): Course Final Examination

8. Reading Materials:

Textbook:

1. *Selly, Richard C. and Sonnenberg, Stephen A. 2015. Elements of Petroleum Geology. Third Edition, Cambridge*
2. *Alistair R. Brown (2011), Interpretation of Three-Dimensional Seismic Data - Seventh Edition, The Leading Edge. 24. 211.*
3. *Mark Cook (2021), Petroleum Economics and Risk Analysis, Elsevier*
4. *Martin Kennedy (2015), Practical Petrophysics, Elsevier*
5. *Veeken, Paul & Moerkerken, Bruno. (2013). Seismic Stratigraphy and Depositional Facies Models.*

References:

1. *Gadallah, Mamdouh & Fisher, Ray. (2009). Exploration Geophysics. Springer*
2. *Hunt, J.M. 1996, Petroleum geochemistry and geology. (2nd edition), W.H. Freeman and Company.*
3. *Tissot, B.P. and Welte, D.H., 1984, Petroleum Formation and Occurrence (2nd edition), Springer-Verlag.*
4. *Rider, M.H., 1999, The geological interpretation of well logs*

1. Course Number and Title: GMT 509 PG - Petroleum Engineering

2. Credit Hours: 3

3. Course Description: The aim of the course is to provide students with a comprehensive overview of petroleum engineering and its different sub-disciplines. This course will cover petroleum drilling, completions and production, reservoir mechanics, fundamentals of rock and fluid properties, composition and PVT properties of petroleum fluids; basic physical and

chemical properties of petroleum reservoir fluids related to reservoir processes and production, reservoir drive mechanisms and enhanced recovery techniques, reservoir modelling and simulation, volume estimation, and production logging. It will also cover the reservoir management processes and surface facilities required for optimum field management.

4. Learning outcomes: On completion of the course the learners will be able to –

- Analyse and apply theoretical knowledge in the area of petroleum geology, reservoir engineering and production technology
- Explain the basic procedures and role of all fundamental systems used in petroleum drilling.
- Develop awareness of the multiple aspects of drilling operations and the challenge of analysing and synthesizing the numerous technical issues encountered during drilling.
- Explain basic concepts of reservoir engineering, methods of oil production and technologies for oil recovery.
- Define basic properties of reservoir rocks and fluids and methods for their calculation and measurement
- Distinguish between major enhanced oil and gas recovery techniques
- Analyse the key issues in the design and optimisation of petroleum production systems.
- Develop an understanding of reservoir modelling and simulation processes, volume estimation
- Apply a critical-thinking and problem-solving approach towards the principles of petroleum engineering.
- Apply theoretical and practice skills in data analysis used for real petroleum engineering problems through case studies.

5. Course content:

Unit/Chapter	No. of Lectures
Unit 1: Introduction to petroleum Engineering: Definition, historical development, branches, energy future and role of petrolem engineers	2
Unit 2: Introduction to Reservoir Engineering: History and Relation with other disciplines; Role and activities of reservoir engineers; Reserve definition and uncertainty; Reserve evolution; Field Optimization and development planning	3
Unit 3: Reservoir Rock Properties and Evaluation: Porosity; Permeability; Relative Permeability; Water saturation; Capillary Pressure; Wettability; Rock Compressibility; Total Rock Compressibility	6
Unit 4: Reservoir Fluid Properties: Components of reservoir fluid; Phase behaviour; Gas properties; Oil properties; PVT analysis	4
Unit 5: Volumetric estimation of Resources: Basic concepts; Data; Stochastic method; Deterministic method	3
Unit 6: Material balance: Basic concepts; Data; Gas Material Balance; Oil Material Balance	3
Unit 7: Introduction of the drilling engineering:	4

Drilling rig components; drilling process, drill string design, drill bits properties, drilling mud; vertical and directional drilling techniques; Casing design, wellbore stability, casing cementing design; managed pressure drilling technology, drilling time and risk estimates; Unscheduled event during drilling operation, tubing string design, introduction of packer types	
Unit 8: Well completion and stimulation: objectives, function; completion equipment; well completion tools selection; perforation techniques; formation damage; well completion fluids, gravel pack techniques; formation stimulation, well completion quality control; methods of well stimulation	5
Unit 9: Geological modelling and reservoir simulation: data for geological modelling; data quality control (QC) and quality assurance (QA); scale and integration of data; modelling procedure; methods of reservoir simulation; general structure of flow reservoir models; model uncertainty analysis	5
Unit 10: Reservoir management: Processes; workflow; case histories demonstrating applications of reservoir management principles	2
Unit 11: Principles of oil & gas production mechanism: Primary recovery; Secondary recovery- introduction, waterflooding, and gas flooding; Tertiary Recovery/Enhanced Oil Recovery (EOR) - processes, screening criteria, implementation of EOR projects; Infill Recovery	5
Unit 12: Production logging: importance and uses; logging tools; types, methods, and data interpretation	2
Unit 13: Introduction to surface facilities design: field process facilities; natural gas processing; crude oil processing, heavy oil processing; produced water treatment; injection water treatment	2

6. Instructional Strategies:

Lecture, Discussion, Question-Answer, Presentation

7. Assessment:

Formative (30%): Attendance, In-course Examination/Assignment

Summative (70%): Course Final Examination

8. Reading Materials:

Textbook:

1. *Fanchi, J.R. and Christiansen, R.L. (2017). Introduction to Petroleum Engineering, John Wiley & Sons, Inc., Hoboken, New Jersey.*
2. *Ringrose, P. and Bentley, M. (2015). Reservoir Model Design, Springer.*
3. *Ezekwe, N. (2010). Petroleum Reservoir Engineering Practice, Prentice Hall.*

References:

1. *Bellarby, J. (2009). Well Completion Design: Developments in Petroleum Science, Elsevier.*
2. *Bond, D., Krevor, S., Muggeridge, A., Waldren, D. and Zimmerman, R. (2018). The Imperial College Lectures in Petroleum Engineering, v. 3, World Scientific Publishing Europe Ltd.*
3. *Lyons, W.C. and Plisga G.J. (ed) (2005). Standard Handbook of Petroleum & Natural Gas Engineering, 2nd Ed., Elsevier.*
4. *Renpu, W. (2011). Advanced Well Completion Engineering, Elsevier.*
5. *Blunt, J.M. (2017). The Imperial College Lectures in Petroleum Engineering: Reservoir Engineering, v. 2, World Scientific Publishing Europe Ltd.*

1. Course Number and Title: GML 510 PG - Subsurface Characterisation and Reservoir Modelling Lab

2. Credit Hours: 3

3. Course Description: In this lab course students will learn the principles of geological interpretation of gravity, magnetic, seismic, well logs and, core data, and the integration of these subsurface data for petroleum exploration and development. Special emphasize will be given on interpreting 2D and 3D data in a workstation environment. Hands-on exercises will include structural interpretation, seismic stratigraphy, seismic facies analysis, lithofacies prediction, reconstruction of complex depositional/erosional signals in various environments, integration of seismic and well data, reservoir mapping, and reservoir modelling. Identification of lithology, diagenetic state, provenance, and porosity is also one of the key components of this course.

4. Learning outcomes: On completion of the course the learners will be able to –

- Identify the provenance, diagenetic state and porosity of the reservoir rocks
- Interpret 2D and 3D seismic data in a workstation environment
- Perform petrophysical interpretation of wireline logs and Well correlation
- Utilize gravity, magnetic data for petroleum exploration
- Integrate all the data sources to build reservoir models and field development plans

5. Course content:

Unit/Chapter	No. of Lectures
Unit 1: Petrographic Characterization: Lithology and Provenance analysis; Diagenesis; Porosity - Cement – Matrix; Porosity reduction and Evolution	5
Unit 2: Petrophysical Characterization and Well Correlation: Lithology Identification; Fluid Type identification; Porosity; Permeability; Water Saturation; Well correlation	3
Unit 3: Seismic Reservoir Characterization: Structural and Stratigraphic analysis; Identification of DHI's; Well to Seismic Tie; Time to Depth Conversion; Rock properties estimation from seismic	4
Unit 4: Geological Mapping and Cross sections:	3

Thickness mapping; Structural mapping; Mapping of reservoir properties	
Unit 5: Application of Gravity, Magnetic and Resistivity methods: Reduction of gravity data and preparation of maps and profiles; Interpretation of residual maps and profiles; Interpretation of magnetic maps and profiles; Resistivity survey - sounding curve preparation and manual interpretation	2
Unit 6: Reservoir Modelling: Structural framework modelling; Layering and Upscaling; Facies modelling; Petrophysical Modelling; Volume Estimation	5

6. Instructional Strategies:

Laboratory investigation and interpretation, Practical in hands

7. Assessment:

Formative (40%): Attendance, Submission of assignment/report/lab note-book

Summative (60%): Practical Examination

8. Reading Materials:

Textbook:

1. *Richard E. Bischke, David Metzner, Daniel J. Tearpock, James Brenneke, 2020, Applied Three-Dimensional Subsurface Geological Mapping: With Structural Methods, 3rd edition*
2. *Rider, M.H., 2011, The geological interpretation of well logs*
3. *W. M. Telford, L. P. Geldart and R. E. Sheriff (1991), Applied Geophysics, Cambridge University Press*
4. *Alistair R. Brown (2011), Interpretation of Three-Dimensional Seismic Data - Sixth Edition, The Leading Edge. 24. 211.*

1. Course Number and Title: GMP 511 PG - Project/Geological Field Mapping
(Supervised individual research project on any aspect of Petroleum Geoscience and Engineering or relevant field).

2. Credit Hours: 3

3. Course Description: The aims of this course are to assess the student's ability to provide a critical synthesis of a scientific problem; to enable a student to derive original laboratory or field data, and/or to seek and utilize published/secondary data; to train a student to assess those data and draw appropriate conclusions; to learn how to communicate the experimental strategy, results and conclusions effectively with appropriate citations.

4. Learning outcomes:

- ability to formulate and execute a research project
- ability to analyse, synthesise, summarise and evaluate critically information from literature
- ability of data handling and evaluation
- ability to define problems, devise and evaluate possible solutions
- ability to communicate effectively through the report and a poster presentation

- ability to consider issues from a wide range of perspectives
- an in-depth understanding of the student's field of specialisation
- appreciation of the use and limitations of data in testing a hypothesis
- ethics and integrity in research

5. Course Content: The Project Report should contain high level of practical work and has to be submitted within allocated time which has to have the following

- Clearly stated aims/objectives
- Thoroughly researched background
- Data presentation and analysis in a clear and concise manner.
- Cogent interpretation of discussion.
- Perceptive Conclusions and broader scientific significance.
- Appropriate references

Evidence of considerable application of numerical/computing techniques and or laboratory techniques as appropriate and excellent presentation in terms both of English and of layout (e.g., appropriate headings, consistent reference style and reference list, sizing and clarity of figures, etc.) is expected. Project report submission will be followed by Project defence/Poster presentation.

6. Instructional Strategies:

Consultations, literature review with appropriate citations, attending recommended courses, workshops/seminars and appropriate training in data handling and analysis etc.

7. References: Supervisor will guide the students in going through the relevant literatures during the course of the work.

1. Course Number and Title: GMR 512 PG – Thesis (Supervised individual original research on any aspect of Petroleum Geoscience and Engineering or relevant field)

2. Credit Hours: 6

3. Course Description: The aims of this course are to assess the student's ability to provide a critical synthesis of a scientific problem; to enable a student to derive original laboratory or field data, and/or to seek and utilize published data; to train a student to assess those data and draw appropriate conclusions; to learn how to communicate the experimental strategy, results and conclusions effectively with appropriate citations; to provide training in how to formulate a research problem. Therefore, this course would enable students to put their specialist skills, knowledge, and understanding into practice through the medium of a significant individual research project and written dissertation. Thesis/project might involve students working within one of the Department's established research groups or can work in collaboration with another industrial or academic partner. Wherever is the work, the students will be supervised, throughout the project/thesis duration by a supervisor assigned by the Department. The supervisor will provide advice on the approaches and methods that are best suited to the research problem and on collection/analysis of data and will guide in producing a well-written dissertation.

4. Learning outcomes:

Knowledge and Understanding:

- an in-depth understanding of a specialised area
- the principles and methodology of experimental techniques and
- data handling and evaluation.

Intellectual Outcomes:

- ability to define problems, devise and evaluate possible solutions
- ability to solve routine and unfamiliar problems elegantly
- ability to consider issues from a wide range of perspectives

Practical and Transferable Outcomes:

- ability to formulate and execute a research project individually
- ability to analyse, synthesise, summarise and evaluate critically information from literature
- ability to communicate effectively through the research report and oral presentation.
- ability to present research findings to technical audiences as well as generalized audiences
- ability to publish papers in peer reviewed journals
- ability to work in a professional organization in the specialised field of expertise.

Ethical Outcomes:

- clear understanding of data protection issues and appreciation of the use secondary data
- clear understanding of plagiarism
- honesty and transparency in developing, undertaking, reporting and communicating research
- research ethics and integrity

5. Course Content: The work has to be completed within allocated time (generally **within 12 weeks** after completion of the final examination) by completing the following steps:

- Proposal Development and synopsis presentation
- Literature review
- Methodology Selection
- Secondary Data Collection
- Carrying out field studies
- Carrying out laboratory analysis
- Data Analysis and Interpretations
- Preparation of draft of dissertation/thesis following given guidelines
- Submission of Dissertation/Thesis
- Thesis Defence

A good thesis requires to have

- Clearly stated aims/objectives
- Thoroughly researched background

- Data presentation and analysis in a clear and concise manner.
- Cogent interpretation of discussion.
- Perceptive Conclusions and broader scientific significance.
- Appropriate of references

Evidence of following skills should be reflected in it

Intellectual skills: considerable evidence of independence and initiative beyond the instructions

Numeracy and IT skills: application of numerical/computing techniques using relevant software

Laboratory skills: use of well-defined laboratory techniques as appropriate

Writing Skills: relevant, logical, concise and succinct writing

Presentation skills: both in terms of English and of layout (e.g., appropriate headings, consistent reference style and reference list, sizing and clarity of figures, etc.).

6. Instructional Strategies:

Consultations, literature review with appropriate citations, attending recommended courses, workshops/seminars and appropriate training in data handling and analysis etc.

7. References: Supervisor will guide the students in going through the relevant literatures during the course of the work.