CURRICULUM

Four Year
Bachelor of Science (Honors)
Degree in Oceanography

For the Academic sessions
2019-2020, 2020-2021,
2021-2022, 2022-2023, 2023-2024, 2024-2025

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

Contents

About the University of Dhaka

On the first day of July 1921 the University of Dhaka opened its doors to students with Sir P.J. Hartog as the first Vice-Chancellor of the University. The University was set up in a picturesque part of the city known as Ramna on 600 acres of land.

The University started its activities with 3 Faculties, 12 Departments, 60 teachers, 877 students and 3 dormitories (Halls of Residence) for the students. At present the University consists of 13 Faculties, 83 Departments, 12 Institutes, 20 residential halls, 3 hostels and more than 56 Research Centres. The number of students and teachers has risen to about 37018 and 1992 respectively.

The main purpose of the University is to create new areas of knowledge and disseminate this knowledge to the society through its students. Since its inception the University has a distinct character of having distinguished scholars as faculties who have enriched the global pool of knowledge by making notable contributions in the fields of teaching and research.

The University of Dhaka is dedicated to the advancement of learning, and is committed to promoting research in all fields of knowledge. As there are plans for further expansion of facilities, plans for new avenues and opportunities, the course curricula are updated and new research projects are undertaken every year. As the pioneer and the largest seat of learning in the country, the University of Dhaka has taken the task to foster the transformation processes of the individual students and the country as a whole through its educational and research facilities keeping up with demands of the day. The University of Dhaka is at this moment one of the leading institutions of higher education in Asia.

The University of Dhaka is well prepared to meet the challenges of the future days with its spirit of freedom, justice and truth as a foundation concomitant to the objectives envisaged by the founding fathers.

The open-minded character of the University of Dhaka embodying the features of beauty and historical origins can be seen as one enters the campus.

About the Faculty of Earth and Environment Sciences

The Faculty of Earth and Environmental Sciences (FEES) is one of the newest faculties in the almost a century old University of Dhaka. The FEES started functioning in 2008 with a vision to create new hub of teaching and research in various fields of earth and environmental sciences to face the major challenges environmental challenges of 21st Century and achieving sustainable development. Although the Faculty is new, it has an accumulation of about 200 years of teaching and research experiences through its constituting departments. The faculty started with two departments, Geology and Geography and Environment, and subsequent three more, Disaster Sciences and Management, Oceanography, and Meteorology, have been included. Currently FEES teaching and research programs includes all the major branches of earth and environmental sciences encompassing aspects covering space to the centre of the Earth. The faculty is led by a dean, elected by all the teachers of constituting departments once in every two years.

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

Dean's Award

Students who have obtained CGPA 3.75 without having any improvement, no F grade and no academic loss during his/her eight semesters and having at least 90% attendance shall be eligible for the Dean's Award.

About the Department

Department of Oceanography have started its journey in 2012 with Master of Science (MS) programme and introduced Bachelor of Science (BS) programme in 2014. The Department currently offers degrees in Bachelor of Science (BS) with Honours, Master of Science (MS), Master of Philosophy (MPhil) and Doctor of Philosophy (PhD) in Oceanography. The BS (Hons.) is a four-year integrated programme consisting 150 credit hours of theory courses, lab, field work and viva voce. Under the semester system, the four-year B.S Honors (integrated) Degree in Oceanography at the University of Dhaka is a programme of eight semesters. Length of each semester is six months. Students are required to take all courses equivalent to 150 credit hours. The MS degree is a one programme based either on course work with thesis or on course work with project. The MS programme consists of 52 credits and divided into three semesters. The MPhil is a two-year programme of course work and research. The PhD programme essentially involves research work. The Department enrolls 40 students in each academic year as first-year honours students.

The Department of Oceanography at the University of Dhaka, aims to advance our knowledge of all facets of the ocean environment around Bangladesh. Emphasis will be given to the physical, chemical, biological, geological and atmospheric aspects of the oceans around Bangladesh, but the intention is to use this new knowledge to draw conclusions which are globally relevant. Future research is expected to pave the way to the science underpinning operational oceanography. Department of Oceanography promotes research in diverse area related to oceanography including physical oceanography, chemical oceanography, biological oceanography, satellite oceanography, marine geology, marine resource management, living and non-living resources, marine fisheries, ocean dynamics, paleontology and paleoceanography etc.

Department of Oceanography officially signed Memorandum of Understanding (MoU) with many international universities and institutions including Western Sydney University, Australia; National Marine environment Forecasting Center, State Oceanic Administration, People's Republic of China; National Institute of Oceanography, India; Council of Scientific and Industrial Research, India etc. to promote collaborating research. One of the department's faculty and a few of its' students are currently enrolled in PhD programme within this collaborating organizations.

Facilities Available

Ocean Cruise and Fieldwork

Department of oceanography has arranged 5 cruises to Bay of Bengal with the help of Bangladesh Navy and collected huge rare data from Bay of Bengal for the first time in Bangladesh and has published many qualities paper in both national and international journal based on those data. In a research cruise, generally following data of ocean water are collected: Turbidity, Fluorescence, Chlorophyll content, Water Depth, Sediment Sample, Water Sample, Zooplankton sample, Phytoplankton sample, Nutrient sample etc. Department

of Oceanography has also arranged field works in subject related location like- Cox's Bazar, Saint Martin, Sundarban, Kuakata etc to teach undergraduate student the basic of conducting research field work so that they could be able to do their own research field in postgraduate level.

Photograph: Ocean Cruise and Fieldwork

Library

The department seminar has a modest collection of books, journals and maps. The library provides reading facilities only for students.

Computer Laboratory

The department has a good number of PCs which provide support for research in the field of satellite oceanography, GW modeling and other oceanographic research. Recently, the department has established a computer-based GIS laboratory equipped with laser printer and latest version of PCs.

Physical Oceanography Laboratory

Physical oceanography focuses on describing and understanding the evolving patterns of ocean circulation and fluid motion, along with the distribution of its properties such as temperature, salinity and the concentration of dissolved chemical elements and gases. The objectives of the Physical Oceanography Laboratory are to document the state of the ocean and its variability to better understand the physical and biogeochemical processes that govern ocean currents, the structuring of pelagic ecosystems and the observed state of the sea surface.

The Laboratory of Physical Oceanography provides teaching support to all subjects of the career. It has a Lab facility, as well as a sieve for analysis of sediment samples (mainly sand). The main equipment it possesses for its operations are: Rosette sampler (A device for water

sampling in deep water), Conductivity temperature and Depth (CTD), Grab sampler, kits for coastal observations (clinometers, compasses, boards), multiparametric probe (Temperature / Conductivity /pH) and GPS (Global Positioning System).

Chemical Oceanography Laboratory

The Chemical Oceanography Lab investigates the geochemical, physical and biological processes that regulate the distribution of trace metals and nutrients in estuarine, coastal and open-ocean environments. The laboratory carries out the tests the state of chemical parameters in seawater, sediment and biota (algae, shellfish, fish). Measurements in sea water samples include pH value, dissolved oxygen content, concentration of dissolved inorganic forms of nutrient (nitrates, ammonia, orthophosphates, silicates) and organic phosphorus and nitrogen. Our field research also involves mapping the distributions of trace metals in different marine environments in order to quantify their sources, sinks, biogeochemical cycling and role in modulating biological productivity. The overarching goal of the Chemical Oceanography Lab is to improve the spatial and temporal resolution of nutrients and trace metal observations in the marine environment. We achieve this through field studies, oceanographic cruises and the development of automated analyzers with potential for in situ deployment.

Biological Oceanography Laboratory

The Laboratory of Biological Oceanography is a specialized infrastructure for the study and analysis of marine organisms; and its relationship with the physical environment. The main equipment it holds for its works are: microscopes, stereomicroscopes, phyto-zooplankton nets and a Niskin water sample bottle.

International Centre for Ocean Governance (ICOG)

International Centre for Ocean Governance (ICOG) is established as a cooperative research center by the joint initiative of Department of Oceanography at the University of Dhaka and School of Law, University of Western Sydney, Australia on 27th March 2017. ICOG is the first research center of its kind in Bangladesh. It can play a crucial role to achieve on the ground change, securing protection for the Bay of Bengal environment and the economic and social sustainability of all actors in the region. It can use its resources to build and enhance resource capacity of the Government of Bangladesh to govern and manage the activities in marine and coastal areas by providing new theoretical knowledge and practical experience on sustainable ocean governance to senior and mid-level career academics and government and non-government officials, researchers and students as well.

Extracurricular Activities

Students of the department actively participate in the departmental and interdepartmental indoor and outdoor events of games, sports and other cultural activities regularly.

Details of the Degree Programme

Title Of the Program: **B.S. (Honors) in Oceanography**
Duration of the Program**: 4 Year**
Eligibility for Admission**: A candidate have to fulfil the following minimum requirement to be considered eligible to get admitted in oceanography:**

Grade of H.S.C. / Equivalent Examination	Mark of University Admission Test
Mathematics or Physics, Biology or Chemistry - A	Mathematics 09 or Physics 10 or Biology 10 or Chemistry 10

Under the Semester System, the four-year B.S Honors (integrated) Degree in Oceanography at the University of Dhaka is a programme of eight semesters. Each semester consists of six months. The duration of B.S Honors is four years divided into eight semesters. Students are required to take all courses equivalent to 150 credit hours.

Credit and distribution of courses over the Semester

Theory:

2 credit = 30 classes (50 Min.) = 50 marks
3 credit = 45 classes (50 Min.) = 100 marks
4 credit = 60 classes (50 Min.) = 100 marks

Practical/Lab:

1 credit = 10 classes (3 hours duration) = 25 marks
2 credit = 20 classes (3 hours duration) = 50 marks

Field Trip:

1 credit = 1~2 full working days of field work = 25 marks
2 credit = 3~4 full working days of field work = 50 marks

Viva-voce: 1 credit/2 credit = 50 marks

The course and credit over eight semesters are illustrated below:

Class Year	Number of Courses		Total Course	Credit Distribution		Total Credit
	First Semester	Second Semester		First Semester	Second Semester	
First Year	7	7	14	18	19	37
Second Year	7	7	14	19	19	38
Third Year	7	8	15	18	19	37
Fourth Year	8	7	15	20	18	38
Total			58			150

Assessment and Evaluation of Learning Achievement

Assessment System

i. Theory courses

Type of Assessment	Marks
FORMATIVE	
In-Course/Midterm Exam	25%
Attendance	5%
SUMMATIVE	
Course final examination	Subjective: 70%

ii. Practical course

In-course assessment + class attendances	40%+10%
Course final examination	50%

iii. Marks of attendances

Attendance %	Marks%
90 and above	05
85 to 89	04
80 to 84	03
75 to 79	02
70 to 74	01
Less than 74	00

iv. In-course Assessment for Theory Courses

(a) In-course Assessment may be done by taking class test and/or by giving assignments.

(b) The course teacher will announce the dates of in-course examinations at the beginning of the course. The in-course assessment will be of one hour duration and the teacher concerned will be responsible to assess the students sitting in his/her course. There will be 2 tests for each course.

(c) Maximum duration of in-course test will be one class hour.

v. Course Final Examination (Theory and practical Courses)

(a) Student having 75% or more attendance on average (collegiate) are eligible to appear in the final examination.

(b) Student having 60-74% attendance are considered to be non-collegiate and will be eligible to sit for the final examination on payment on fine Tk. 1,000/= (One thousand).

(c) Student having attendance less than 60% will not be allowed to sit for the final examination but may ask seek readmission in the program.

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

Credit	**Duration of Examination**
4 credit courses	4 hours
3 credit courses	3 hours
2 credit courses	2 hours

(e) Duration of practical examinations will be between 3-5 hours irrespective of credit hours.

The Class Test (s) for first In-course Assessment will be taken usually after covering 40% of the course topics and second In-course Assessment will be taken usually after covering 80% of the course topics. The Course Final Examination will be taken upon completion of the entire course. In Final Examination, each theory course will be evaluated by two teachers of the Department. If a single teacher teaches a course, then the semester final test scripts must also be evaluated by two teachers, one of whom must be the course teacher, and another, a suitable second examiner who may be either from DU or outside DU. In the semester final examination if the difference of marks in any course is more than 20%, the script will be evaluated by a third examiner. The final marks obtained will be averaged of the nearest two marks, or third examiners marks if the difference between his/her marks and the two other examiner's marks are the same.

The total marks in a course will be converted into letter grade as under:

Numerical Marks	Letter Grade	Grade Point
80 above	A+	4.00
75 -79	A	3.75
70 – 74	A-	3.5
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
Below 40	F	0.00

Promotion

For promotion from one class year to next class year, a student is required to obtain a minimum CGPA (Cumulative Grade Point Average) or GPA (only for 1st Semester) as under:

Class Year	**Minimum CGPA**
From First Year to Second Year	2.00
From Second Year to Third Year	2.00
From Third Year to Fourth Year	2.00

The minimum CGPA of a student, as mentioned above, is calculated taking into consideration the grade points obtained in courses of all previous class years. Besides, a

student failing to clear up university or departmental dues shall not be promoted to the next class year.

Degree Requirements

For the B.S. Honors degree, each student is required to:

i) Complete 150 credit hours without a F grade in any course
ii) Earn a minimum CGPA of 2.50: and
iii) Complete the program in maximum six consecutive academic years including the year of first admission into the program.

For appearing at each semester final examination, every student is to fill in examination entry form supplied by the Controller of Examination on payment of dues.

Credit Transfer

No credit transfer from any other programs or institutions is allowed for the B.S. Honours degree.

Improvement of Grades

A student earning F grade in a course in any year must improve the grade with any of the following two batches. A student is allowed to seat for improvement examinations in a course not more than one times. No improvement is allowed for marks in mid-term examination and viva voce, as well as in course(s) in which a student did not attend classes. Students obtaining less than C+ grade in any course may also choose to improve the grade by appearing at the semester final examination with the following batch only. In such cases, the best one of the two examinations will be considered for improving the result. Students willing to improve the grade in a course should apply to the Chairman of the Department at least four weeks before the start of the semester final examination.

Re-admission

A student failing to get the requisite grade points for promotion to the next year may seek re-admission with the following batches. For re-admission a student should apply within one month after the publication of result of the concerned year. On re-admission, grades obtained earlier by a student in the class year of re-admission shall be canceled and the student shall have to retake all the courses and examinations. Re-admission in a class-year shall be allowed only once in a class and a student shall not be allowed re-admission in more than twice during the entire program.

Semester-wise Distribution of Courses

Course Structure: B.S. Programme in Oceanography

First Semester

Course No.	Course Title	Credit Hours
OCN 101	Fundamentals of Ocean Sciences	2
OCN 102	Marine Biology: Invertebrates	3
OCN 103	Fundamentals of Marine Chemistry	3
OCN 104	Introduction to Atmospheric Science	2
OCN 105	Marine Botany	2
OCN 106	Calculus	3
OCN 107	Practical/Field Work + Viva voce	2+1=3
Sub-total		18

Second Semester

Course No.	Course Title	Credit Hours
OCN 111	Marine Geology	3
OCN 112	Hydrodynamics and Coastal Hydraulics	2
OCN 113	Marine Geophysics	2
OCN 114	Differential Equation & Linear Algebra	3
OCN 115	Marine Biology: Vertebrates	3
OCN 116	Marine Analytical Chemistry	3
OCN 117	Practical/Field Work + Viva voce	2+1=3
Sub-total		19

Third Semester

Course No.	Course Title	Credit Hours
OCN 201	Physical Oceanography	3
OCN 202	Oceanography of the Bay of Bengal	2
OCN 203	Marine Biogeochemistry	3
OCN 204	Ocean Minerals and Energy Resources	2
OCN 205	Marine Biochemistry and Molecular Biology	3
OCN 206	Computer Programming	3
OCN 207	Practical/Field Work + Viva voce	2+1=3
Sub-total		19

Fourth Semester

Course No.	Course Title	Credit Hours
OCN 211	Marine Meteorology	2
OCN 212	Satellite Oceanography	3
OCN 213	Marine Planktonology & Benthic Organisms	3
OCN 214	Marine Sedimentology & Stratigraphy	2
OCN 215	Marine Microbiology	3
OCN 216	Numerical Techniques in Oceanography	3
OCN 217	Practical/Field Work + Viva voce	2+1=3
Sub-total		19

Fifth Semester

Course No.	Course Title	Credit Hours
OCN 301	Acoustical Oceanography	2
OCN 302	Molecular Methods in Oceanography	3
OCN 303	Marine Ecology	3
OCN 304	Fisheries Oceanography	2
OCN 305	Petroleum Geology & Geophysics	3
OCN 306	Marine Mammals	2
OCN 307	Practical/Field Work + Viva voce	2+1=3
Sub-total		18

Sixth Semester

Course No.	Course Title	Credit Hours
OCN 311	Ocean Waves & Tidal Energy	2
OCN 312	Marine Ecological & Ecosystem Modeling	2
OCN 313	Population Dynamics of Marine Organisms	2
OCN 314	Marine Biotechnology and Therapeutics	3
OCN 315	Submarine and Underwater Communication	2
OCN 316	Geophysical Fluid Dynamics	3
OCN 317	Coastal & Marine Aquaculture	2
OCN 318	Practical/Field Work + Viva voce	2+1=3
Sub-total		19

Seventh Semester

Course No.	Course Title	Credit Hours
OCN 401	Global Climate Change	2
OCN 402	Coastal Zone Management	2
OCN 403	Coastal and Marine Pollution	2
OCN 404	Marine Governance and Ocean Policy	2
OCN 405	Coastal Landscape and GIS	3
OCN 406	Coastal and Offshore Structure	3
OCN 407	Statistical Techniques for Oceanographer	3
OCN 408	Practical/Field Work + Viva voce	2+1=3
Sub-total		20

Eighth Semester

Course No.	Course Title	Credit Hours
OCN 411	Mathematical Modeling in Oceanography	3
OCN 412	Paleontology & Paleo-oceanography	3
OCN 413	Evolution and Earth's Biosphere	2
OCN 414	Law of the Sea	2
OCN 415	Marine Biodiversity and Conservation	3
OCN 416	Research Methodology	2
OCN 417	Practical/Field Work + Viva voce	2+1=3
Sub-total		18

Grand total **(18+19+19+19+18+19+20+18=150)**

First Semester

Course Number and Title: OCN 101: Fundamental of Ocean Sciences
Credit hours: 2

Introduction to the Course: This is a basic course designed to get student familiar with oceanography. It is a common course that discusses with all the branches of ocean sciences.

Specific Objectives: 1. To encourage students, learn about the history of Earth and the science of oceanography. 2. To teach students about different branches of oceanography and their interrelation. 3. To enrich their knowledge about basic ocean processes and the causes behind them. 4. To make them familiar with coastal land forms and the changes.

Course Content:

SL.	Topics	No. of Lectures
1.	History: Early history: development in the recent past; Branches; Oceanographic institutions	1
2.	Origin of the Earth and Ocean: The age of the Earth and the geological time, scale; structure of the Earth's interior and its composition; features of the Ocean; Continental drift and sea floor spreading; Plate tectonics-the types of plate boundaries-rifting and subduction zones; the trenches	3
3.	The sea floor and continental margins: the ocean basins- origin and morphology; identification of components of the ocean margin; ridges and rises; processes responsible for creating the ocean margin features; the shelf, slope and abyssal plain. Active and passive continental margin, trenches, oceanic ridges, submarine canyon, continental shelves & slope, ocean floor of the Atlantic, Pacific and Indian Ocean.	4
4.	Coastal Landform: Cliff, Sand dunes. Shores, Beaches, Tidal flat, Mud flat, lagoons.	2
	MIDTERM EXAMINATION – I	
5.	Introduction to marine sediments: sediment sources and pattern of sediment deposition from the self to the deep ocean; sediment size and accumulation; sampling of sediments; dominant transportation processes; sea bed resources.	4
6.	Biological basic terms, zonation of the oceans, history, physical & chemical properties of seawater, water masses, density, pressure, salinity, temperature change and causes, ocean heat content.	3
7.	Ocean Currents: Causes, types, mean current in Atlantic, Pacific and Indian Ocean.	2
8.	Ocean Tide: Causes and effects. Global distribution, Implication.	2

9.	Waves: causes, characteristics of wave actions, wave energy.	2
10.	The marine environments: general conditions, distribution of life in the oceans, Man-Ocean relation.	2
	MIDTERM EXAMINATION - II	
11.	Divisions of the marine environment- pelagic and benthic environments, Basic marine life styles, ocean acidification, marine climatic Zone, EL-Nino. La-Nina,	2
12.	Seal level changes: Definition, causes, past, present and future trends of sea level changes, effects of sea level change on marginal marine environments.	3
		Total = 30

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance

Learning Outcomes: After completing this course, students will get a full idea about diversity of the fields of oceanography and what are their scopes in this subject to flourish themselves. They will get an overall idea about the topics they will learn in future throughout their B.S. (Hons) course. It will give them an outline to develop and prepare themselves as an oceanographer.

Assesment:

Type of Assessment	Marks
FORMATIVE	
In-Course Exam	12.5
Attendance	2.5
SUMMATIVE	
Final Examination	35

Reading Materials:

1. Duxury, A.B. R Duxubury A.C (1999): Fundamentals of Oceanography (3rd Ed.), WCB/MC Graw-Hill.
2. Thurman, H.V. (1994): Introductory Oceanography (7th Ed.), Macmillan Pube. Comp.
3. Seibold, E. & Berger, W. H: The sea Floor- An Introduction to Marine Geology (3rd Ed.).
4. Erickson & Timothy (2002): Marine Geology.
5. *The Ocean Basins: Their Structure and Evolution* (2nd edition). Open University. ISBN 0750639830.
6. *The Sea Floor -An Introduction to Marine Geology* (3rdedition). E. Seibold and W.H. Berger. ISBN 3540601910.
7. Rhatt, J.J., Oceanography, 13. Van Nostrand Company, New York.
8. King, C.A.M., Oceanography for Geographers, Edwin Arnold Publishers Ltd., London.
9. Sharma, R-C. andVatal, M. Oceanography for Geographers, Chaitanya Publishing House, Allahabad, India.
10. Carol M Lalli& Timothy Parsons (1997) Biological Oceanography: An Introduction, 2nd ed. Butterworth-Heinemann Publishers. ISBN 0750633840.

Course Number and Title: OCN 102: Marine Biology: Invertebrates
Credit Hours: 3

Introduction to the Course:
This course is designed for first year B.S. students of Oceanography. This course includes detail study of marine invertebrates which are spectacularly diverse, interesting and prominent in every marine environment on the planet etc. This course introduces students to the diversity of marine invertebrate life. The different marine invertebrate groups are introduced through examination of their evolution and phylogenetic relationships. Students explore adaptations of invertebrate groups to the marine environment in terms of comparative physiology and body architecture. A section on reproduction and development highlights the diversity of reproductive patterns among marine invertebrates. This course fulfills the Core Curriculum requirement for biological oceanography.

Specific Objectives:

This course is an introductory survey of the major groups of invertebrates, their characteristics and adaptations, with a focus on organisms inhabiting the marine environment. Throughout this course, we will emphasize evolutionary developments that unite and/or separate major groups and adaptations to the conditions in which organisms occur. The course will provide a foundation for further education in biological oceanography.

Course Content:

SL.	Topics	No. of Lectures
1.	The Protozoa: Classification, Structures and features, nutrition, reproduction and development.	2
2.	Phylum: Porifera: Classification, Phylogeny, Structures and features, nutrition, reproduction and development.	3
3.	Cnidaria: Features of the group, Structure and function of nematocysts, Generalized life cycle and body structure, Class Hydrozoa, Class Scyphozoa, Class Anthozoa.	3
4.	Ctenophora (comb jellies): Characteristics of the phylum, General body plan, Colloblasts, Reproduction, Classes: Tentaculata, Nuda.	2
MIDTERM EXAMINATION - I		
5.	Platyhelminthes (flatworms): Features of the Phylum, Cephalization (adaptive features), Protonephridia: flatworms and other invertebrates, Class Turbellaria (free-living flatworms), Class Trematoda (flukes), Class Monogenea, Class Cestoda (tapeworms).	4
6.	Mesozoans: Features, Phylum Rhombozoa, Phylum Orthonectida	2
7.	Nemertea (Rhynchocoela): Characteristics of the phylum, Phylogenetic relationships Systems, Development (Spiral cleavage)	2

8.	Gastrotricha: Features, Order Macrodasyoidea, Chaetonotoidea. Rotifera: Feature, Structure: head, trunk, digestive tract, Reproduction and life cycle, development.	3
9.	Kinorhyncha: Features, General structure	1
10.	Nematoda (Roundworms) and Namatomorpha (horsehair worms): Characteristics of the phylum, Structures, Nutrition, Reproduction and development, Parasitism Acanthocephala: Features, Structures, Reproduction and life cycle	3
	MIDTERM EXAMINATION - II	
11.	Annelida: Features of the group, Class Polychaeta, Class Oligochaeta, Class Hirudinea (Leeches)	2
12.	Mollusca: Classification, The hypothetical ancestral mollusk, Evolutionary trends within the phylum, the shell, life cycle and development with special importance on economically important species like crabs.	4
13.	Arthropoda: Classification, General information and diagnostic features, Comparisons with annelids, nutrition, life cycle and development with special importance on economically important species like shrimp. Sipunculida "peanut worms", Echiurida "spoon worms" and Chaetognatha "arrow worms: General features, Body structure, Nutrition, Tardigrada "water bears": Features, Annelid-arthropod affinities.	4
	MIDTERM EXAMINATION - III	
14.	Onychophora: Phylogenetic importance of group, General structure; habitat, Arthropod affinities, Annelid affinities, Nutrition.	3
15.	The lophophorate coelomates: Lophophorate features, Relationships to protostomes and deuterostomes, Bryozoa (or Ectoprocta), "lamp shells".	4
16.	Echinodermata: Characteristics, "brittle stars", Echinoidea, sea cucumbers", Class Crinoidea "sea lilies".	3
		Total = 45

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance

Learning Outcomes:

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

- Understand the structure and function of invertebrates found in the marine environment.
- Understand the diversity of marine organisms.
- Understand the use of classificatory schemes and describe the characters that define these organisms.
- Recognise the body forms of the major marine phyla and the evolutionary trends that they represent.
- Explain how form, function and reproduction of marine invertebrates are influenced by the marine environment.
- Identify how the biology of marine invertebrates will influence their responses to future climate change.
- Understand the distinctive characteristics of organisms that are adapted to life in marine ecosystems
- Describe important evolutionary transitions among major taxa and how they affect the diversity, distribution, form, and function of earth's biota in general and marine organisms in particular.

Assesment:

Type of Assessment	**Marks**
FORMATIVE	
In-Course Exam	25
Attendance	5
SUMMATIVE	
Final Examination	70

Reading Materials:

1. Ronald L. Shimek, A Pocket Expert Guide to Marine Invertebrates: 500+ Essential-to-Know Aquarium Species Paperback.
2. Ruppert, Edward E.; Fox, Richard, S.; Barnes, Robert D. (2004). *Invertebrate Zoology, 7th edition*. Cengage Learning. p. 947. ISBN 81-315-0104-3.
3. Carson, Rachel (1997). *The Sea Around Us*. Oxford Paperbacks. pp. 190–191. ISBN 0195069978.
4. Jordan, E.L. and Verma, P.S. 2001. Invertebrate Zoology, S. Chand and Company. Ramnagar, New Delhi.
5. Kotpal, R.L. 2007. Modern Text Book of Zoology, Invertebrate (Animal Biodiversity –II). Capital Offset Press, New Delhi, India.
6. J. Levinton (2009) *Marine Biology: Function, Biodiversity, Ecology.* (3rd edition, Oxford University Press).
7. Sumich, James, L & Morrissey, John, F. *(2008) Introduction to the Biology of Marine Life,* 9th edition.Jones & Bartlett Publishers. ISBN: 0-7637-3313-X.

Course Number and Title: OCN 103: Fundamentals of Marine Chemistry
Credit: 3

Introduction to the Course:

This course is a core course which introduces the students to the chemistry of the oceans. This course includes detail study of the properties, composition and structure of the components of ocean waters (metals, gases, organic compounds and nutrients) in the ocean. This involves studying the structural and compositional transformations.

Specific Objectives:
The objectives of this course include:

1) Introduce the students to the fundamentals of chemical oceanographic principles and applications.
2) Provide the students with the opportunities to develop skill and undertake responsibilities for chemical oceanographic theory exploration.
3) Get the students acquainted with advances in research opportunities in the marine environment.

Course Content:

SL.	Topics	No. of Lectures
1.	Introduction- Scope and History of chemical oceanography, Major features of ocean circulation, Physical properties of sea water.	2
2.	Major constituents of seawater Salinity, chlorinity, conductivity, and density, Relationships between chlorinity and salinity, Residence times.	3
3.	Simple gas laws, Solubility in water, Sources and sinks within the ocean, Atmospheric exchange by diffusion, Air injection, Solubility of salts, Freezing point and boiling point, Osmotic pressure, Electrostriction, Carbon dioxide.	5
	MIDTERM EXAMINATION – I	
4.	Nutrients- Phosphorus, Nitrogen, Silicon, Other nutrients, Quantitative relationships, Initial nutrients.	2
5.	Trace metals and other minor elements- Analytical considerations, various patterns of distribution, Mercury, an interesting special case, Speciation, Iron, another special case, and Trace elements in sediments.	4
6.	Radioactive clocks- Radioactivity, Radionuclides in seawater, the uranium series, C-14.	3
7.	Organic matter in the sea-Historical note, Primary production, Other sources of organic matter, Fate of the primary product, Measurement of organic carbon in seawater, Concentration and age of marine organic matter, Nature of marine organic matter.	6

	MIDTERM EXAMINATION – II	
8.	Anoxic marine environments-Rates of oxygen consumption, Anoxic oxidation, The Black Sea, River input, Air-sea exchange, Sediment-water exchange, Residence times	5
9.	Chemical extraction of useful substances from the sea- Salt, Evaporation of seawater, Rock salt, Magnesium, Bromine, Gold.	5
	MIDTERM EXAMINATION - III	
10.	Geochemical history of the oceans- Illustrative rates, Early history of the ocean volume, Glacially caused changes in ocean volume, Mass of salt in the ocean, Composition of sea salt, Oxygen, Strontium isotopes, The churning of the Earth.	10
		Total = 45

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance.

Learning Outcomes:

Having successfully completed this course, student will be able to:

- Acquired basic knowledge in the field of Marine Chemistry.
- Demonstrated an understanding of the terminology and definitions used in the marine field.
- Able to convert between the different units used in chemical oceanography.
- Aware of the behavior and importance of trace metals dissolved in seawater.
- Aware of some of the different chemical tracers used in oceanography.
- Familiar with the ocean circulation and different important marine cycles
- Familiar with conservative and non-conservative elements and their behaviour in the oceans using examples including nutrients, major and minor element, and trace metals.
- Familiar with the behavior of dissolved gases in the ocean and their impact on ocean anoxia and carbonate chemistry.

Assesment:

Type of Assessment	**Marks**
FORMATIVE	
In-Course Exam	25
Attendance	5
SUMMATIVE	
Final Examination	70

Reading Materials:

Emerson, S.R and Hedges, J.1., *Chemical Oceanography and the Marine Carbon Cycle.* Cambridge University Press, Cambridge, UK, *2008.*

Pilson, M.E.Q. *An Introduction to the Chemistry of the Sea*. Prentice Hall, Ne\N, Jersey. USA, *1998.*
Burdige David, *Geochemistry of Marine Sediments*. Princeton University Press, *2006.*
Morel, Francois M. M. and Janet G. Hering. *Principles and Applications of Aquatic Chemistry*. Wiley - Interscience, New York, 1993.
Millero, Frank J. *Chemical Oceanography*, Third Edition. CRC Press, New York, *2006.*
Seawater: Its Composition, Properties and Behavior, 2nd Edition by The Open University, ISBN: 0750637153.

Course Number and Name: OCN 104: Introduction to Atmospheric Science
Credit Hours: 2

Introduction to the Course:
This course is designed to introduce key concepts in atmospheric science to first year BS students. The syllabus introduces key topics in weather, composition and climate science. This course will allow students to broaden their understanding of atmospheric process, interactions and develop a strong base to apply to their research.

Specific Objectives:
Atmospheric Science is an exciting and fascinating subject that deals with atmosphere, which is essential for persisting life. For the last several decades, environmental problems like pollution, global warming, ozone layer depletion, acid rain, deforestation, and desertification are the major focus of scientists, policy makers, and common public across the world. Our life-supporting environment and various environmental problems are highly complex and require interdisciplinary efforts to understand them. Therefore, the aim of this course, to cover the fundamental understanding of atmosphere, the formation process of thunderstorm and lightning, cause and effect of climate change, and the identification of environmental threats.

Course Content:

SL.	Topics	No. of Lectures
1.	Structure and composition of the atmosphere, Equation of state for dry and moist air, Adiabatic and Isothermal Processes, Humidity Parameters, Virtual Temperature, Standard Atmosphere, Barometric Altimetry, Laws of thermodynamics, Entropy, Potential Temperature, Pseudo- adiabatic Process, Equivalent Temperature, Equivalent Potential Temperature, Claussius – Clapeyron Equation, Stability and Instability, Parcel Method and Slice Method, Entrainment in Cb clouds.	5
2.	Thermodynamic Diagram: p, α – diagram, Emagram, T - φ gram, Uses of thermodynamic diagrams, Precipitable Water Vapor, Rate of Precipitation, Role of Convective Available Potential Energy (CAPE) and Convective Inhibition Energy (CINE) in thunderstorm development.	3

3.	Radiative Transfer in the Atmosphere- Temperature of the Sun and spectral distribution of solar radiation.	2
	MIDTERM EXAMINATION – I	
4.	Long wave radiation, black body radiation budget of radiation energy. Passage of solar radiation through the atmosphere, Atmospheric Windows, emissivity, Absorption spectra of atmospheric gases, optically thick and thin approximations, aerosol scattering, calculations of radiative heating and cooling. Terrestrial radiation and its passage through the atmosphere. Raleigh and Mie scattering. Role of atmospheric dust in radiation balance, effect of volcanoes.	5
5.	Atmospheric aerosols: Concentration and size, sources, and transformation, Chemical composition, transport and sinks, residence times of aerosols, geographical distribution and atmospheric effects. Continental and Marine (Origin, Physical and Chemical characteristics), Cloud Morphology, Warm Cloud Microphysics (Nucleation and Condensation), Growth of cloud droplets by collision and coalescence, Cold Cloud Microphysics (Nucleation and growth of ice), Ice in the atmosphere.	6
6.	Chemistry of the atmosphere: Evolution of earth's atmosphere, Nitrogen, hydrogen halogen, sulfur, carbon-containing compounds in the atmosphere, ozone and neutral chemistry, chemical and photochemical processes, Chemical and dynamical life time of atmospheric constituent.	4
	MIDTERM EXAMINATION – II	
7.	Ozone in the Atmosphere: Evolution of the ozone layer, sources and sinks of tropospheric and stratospheric ozone, chlorofluorocarbons, ozone and UV-radiations, supersonic transport.	3
8.	Air Pollution: Sources of anthropogenic pollution, Atmospheric effects-smog, visibility	2
		Total = 30

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance

Learning Outcomes:

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

1. Explain the difference between weather and climate and the structure of the atmosphere
2. Acquire the Knowledge about the composition by which the atmosphere is made of.
3. Integrate thermodynamics processes to study the structure and function of our life-supporting atmosphere and to understand causes, effects, and solutions of different environmental problems.
4. Differentiate the types of cloud and how they produce thunderstorm and lightning
5. Identify the different type of precipitation in the globe and the formation process of rain and snow.

6. Utilize the laws of radiation to explain radiation transfer in the environment and solve problems related to radiation budgets.
7. Apply the energy budget concept to explain the Earth's climate at the surface and estimate a surface energy balance at a particular location with given incoming solar radiation, surface albedo and information about any relevant surface features.
8. Identify the different type and size of aerosols in the atmosphere.
9. Create an understanding how aerosol effects on the seasonal to inter-annual scales and develop awareness of its variability to the climate change.
10. Identify the causes for Ozone layer depletion and improve our responsiveness to save our world from destruction.

Assesment:

Type of Assessment	Marks
FORMATIVE	
In-Course Exam	12.5
Attendance	2.5
SUMMATIVE	
Final Examination	35

Reading Materials:

Atmospheric Sciences: An introductory Survey by J.M. Wallace and P.V. Hobbs, Academic Press.
Introduction to Theoretical Meteorology by S.L.Hess
Introduction to Atmospheric Chemistry by P.V. Hobbs
Atmospheric Chemistry and Physics: From Air Pollution to Climate Change by John H. Seinfeld, Spyros N. Pandis.
Chemistry of the Upper and Lower Atmosphere by Barbara J. Finlayson-Pitts, Jr., James N. Pitts.
A Short course in cloud physics by R.R. Rogers
Physical Meteorology by H.G. Houghton.
An Introduction to Atmospheric Thermodynamics by A.A. Tsonis, Cambridge
Physics of the Cloud by B.J. Mason
Microphysics of cloud and Precipitation by Pruppacher and Klett
Physical Meteorology by J.C. Jhonson
Cloud Dynamics by R.A. Houze
Clouds Rain and Rainmaking by B.J. Mason
Chemistry of Atmospheres by Richard P. Wayne.
Basic Physical Chemistry for Atmospheric Sciences by P.V. Hobbs

Course Number and Title: OCN 105: Marine Botany
Credit hours: 2

Introduction to the course:
The course is taught in the 1st year 1st semester classes of four years integrated B.S. (Honours) program in Oceanography under the University of Dhaka. It is a basic course on Marine Botany. Marine habitats include a diverse group of plants starting from unicellular algae, seaweeds, sea grasses, salt marshes and mangrove forests. A variety of ecological functions and primary productions are carried out in the coastal wetlands and oceans by these plants. In the replenishment of atmospheric oxygen phytoplankton population occupied in the vast area of the oceans of the world play significant role. The present course on Marine Botany has therefore been designed to emphasize the types, systematics, distribution and roles in the environment and food chain of all marine plants. Their beneficial and harmful effects along with the synthesis of most valuable seaweed based commercial products have also been highlighted.

Specific objectives:
(a) Get to know marine environment, plants and factors affecting their life
(b) Learn taxonomy, phylogeny and diversity of all functional group of marine algal plants
(c) Acquire knowledge on algal photosynthesis, respiration, primary productivity their relationships with physicochemical factors of the oceans.
(d) To know environmental controls on the diversity and abundance of marine plants
(e) Learn habitat, distribution and biology of micro- and macroalgae and coral reefs, harmful algal blooms and cyanobacteria of oceans.
(f) Evaluate the distribution and adaptations of sea grass, marsh plants and mangroves
(g) Acquire knowledge on economic botany and biotechnology of marine plants.

Course Content:

SL.	Topics	No. of Lectures
1.	Introduction to marine botany: Marine environment and plants, factors affecting marine life, importance of marine macrophytes and microphytes.	3
2.	Introduction to the Algae: Introduction to botanical taxonomy and phylogeny. Diversity, Taxonomy, and Functional Forms of algae.	3
3.	Algal Physiology: Photosynthesis, Respiration, and Primary Productivity. Relationships with light, temperature, pH, osmotic changes, etc.	4
MIDTERM EXAMINATION – I		
4.	Algal Ecology - Environmental Controls on Algal Diversity and Abundance: Light, Temperature, Water Motion, Salinity, Human Affairs and Marine Plants.	4

5.	Macroalgae: Habitat, distribution, biology, importance of Rhodophyta, Chlorophyta and Heterokontophyta. Coral Reef, macroalgae and eutrophication processes, Microalgae (Phytoplankton): Habitat, distribution, biology, importance of Bacillariophyta, Dinophyta and Haptophyta. Harmful algal blooms (HABs).	6
6.	Cyanobacteria: Habitat, distribution, biology, importance.	2
7.	Marine angiosperms: distribution and adaptations.	3
MIDTERM EXAMINATION - II		
8.	Mangroves, Marsh Plants, Seagrasses	3
9.	Economic botany and plant biotechnology	2
		Total = 30

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance

Learning Outcomes:

1. Concept on marine botany, Marine plants distribution based on light penetration and nutrients, Vertical subdivisions of ocean, plants of estuaries, continental slopes, Geological, physicochemical and biotic factors affecting marine life, Major ionic composition and nutrient cycles of oceanic water, Beneficial and harmful effects caused by marine plants

2. Algae by definition, examples of marine seaweeds and their habitats, Algae and 5 Kingdom system, algal divisions with distinct features, Phylogenetic arrangement of algal plants of marine habitats, Microalgal community, diversity, taxonomy, drift seaweeds, blooms, Macroalgal communities, drift seaweeds and blooms, Functional forms of benthic algae and grazing difficulty

3. Biological activities and processes, Photosynthesis and respiration, Primary producers and productivity, measurement techniques, Relationships with light, effect of temperature on productivity, Effect of pH, osmotic changes
Concept of ecology, controlling factors on algal diversity, Sun and shade plants, light as a signal, Effects of temperature and water motion, Human affairs and marine plants, mechanical and thermal, Oil spills, domestic wastes, biological damage, exotic species, Global warming, ozone layer changes and UV penetration

4. Concept of marine macroalgae with examples (giant kelp), Habitats, macroalgae occupied within mangroves, Sublittoral distribution, horizontal belts, Distribution, biology and importance, Definition of corals, algal symbionts of corals, broad groups, Kinds of coral reefs, zoozanthallae, global distribution of different corals, distribution with depths, Eutrophication, concept, connection with macroalgae, Microalgae, habitat, distribution, response to submarine

light and nutrients, Seasonal fluctuation of phytoplankton, their importance, HAB's (harmful algal blooms).

5. Why the are called so, diagnostic features of cyanobacteria? Habitat, distribution and biology, complementary chromatic adaptation, Biology of nitrogen fixation and its importance.

6. Groups of marine flowering plants, geographical distribution of salt marsh and mangals, Adaptations, salt marsh angiosperms, Concept of mesophytes, hydrophytes and xerophytes, their comparisons, Morphological and anatomical adaptations, Mangrove types, compositions, adaptations and taxonomy, Origin, evolution and biogeographic distribution, Bangladesh mangroves, potential impacts of sea level rise

7. Marine plant resources, macroalgae, sea vegetables, marine food chain based on microalgae, sea grass. Some common oriental sea food, commercial products and ingredients from marine macroalgal vegetation. Plant biotechnology, Zostera marina.

Assesment:

Type of Assessment	**Marks**
FORMATIVE	
In-Course Exam	12.5
Attendance	2.5
SUMMATIVE	
Final Examination	35

Reading Materials:

Clinton J. Dawes, Marine Botany, 2nd Edition, 1998, John Weily & Sons Inc., USA.

Second Semester

Course Number and Title: OCN 106: Calculus
Credit hours: 3

Introduction to the Course: In this course students will learn the basic ideas, tools and techniques of differential calculus, integral calculus and vector calculus and will use them to solve problems from real-life applications.

Specefic Objectives: Learn to find and use limits of functions. Learn to find the derivatives of elementary algebraic functions and trigonometric functions. Learn to use derivatives for graphing algebraic and trigonometric functions and to solve optimization problems. Learn to evaluate definite and indefinite integrals and use them in applications.

Course Contents:

SL.	Topics	No. of Lectures
1.	Concepts of Functions, Application to Graphing, Limits, Continuity.	3
2.	Rate of Change: The Derivative, Differentiation Rules, Rates, Linear Approximations, Successive Differentiation of various types of Functions, Leibnitz's Theorem.	4
3.	Analysis of Functions: Increase, Decrease and Concavity, Rolle's Theorem; Mean Value theorem.	3
MIDTERM EXAMINATION - I		
4.	Maclaurin and Taylor Polynomials and Series, Absolute Maximum and Minimum, Maximum and Minimum values of Functions.	2
5.	Partial Differentiation	2
6.	Evaluation of Indeterminate forms by L'Hospitals rule, Euler's Theorem.	2
7.	The Indefinite Integral, Integration by the Method of Substitutions, Integration by parts; Reduction Formula, Trigonometric Integrals, Integrating Rational Functions by Partial Fractions, Integration by the Method of successive reduction.	7
8.	Definite Integrals and its properties	2
MIDTERM EXAMINATION - II		

9.	The Fundamental Theorem of Calculus, Applications of the Definite Integral in Geometry, Science and Engineering (Area between curves; volumes by slicing, disk & washers; volumes by Cylindrical shells, length of a plane curve, Area of a surface of revolution, Work, Fluid pressure and force), Graphing in polar coordinates, Improper integrals, Beta function and Gamma function.	6
10.	Three dimensional space	2
11.	Introduction to vectors	2
	MIDTERM EXAMINATION - II	
12.	Calculus of vector valued functions, Unit tangent, normal and Bi-normal vectors, Topics in Vector Calculus Vector fields, Gradient, Divergence and Curl, Applications.	7
13.	Air Pollution: Sources of anthropogenic pollution, Atmospheric effects-smog, visibility.	3
		Total = 45

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance

Assesment:

Type of Assessment	**Marks**
FORMATIVE	
In-Course Exam	25
Attendance	5
SUMMATIVE	
Final Examination	70

Reading Materials:

Calculus by Howard Anton.

Applied Calculus by Hughes-Hallett, Gleason, Lock and Flath et.al.

Calculus by Dennis G. Zill

Calculus by Robert T. Smith, Ronald B. Minton

Course Number and Title: OCN 111: Marine Geology
Credit: 3

Introduction to the course: This course aims to inform our undergraduate students about many of the important physical aspects of deep-marine systems. The course involves the study of the range of sediment delivery processes from shelf to deep water, their deposits, trace-fossil assemblages and bed-thickness distributions as an archive of controls (e.g., seismicity, climate change, etc.).

Specific Objectives: 1. To teach the relation between oceanography and geology in details. 2. To enrich the knowledge about different branches of geology so that they student could use them in the field of oceanography. 3. To give a broad outline of the geological evolution of the ocean basins. 4. To give a broad outline of the methods currently employed to investigate the superficial and deep structural features of the sea bed.

Course Content:

SL.	Topics	No. of Lectures
1.	Introduction to Geological oceanography: development in the recent past. Scope origin and distribution of ocean; ocean morphology –physical feature of deep ocean floor –ocean ridges, rises, and Trenches; submarine canyons; physical and chemical properties of ocean water; SMOW; Ocean circulation and ocean currents; waves and Tides coastral morphology and major coastral process coastralnearshore shelf slope and Abbysal-plan.	6
2.	Sedimentation; oceanic crust; Rifting and Sea-floor spreading; Major Features and Evolution of the oceans; Mid-ocean ridges and volcanism; Eustasy and relative sea-level changes; Mineral resources of the oceans.	4
MIDTERM EXAMINATION – I		
3.	The marine environments: general conditions, distribution of life form in the oceans; divisions of the marine environment- pelagic and benthic environments, Basic marine life styles.	3
4.	Seal level changes: Geological evidence and consequences: Eustatic vs. relative sea level changes: effects of sea level change on marginal marine environments.	4
5.	Geological Oceanography of the Bay of Bengal: Bay of Bengal-Evolution; Major morphometric features; the shelf, slope, 90° East Ridge, Plate boundary, active subduction, passive margin, sediment budget.	5
6.	Swatch of No Ground: Origin, geological characteristics, size and extent, sediment dynamics, water mass, importance.	3
MIDTERM EXAMINATION - II		
7.	Bengal deep sea fan: Extents, types, sediment types, sedimentary sequences.	3

8.	Palae-environment of the Bay of Bengal: Methods of reconstruction, deep sea drill, core, oxygen isotope stage, sea level changes.	4
9.	Off-shore islands: Formations, types, distribution and recording, characteristics.	3
MIDTERM EXAMINATION - III		
10.	St. Martin Island: Geology and formation, morphology, ecology, sustainable management.	5
11.	Economic importance of various groups of marine vertebrates.	5
		Total = 45

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance

Learning Outcomes: Have a solid grounding in marine geology. Understand the framework provided by Plate Tectonics. Describe sediments found in different water depths and settings, and understand the sedimentary processes leading to their deposition. Describe the main geological and geophysical techniques for observing the seabed and sub-seabed. Understand the driving forces behind, consequences, and importance of sea-level changes in the geological record.

Assesment:

Type of Assessment	**Marks**
FORMATIVE	
In-Course Exam	25
Attendance	5
SUMMATIVE	
Final Examination	70

Reading Materials:

1. Duxury, A.B. R Duxubury A.C (1999): Fundamentals of Oceanography (3rd Ed.), WCB/MC Graw-Hill.
2. Thurman, H.V. (1994): Introductory Oceanography (7th Ed.), Macmillan Pube. Comp.
3. Seibold, E. & Berger, W. H: The sea Floor- An Introduction to Marine Geology (3rd Ed.).
4. Erickson & Timothy (2002): Marine Geology.
5. *The Ocean Basins: Their Structure and Evolution* (second edition). Open University. ISBN 0750639830
6. *The Sea Floor ---An Introduction to Marine Geology* (third edition). E. Seibold and W.H. Berger. ISBN 3540601910

Course Number and Title: OCN 112: Hydrodynamics & Coastal Hydraulics
Credit hours: **2**

Introduction to the course: Hydrodynamics is the study of liquids in motion. Examples of applications include: determining the mass flow rate of petroleum through pipelines, measuring flows around bridge pylons and off shore rigs, ship hull designing, predicting weather patterns and wave dynamics and measuring liquid metal flows. Hydraulics deals with the mechanical properties of liquids, which focuses on the uses of fluid properties. Hydraulic applications are pipe flow, dam design, (fluidics and fluid control circuitry), pumps, turbines, hydropower, computational fluid dynamics, flow measurement, river channel behavior and erosion. Other applications are; wave dynamics, sedimentation transport, coastal erosion and river hydrology.

Specific Objectives: Students will be able to apply basic principles of general marine hydrodynamics problems.They will demonstrate knowledge and comprehension of basic principles of marine hydrodynamics.Theywill be able to apply basic principles of marine hydrodynamics in simple mathematical problem solving involving marine structures/vehicles. They will be able to use computer software in analysis, modeling, and design of marine systems.design a range of hydraulic structures including: fixed and movable crest weirs; gated control structures; pipe conveyance structures; spillways and energy dissipation structure; critical flow measuring flumes; gulley control structures ; weir and culvert type structures using the minimum specific energy concept.

Course Content:

SL.	Topics	No. of Lectures
1.	Introduction: Nature and properties of fluid, forces and flows. Dimensions, dimensional homogeneity and units, Continuum hypothesis, Measures of fluid mass & weight, Density, specific weight, specific gravity.	3
2.	Ideal or perfect fluid, Viscosity, Effects of Viscosity, Kinematic Viscosity, Compressibility of fluids, Surface Tension. Incompressible fluid, rotational flows, Boussinesq approximation, Boundary conditions. Pressure and Depth, The Hydrostatic Pressure, Atmospheric pressure.	4
3.	Fluid kinematics: The velocity field, Eulerian and Lagrangian flow descriptions: The particle derivative, steady and unsteady flows, One-, two- and three dimensional flows, Stream line, Path line, Streak line, Control volume, Equation of Continuity, Cartesian Coordinates, Spherical Polar coordinates, Cylindrical polar coordinates, linear strain rate, shear strain rate.	4
MIDTERM EXAMINATION – I		
4.	Motion in Two Dimensions: Stream Function, Physical Interpretation of Stream function, Complex potential and Complex Velocity, Source, Sink, Doublet, Vorticity, Body force and Surface force and circulation.	3

5.	Currents: Classification, behavior and other effects, Inertial boundary currents along curvy coastlines: flow separation.	3
6.	Waves: Introduction, Wave motion, Stationary Waves, Surface waves, Two-Dimensional Wave Equation and Characteristics, Waves at sea, Some Special Waves. Coastal Shock Waves and Bores.	5
7.	The dynamics of the Bangladesh coastal marine layer: supercritical flow, expansion fans and oblique shocks. Coastal Gravity currents.	4
MIDTERM EXAMINATION - II		
8.	The inertial behavior of upwelling jets and fronts: application to the Oregon coastal jet.	3
9.	Coastal erosion, Planning and methods of coast protection works - Design of shore defense structures.	2
		Total = 30

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance

Learning Outcomes:
Understand basic features of Eulerian and Lagrangian descriptions of flow. Set up and solve basic mathematical problems involving transport theorem, mass and momentum conservation. Derive and analyze continuity equation and Euler's equation. Derive and analyze Navier-Stokes equations (for Newtonian fluids). Derive and analyze kinematic and dynamic boundary conditions. Set up and solve basic mathematical problems involving treatment of gravity force.

Define verbally and mathematically the basic principles of marine hydrodynamics including: ideal rotational and irrotational fluid flows (vorticity, vortical flow, simple potential flows), viscous and boundary layer flow, derive mathematically the basic principles of marine hydrodynamics, set up and solve simple mathematical problems involving marine hydrodynamics.

Assesment:

Type of Assessment	**Marks**
FORMATIVE	
In-Course Exam	12.5
Attendance	2.5
SUMMATIVE	
Final Examination	35

Reading Materials:

1. Fluid Dynamics by P.K. Kundu& J.M. Cohen
2. Theoretical Hydrodynamics by L.M. Milne-Thomson
3. Fundamentals of Fluid dynamics by Bruce R. Munson, Donald F. Young, Theodore H. Okiishi
4. Mathematical Methods for Physics & Engineering by K.F. Riley, M.P. Hobson, S.J. Bence (2000, Cambridge)
5. Practical hydraulics by Melvin Kay
6. A first course in Hydraulics by John Fenton
7. Handbook of Coastal and Ocean Engineering by Young C Kim (California State University, Los Angeles, USA)
8. Coastal hydraulics: (2nd edition). A.M. Muir Wood and C.A. Fleming; Macmillan Press, London, 1981.

Course Number and Title: OCN 113: Marine Geophysics
Credit hours: 2

Introduction to the Course: This course provides an introduction to marine geophysics and geological interpretation of marine geophysical data. The course covers the theory behind standard marine geophysical mapping, focusing particularly on acoustic methods. The course includes a historical overview of how geophysical methods have been used to explore the oceans and how seafloor mapping has contributed to understanding of Earth's evolution.

Specific Objectives: 1. To teach use of geophysics in marine science. 2. The use of different geophysical methods 3. To give a broad idea about applying different geophysical methods for marine resource exploration 4. To teach the interpretation of geophysical data acquired from survey.

Course Content:

SL.	Topics	No. of Lectures
1.	The earth as a planet; different motions of the earth; gravity field of the earth, Clairaut's theorem, size and shape of earth; geochronology; seismology and interior of the earth; variation of density, velocity, pressure, temperature, electrical and magnetic properties of the earth; earthquakes-causes and measurements, magnitude and intensity, focal mechanisms, earthquake quantification, source characteristics, seismotectonics and seismic hazards; digital seismographs, geomagnetic field, paleomagnetism; oceanic and continental lithosphere; plate tectonics; heat flow; upper and lower atmospheric phenomena.	3
2.	Scalar and vector potential fields; Laplace, Maxwell and Helmholtz equations for solution of different types of boundary value problems in Cartesian, cylindrical and spherical polar coordinates; Green's theorem; Image theory; integral equations in potential theory; Eikonal equation and Ray theory. Basic concepts of forward and inverse problems of geophysics, Ill-posedness of inverse problems.	4

3.	'G' and 'g' units of measurement, absolute and relative gravity measurements; Land, airborne, shipborne and bore-hole gravity surveys; various corrections in gravity data reduction – free air, Bouguer and isostatic anomalies; density estimates of rocks; regional and residual gravity separation; principle of equivalent stratum; upward and downward continuation; wavelength filtering; preparation and analysis of gravity maps; gravity anomalies and their interpretation – anomalies due to geometrical and irregular shaped bodies, depth rules, calculation of mass.	3
MIDTERM EXAMINATION – I		
4.	Earth's magnetic field – elements, origin and units of measurement, magnetic susceptibility of rocks and measurements, magnetometers, Land, airborne and marine magnetic surveys, corrections, preparation of magnetic maps, upward and downward continuation, magnetic anomalies-geometrical shaped bodies, depth estimates, Image processing, concepts in processing of magnetic anomaly maps; Interpretation of processed magnetic anomaly data.	3
5.	Conduction of electricity through rocks, electrical conductivities of metals, non-metals, rock forming minerals and different rocks, concepts of D.C. resistivity measurement, various electrode configurations for resistivity sounding and profiling, application of filter theory, Type-curves over multi-layered structures, Dar-Zarrouck parameters, reduction of layers, coefficient of anisotropy, interpretation of resistivity field data, equivalence and suppression, self-potential and its origin, field measurement, Induced polarization, time and frequency domain IP measurements; interpretation and applications of IP, ground-water exploration, environmental and engineering applications.	4
6.	Basic concept of EM induction, Origin of electromagnetic field, elliptic polarization, methods of measurement for different source-receiver configuration, components in EM measurements. Skin-depth, interpretation and applications; earth's natural electromagnetic field, tellurics, magneto-tellurics; geomagnetic depth sounding principles, electromagnetic profiling, methods of measurement, processing of data and interpretation. Geological applications including groundwater, mining and hydrocarbon exploration.	2
7.	Seismic methods of prospecting; Elastic properties of earth materials; Reflection, refraction and CDP surveys; land and marine seismic sources, generation and propagation of elastic waves, velocity – depth models, geophones, hydrophones, recording instruments (DFS), digital formats, field layouts, seismic noises and noise profile analysis, optimum geophone grouping, noise cancellation by shot and geophone arrays, 2D and 3D seismic data acquisition, processing and interpretation; CDP stacking charts, binning, filtering, dip-moveout, static and dynamic corrections, Digital seismic data processing, seismic deconvolution and migration methods, attribute analysis, bright and dim spots, seismic stratigraphy, high resolution seismics, VSP, AVO. Reservoir geophysics.	3
8.	Geophysical signal processing, sampling theorem, aliasing, Nyquist	3

	frequency, Fourier series, periodic waveform, Fourier and Hilbert transform, Z-transform and wavelet transform; power spectrum, delta function, auto correlation, cross correlation, convolution, deconvolution, principles of digital filters, windows, poles and zeros.	
	MIDTERM EXAMINATION - II	
9.	Principles and techniques of geophysical well-logging. SP, resistivity, induction, gamma ray, neutron, density, sonic, temperature, dip meter, caliper, nuclear magnetic, cement bond logging, micro-logs. Quantitative evaluation of formations from well logs; well hydraulics and application of geophysical methods for groundwater study; application of bore hole geophysics in ground water, mineral and oil exploration.	2
10.	Radioactive methods of prospecting and assaying of minerals (radioactive and non radioactive) deposits, half-life, decay constant, radioactive equilibrium, G M counter, scintillation detector, semiconductor devices, application of radiometric for exploration and radioactive waste disposal.	2
11.	Geophysical inverse problems; non-uniqueness and stability of solutions; quasi-linear and non-linear methods including Tikhonov's regularization method, Backus-Gilbert method, simulated annealing, genetic algorithms and artificial neural network.	1
		Total = 30

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance.

Learning Outcomes: 1. Marine Geophysics uses and other Branches and uses of Marine Geophysics sciences 2. Detailed knowledge regarding geophysics surveys include magnetic, seismic, gravity should widen the scope of surveying operation. 3. Understand Earth magnetic field, core field, and international geomagnetic reference. 4. Understand magnetic anomalies caused by geology.

Assesment:

Type of Assessment	**Marks**
FORMATIVE	
In-Course Exam	12.5
Attendance	2.5
SUMMATIVE	
Final Examination	35

Reading Materials:

1. Applied Geophysics by W.M. Telford, l.P. Geldart, R.E. Sheriff
2. Fundamental of Geophysics by Lowrie William
3. Mathematical geophysics by Jean-Yves Chemin, Benoit desjardins, Isabelle Gallagher, Emmanuel Grenier

Course Number and Title: **OCN 114: Differential Equation and Linear Algebra**
Credit hours: **3**

Introduction to the Course:
This is a one-term introduction to ordinary differential equations with applications. Topics include classification of, and what is meant by the solution of a differential equation, first-order equations for which exact solutions are obtainable, explicit methods of solving higher-order linear differential equations, an introduction to systems of differential equations. Applications of first-order linear differential equations and second-order linear differential equations with constant coefficients will be studied.

Specific Objectives:
Learn to solve first-order differential equations. Learn to solve linear differential equations of higher-order. Learn to solve application problems modeled by a second-order differential equation. Learn to solve differential equations with variable coefficients. Learn to solve systems of equations of differential equations. Learn to estimate solutions of a differential equation.

Course Contents:

SL.	Topics	No. of Lectures
1.	Differential equations & Mathematical Models Integrals as General and Particular solutions.	3
2.	Separable Equations & Applications, Linear first order differential equations. Substitution methods & Exact Equations.	4
3.	Introduction to Linear Systems, Matrices, Gaussian Elimination & Gauss – Jordan Elimination method.	3
	MIDTERM EXAMINATION - I	
4.	Reduced Row-echelon Matrices, Matrix Operations, Inverse of Matrices, Determinants.	4
5.	The Vector Spaces R3 and Rn & Subspaces. Linear Combination & Independence of Vectors, Basis and Dimension for Vector Spaces.	8
6.	Method of Variation of Parameters, Introduction to Eigenvalues	3
	MIDTERM EXAMINATION - II	
7.	Diagonalization of Matrices, Application involving Powers of Matrices.	4
8.	First order Systems & Applications, Matrices and Linear Systems. The Eigenvalue Method for Linear Systems, Multiple Eigenvalue Solutions.	6
	MIDTERM EXAMINATION - III	
9.	Partial Differential Equation: Solution of Wave Equation, Diffusion Equation,	6

10.	Partial Differential Equation: Laplace's Equation, Heat Equation	4
		Total = 45

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance.

Learning Outcomes:
Will be able to explain the concept of differential equation. Classifies the differential equations with respect to their order and linearity. Explains the meaning of solution of a differential equation. Will be able to solve first-order ordinary differential equations. Solves exact differential equations. Converts separable and homogenous equations to exact differential equations by integrating factors. Solves Bernoulli differential equations. Will be able to find solution of higher-order linear differential equations. Expresses the basic existence theorem for higher- order linear differential equations. Solves the homogeneous linear differential equations with constant coefficients. Applies the method of undetermined coefficients to solve the non-homogeneous linear differential equations with constant coefficients. Uses the method "variations of parameters" to find to solution of higher-order linear differential equations with variable coefficients. Solves the Cauchy-Euler equations. Will be able to solve systems of linear differential equations. Determines the type of a linear differential equation systems. Solves the linear systems in normal form. Solves the homogeneous linear systems with constant coefficients.

Assesment:

Type of Assessment	**Marks**
FORMATIVE	
In-Course Exam	25
Attendance	5
SUMMATIVE	
Final Examination	70

Reading Materials:
1. Differential Equations and Linear Algebra by C.H. Edwards and D.E. Penny, Prentice Hall, 2001
2. Differential equation by Shepley L. Ross
3. A First Course in Differential Equations (10^{th} Edition) by Dennis G Zill
4. Elementary Linear Algebra by Howard Anton and Chris Rorres

Course Number and Title: OCN 115: Marine Biology: Vertebrates
Credit Hours: 3

Introduction to the Course:

This course provides students with a solid background in basic biology with an emphasis on marine vertebrate organisms such as fish, sharks, birds, turtles and marine mammals. Aquatic vertebrates (including sharks, rays, cetaceans, penguins and other aquatic birds) are generally considered very charismatic animals and attract much public and research attention. As a group they also adapt to the challenges of life in water in a diverse range of ways. In this course, students will learn about the different form, function, ecology and physiology of each group of aquatic vertebrates.

Specific Objectives:

The aim of this course is to provide you with an in-depth insight into the range of adaptations for life in the water and the ways in which biology has adapted to cope with the challenges of low oxygen, high pressure and unpredictability in resources. This insight will help you to develop your critical and creative thinking about how life has adapted to deal with specific challenges and provide key employability skills in analysis and communication.

Course Content:

SL.	Topics	No. of Lectures
1.	Classification of the Phylum Chordate up to Order with special emphasis on the aquatic ones.	4
2.	Marine Fishes - Protochordates, Class Agnatha – Jawless fish, Class Chondrichthyes – Cartilaginous fish (sharks, rays)	6
	MIDTERM EXAMINATION – I	
3.	Marine Fishes, Class Osteichthyes – Bony fish.	4
4.	Marine Reptiles – Sea Crocodiles, Sea Snakes, Sea Lizards, and Sea Turtles.	8
5.	Marine Birds - Common Shorebirds	3
	MIDTERM EXAMINATION - II	
6.	Marine Birds - Diving Shorebirds, Diving Pelagic Birds, Penguins.	6
7.	Marine Mammals: Cetaceans: Whales and Dolphins	4
	MIDTERM EXAMINATION - III	
8.	Marine Mammals: Seals and Other Marine Mammals	5
9.	Economic importance of various groups of marine vertebrates	5
		Total = 45

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance.

Learning Outcomes:

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

- Describe the form, function and basic ecology and physiology of a range of aquatic vertebrates
- Explain, in some detail, the role and importance of aquatic vertebrates
- Explain, in some detail, a range of case studies of aquatic vertebrate form, function, ecology and physiology
- Identify the main marine vertebrate.
- Identify the origin of chordates

Assesment:

Type of Assessment	**Marks**
FORMATIVE	
In-Course Exam	25
Attendance	5
SUMMATIVE	
Final Examination	70

Reading Materials:

1. Robert, T. Orr. 1982. Vertebrate Biology. Saundars College Publishing.
2. Young, J.Z. 1981. The Life of Vertebrates (3rd edition). Oxford University press.
3. J. Levinton (2009) *Marine Biology: Function, Biodiversity, Ecology.* (3rd edition, Oxford University Press).
4. Sumich, James, L & Morrissey, John, F. *(2008) Introduction to the Biology of Marine Life,* 9th edition.Jones & Bartlett Publishers. ISBN: 0-7637-3313-X.
5. Joanna Burger,1989, Seabirds and Other Marine Vertebrates, First Edition, Columbia University Press. ISBN-13: 978-0231063623
6. Jefferson, T. A. , Webber, M. A. & Pitman, R. L. (2009) *Marine Mammals of the World A Comprehensive Guide to their Identification* London ; Burlington, MA: Academic ISBN 978-0-12-383853-7 7-16
7. Bird Life International (BLI) (2008). *Sterna fuscata*. In: IUCN 2008. IUCN Red List of Threatened Species. Retrieved 7 August 2009.

Course Number and Title: OCN 116: Marine Analytical Chemistry
Credit Hours: 3

Introduction to the Course:

This course focuses on analytical methods and data analysis of chemistry. It includes understanding types of chemical and other analytical techniques oceanography, how to assess data quality, how to document and present results effectively considering error during measurements.

Specific Objectives:

The primary objective of this course is to acquire basic concepts, principles, and techniques of modern analytical chemistry that would empower students with an analytical mind set and the abilities to solve diverse analytical problems in an efficient and quantitative way that conveys the importance of accuracy and precision of the analytical results.

Course Content:

SL.	Topics	No. of Lectures
1.	**Basic concepts in analytical chemistry:** Background aspects, classical and modern concepts of analytical detection and quantification. Sensitivity, selectivity, specificity, concentration limit, dilution limit, etc. of chemical reactions sampling and sample preparation for quantitative analysis, group separation, elemental analysis, and analysis of insoluble materials.	6
2.	**Acid-Base reactions:** Acid-base equilibria and buffers in analytical chemistry, indicators, chemical equilibria in solution, complexation and equilibria oxidation-reductions in chemical analysis.	4
MIDTERM EXAMINATION - I		
3.	**Separation methods:** Precipitation and co-precipitation phenomenon, group chemistry for qualitative analysis, solvent extraction, ion exchange separation and chromatographic methods: paper and thin layer chromatography.	6
4.	**Complexometric titrations:** Complexation of metal ions, complexation equilibria, Complexometric titration with chelating agents such as EDTA, NTA etc. Organic reagents in analytical chemistry, Metal indicators and their characteristics, Limitations of complexometric measurements.	4
5.	**Instrumental methods of chemical analysis:** Spectroscopic methods: UV and visible radiation, absorbance and transmittance, absorptivity, the Beer-Lamberts law, basic components of a spectrometer, qualitative and quantitative analysis, and Potentiometric analysis, stoichiometric determination of metal-ligand complexes.	5
MIDTERM EXAMINATION - II		
6.	**Errors in analytical measurements:** The significant figure convention, accuracy, precision, mean deviation, standard deviation, types of error. Treatment of analytical results, Sensitivity and detection limit of instrument,	4

	quality assurance and quality control of analytical results.	
7.	**Analytical chemistry of chemical pollutants:** Collection of environmental, samples and measurements of important parameters such as BOD, COD, DO, pH and temperature for water quality assessments. Potentiometric and complexometric analysis of water quality (hardness nitrate, ammonia etc.). Analysis of volatile organics and gases like NOx; and SO_X in the atmosphere.	6
MIDTERM EXAMINATION - III		
8.	**Redox Reactions:** Oxidation-reduction equilibria in chemical analysis, redox titration curve, indicators for oxidation-reduction titration, $KMnO_4$ as a standard oxidants titration with $K_2Cr_2O_7$ and cerium(IV), redox titration involving iodine, iodometric and iodimetrictitrationmethods.	5
9.	**Solvent extraction in analytical chemistry**: Separation processes, liquid-liquid extraction, distribution of solute between solvent pair, effect of number of extractions, batch and continues extractions, some examples of liquid-liquid extraction.	2
10.	**Gravimetric Methods of analysis:** Principle of gravimetric methods, properties of precipitates and precipitating agents, coagulation and peptization of precipitates, treatments of colloidal precipitates, co-precipitation and post precipitation, drying andignition of precipitates, results and calculation.	3
		Total = 45

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance.

Learning Outcomes:

Upon successful completion of this course, students will have the knowledge and skills to:
1. Understand the basics of the major analytical techniques including sample preparation, standardization and data analysis for each technique
2. Evaluate strengths and weakness of different analytical techniques for different applications
3. Design an analytical regimen to obtain data relevant to their research proposal
4. Report in detail on a chosen technique and on analysis of the data
5. Communicate effectively a variety of data analysis tools to oceanographic research problems. 6. To develop an understanding of the range and uses of analytical methods in chemistry
7. To establish an appreciation of the role of chemistry in quantitative analysis
8. To develop an understanding of the broad role of the chemist in measurement and problem solving for analytical tasks
9. To provide an understanding of chemical methods employed for elemental and compound analysis
10. To provide experience in some scientific methods employed in analytical chemistry

Assesment:

Type of Assessment	Marks
FORMATIVE	
In-Course Exam	25
Attendance	5
SUMMATIVE	
Final Examination	70

Reading Materials:

1. Quantitative Chemical Analysis, S. E Manahan, Books/Cole Publishing Co.
2. Modern Methods of Chemical Analysis, R. L Pecsok, L. D. Shields, T. Cairns, and McWillaim, John Wiley & Sons.
3. Fundamentals of Analytical Chemistry, D. A. Skoog, D. M. West, F. J Holler and S. R Crouch, Saunders College Publishing.
4. Analytical Chemistry, G. D. Christian, John Wiley & Sons.
5. Modern Analytical Chemistry, D. Harvey, McGraw-Hill Higher Education.
6. Analytical Chemistry Principles, J. H. Kennedy, Saunders College Publishing.
7. A Text Book of Macro and Semimicro Qualitative Inorganic Analysis, A. I. Vogel, Longman, Green and Co. Ltd.

Third Semester

Course Number and Title: OCN 201: Physical Oceanography
Credit hours: 3

Introduction to the Course: Physical oceanography is important in many different ways. Much of the world's human population lives near the coast where the effects of marine weather, hurricanes, waves, tides, and coastal currents are manifested. Regional current systems, such as the Gulf Stream, are important components of the global ocean circulation. El Nino is an example of a larger-scale phenomenon whose equatorial origin belies its global impacts on the atmosphere and ocean. Finally, the oceans play an important role in the planetary climate system and the recent interest in climate change.

Specific Objectives: To introduce students to the basic principles underlying physical processes in the ocean. To show students that the basic physical principles can be represented with mathematical equations. To apply these basic physical principles to develop an understanding of specific ocean phenomena and processes.

To understand some of the important linkages between physical oceanography and the other oceanographic disciplines-- marine biology, chemical oceanography, and marine geology. To help understand why physical oceanography is important in the earth system and to learn about the interactions with other components of the system, particularly the atmosphere.

Course Contents:

SL.	Topics	No. of Lectures
1.	Physical Oceanography: Introduction. Definition, Scope, Multidisciplinary investigation application for Bangladesh.	3
2.	Relief of the Ocean: Physical feature of the ocean floor, ocean floor topography, trenches, oceanic ridges, submarine canyon, passive and active continental margin, continental shelves & slope, ocean floor of the Atlantic, Pacific and Indian Ocean.	7
	MIDTERM EXAMINATION - I	
3.	Ocean Sediments: Source of sediments, types, characteristics, depositional environments.	4
4.	Ocean temperature: Temperature change, causes, vertical and horizontal distribution and Implication	6
5.	Ocean Salinity: Salinity change, causes, distribution and implication.	2
6.	Ocean Currents: Causes, types, mean current in Atlantic, Pacific and Indian Ocean.	3
MIDTERM EXAMINATION – II		

7.	Ocean Tide: Causes and effects. Global distribution, Implication.	3
8.	Waves: causes, characteristics of wave actions, wave energy	4
9.	Storm surges and cyclones, characteristics, environmental consequences and management.	3
MIDTERM EXAMINATION – III		
10.	Sea-level change: Definition, causes, past, present and future trends of S. L. changes. Consequences of S. L. changes.	6
11.	Marine Environment: Marine climatic Zone, EL-Nino. La-Nina, Man-Ocean relation.	4
		Total = 45

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance.

Learning Outcomes:
You will able to explain the basic physical variables predicted by numerical ocean circulation models. You will be able to define the variables, discuss how they are measured, and name the units used. You will refamiliarize yourself with the primary physical forces, balances and processes affecting the ocean - including tides. You will be able to define terms commonly used to discuss ocean circulation.

Assesment:

Type of Assessment	**Marks**
FORMATIVE	
In-Course Exam	25
Attendance	5
SUMMATIVE	
Final Examination	70

Reading Materials:
1. Introduction to physical oceanography by Robert H. Stewart
2. Physical Oceanography by Knauss
3. Introduction to Physical Oceanography by George L. Mellor.
4. Introductory Dynamical Oceanography by Stephen Pond and JL Pickard
5. Physical Oceanography, A mathematical introduction with MATLAB by Reza, Malek-Madani
6. Rhatt, J.J., Oceanography, 13. Van Nostrand Company, New York.
7. King, C.A.M., Oceanography for Geographers, Edwin Arnold Publishers Ltd. London
8. Sharma, R-C. andVatal, M. Oceanography for Geographers, Chaitanya Publishing House, Allahabad, India.
9.. Carson, R.J., The Sea Around, Staples Press Ltd. London.
10. Engel, L., The Sea, Time Incorporated, London.
11. Elements of Physical Oceanography by Hugh J. Mclellan

Course Number and Title: OCN 202: Oceanography of the Bay of Bengal
Credit hours: 2

Introduction to the Course:
Formed about 55 million years ago due to collision of northward moving Indian plate with Eurasian plate, Bay of Bengal isalarge but relatively shallow embayment of the northeastern Indian Ocean, occupying an area of about 839,000 square miles (2,173,000 square km) with a number of large rivers—the Mahanadi, Godavari, Krishna, and Kaveri (Cauvery) on the west and the Ganges (Ganga) and Brahmaputra on the north – flowing into it. An area of about 118,813 km^2 of the Bay of Bengal has recently been included within the maritime boundary of Bangladesh. As such, all information about the Bay of Bengal is very important to achieve the maximum benefits from the marine resources.

Bathymetric features of the Bay of Bengal are: Bengal fan, basins, canyons, ridges (aseismic and seismic), subduction zone, plate boundary deformation zone and seamounts, of which, the Bengal Fan is the most important feature. The canyons surrounding the Bay of Bengal supply sediments to the Bay of Bengal, with Ganges and Brahmaputra Rivers themselves discharging about a billion tons of continental sediments per year into the Bay of Bengal, which reach as far as 8^0S, i.e. about 3000 km away from the Ganges mouth. They constitute the largest fan system on Earth and rest on Early Cretaceous oceanic basement.

Specific Objectives:
Oceanography of the Bay of Bengal provides the clearest possible understanding of the geological and morphological characteristics of the continental margin and its adjacent seabed. To a large extent, these characteristics reflect the region's tectonic and sedimentary history. This course also provides an understanding of the physical, chemical and biological characteristics of water, different models of surge propagation and geo-politics of the territory.

Course Contents:

SL.	Topics	No. of Lectures
1.	**Introduction:** Location, boundary, historical perspectives, human occupancy	3
2.	**Physical Oceanography of the Bay of Bengal:** Continental shelf: Bottom topography, bathymetric changes, sediment dispersal. Ocean dynamics: Tidal characteristics, vertical and horizontal distribution of ocean temperature, salinity and density; aerial and seasonal variation of ocean currents, sediment transport, estuaries and estuaries dynamics.	7
	MIDTERM EXAMINATION – I	
3.	**3. Geological Oceanography of the Bay of Bengal:** the shelf, slope, 90° East Ridge, Plate boundary, active subduction, passive margin, sediment budget. Swatch of No Ground: Origin, geological characteristics, size and extent, sediment dynamics, water mass, importance. Bengal deep sea fan: Extents, types, sediment types, sedimentary sequences. Palae-environment of the Bay of Bengal: Methods of reconstruction, deep sea drill, core, oxygen isotope stage, sea level changes. Off-shore islands: Formations, types, distribution and recording, characteristicsSt. Martin Island: Geology and formation, morphology, ecology, sustainable management	4

4.	**Chemical Oceanography of the Bay of Bengal:** Water chemistry, sediment chemistry. Horizontal and vertical profiles of nutrients (No_3, No_2, NH_4, Si), vertical profiles of O_2, CO_2, Bio-geo-chemistry of the Bay of Bengal.	6
5.	**Biological Oceanography of the Bay of Bengal:** Mixed layer depth, photosynthesis, chlorophyll concentration, primary production, secondary production, phytoplankton, zooplankton, benthos, fisheries production	2
6.	**Satellite Oceanography of the Bay of Bengal:** Sea Surface Temperature (SST), Water circulation of the Bay of Bengal, chlorophyll concentration.	3
MIDTERM EXAMINATION – II		
7.	**Satellite Oceanography of the Bay of Bengal:** Sea Surface Temperature (SST), Water circulation of the Bay of Bengal, chlorophyll concentration.	1
8.	**Modeling:** Box model, 2 dimensional and 3-dimensional model, Physical, biological, ecological, bio-geo-chemical and ecosystem model of the Bay of Bengal. Storm surge modelling.	3
9.	**Geopolitics of Bay of Bengal**: Geo-political importance of Bay of Bengal, Case study: Bangladesh Myanmar maritime boundary conflict and verdict.	1
		Total = 30

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance.

Learning Outcomes:
Participating in this course will provide students with the baseline knowledge on the geological and morphological characteristics of the continental margin and its adjacent seabed, covering topics related to the physical, chemical and biological characteristics of water, different models of surge propagation and geo-politics of the Bay of Bengal.

Assesment:

Type of Assessment	Marks
FORMATIVE	
In-Course Exam	12.5
Attendance	2.5
SUMMATIVE	
Final Examination	35

Reading Materials:

1. Seibold, E. & Berger, W. H: *The sea Floor- An Introduction to Marine Geology* (3rd Ed.).
2. Erickson & Timothy (2002): *Marine Geology*.
3. *The Ocean Basins: Their Structure and Evolution* (second edition). Open University. ISBN 0750639830
4. *The Sea Floor ---An Introduction to Marine Geology* (third edition). E. Seibold and W.H. Berger. ISBN 3540601910

5. *Marine Biogeochemical Cycles* (second edition). Open University.
6. *Marine Geochemistry.* H.D.Schulz and M. Zabel (ed.). ISBN 354066453X
7. Carol M Lalli& Timothy Parsons (1997) *Biological Oceanography: An Introduction*, 2nd edition. Butterworth-Heinemann Publishers. ISBN 0750633840.

Course Number and Title: OCN 203: Marine Biogeochemistry
Credit Hours: 3

Introduction to the Course:

This is an advanced course that explores the relationships between marine chemistry, marine biological and geochemical processes - with a focus on developing an understanding of the interplay and responses between ocean chemistry, marine biology and global change. Topics covered include the theory and application of chemical and isotopic tracers in oceanography and palaeoceanography, macro- and micro-nutrient cycling, sediment and suspended particulate interactions and element speciation.

Specific Objectives:

Marine biogeochemistry provides a broad foundation and good understanding of current issues in relevant field. The study examines the distribution of chemical components into the ocean, their residence time and the ways in which they are transported. The student gets an overview of how different processes influence the chemistry of the ocean, including the role of vertical mixing, advection, biological processes and gas exchange between the air-sea interfaces. The study also discusses the use of chemical tracer elements to quantify the mixing processes in the ocean. The objective is to make the students able to
1) To conduct simple chemical equilibrium calculations
2) To construct simple mass balance box models – for example what would the concentration of atmospheric CO_2 be if there was no ocean biology?
3) To explain the distribution of life and chemical elements in the ocean, understand the relationships between these patterns and the physical processes affecting these patterns.
4) To identify the processes affecting the distribution and cycling of an element through the ocean.
5) To distinguish the implications of the rates of biological processes from those of the abundance of the organisms driving those processes
6) Interpret graphical data for a wide range of physical, chemical and biological patterns and activities in the ocean

Course Content:

SL.	Topics	No. of Lectures
1.	The physical chemistry of sea water: The crustal-ocean-atmosphere factory, The waters of the sea, Seasalt is more than NaCl, Salinity as a conservative tracer, The nature of chemical transformations in the ocean; Gas solubility and exchange across the air-sea interface.	4

2.	The redox chemistry of seawater: The importance of oxygen; Organic matter: production and destruction; Vertical segregation of the biolimiting elements; Horizontal segregation of the biolimiting elements; Trace elements in seawater; Diagenesis.	6
	MIDTERM EXAMINATION - I	
3.	The chemistry of marine sediments: Classification of sediments; Clay minerals and other detrital silicates;	3
4.	Calcite, alkalinity, and the pH of seawater; Biogenic silica; Evaporites; Iron-manganese nodules and other hydrogenous minerals; Metalliferous sediments and other hydrothermal deposits; Global pattern of sediment distribution; Why seawater is salty but not too salty	7
5.	Organic biogeochemistry: Marine biogeochemistry: an overview; The production and destruction of organic compounds in the sea; The marine nitrogen and phosphorus cycles;	2
6.	The marine carbon cycle and global climate change; The origin of petroleum in the marine environment; Organic products from the sea: Pharmaceuticals, Nutraceuticals, Food additives, and Cosmoceuticals.	3
MIDTERM EXAMINATION – II		
7.	Marine pollution: Marine pollution: the oceans as a waste space.	2
8.	Light stable isotopes: Water stable isotopes: atmospheric composition and application in polar ice core studies; Stable isotope applications in hydrologic studies;	4
9.	Elemental and isotopic proxies of past ocean temperatures; Sulfur-rich sediments; High-molecular-weight petrogenic and pyrogenic hydrocarbons in aquatic environments.	4
MIDTERM EXAMINATION – III		
10.	Radiocarbon. Noble gases as mantle tracers.	3
11.	Radiogenic isotopes: Sampling mantle heterogeneity through oceanic basalts: Isotopes and trace elements; Radiogenic isotopes in weathering and hydrology; Long-lived isotopic tracers in oceanography, paleoceanography, and Ice-sheet dynamics; Records of Cenozoic ocean chemistry.	7
		Total = 45

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance.

Learning Outcomes:

At the end of this course, students will be able to:
- understand how different cycles are influenced by biogeochemical processes such as ocean circulation, biological processes, air-sea gas exchange and riverine input
- explain the main features of Marine biogeochemistry and related subjects such as physical oceanography, meteorology and climate, and has a thorough knowledge of a specialized topic in Marine biogeochemistry
- can explain key concepts in Marin biogeochemistry, and discuss similarities and differences between these
- Aware of how chemical, biological, physical and geological processes are linked in the ocean.

Assesment:

Type of Assessment	**Marks**
FORMATIVE	
In-Course Exam	25
Attendance	5
SUMMATIVE	
Final Examination	70

Reading Materials:

1. Libes S.M. 2011. Introduction to marine biogeochemistry. 2nd Edition.
2. Holland H.D., Turekian K.K. 2011. Isotope Geochemistry.
3. Schlesinger, W.H., 2005. Biogeochemistry. Vol. 8 in: Treatise on Geochemistry. Elsevier Science. ISBN 0-08-044642-6
4. Vladimir N. Bashkin, 2002, Modern Biogeochemistry. Kluwer, ISBN 1-4020-0992-5.
5. Samuel S. Butcher et al. (Eds.), 1992, Global Biogeochemical Cycles. Academic, ISBN 0-12-147685-5.
6. Susan M. Libes, 1992, Introduction to Marine Biogeochemistry. Wiley, ISBN 0-471-50946-9.
7. DmitriiMalyuga, 1995, Biogeochemical Methods of Prospecting. Springer, ISBN 978-0-306-10682

Course Number and Title: OCN-204: Ocean Minerals and Energy Resources
Credit hours: 2

Introduction to the Course:
Minerals form all over the world, covering both land and ocean parts. Therefore, it is imperative to understand the structure and composition of the earth as a whole, specifically the marine parts. Mineral resource classification is the classification of mineral resources based on an increasing level of geological knowledge and confidence.

Understanding the formation of minerals, their exploration and exploitation in Bangladesh and adjoining states is important to have a clear idea about the type of mineral, possible availability and their place of origin. The Bay of Bengal is an inseparable part of Bangladesh. It is of no doubt that use of marine resources for long term energy security has the potential to determine Bangladesh's future development and economic growth.

Renewable energy has become increasingly important nowadays due to depletion of non-renewable energy in the world, which is why, it is important to have a basic idea about the entire renewable energy resources of the world. Only a few of them have potentiality in terms of production capacity in Bangladesh. Exploration of non-renewable and renewable resources require permit and license from maritime states (inside maritime boundaries) and Seabed Authority (for high seas area). Geopolitics also plays important role in ocean transportation, digital connectivity, etc.

Specific Objectives:
This course specifically provides mineral related knowledge, non-renewable and renewable resources of the ocean, permitting and licensing of mineral extraction as well as exploration and exploration of non-renewable and renewable resources. All economic marine mineral and energy resources of Bangladesh and surrounding states will be covered.

Course Content:

SL.	Topics	No. of Lectures
	<u>Module-I: Ocean minerals</u>	
1.	Introduction and scope.Study of physical and chemical properties of minerals. Genesis of minerals.Chemical composition of Earth's crust;Geochemical classifications of the elements;Environments of mineral formation. Detailed classification and study of minerals with particular emphasis on Rock forming minerals.Paragenesis;Association, occurrence and use of minerals.Determinative mineralogy- physical and chemical tests.	4
2.	Optical mineralogy: Index of refraction; Relief and dispersion; plane-polarized light in minerals; slow and fast rays; extinction angle; elongation and anomalus interference; Michel-Lecy method; Plagioclase feldspar composition; Uniaxial and biaxial minerals.	3
3.	Mineral resources of Bangladesh and subcontinent: Mineral resources of Bangladesh; occurrence; Distribution; Stratigraphic relationship; Reserves and uses of Hydrocarbon (gas, oil and condensates); Coal; Peat; Limestone;	3

	Glass sand; White clay; Placer deposits; Hard rocks; Light weight aggregates; Building materials; Metallic minerals; Important and strategic mineral resources of India, Bhutan, Nepal, and Myanmar; National mineral policy of Bangladesh.	
	MIDTERM EXAMINATION – I	
	Module –II Ocean Energy Resources	
4.	Introduction to the ocean environment: Ocean circulation and stratification; Ocean habitat; Ocean economy; Ocean surface waves: Wave measurement; Linear wave theory; Wave spectrum; Wave energy resource; Ocean tidal currents: Current measurement; Current turbulence; Current energy resource; Site selection and characterization for ocean energy systems.	5
5.	Wave energy systems: Types of wave energy converters; Linear wave-structure interactions; Frequency domain analysis; Hydrodynamic coefficients and their computation; Time domain analysis; Phase control; Arrays; Model testing techniques; Marine current turbines: Types of marine current turbines; Hydrodynamic models (BEM, Lifting line, IBEM); Hydrofoil data and analysis; Cavitation and strength; Design criteria; Multiple turbine interaction; Other types of energy systems: Ocean Thermal Energy Conversion (OTEC); Energy from salinity gradient	6
6.	Power take-off systems: Air turbines, Water turbines; High pressure hydraulic systems; Electrical generation; Energy storage; Mooring and anchoring systems. Farm layout. Offshore electrical grid and connection systems. Operation and maintenance of ocean energy devices. Offshore operations. Maritime safety issues.	4
	MIDTERM EXAMINATION - II	
7.	Economic analysis: Cost, Financing mechanisms; Economic evaluation; Life -cycle assessment.	3
8.	Policy issues: Socio-economic impact; Licensing & permitting; Environmental impact assessment.	2
		Total = 30

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance.

Learning Outcomes:

Participation in the course will equip students with the knowledge of minerals, especially in the oceanic environment. This course will also provide every information about non-renewable and renewable resources of the ocean, permitting and licensing of mineral extraction in the marine areas. Students will come to know about cost-benefit and life cycle of marine development projects which are practiced across the world. All the economic marine mineral and energy resources of Bangladesh (land part and marine areas) will be assessed.

Assesment:

Type of Assessment	Marks
FORMATIVE	
In-Course Exam	12.5
Attendance	2.5
SUMMATIVE	
Final Examination	35

Reading Materials:

1. Hurlbut C.S. and Klein C. Manual of Mineralogy.
2. Berry L.G., Mason B. and Dietrich R.V. Mineralogy: Concepts, Descriptions and Determinations.
3. Berry L.G. and Mason B. Elements of mineralogy.
4. Perkins D. Mineralogy.
5. Vanders I. and Kerr P.F. Mineral recognition.
6. Deer W.A. Howie R.A. and Zussman J. An introduction to the rock-forming minerals.
7. Read H.H. Rutley's elements of mineralogy.
8. Kerr P.F. Optical mineralogy
9. Winchell A.N. Elements of optical mineralogy. Part I, II and III.
10. Sinha R.K. and Sharma N.L. Mineral economics.
11. Beyschlag F. *et.al.* The deposits of the useful minerals and rocks.

Course Number and Title: OCN 205: Marine Biochemistry & Molecular Biology
Credit: 3

Introduction to the Course:

The biochemistry and molecular biology major introduces students to the chemistry of living organisms and the experimental techniques that are used to probe the structures and functions of biologically important molecules. Students who enjoy both chemistry and biology will find this major a rewarding field of study.

Specific Objectives:

The course aims to provide an advanced understanding of the core principles and topics of Biochemistry and their experimental basis, and to enable students to acquire a specialised knowledge and understanding of selected aspects.

Course Contents:

SL.	Topics	No. of Lectures
1.	**Introduction** The molecular logic of life; Biomolecules: composition and principles of organization; Energy and principles of bioenergetics; Prospects and application of molecular biology in marine science	4
2.	**Water** Non-covalent interactions, Properties of water; Acid/base properties, pH buffering capacity. **Cells and organelles and their composition** Comparison of prokaryotic and eukaryotic cells, Sub-cellular organelles and their functional characteristics, common structural features of bacterial cells. **Amino acids** Classification, structural features, Buffering capacity, acid-base properties, characteristic chemical reactions, optical behavior, Essential amino acids, nonstandard amino acids, synthesis of important biomolecules	6
	MIDTERM EXAMINATION - I	
3.	**Proteins** Primary structure – the peptide bond, sequence homology and evolution, Secondary structure of proteins - protein conformation, planar peptide bondsα-keratins andβ-keratins – conformation and structure, structures of collagen and elastin, filamentous proteins, actin, myosin and microtubules.Tertiary structures of proteins - distinctive tertiary structures of myoglobin and ribonuclease, renaturation of ribonuclease, factors contributing to oxygen saturation curve of hemoglobin, sickle-cell anemia and its relation to hemoglobin.	5

4.	**Enzymes** Basics concepts – characteristics, classification, catalytic properties, lowering of activation energy, prosthetic group, coenzyme, cofactor, concept of specificity of enzyme, identification of residues at active sites and effect of substrate concentration, temperature and pH on enzyme activity; activity unit, specific activity, turnover number.	4
5.	**Carbohydrates** Monosaccharides - their biological properties, color reactions of carbohydrates, important derivatives of monosaccharides, sugar acids, important reactions of carbohydrates. Disaccharides and oligosaccharides of biological importance - maltose, lactose, sucrose and other disaccharides.	3
6.	**Carbohydrates** Polysaccharides –storage and structural polysaccharides, structures and function of starch, glycogen and cellulose, other polysaccharides of biological interests, biological degradation, artificial sweeteners, dextrans. Glycosaminoglycans - structures and functions; the pentose phosphate pathway; the TCA cycle.	3
MIDTERM EXAMINATION – II		
7.	**Lipids** Chemical nature, biological functions, classification with representative examples, fatty acids - nomenclature, saturated and unsaturated fatty acids and fats, essential fatty acids; triacylglycerol, phospholipids, sphingolipids, cerebrosides, gangliosides, action of phospholipases on membrane phospholipids. Fatty acid synthesis, β-oxidation	4
8.	**Chemistry of nucleic acids** Classification and composition of nucleic acids, bases, sugars, nucleosides, nucleotides and polynucleotides.	3
9.	**DNA as genetic material** Gene concept, conceptual relationship between gene and chromosomes, and gene and enzymes.	3
MIDTERM EXAMINATION – III		
10.	**DNA as genetic material** Gene concept, conceptual relationship between gene and chromosomes, and gene and enzymes	4
11.	**Gene expression** Replication as continuity of transfer of genetic information. Transcription, types of RNAs, their characteristics and function. Translation leading to functional protein synthesis, colinearity of genes and proteins.	6
		Total = 45

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance.

Learning Outcomes:

At the end of this course, students will be able to:
1. Describe the molecular and structural unity of life, explain how the diversity of living things is generated
2. Demonstrate knowledge of how genetics, biochemistry and direct observation are used to elucidate cell organization and function.
3. Develop an in-depth understanding of biomolecular behavior from fundamental physical and chemical principles.
4. Understand the basic chemical and physical principles governing the structure and function of biomolecules.
5. Understand the principles underlying and the applications of current techniques and model systems commonly used in biochemistry and molecular biology.

Assesment:

Type of Assessment	**Marks**
FORMATIVE	
In-Course Exam	25
Attendance	5
SUMMATIVE	
Final Examination	70

Reading Materials:

1. The Machinery of Life by David Goodsell (2nd Ed.) ISBN 9780387982731.
2. Lodish et al., Molecular Cell Biology, 6th edition.
3. Principles of Biochemistry (2008) Lehninger A.L. (ed.)
4. Biochemistry. (2002) Stryer, L.
5. Principles of Biochemistry (1995) Zubay, G.L., Parson, W.W. & Vance, D.E.
6. Harper's Biochemistry (1990) Murray, R.K. et al
7. Biochemistry (2004) Voet, D. & Voet J.G.
8. Biochemistry and Molecular Biology (2005) Elliott, W.H. & Elliott, D.C.
9. Fundamentals of Biochemistry (1999) Voet, D., Voet, J.G & Pratt,C.W.
10. Introduction to Protein Structure (1999) Branden C. & Tooze J.
11. Genes X (2010) Lewin, B.
12. Essential Genes (2006) Lewin.
13. Essential Genetics: A genome perspective. Hartl and Jones. (4th Edition)
14. Principle of Genetics. Gardner, E.J., Simmons, M.J. & Snustad, D.P. (8th Edition)
15. Genetics (2002) Strickberger, M.
16. Molecular Biology of the Cell (2002) Alberts. et al.
17. Molecular Biology of the Gene (2008) Watson et al.
18. Cell and Molecular Genetics (1987) Schlesf, R.
19. Microbial Genetics (2006) S.Maloy, J.Cronan Jr and Friefelder, D
20. Concept of Genetics (2002) Klug, W.S. & Michael, R & Cummins, M.R.
21. Genetics: A molecular approach (2005) Russel, P.J.

Course Number and Title: OCN 206: Computer Programming
Credit hours: 3

Introduction to the course: The goal of this course is to introduce students to the fundamental concepts of Scientific Programming using Matlab/FORTRAN and similar programming languages and we will introduce the necessary mathematical concepts as we go (including linear algebra, differential equations).The course will cover the syntax and semantics of Matlab/ FORTRAN including data types, control structures, comments, variables, functions, and other abstraction mechanisms. Once the foundations of the language have been established students will explore different types of scientific programming problems including curve fitting, optimization, integration, differentiation, statistical analysis, ODE solving, image processing, clustering, and simulation.

Specific Objectives: Understand the fundamental abstractions in procedural programming (variables/values/types, assignment, control flow (conditionals/loops/error handling), procedural abstraction, commenting and documentation, test-based development. Understand the matlab specific compound data types (vectors, matrices, cell arrays and the basic linear algebra underlying them (linear maps, matrix multiplication, factorization). Numerical Analysis Concepts: understand the scope and limits of mathematical modeling. Ordinary Differential Equations: differentiable functions, differential equations, computational solution techniques.

Course Contents:

SL.	Topics	No. of Lectures
1.	FORTRAN:Introductions to Computers and Fortran Languages, Disk Operating System: MS DOS, WINDOWS.	4
2.	Problem-Solving Techniques using Computers: Flowcharts, Algorithms, Pseudo code;Programming in FORTAN: Syntax and Semantics, Data types and structure impute/output, loops decision statements, arrays, user defined functions, subroutines and recursion;Computing using FORTAN: Construction and implementations of FORTAN Programs for solving problem in mathematics and sciences.	6
	MIDTERM EXAMINATION - I	
3.	MATLAB: A brief history review of MATLAB, Fundamentals of MATLAB Programming, Variable and Constants, Data Structure, Basic Structure of MATLAB.	5
4.	Fundamental of Mathematical calculations, Flow Control Structure of MATLAB language.	4
5.	Writing and Debugging MATLAB functions, Two Dimensional Graphics.	3

6.	Calculus Problem,Series Expansions and Series Evaluations, Differential Equation problems.	3
MIDTERM EXAMINATION – II		
7.	MIKE: Time Series Editor: Introduction, New File Dialog, Export to ASCII File, File properties Dialog.	4
8.	Tabular View, Graphical View, Graphical settings, Font settings, File formats, Tools.	3
9.	Profiles Series Editor: Introduction, Properties, Geographical Information, Tabular View, Graphical View, Navigation View	3
MIDTERM EXAMINATION – III		
10.	Grid Series Editor: Introduction, Create New dataset, Open an existing dataset, editing the dataset, Edit, view, Tools, Data Overlay.	4
11.	Bethymetry Editor, Mesh Generator, Data Viewer, Data Manager, Data Extraction FM, Result Viewer, Climate Change	6
		Total = 45

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance.

Learning Outcomes:

Write simple Matlab/FORTRAN programs using functions defined in .m files including conditionals, loops, all the standard scalar types, and file I/O. Use Matlab/ FORTRANvector and matrix expressions to express fundamental data operations without loops. visualize calculated data using the 2d and 3d plot functions, set up, solve, and visualize the solutions of ODEs and Difference Equations using Matlab/ FORTRAN.

Assesment:

Type of Assessment	**Marks**
FORMATIVE	
In-Course Exam	25
Attendance	5
SUMMATIVE	
Final Examination	70

Reading Materials:

1. Introduction to Fortran 90/95 by Stephen J. Chapman, Tata McGraw-hill Publishing Company Limited.
2. Programming in Fortran, Schaum's Outline Series
3. Solving Applied Mathematical Problems with MATLAB by DingyuXue, Yangquan Chen
4. MATLAB An introduction with Applications by Rao V. Dukkipati
5. MATLAB An introduction with Applications by Amos Gilat
6. MIKE manual user guide by DHI

Fourth Semester

Course Number and Title: OCN 211: Marine Meteorology
Credit hours: 2

Introduction to the Course:
Welcome to Marine Meteorology! This is a lecture-based course, in which students can earn two units of credit. This course introduces atmospheric phenomena, ocean atmospheric process and the dynamics of these process. It is designed to provide comprehensive knowledge of the earth's atmosphere and its changing behavior.

Specific Objectives: This course provides a first look at various aspects of meteorology including solar radiation, thermodynamics of dry and moist air, global circulation, environmental issues, winds, cloud formation, stability, precipitation processes. The course will also cover meteorological terminology, synoptic-scale climate processes, and will discuss about the formation and dissipation of tropical cyclone. Basic physical principles and processes are emphasized that are important for understanding the ocean atmospheric process.

Course Content:

SL.	Topics	No. of Lectures
1.	The composition of atmosphere: The composition of dry air, Water vapour, Ozone, Carbon Dioxide, Aerosols, Air pollution & weather and climate.	3
2.	Solar radiation: Characteristics of the Sun, the nature of solar radiation, geographical and seasonal Distribution of solar radiation, depletion of solar radiation, Disposition of solar radiation under cloudless and cloudy skies and mean disposition of solar radiation, characteristics of terrestrial radiation, absorption and transmission of terrestrial radiation and radiative heating or cooling. Thermodynamics of dry and moist air:The law of conservation of energy, specific heat, laws of thermodynamics, Internal energy of real and ideal gases, adiabatic and non-adiabatic processes in the atmosphere,entropy, potential temperature, Poisson equation for dry air, the three sate of water substances, latent heat, relative humidity, virtual temperature, wet bulb temperature and dew point temperature. Vertical stability of the atmosphere:Environmental lapse rate, dry and saturated adiabatic lapse rate, latent instability, conditional states, vertical acceleration of a parcel of air, positive and negatives area, relation between potential and latent instability, Geopotential, pressure -height curve, Thermodynamic diagram, use of Tephigram, Statement of Normand's theorem, Computation of derived moisture variable and the height of pressure surface using Tephigram.	7
	MIDTERM EXAMINATION - I	
3.	Clouds and precipitation: Condensation nuclei, Ice nuclei, supercooling of droplets, the formation of clouds, cloud classification, precipitation from water and mixed clouds. How precipitation forms- Bergeron and Collision-Coalescence process and precipitation measurement, fog, snow, haze, mist and	5

	dew formation. Dynamic meteorology: Local and Material Time Derivatives, Conservation Principles, Euler and Navier Stokes Equations, Hydrostatic Approximation, Advection, Vorticity, Divergence, Scale Analysis, The Equations in Rotating Coordinates Spherical Coordinates, Dynamical Effects of Rotation, Equations of Motion, Continuity Equation. Equation of State.	
4.	First Law of Thermodynamics, The Complete System of Equations, Elementary Solutions, Geostrophic Balance, Balanced Curved Flow; Gradient Wind, Cyclostrophic and Inertial Flow, Vertical Shear: The Thermal Wind, Shallow Water Equations, Linear Wave Motion, Rotational and Gravity Waves, Equatorial Waves, Atmospheric Wave Motion, Free Rossby Waves, Forced Rossby Waves: Orographic and Thermal, Acoustic Waves, Lamb Mode, Kelvin Waves, Potential Vorticity Conservation: Theory and Applications. GroupVelocity, Quasi-geostrophic Equations, Derivation of the system, The Omega Equation, different weather pattern, Air mass characteristics, Thermal wind implications, Locating fronts, Vertical cross sections, Backdoor cold fronts, Upper level fronts, Satellite imagery, radar imagery.	5
5.	Filtering of Gravity Waves, Geostrophic Adjustment. Synoptic meteorology:Air pressure and winds.	2
6.	Polar and subtropical jets, Role in cyclogenesis, Vertical motion associated with jet streaks, Thunder storms, cold wave, heat wave, Tropical Cyclones-Characteristics, Formation, Climatology, Monsoon meteorology, Sea and land breezes, Lake effect snow, Mountain /valley winds, Down slope winds, Topographic blocking, Polar lows etc.	3
MIDTERM EXAMINATION - II		
7.	Wave formation, propagation and decay: Importance of fetch in wave development and its limitations to wave development; Differences inwind waves from swell waves; Example of how waves propagate from its source initially as a wind wave and its final GC travel path as a swell wave some distance down wind, first as a diminished height, and second, the increase in its period wave length; Brief discussion of fetch area and gate; With the use of the Bowditch tables, a brief exercise in determining wave propagation and decay, using true wind values from first exercise; Tie in wind and waves and fetch with discussion of North Wall Gulf Stream and Teuhauntepec episodes; Overview of OPC wind and wave charts, emphasizing differences between regional charts in feet and full ocean charts in meters.	3
9.	Ocean Atmospheric Processes: Basic measurements of meteorological/ oceanographic parameters. Importance of observations from Sea. Collection of marine data from Ship's log and their compilation. Importance of oceans in the atmospheric processes, and their role in weather/climate. Observations from oceans (in situ) and their procedural aspects; VOF. Surface meteorological and upper air observations on board ships, collection, exchange and archival. Ships Weather log. PMO/data collection.	2
		Total = 30

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance.

Learning Outcomes: Upon completion of the course, the student should be able to:
1. Demonstrate a familiarity with the basic vocabulary of meteorology.
2. Understand the mechanics of the earth's atmosphere.
3. Describe and explain the origin, composition, structure, short-term and long-term behaviors of the earth's atmosphere.
4. Understand and analyze important environmental problems related to the earth's atmosphere.
5. Have a basic understanding of the atmosphere and its processes to enhance appreciation of our planet.
6. Critically examine the phenomena of the Solar and Terrestrial Radiation and understanding the energy transfer by radiation, conduction, convection, and evapotranspiration and explain the factors that determine the distribution of solar energy over the Earth's surface and describe global patterns of temperature.
7. Understand and critically examine the atmospheric phenomena of temperature, moisture conditions, atmospheric stability, forms of condensation and precipitation, air pressure and winds, circulation of the atmosphere, role of air masses, and weather patterns.
8. Describe the major cloud types and explain the phenomena of rainfall, fog, snow, sleet.
9. Define a cold and warm front and explain the processes leading to the formation of each and also explain the formation of cyclones and anticyclones, tornadoes, hurricanes and typhoons.
10. Explain the earth's heat budget, including the variations of solar energy input, the distribution of heat and temperature lags.
11. Understand how atmospheric measurements are taken for pressure, temperature, humidity, cloud cover, precipitation and wind.
12. Describe the interrelationships between atmospheric pressure gradients, Earth's rotation, and resulting atmospheric circulation
13. Understand how different types of wave formation and propagation on the ocean and atmosphere.
14. Understand how to measure meteorological/ oceanographic parameters.
15. Understand the Importance of oceans in the atmospheric processes, and their role in weather/climate.

Assesment:

Type of Assessment	**Marks**
FORMATIVE	
In-Course Exam	12.5
Attendance	2.5
SUMMATIVE	
Final Examination	35

Reading Materials:

1. The atmosphere, seventh edition by Frederick K. Lutgens and Edward J. Tarbuck
2. Monsoon Meteorology, Academic Press, 1971 by Colin S. Ramage
3. The Monsoon, 12th Edition, by Dr. P K Das
4. Compendium of meteorology, Volume-1, WMO No. 364
5. Dynamical and physical meteorology By george J. Haltiner and frank l. Martin
6. An Introduction to Dynamic Meteorology, Fifth Edition by James R. Holton
7. Cloud Dynamics, volume 104 by Robert A. Houze Jr.

Course Number and Title: OCN 212: Satellite Oceanography
Credit hours: 3

Introduction to the Course:
The course is plan to give the students a broad knowledge of different remote sensing techniques in oceanography, with special focus on satellite measurements.

Specific Objectives:
1. To discuss remote sensing techniques used for oceanography, including characterization of strengths and limitations of the techniques 2. To identify problems regarding the transfer of electromagnetic radiation through the atmosphere as well as having good knowledge on the interaction of the electromagnetic radiation and the surface 3. To explain the differences between measurements of surface properties and measurements of profiles of different meteorological parameters in the atmosphere 4. To identify which spectral regions that can be used to measure the different meteorological and oceanographic parameters and explain why.

Course Content:

SL.	Topics	No. of Lectures
1.	The basic concepts of oceanography: The basic concepts of hydrophysical processes in the ocean; The main external forces driving ocean currents (earth rotation and wind stress); The heat flux through the ocean surface resulting in vertical stratification of water properties (temperature, salinity and density); The main features of horizontal water circulation (geostrophic flow, Rossby waves and Ekman drift); Vertical circulation (Upwelling), The role of stratification in phytoplankton ecology.	3
2.	Satellites and sensors:The basic principles of space technology; The basic elements and sampling characteristics of satellite orbits; Electromagnetic spectrum and satellite sensors; Active and passive sensors; Data transmission to the Earth; Orbit determination techniques. Remote sensing of the sea:The general principles of remote sensing of the sea; Sensor calibration; Atmospheric correction; Positional registration; Oceanographic sampling for "sea truth"; Image processing; The main types of sensors: Visible wavelength "ocean color" sensors; Infrared radiometers of sea surface temperature; Passive microwave radiometers; Active radar-altimeters of sea surface topography; Active microwave sensors of sea surface roughness.	7
	MIDTERM EXAMINATION - I	
3.	Oceanographic Applications:Infrared Measurement of Sea Surface Temperature:Infrared radiometry, Interpretation of sea surface temperature, Advanced Very High Resolution Radiometer (AVHRR), Multi-Channel Sea Surface Temperature (MCSST) algorithm, Geostationary Operational Environmental Satellites (GOES), Coast Watch sea surface temperature data source and software	4

4.	Oceanographic Applications: Radar-altimeters:Basic principles of satellite altimetry, TOPEX/Poseidon satellite Sea Surface Height: a. Geoid, b. Tides, c. Geostrophic circulation; Sea Surface Roughness: d. Microwave scatterometer Synthetic Aperture Radar	5
5.	Oceanographic Applications: Ocean Color:Basic principles of satellite measurements of ocean color, Coastal Zone Color Scanner (CZCS);	4
6.	Sea-viewing Wide Field-of-view Sensor (SeaWiFS); MODerate resolution Imaging Spectroradiometer (MODIS); Patterns of phytoplankton distribution in the World Ocean. Ocean Color and Phytoplankton: Chlorophyll and photosynthesis, Vertical distribution of phytoplankton in the ocean.	2
MIDTERM EXAMINATION - II		
7.	Ocean Color and Phytoplankton: Chlorophyll and photosynthesis, Vertical distribution of phytoplankton in the ocean.	4
8.	Estimation of phytoplankton biomass from satellite ocean color observations, Estimation of chlorophyll fluorescence from MODIS ocean color observations, Coccolithophores and harmful algal blooms, Seasonal cycles of phytoplankton biomass, Global phytoplankton biomass and primary production	3
9.	Mesoscale variability and coastal pollution:The main contributors to ocean color: a. Phytoplankton (CHL) b. Suspended sediments (TSS) c. Color Dissolved Organic Matter (CDOM)	3
MIDTERM EXAMINATION - III		
10.	Horizontal transport of phytoplankton and pollutants in the Black Sea, Spring bloom in Southern California Bight resulting from coastal upwelling, Stormwater plumes in the Southern California Bight.	6
11.	Multi-disciplinary approach: El-Nino 1997-1998 off California: Rossby waves, Kelvin waves and heat distribution in the Pacific Ocean, El Nino-Southern Oscillation (ENSO) cycle, 1997-1998 El Nino event in the Pacific Ocean.	4
		Total = 45

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance.

Learning Outcomes:
1. Identify sample areas in optical imagery. 2. Explain the spatial, spectral and radiometric resolution 3. Apply transformations and classification algorithms 4. Make use of optical and radar data 5. Analyze the sample areas for classification 6. Create a classified image 7. Evaluate the quality of image classification.

Assesment:

Type of Assessment	**Marks**
FORMATIVE	
In-Course Exam	25
Attendance	5
SUMMATIVE	
Final Examination	70

Reading Materials:

1. Measuring the Oceans from Space: The principles and methods of satellite oceanography (Springer Praxis Books / Geophysical Sciences) by Ian S. Robinson.
2. Methods of Satellite Oceanography by Robert H. Stewart.
3. Satellites, Oceanography and Society, By D. Halpern.
4. Regional Satellite Oceanography by Serge Victorov

Course Number and Title:OCN 213: Marine Planktonology & Benthic Organisms
Credit hours: 3

Introduction to the Course:
The course is taught in the 2nd year 3rd semester classes of four years integrated B.S. (Honors) program in the Department of Oceanography under the University of Dhaka. It is a basic course on marine plankton and benthic organisms. Microscopic and sub-microscopic algae, bacteria, protozoa, crustacean and rotifers are the principal components of oceanic plankton population. Among benthic organisms, isopod, amphipod, bristle worm, shell bearing organisms, sand dwellers, ghost crab, etc. are the main. All these organisms perform a tremendous function in the food chain by inputting energy and maintaining environmental balance. The production of all marine biological resources is fully dependent on the functional aspects of all these organisms. So, the knowledge on plankton and benthic organisms from the marine environment plays a significant role in the biological production harvesting and management programs. It is also contributory in the field of higher research in oceanography.

Specific Objectives:
(a) Learn about the earth and marine environment and physical factors operating in the oceans
(b) Get to know the extent of chemical parameters such as O2, CO2, nitrate, phosphate, silicate, salinity and pH, their origin, range of concentration, distribution and role
(c) To know about shore environments, adaptive factors, competition, predation, kelp forests and characteristics of kelps, characteristics of sandy and muddy shore and their species composition
(d) Learn the concept of zoogeography, distribution of marine animals over a geographical range, species pairs, allopatric and sympatric speciation, zoogeography of indo-west Pacific region, geographical barriers and their effects
(e) Acquire knowledge on coral and their ecology, kind of trophic structure, competition, predation and grazing go there, physical factors do prevail there and production in the coral ecosystem; definition and ecology of mangrove forests
(f) To know the distribution of shallow water benthic plants and animals of the oceanic ecosystems
(g) To study the larval ecology with their biological relationships and dispersal, energy subsidy food threshold hypothesis, semelparity and iteroparity.
(h) To have knowledge on marine animal association with their groups, association and examples, importance of association among marine animals, their kinds; symbiosis, commensalism and parasitism.
(i) Learn the classification of marine environment such as littoral, neretic, bathyal, abysal and hadal with their organism.
(j) Acquire knowledge on plankton, their classification and composition, floating mechanisms adaptive to plankton, methodology involved to study the qualitative and quantitative aspects of plankton and their preservation techniques, plankton in relation to fisheries
(k) Get to know spatial and temporal distribution of plankton in marine environment, how do they act with Langmuir circulation, fronts, marginal value theorem, patchy distribution, vertical diel migration, horizontal distribution of marine zooplankton
(l) To learn primary productivity by photoautotrophic and chemosynthetic organisms of oceans, distribution and pattern of primary productivity in oceans, factors affecting productivity.

(m) Know the status of particulate and dissolved organic matter in the oceanic ecosystems, fecal pellets, moults, marine snow, DOM, secondary productivity and carrying capacity, phytoplankton and zooplankton interrelationships, DOM and POM distribution and marine food chains
(n) To know the types and size of marine bacteria, their role
(o) Acquire knowledge on the general account and forms of larvae

Course Contents:

SL.	Topics	No. of Lectures
1.	Physical parameters of sea: tides, waves, light, temperature, currents, density &pressure;Chemical parameters of sea: salinity, dissolved oxygen, pH and nutrients;Shore Environment: Distribution of life on rocky shore, sandy shore and muddyshore; Zonation and adaptations of organisms;Zoogeography of marine environment with special reference to Indo-west Pacificregion;Ecology of coral reefs and mangrove habitats; their special features.	6
2.	Benthos: Distribution of shallow water benthic organisms; Fauna of deep seaand hadal regions – their adaptations;Larval Ecology: Types of larvae and their distribution. Chemicalcommunications and settlement of larvae of marine benthic organisms;Marine animal associations: Commensalism, symbiosis and parasitism.	4
	MIDTERM EXAMINATION - I	
3.	Classification of marine environment: general characters of the populationsof the primary biotic divisions (plankton, nekton and benthos).	3
4.	Introduction to plankton: general classification and composition of plankton.Floating mechanisms in plankton.Collection of plankton: general account of instruments and nets employed.Methods of fixation and preservation; Analyses of samples.Standing crop estimation methods.Plankton in relation to fisheries: general account.	5
5.	Distribution of plankton in space and time:Horizontal distribution: neretic and oceanic plankton;	4
6.	geographicaldistribution and indicator species.Vertical distribution: vertical migrations. Seasonal changes in plankton.	3
	MIDTERM EXAMINATION - II	
7.	Primary production: General account of productivity in different oceans.Factors affecting primary production: nutrients, light, temperature,organic micro-nutrients and inhibitors, grazing.	4
8.	Particulate & dissolved organic matter in the seaSecondary production (Zooplankton) of the sea.Phytoplankton – Zooplankton inter-relationships.	3

9.	Distribution of particulate and dissolved organic matter in the sea.General survey of marine food chains: Pelagic food chains;	3
MIDTERM EXAMINATION - III		
10.	Benthic food chains.Pelagic food pyramid and factors affecting its production & stability.Mass-mortality in the seas;Marine bacteria: general account on their distribution & their role in the sea	6
11.	General account of larval forms of Crustacea, Mollusca, &Echinodermata.Moulting and growth in decapod crustaceans; regulating factors.	4
		Total = 45

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance.

Learning Outcomes:

Introduction to the marine and terrestrial environment of the Earth. Characteristics of oceanic water in terms of salinity and nutrients. Concept on the plankton and the benthic organisms. Penetration of light in seawater causing vertical ecological zones. Significance of temperature, tides, waves, currents, density and pressure.

Oxygen, source depth gradients, DO profile for Eastern Tropical Pacific Ocean as an example.CO2, origin inputs and utilization and further conversion of compounds, proportion of CO2, carbonate and bicarbonate in water. Nutrients that can be of limiting in sea, role of silica and diatom. Nitrogen cycle and its biological fixation, role of cyanobacteria in it. Salinity causal factors, major ionic constituents of seawater, mean global distribution of surface salinity, biological significance of salinity

Shore environments, types, adaptive features in rocky, sandy and muddy shores, characteristic organisms and their distribution. Competition and predation among organisms. Kelp forests, composition, distribution. Sandy shore, environmental characteristics, species composition and macrofauna. Meiofauna adaptation and body forms.

Zoogeography by definition, species pairs, allopatric and sympatric speciation and environmental harshness. Distribution of marine animals over a geographical range. Zoogeography of Indo-west Pacific region. Geographical barriers and zoogeographical effects

Corals by definition, ecology, trophic structure, competition, predation and grazing. Physical factors governing coral reef and production estimates. Ecology of mangrove forests.

Benthic plants, sea grasses, sea weeds, coralline algae, episamic algae, stromatoliths with examples and biological features. Benthic animals, infauna, epifauna and epibenthos habitats, characters and examples. Classification depending on size. Fauna of deep sea and hadal region.

Definition of larva, ecological patterns and biological relatiohships. Dispersal and size threshold hypotheses. Energy subsidy and food threshold hypotheses. Environmental constraints, parental investment, semelparity and iteroparity and hermaphroditism. Reproductive effort and history of phylogeny.

Introduction to marine animal groups with examples. Association its necessity, symbiosis, symbiotic bacteria, commensalimsm and parasitim. Biological significance of associations.

Vertical zonation of marine environment, littoral, neretic, bathyal, abysal, and hadal regions of oceans. Primary biotic divisions of the oceans. Communities of plankton, nekton and benthos

General classification and composition of phyto and zooplankton of the marine environment. Floating mechanisms of plankton with their adaptive features. Collection procedure, fixation and preservation and standing crop estimation methods of plankton. Plankton in relation to fisheries.

Distribution of plankton in space and time over global oceanic habitats. Langmuir circulation, fronts, marginal value theorem and patchy distribution of plankton. Vertical migration pattern of zooplankton, diel features, spatial and temporal variations of the population.
Concept of primary productivity, its significance, difference with chemosynthetic production. Communities of marine organisms associated with the process of primary production. Primary productivity pattern of different oceans of the globe. Factors affecting primary productivity.
Particulate and dissolved organic matter originated in the sea via secondary production processes. Role of fecal pellets, moults, formation and composition of marine snow and dissolved organic matter (DOM) in the oceans. Concepts on the secondary production, carrying capacity and zooplankton productivity. Interrelationships between phytoplankton and zooplankton.
Origin and distribution of dissolved organic matter (DOM) and particulate organic matter (POM). Vertical distribution of POM and DOM of the sea. Marine food chain operations.
Characteristic features of marine bacteria, types, origin, molecular tree. Harmful and beneficial roles of marine bacteria. Their size ranges. Microbial loop, definition, schema and structure.
General account of larval forms in the oceans, Molluscs, Echinodermata. Schematic representation of factors known to influence the settlement and metamorphosis of planktonic larvae.

Assesment:

Type of Assessment	**Marks**
FORMATIVE	
In-Course Exam	25
Attendance	5
SUMMATIVE	
Final Examination	70

References:

1. Nicol JAC. The biology of marine animals. Pitman
2. Barnes RD. Invertebrate Zoology. Saunders
3. Newell RC. Biology of Intertidal animals. Logos
4. Angel MV. Biological Oceanography. Methuen
5. Raymont JEG. Plankton & productivity in Oceans.Pergamon
6. Parsons TR. et al Biological Oceanographic processes.Pergamon
7. Friedrich H. Marine Biology. S & J
8. Nicol JAC. The Biology of marine animals. Pitman
9. Prosser CL. Comparative animal physiology. Saunders
10. Newell RC. (Ed) Adaptation to environment. Butterworth
11. Palmer JD. Biological clocks in marine organisms. Wiley Eastern
12. Angel MV. Biological Oceanography. Methuen

Course Number and Title: OCN 214: Marine Sedimentology & Stratigraphy
Credit hours: 2

Introduction to the Course: This course will introduce students to the basic principles used in the study of sedimentology and Stratigraphy in the field of oceanography.

Specific Objectives:
1. This course will focus on the processes that influence the formation of sediments and sedimentary Rocks. 2. It will also give emphasis on the physical, chemical, and biological aspects of sediments and sedimentary rocks. 3. Special emphasis will also be placed on the features of sedimentary rocks that are used to make environmental and climatic interpretations, and on the techniques used to put strata in context of time and space. 4. Lab exercises will be incorporated into the lectures and will be used to reinforce major topics. 5. There will also be a required field trip.

Course Contents:

SL.	Topics	No. of Lectures
	Module-I Sedimentology	
1.	Scope and application; Relation to other geological disciplines. Facies relationships and associations; Facies construction; Facies interpretation;Facies models-methods, Functions and applications. Sequence and cyclicity; concepts and principles of sequence; Basin-forming process; External controls on Basin-fill.	3
2.	Study of selected environments: Alluvial fans-sedimentary processes and controls; Facies types; Fan sequences; Fluvial systems-Classifications; Fluid dynamics; Flow regime; Facies models; Modern examples and ancient sequences;Interdeltaic shoreline environments; Tidal clastic systems-procsses; Facies association. Vertical facies sequences; Modern and ancient examples;Deep-sea fan environment – morphology; processes; Turbidite sequences- Facies models; Modern examples and ancient sequence palaeocurrent and basin analysis-Directional structures and Fabric- Scalar and compositional properties; Method of analysis; Interpretation. Sedimentation and Tectonics theories; Subsidence and sedimentation.;Orogenic sediments-tectonics and sedimentary properties.Sediment Transport and Deposition;Siliciclastic Sedimentary Rocks, Carbonate Sedimentary Rocks.	7
	MIDTERM EXAMINATION - I	
	Module-II Stratigraphy	
3.	Introduction, scope, Stratigraphic concepts-strata and stratification; Stratigraphic contacts-conformable strata; Laterally adjacent lithosomes; Unconformable contacts;	5
4.	Vertical and lateral successions of strata-Nature, Cyclic successions. Stratigraphic classification; Stratigraphic column; Stratigraphic subdivisions and Stratigraphic procedures. Unconformities and their significance. Stratigraphic correlation-principles and methods of Stratigraphic correlation	5

5.	Sedimentary facies; Walther's law; Effects of climate and sea level on sedimentation patterns.	2
6.	Seismic Stratigraphy; Cyclic Stratigraphy; Sequence Stratigraphy; Magneto Stratigraphy; Biostratigraphy; Chronostratigraphy; Regional and gobal stratigraphic cycles.	3
MIDTERM EXAMINATION - II		
7.	Depositional Environments-environmental criteria; Factors; Elements and parameters. Classification; Description and recognition of major environmental complexes.	3
9.	Stratigraphic problems, Times and place- Archaean, Proterozoic, Archaeological and Quaternary. Stratigraphic architecture.	2
		Total = 30

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance.

Learning Outcomes:
1. Observe and compare sedimentary depositional environments from outcrops, drill cores and diagrams. 2. Apply stratigraphic methods to analyse the evolution of past environments. 3. Explain the basic principles, chemical and physical processess at the surface of the Earth. 4. Describe the debates and history of the early thinkers in Geology and explain how that has influenced modern Earth Science. 5. Recognise and examine fundamental weathering processes.

Assesment:

Type of Assessment	**Marks**
FORMATIVE	
In-Course Exam	12.5
Attendance	2.5
SUMMATIVE	
Final Examination	35

References:

1. Boggs J.S. Principles of sedimentology and Stratigraphy.
2. Dunbar C.O. AND Rodgers J. Principles of Stratigraphy.
3. Krumbein W.C. AND Sloss L.L. Stratigraphy and sedimentation.
4. Leeder M.R. Sedimentology-process and product.
5. Reading H.G. Sedimentary environments process, facies and Stratigraphy.
6. Reineck H.E. and Singh I.B. Depositional sedimentary environment.
7. Weller J.M. Stratigraphic principles and practice.
8. Walker R.G. and James N.P. 1992. Facies models; Response to sea level change. Geological association of Canada.
9. Friedman G.M and Sanders J.E. Principles of sedimentology.
10. Leeder M.R. Sedimentology – process and product.
11. Selley R.C. Introduction to sedimentology.
12. Emery D. and Myres K.J. 1996. Sequence stratigraphy. Blackwell Science.

Course Number and Title: OCN-215: Marine Microbiology
Credit hours: 3

Introduction to the Course:
Our curriculum is designed to educate in a variety of important microbiological disciplines, as well as to promote and develop skills and competencies that have enduring value beyond the classroom.

Specific Objectives:
Students will learn in-depth concepts of biology with focus on microbiology through various graduate courses. This knowledge will provide students with insight into the complexity of microbiology and biological systems. Students will be able to implement the knowledge, skills and values of biological sciences into occupational pursuits, making them attractive candidates in the job market.

Course Contents:

SL.	Topics	No. of Lectures
1.	**Introduction to marine microbiology:** Marine microbes and domains of life; Physiological aspects of marine prokaryotes, archaea, proteobacteria, cyanobacteria, planctomyces, spirochaetes, hyperthermophiles; Environmental factors and their influence in microorganism development.	7
2.	**Diversity of microorganisms:** Principal groups and characteristics of marine bacteria	3
MIDTERM EXAMINATION - I		
3.	**Diversity of microorganisms:** Viruses in marine environments; Distribution, number and biomass of microorganisms at the sea; Life in extreme environments: thermophylus, acidophylus, alcalophylus, halotolerant etc.	7
3.	**Role of microorganisms in marine trophic networks:** Microbes-important part of the food chain; Cycles of elements at sea (nitrogen, sulfur and phosphorus); Production and decomposition of organic material; Microbial role in sediment formation; Microbial activity at hydrothermal vents.	5
4.	**Interactions of microorganisms:** Microbe-microbe interaction and interaction with other marine organisms.	3
MIDTERM EXAMINATION - II		
5.	**Interactions of microorganisms:** Metabiosis between organisms; Symbiosis in marine environment: Commensalism, mutualism, parasitism; Negative associations: competition, predation and parasitism.	6
6.	**Isolation, cultivation and identification of marine microorganisms:** Sampling techniques; Isolation of microorganisms;	4
MIDTERM EXAMINATION - III		

7.	**Isolation, cultivation and identification of marine microorganisms:** Culture medium and culture conditions for marine microorganisms; Molecular methods for microbial identification.	3
9.	**Marine microbes and biotechnology**: Marine natural products- microbial enzymes,anti-microbial peptides, fungal metabolites, polysaccharides from marine organisms; Pharmaceuticals- nutraceuticals, cosmeceuticals, selenoneine; Blue biotechnology-bioenergy and biofuels; Use of marine microorganisms in biomineralization.	7
		Total = 45

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance.

Learning Outcomes:
Describe how microorganisms are used as model systems to study basic biology, genetics, metabolism and ecology marine microbiology. Identify ways marine microorganisms play an integral role in disease, and microbial and immunological methodologies are used in disease treatment and prevention.

Assesment:

Type of Assessment	**Marks**
FORMATIVE	
In-Course Exam	25
Attendance	5
SUMMATIVE	
Final Examination	70

Reading Materials:

1. Marine Microbiology: ecology and applications (2004) by Munn, C.B. (Colin B.). Ed. Garland Scince-Bios Scientific Publishers, London; New York.
2. Marine Microbiology (2005) by John H. Paul. Ed. San Diego.
3. Microbial ecology of the oceans (2000) by David L. Kirchman. Ed. Wiley-Liss, New York.
4. Marine Microbiology (Methods in Microbiology, vol 30; 2003) by John Paul (Ed). Academic Press.
5. Molecular marine microbiology (2000) by Douglas hoyt Bartlett. Jmmb Symposium series, V.1.
6. Microbial sediments (2013) by Robert E. Riding, S.M. Awramik, Stanley M. Awramik. Springer
7. Marine Microbiology: Bioactive Compounds and Biotechnological Applications (2013) by Se-Kwon Kim.
8. Springer Handbook of Marine Biotechnology (2015) by Se-Kwon Kim.

Course Number and Title: OCN 216: Numerical Techniques in Oceanography
Credit hours: 3

Introduction to the Course: The course will develop numerical methods aided by technology to solve algebraic, transcendental, and differential equations, and to calculate derivatives and integrals. The course will also develop an understanding of the elements of error analysis for numerical methods and certain proofs. The course will further develop problem solving skills.

Specific Objectives:

1. derive appropriate numerical methods to solve algebraic and transcendental equations
2. develop appropriate numerical methods to approximate a function
3. develop appropriate numerical methods to solve a differential equation
4. derive appropriate numerical methods to evaluate a derivative at a value
5. derive appropriate numerical methods to solve a linear system of equations
6. perform an error analysis for various numerical methods
7. prove results for various numerical root finding methods
8. derive appropriate numerical methods to calculate a definite integral
9. code various numerical methods in a modern computer language

Course Contents:

SL.	Topics	No. of Lectures
1.	Error Analysis: Introduction, Numbers and their Accuracy, Round off Errors, Errors and their Computation, Absolute Error, Relative Error and Percentage Error, Convergence	4
2.	Solutions of Equation in One Variable: The Bisection Method, Fixed Point Iteration Method, Newton-Raphson's Method, Error Analysis for Iterative Methods.	6
	MIDTERM EXAMINATION - I	
3.	Interpolation and Polynomial Approximation: Finite Differences, Forward Differences, Backward Differences, Central Differences,Newton's Formula for InterpolationandLagrange Polynomial and Interpolation	4
4.	Curve Fitting: Introduction, Least-Squares Curve Fitting Procedures, Fitting a Straight Line, Nonlinear Curve Fitting, Power Function, Polynomial of the nth degree, Exponential function.	4
5.	Numerical Differentiation and Integration: Introduction, Numerical Differentiation, Error's in Numerical differentiation, Elements of Numerical integration, Trapezoidal rule, Simpson's 1/3 - Rule, Simpson's 3/8 Rule.	5

6.	Numerical Solution of Initial Value Problem for Differential Equation: Euler's Method.	2
MIDTERM EXAMINATION - II		
7.	Taylor's Series Method, Runge-Kutta Methods of Order Two and Order four.	4
8.	Solutions of Liner System of Equations: Gaussian Elimination Method with backward substitutions,Matrix Factorization	3
9.	LU Decomposition Method.Eigenvalues and Eigenvectors, The Eigenvalue Problem.	3
MIDTERM EXAMINATION - III		
10.	Numerical Solution of Partial Differential Equations: Finite-Difference Approximations to Derivatives, Laplace's Equations, , Jacobi's Method, Gauss Seidel Method.	6
11.	Applications in Oceanographic Model.	4
		Total = 45

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance.

Learning Outcomes:
1. Explain the consequences of finite precision and the inherent limits of the numerical methods considered. 2. Select appropriate numerical methods to apply to various types of problems in science inconsideration of the mathematical operations involved, accuracy requirements, and available computational resources. 3. Demonstrate they understand the mathematics concepts underlying the numerical methods considered. 4. Demonstrate understanding and implementation of numerical solution algorithms applied to the following classes of problems: a. Finding roots of equations b. Solving systems of algebraic equations c. Curve fitting d. Interpolation e. Numerical differentiation of data and functions f. Numerical integration of data and functions g. Solutions of ordinary differential equations including: i. Initial value problems ii. Boundary value problems iii. Systems of equations

Assesment:

Type of Assessment	**Marks**
FORMATIVE	
In-Course Exam	25
Attendance	5
SUMMATIVE	
Final Examination	70

Reading Materials:
Numerical Analysis by Richard L. Burden, J. Douglas Faires
Mathematical Methods for Oceanographers: An Introduction by Edward A. Laws

Fifth Semester

Course Number and Title: OCN 301: Acoustical Oceanography
Credit hours: 2

Introduction to the Course: This course covers the basic theory of acoustics in fluids, sound propagation and scattering in the ocean environment.

Specific Objectives: The objective of the course is to provide students with an understanding of the physical processes that occur in the oceans and the effects they have on the propagation of underwater sound. The students should expect to gain a theoretical and phenomenological basis of sound propagation and scattering in the ocean, and learn about inversion methods for measuring physical and bio-geo-chemical properties of the ocean.

Course Contents:

SL.	Topics	No. of Lectures
1.	Fundamentals: Simple propagation, rays, sources and receivers, radiated sound, bioacoustics, waveguides, scattering by bubbles, interior fluctuations, and rough surfaces. The near surface ocean: upper ocean boundary layer and rain.	4
2.	SONAR systems: Transducers and their directivities, Transducer arrays, Array steering, Shaped transducers, High power transducers.	2
3.	Fourier representation of signals, Filters and noise, Temporal resolution and bandwidth, Improving signal to noise ratio.	2
MIDTERM EXAMINATION - I		
4.	Perception of bodies and bubbles by scattering phenomena, Scattering characteristics of marine life, Signals scattered by fish and other bodies.	4
5.	Volume scattering in the ocean, Field estimate of fish densities, Bioacoustics: sensing of plankton and nekton; passive acoustics and marine animals, marine Mammals.	4
6.	Sediment characteristics, Marine seismic measurements, Head waves, Reflection measurements, Echo sounding of the sea floor.	3
7.	Diffraction of impulsive signals, Doppler effect of moving objects, Doppler navigation, Mean Squared pressure, Remote sensing of the sea floor, Acoustic tomography.	4
MIDTERM EXAMINATION - II		
8.	Ocean Dynamics: tomography, time reversal, turbulence.	2
9.	Ocean Bottom: imaging hydrothermal vents, large scale mapping.	2
10.	Other topics: noise from pile driving, ocean energy devices, etc.	1
		Total= 30

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance

Learning Outcomes: 1. Read and visualize acoustic recordings.
2. Able to analyze and interpret results.
3. Conduct literature reviews.
4. Become familiar with writing research articles.

Type of Assessment	Marks
FORMATIVE	
In-Course Exam	12.5
Attendance	2.5
SUMMATIVE	
Final Examination	35

Reading Materials:

Textbook: Sound in the Sea, Medwin, Cambridge University Press, 2005.

Reference books**:**

1. Fundamentals of Acoustics : L.E. Kinsler & A. R. Frey, John Wiley, 1st edn., 2000.
2. Acoustical Oceanography :C S Clay & H Medwin, Academic Press, 1st edn., 1998.
3. Principles of Underwater Sound :D G Tucker & B K Gazey, McGraw Hill, 3rd edn., 2003.
4. Computational Ocean Acoustics (Modern Acoustics and Signal Processing) :F.B. Jensen, W. A. Kuperman, M. B. Porter and H. Schmidt, Springer, 2nd ed., 2011.
5. Ocean Acoustics: Theory and Experiment in Underwater Sound :I. Tolstoy and C. Clay, Acoustical Society of America, 1987.
6. Ocean Ambient Noise: Measurement and Theory (The Underwater Acoustics Series) :W. M. Carey and R. B. Evans, Springer, 2011.
7. Fundamentals of Ocean Acoustics (Modern Acoustics and Signal Processing) : L.M. Brekhovskikh and Yu.P. Lysanov, Springer, 3rd edition, 2007.
8. Ocean Acoustics: J.A. DeSanto, Springer, 2009.
9. Sounds in the Sea: From Ocean Acoustics to Acoustical Oceanography: H. Medwin, Cambridge University Press, 2005.
10. Fundamentals of Shallow Water Acoustics : B. Katsnelson, V. Petnikov and J. Lynch, Springer, 2010.
11. Advances in Ocean Acoustics - Proceedings of the 3rd International Conference on Ocean Acoustics : Ji-Xun Zhou, Zhenglin Li and Jeffrey Simmen, American Institute of Physics, 2012.
12. Principles of Sonar Performance Modeling, Ainslie, Springer, 2010.
13. Underwater Acoustics: Analysis, Design and Performance of Sonar, Hodges, Wiley, 2010.
14. Inverse Problems in Underwater Acoustics, Taroudakis and Makrakis, Springer, 2001.
15. Fundamentals of Acoustical Oceanography, Medwin and Clay, Associated Press, 1998.
16. Ocean Acoustic Tomography, Munk, Worcester, and Wunsch, Cambridge University Press, 1995.
17. Oceanography and Acoustics: Prediction and Propagation Models, Robinson and Lee, American Institute of Physics, 1994.
18. The Sonar of Dolphins, Au, Springer-Verlag, 1993.
19. Underwater Acoustic Systems, Coates, John Wiley & Sons, 1989.
20. Sound transmission through a fluctuating ocean, Flatte, Cambridge University Press, 1979.

Course Number and Title: OCN 302: Molecular Methods in Oceanography
Credit Hours: 3

Introduction to the Course:

Molecular biology is the basic science that has as its goal an explanation of life processes at the subcellular and molecular level. Recent years have seen explosive advances in the study of DNA and molecular genetics, including gene cloning, sequencing and mapping. Molecular biology students complete a comprehensive curriculum in the fundamentals of science. The requirements of the molecular biology major assure competence in the broad scientific theory and application of molecular biology, while allowing flexibility for students to develop strength in their biochemical, biological or oceanographic discipline.

Specific Objectives:

The course aims to provide an advanced understanding of the core principles and topics of Molecular biology and their experimental basis, and to enable students to acquire a specialized knowledge and understanding of selected aspects.

Course Contents:

SL.	Topics	No. of Lectures
1.	Isolation, detection, quantitation and preservation of DNA, RNA and protein from biological samples.	3
2.	Polymerase chain reaction (PCR) and Real-time PCR.	3
3.	DNA based molecular marker systems- RFLP, AFLP, RAPD; STR based genotyping; DNA barcoding.	4
MIDTERM EXAMINATION - I		
4.	Molecular hybridization techniques- Southern, Western and Northern blotting.	3
5.	Gene expression analysis- micro-array, SAGE, differential display, etc.	2
6.	Gel electrophoresis- Agarose gel electrophoresis, PAGE, denaturing gradient gel electrophoresis, temperature gradient gel electrophoresis, capillary gel electrophoresis, etc.	5
7.	Molecular cloning- vectors, restriction enzymes and digestion, transformation, recombinant gene and protein expression, promoter and other regulatory sequence analysis, screening and selectable markers.	5
MIDTERM EXAMINATION - II		
8.	DNA sequencing techniques, next generation DNA sequencing, genome sequencing.	4
9.	Modulation of gene expression through RNA interference (RNAi).	3
10.	Techniques to study DNA-protein, RNA-protein, protein-protein interactions- EMSA, REMSA, ChIP, Y2H systems, etc.	5
11.	Immunoassays- ELISA, RIA, Gel diffusion assay, etc.	3
MIDTERM EXAMINATION - III		
12.	Flow cytometry.	1

13.	Genetic mutation analysis.	1
14.	Chromatographic techniques- affinity chromatography, ion exchange chromatography, size exclusion chromatography, etc.	2
15.	Immunofluorescence based imaging.	1
		Total= 45

Instructional Strategies: Lecture, Discussion, Question-Answer, Class performance.

Learning Outcomes:

1. Analyze the main structural elements and processes that participate in reproduction, growth, maintenance and regulation of the cell.
2. Explain the fundamental structure, properties and processes in which nucleic acids play a part. 3. Discuss the molecular mechanisms by which DNA controls development, growth or morphological characteristics of organisms.
4. Explain the principles and laws of inheritance at the cell, individual and population levels.
5. Explain the emergence of mutations and their influence on the survival of individuals and species with the proposal of the method of targeted introduction of mutations due to the creation of new gene variations that can be used for further research
6. Explain the principles of cloning and genetic manipulation and their application in genetic analysis.

Type of Assessment	**Marks**
FORMATIVE	
In-Course Exam	25
Attendance	5
SUMMATIVE	
Final Examination	70

Reading Materials:

a. Molecular biotechnology: principles and applications of recombinant DNA; Bernard R. Glick, Jack J. Pasternak and Cheryl L. Patten- 4th Ed., 2010, ASM press.

b. Principles and techniques of biochemistry and molecular biology; edited by Keith Wilson, John Walker. – 7th ed., 2010, Cambridge University Press.

c. Molecular diagnostics: fundamentals, methods, and clinical applications; Lela Buckingham, Maribeth Flaws- 2007, by F. A. Davis Company, Philadelphia.

d. Next-Generation Genome Sequencing: toward personalized medicine; Michal Janitz- 2008, WILEY-VCH Verlag GmbH & Co.

e. Immunology; Judith A. Owen, Jenni Punt and Sharon A. Stranford- 7th Ed. 2013, W. H. Freeman and Company.

Course Number and Title: OCN 303: Marine Ecology
Credit Hours: 3

Introduction to the Course: The module aims to provide a high level introduction to the scientific method and approaches to experimental and survey design and data analysis and interpretation. Learning will be enhanced through a practical demonstration at sea of sampling constraints, marine organism identification skills training, laboratory analysis of raw material yielding data for computer sessions used to enhance statistical skills.

Specific Objectives: Introduce you to the principal coastal and oceanic ecosystems. • In each ecosystem, explore how environmental variables affect biological communities and ecological interactions. • Introduce topical research issues on biodiversity, global climate change, and the evolution of life in the oceans.

Course Contents:

SL.	Topics	No. of Lectures
1.	Introduction: Ecology, scope of ecology, sub-division of ecology, Principles and concept of ecology.	5
2.	Marine ecology, history and niche of marine ecology; contrasts to terrestrial ecosystems.	5
	MIDTERM EXAMINATION – I	
3.	Bio-geo-chemical cycles: Carbon cycle, Nitrogen cycle. Trophic structure: Food chain, Food web, Ecological pyramids.	5
4.	Habitat: Ecological niche: realized niche, niche overlap, Gause's competitive exclusion principle, resource partitioning, the nature and global distribution of marine organisms.	5
5.	Ecosystem: concept of ecosystem, types, components of ecosystem, Structure and function of an ecosystem, Major ecosystems, Patterns of the marine environment.	5
	MIDTERM EXAMINATION – II	
6.	Processes: Primary production processes, Microbial ecology, Secondary production.	5
7.	Systems: Estuaries, rock and sandy shores, pelagic ecosystems	5
8.	Systems: Continental shelf, deep sea, mangrove forests, coral reefs.	5
	MIDTERM EXAMINATION – III	
9.	Impacts: Fisheries, aquaculture, disturbance, pollution, conservation.	5
		Total= 45

Instructional Strategies: The course will consist of lectures and in class seminars / discussions. Each week a group of students will be assigned to research a topic relating to

sustainability and will lead an in-class discussion. An extensive reading list will be made available. Students will be expected to familiarize themselves with this material as papers relevant to the week's topic will be discussed in class. The in-class discussion may be based on these readings or any others that are pertinent. A major component of the course will be a 6,000-word research paper on a topic of the student's choosing. The paper will examine a specific ecosystem and the ways in which humans have affected the form and function of that system. The paper will also consider the mechanisms by which the effects on the system were mitigated or eliminated (science, policy, legislation etc.).

Learning Outcomes: Be able to recognize the principal coastal and oceanic marine ecosystems at global, regional and local scales. Have acquired a basic knowledge of the key biological, physical, chemical and evolutionary processes operating in these ecosystems. Have acquired basic knowledge of the types of plants and animals inhabiting marine environments and their ecological and evolutionary adaptations to particular physio-chemical conditions.

Type of Assessment	**Marks**
FORMATIVE	
In-Course Exam	25
Attendance	5
SUMMATIVE	
Final Examination	70

Reading Materials:

2. J. L. Chapman and M. J. Reiss,Ecology: principles and applications. (Cambridge Univ. press)

3. Odum, E.P. 1971. Fundamentals of Ecology.W.B. Saunders C.

4. Verma, P.S. and V.K. Agarwal 1983. Principles of Ecology, S. Chand & Co. Ltd. Delhi, India.

5. Poole R. W. An introduction to quantitative ecology (Mac'Graw Hill, New York)

6. R.S.K. Barnes &R. N. Hughes1999. An Introduction to Marine Ecology

7. Michel J.Kaiser and *et all*2005. Marine Ecology-Processes, systems and impacts (Oxford Univ. press)

Course Number and Title:OCN 304: Fisheries Oceanography
Credit hours: 2

Introduction to the Course:
This course will help students understand how oceanographic processes influence the distribution, recruitment, and abundance of marine vertebrate and invertebrate species from local to global spatial scales and from daily to evolutionary time scales Geological, physical, chemical and biological oceanographic processes are examined from a functional perspective to appreciate how they have shaped and continue to shape marine ecosystems. We will explore how fish and shellfish populations have adapted to key oceanographic features and how they respond to oceanographic variability. Students will examine how a better understanding of these adaptations and responses contributes to the sustainable management of marine fisheries resources.

Course Objectives:

1. To develop an appreciation for the effects of oceanographic processes on the abundance, distribution, and productivity of marine fish and shellfish populations.
2. To develop critical thinking and synthesis skills about the relevance of oceanographic processes in the context of fisheries research and management.
3. To develop professional-level written and oral communication skills as marine scientists working on applied fisheries issues.

Course Contents:

SL.	Topics	No. of Lectures
1.	The ocean as a biological environment**:** Zonation of the marine environment; primary productivity, determination of primary production, factors influencing phytoplankton production, primary productivity and fisheries production.	5
2.	Major marine ecological groups: phytoplankton, zooplankton, benthos, nekton and macrophytes; their characteristics, biology and distributions; major fisheries, fishing grounds and fishing in the Bay of Bengal.	5
	MIDTERM EXAMINATION – I	
4.	Marine provinces and biogeography of the oceans: Large marine ecosystems: definition and classification, productivity, and fisheries catches; latitudinal clines in fishes.	5
5.	Ocean biota and environment**:** Ocean biota's relationships with the physicochemical properties of the ocean; effects of environmental parameters like temperature, currents, light and salinity on fish biology, behavior and abundance.	5
6.	Commercially important groups of fishes: general and brief account of elasmobranches, clupeoids (especially *Tenualosailisha*), salmonoids, scombroids, gadoids, heterosomata, sciaenids, carangids, trichiurids, cat fishes, crustaceans and molluscs.	5

MIDTERM EXAMINATION – II		
8.	Adaptation of marine organism: Morphological and physiological adaptation of marine fish, mammals, invertebrates and macrophytic halophytes in relation to physico-chemical properties of the ocean.	5
		Total= 30

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance.

Learning Outcomes:

1. Familiarity with and understanding of key oceanographic processes affecting fish and shellfish populations and communities.
2. Ability to recognize potential links between variability in fish populations and underlying oceanographic processes.
3. Familiarity with field and analytical methods that are used by researchers studying such links.
4. Ability to compute and appropriately apply commonly used oceanographic quantities.

Understanding of how oceanography can contribute to the management of fisheries and familiarity with relevant case studies.

Type of Assessment	Marks
FORMATIVE	
In-Course Exam	12.5
Attendance	2.5
SUMMATIVE	
Final Examination	35

Reading Materials:

1. Duxbury, A. B. and Duxbury, A.C. 1999. Fundamentals of Oceanography. WCB/McGrawHill Publishing Company.
2. Thurman, H.V. 1994. Introductory Oceanography. 7th edition, Macmillam Publishing.
3. Briggs, J. C., and Bowen, B. W. 2012. A realignment of marine biogeographic provinces with particular reference to fish distributions. Journal of Biogeography, 39: 12-30.
4. Haedrich, R. L. 1996. Deep-water fishes: evolution and adaptation in the earth's largest living spaces. Journal of Fish Biology, 49: 40-53.

Course Number and Title: OCN 305: Petroleum Geology and Geophysics
Credit hours: 3

Introduction to the Course: This broad and interdisciplinary study covers most aspects of petroleum exploration, oil-field development and production. It also includes different geophysical wireline methods to explore oil and gas within a borehole.

Specific Objectives: The objectives of this course are to teach students the importance of energy in our lives, the very significant role that fossil fuels like petroleum (crude oil and natural gas) and coal have in supplying this energy, the environmental effects of producing, transporting, refining, using and burning these fuels, how petroleum is found and wells are drilled to produce it, what are the conditions in nature required for petroleum formation and trapping, the role that geologists and geophysicists have in petroleum exploration and production, and how market factors affect jobs for us in the energy industry.

Course Contents:

SL.	Topics	No. of Lectures
1.	Sedimentary basin classification, geothermal history of sedimentary basin.	5
2.	Source rock evaluation petroleum generation, migration pathways and efficiencies.	5
	MIDTERM EXAMINATION – I	
3.	Concepts of petroleum systems; fundamental types of petroliferous basins hydrocarbon habitats of Bengal basis and some major petroleum basin upper Assam basin, Niger delta Arabian gulf and U.S. gulf coast petroleum reservoir description external geometry of reservoir internal geometry of reservoir distribution of porosity permeability distribution of minerals specially clay minerals reservoir of sediment deposition environment deltaic shallow marine shelf fluvial and turbidities ease studies reservoir evaluation from core analysis and wire line log analysis.	15
	MIDTERM EXAMINATION - II	
4.	Introduction, theoretical background of seismic method, data acquisition and processing geological interpretation seismic modeling.	7
5.	Seismic facies hydrocarbon detection case studies.	3
6.	Interpretation of electrical and electromagnetic dada and their application.	5
	MIDTERM EXAMINATION - III	
7.	Interpretation of gravity and magnetic data and their interpretation application of geophysical well logging for petroleum hydrogeology and environmental geology case studies integration of geophysical methods for hydrocarbon and one deposit exploration.	5
		Total= 45

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance.

Learning Outcomes: 1. Have specialised knowledge in petroleum geoscience disciplines related to petroleum systems especially sedimentology, stratigraphy, and structural geology. 2. Be able to independently critically analyse and synthesise complex information in order to interpret geologic data related to petroleum systems. 3. Be able to communicate their knowledge and understanding to specialist audiences.

Type of Assessment	**Marks**
FORMATIVE	
In-Course Exam	25
Attendance	5
SUMMATIVE	
Final Examination	70

Reading Materials:

Badley M.E. Practical seismic interpretation.
Mcquillin R Bacon and M, Barclay W.: An instruction of seismic interpretation.
Sheriff F.E.and Geldert L.P.Exploration seismology vol. 1 and 2.
Telford WM et.al.Applied geophysics.
Rider, M.H. The geological interpretation of well logs. schlumberger, log interpretation, vol.2 application.

Course Number and Title: OCN 306: Marine Mammals
Credit hours: **2**

Introduction to the Course:
The study of mammals adapted to marine environment has always been an interesting subject for zoologists, mammologists, oceanographers and conservationists. This course aims to detail out the aspects of marine mammals, classification scheme, their habitat preferences, global distributions as well as their interaction with human. In addition, the course deals with the understanding on the basic characteristics, breeding activities, feeding, and development of social behaviour in all groups of marine mammals. Emphasis is equally given to threats to marine mammals.

Specific Objectives:
- To enhance students' understanding about the scientific study of marine mammals involving a variety of approaches.

Course Contents:

SL.	Topics	No. of Lectures
1.	Introduction to marine mammals: Definition and Taxonomy.	2
2.	Diversity, Distribution, Habit and Habitat of the four groups i.e., the cetaceans (dolphins, rorquals and whales), the sirenians (dugongs and manatees), the pinnipeds (seals, sea lions and walruses) and the marine. fissipeds (polar bear and two marine otters) Marine Mammals in Bangladesh.	8
MIDTERM EXAMINATION – I		
3.	Basic characteristics of these groups with special references to their adaptation to marine life and to different oceanic niches.	3
4.	General pattern and possible reasons of evolution of marine mammals.	2
5.	Breeding biology, breeding season, territoriality, mating, pregnancy, gestation, lactation and parental care of an obligate ocean dweller (any cetacean or sirenian; preferably Bottlenose Dolphin) and a semiaquatic marine mammal (any pinniped or marine fissiped; preferably Sea Otter Enhydra lutris).	10
MIDTERM EXAMINATION – II		
6.	Extinct marine mammals. Threats issues. Whaling.	3
7.	Conservation measures. Seal culling.	2
		Total= 30

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance.

Learning Outcomes:

After completion of the course, the students will be able to-

- understand evolutionary basis for the marine mammals;
- learn about feeding behaviour, reproductive behaviour, social behaviour, parental care in marine mammals;
- understand the diversity of marine mammals in Bangladesh.

Type of Assessment	Marks
FORMATIVE	
In-Course Exam	12.5
Attendance	2.5
SUMMATIVE	
Final Examination	35

Reading Materials:

Anderson, Paul K. 2001. Marine Mammals in the Next One Hundred Years: Twilight for a Pleistocene Megafauna?. *Journal of Mammalogy* **82** (3): 623–629. doi:10.1093/jmammal/82.3.623.

Baker, C. S., Cipriano, F. and Palumbi, S. R. 1996. Molecular genetic identification of whale and dolphin products from commercial markets in Korea and Japan. *Molecular Ecology* **5** (5): 671. doi:10.1111/j.1365-294X.1996.tb00362.x.

Clapham, P. J.; Young, S. B.; Brownell, R. L. 1999. Baleen whales: Conservation issues and the status of the most endangered populations". *Mammal Review* **29**: 37. doi:10.1046/j.1365-2907.1999.00035.x.

Groves, C. P., Wilson, D. E. and Reeder, D. M, (eds.). 2005. *Mammal Species of the World*, Third Edition. Johns Hopkins University Press. Baltimore. ISBN 0-801-88221-4.

Hall, M. A. 1998.. An ecological view of the tuna—dolphin problem: impacts and tradeoffs. *Reviews in Fish Biology and Fisheries* **8**: 1. doi:10.1023/A:1008854816580.

History of Whaling". The Húsavík Whale Museum. Retrievable.

Jefferson, T. A., Webber, M. A., and Pitman, R. L. 2011. *Marine Mammals of the World: A Comprehensive Guide to Their Identification*. Academic Press. London. ISBN 978-0-12-383853-7.

Kaschner, K., Tittensor, D. P., Ready, J., Gerrodette, T. and Worm, B. 2011. Current and Future Patterns of Global Marine Mammal Biodiversity. *PLoS ONE* **6** (5): e19653. doi:10.1371/journal.pone.0019653.

Menon, V. and Daniel, J. C. 2009. *Field guide to Indian mammals*. Christopher Helm.

Modern Whaling. The Húsavík Whale Museum. Retrievable.

Pompa, S., Ehrlich, P. R., and Ceballos, G. 2011. Global distribution and conservation of marine mammals. *Proceedings of the National Academy of Sciences* **108** (33): 13600–13605. doi:10.1073/pnas.1101525108.

Price, S. A., Bininda-Emonds, O. R.; Gittleman, J.L. 2005. A complete phylogeny of the whales, dolphins and even-toed hoofed mammals – Cetartiodactyla. *Biol Rev Camb Philos Soc.* **80** (3): 445–473. doi:10.1017/s1464793105006743.

Riedman, M.L. and Estes J. A. 1990. The sea otter (*Enhydra lutris*): behavior, ecology, and natural history. *U.S. Fish and Wildlife Service Biological Report* (Report) (Washington, D.C.): 126.

Rosen, D. A.; Trites, A. W. 2000. Pollock and the decline of Steller sea lions: Testing the junk-food hypothesis.*Canadian Journal of Zoology* **78** (7): 1243. doi:10.1139/z00-060.

Shane, S. H., Wells, R. S. and Würsig, B. 1986. Ecology, behavior and social organization of the bottlenose dolphin: a review. *Marine Mammal Science* **2**(1): 34-63.

Siddiqui, K.U., Islam, M.A., Kabir, S.M.H., Ahmad, M., Ahmed, A.T.A., Rhaman, A.K.A., Haque, E.U., Ahmed, Z.U., Begum, Z.N.T., Hassan,M.A., Khondker, M. and Rahman, M.M. (eds.). 2008. *Encyclopedia of flora and fauna of Bangladesh*, *Vol. 27. Mammals*. Asiatic Society of Bangladesh, Dhaka.

Smith, B. D., Gill, G., Samantha, S., Benazir, A. and Rubaiyat, M. 2006. Abundance of irrawaddy dolphins (*Orcaella brevirostris*) and ganges river dolphins (*Platanista gangetica gangetica*) estimated using concurrent counts made by independent teams in waterways of the sundarbans mangrove forest in Bangladesh. *Marine Mammal Science*: **22** (3): 527–547.

Storer, T.I., Usinger, R.L., Stebbins, R.C. and Nybakken, J.W. 1979. *General Zoology, Sixth Edition*. McGraw-Hill Book Company, New York.

Uhen, M. D. 2007. Evolution of marine mammals:Back to the sea after 300 million years. *The Anatomical Record: Advances in Integrative Anatomy and Evolutionary Biology* **290** (6): 514–22. doi:10.1002/ar.20545.

Urian, K. W., Duffield, D. A., Read, A. J., Wells, R. S. and Shell, E. D. 1996. Seasonality of reproduction in bottlenose dolphins, *Tursiops aduncus*. *Journal of Mammalogy* **77**(2): 394-403.

Weichert, C. K. 1951. Anatomy of the Chordates. *Anatomy of the chordates, Second edition.* McGraw - Hill Book Company, New York

Sixth Semester

Course Number and Title: OCN 311: Ocean Waves and Tidal Energy
Credit Hours: 2

Introduction to the Course: This is an advance course for third year students which includes more details about ocean waves and tides and their effects on different disciplines of oceanography.

Specific Objectives: 1. To enrich knowledge about ocean waves, tides and currents. 2. To develop understanding the effects of atmospheric phenomena on ocean surface and deep water. 3. To teach the effects of relation between astronomy and oceanography and its effects on water mass.

Course Contents:

SL.	Topics	No. of Lectures
1.	Introduction; wave energy, resources and potential, examples from passed and current R&D. Simplified wave theory; orbits, propagation velocities, stored & transported wave energy. Different types (and classification) of wave-energy converters. Principles for primary conversion. Simplified example: immersed heaving body, mechanical resistance, impedance, and reactance. Energy and power aspects: delivered/stored/ consumed, instantaneous/average, active/reactive. Optimum condition for maximum absorbed wave power.	4
2.	Sinusoidal oscillations: phasors, complex amplitudes, complex mechanical impedance. Waves in different branches of physics: dispersion, propagation velocities. Stored and transported wave energy, intensity related to transported wave energy. Radiation resistance, impedance, reactance, and "added" mass. Absorption of wave energy: resonance absorption, resonance bandwidth.	3
3.	Practical issues: primary interface types, device survival, materials, machinery systems and their use in motion control (reactive/latching). Potential theory, Bernoulli's equation, Laplace equation, boundary conditions, linearization. Fluid velocity in terms of velocity potential. Harmonic plane waves. Phase velocity and group velocity for waves propagating on water.	3
	MIDTERM EXAMINATION – I	
4.	Real sea waves, shoaling, refraction and diffraction. Finite-height waves on deep and shallow water. Fourier analysis of irregular waves, measured wave spectrum, standard spectra, directional sea. Synthesized irregular waves. Wave measurements and data, wave parameters derived from spectral moments. Wave elevation and hydrodynamic pressure in terms of velocity potential.	3

5.	Wave's stored potential energy and kinetic energy. Energy transport, wave-power level. Circular waves, far-field coefficients, far field and near field. Introduction to interaction between waves and a system of oscillators, immersed bodies and pressure distributions (OWCs). Single body interaction, six modes of motion; excitation force vector and radiation impedance matrix.	3
6.	Hydrodynamic boundary-value problem. Green's theorem. A useful surface integral taken on the totality of wave-generating surfaces. Waves satisfying the radiation condition. Proof of symmetry of radiation impedance matrix. Radiation resistance in terms of a far-field surface integral. Motion of a buoy in regular waves. Wave excitation and radiation forces. Resultant heave motion.	3
7.	Numerical results for radiation impedance and excitation force for various body geometries. Mooring system alternatives. Static and dynamic loads. Influence on energy absorption. Reciprocity relations: Haskind relation, radiation resistance in terms of far-field coefficients and in terms of excitation-force coefficients. Far-field coefficients referred to local vs. global origin. Froude-Kriloff force and diffraction force, small-body approximation. Morison's formula. Areas of validity of diffraction, mass and viscous forces.	3
8.	Linear time-invariant systems. Fourier transforms. Transfer functions and impulse response functions. Causal systems. Kramers-Kronig relations. An energy relation for non-sinusoidal oscillation.	3
	MIDTERM EXAMINATION – II	
9.	Causal/non-causal system for hydrodynamic radiation/diffraction problem. Non-causal relation between hydrodynamic pressure and wave elevation just above. Optimum (reactive) and sub-optimum (e.g., latching) control for maximizing converted power. Problems related to non-causality in relation to optimum control.	2
10.	Tidal dynamics. Using Kelvin and Sverdrup waves to explain primary features of the observed tides. Introduction to numerical solutions of the tidal equations. Initially, simple problems will be addressed related to a simple geometry of a channel or rectangle.Tidal power. Basic laws of tidal energy generation, transport and dissipation. Harnessing the power of tides for the generation of electricity. The methods for evaluation environmental impact of a tidal power development.	2
11.	Describe and quantify the wind, tidal stream and wave energy resources. Understand the conventional analytical techniques that are applied to wind, tidal stream and wave energy converters with a particular focus on development of mechanical power from environmental flows. Quantify the potential electrical output from renewable technologies and compare this to demand. Appreciate the environmental benefits and consequences of using these resources for large-scale electricity generation. Apply standard methods to assess the economic /commercial viability of a marine energy	1

	technology or project.	
		Total= 30

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance.

Learning Outcomes: 1. Understand the working processes of waves and tides. 2. Understand the causes behind waves and tides generation. 3. Develop a consciousness about impacts of extreme waves on coastal population. 4. Develop knowledge about physical processes working on ocean and their impacts on present day climate.

Type of Assessment	**Marks**
FORMATIVE	
In-Course Exam	12.5
Attendance	2.5
SUMMATIVE	
Final Examination	35

Reading Materials:

- **Mechanics and Fluid Mechanics**

1. Massey, B.S., 2005 Mechanics of fluids, 8th edition, (revised by Ward-Smith, J.). Taylor and Francis, ISBN 0-415-36206-7
2. White, F.M., 2006, Fluid Mechanics, 6th Edition, McGraw-Hill, ISBN 0-071-28646-2.
3. Dean, R.G. and Dalrymple, R.A., (1991) Water wave mechanics for engineers and scientists, World Scientific.

- **Context**

1. Twidell, J. and Weir, T. (2006) Renewable Energy Resources. Second Edition. Taylor and Francis Group.
2. Boyle, G. (2005) Renewable energy power for a sustainable future. Second Edition. Oxford University Press.

- **Wind Turbines**

1. Walker J and Jenkins N (1997) Wind Energy Technology. Wiley Unesco Energy Engineering Series.
2. Manwell JF, McGowan, JG and Rogers, AL.(2010) Wind Energy explained: Theory, Design and Application. Wiley. 2nd Edition. ISBN0-470-01500-4

- **Wave Energy**

1. Cruz, J. (2007) Ocean Wave Energy: Current Status and Future Perspectives. Springer-Berlin.
2. Falnes, J., 2002. Ocean Waves and Oscillating Systems: Linear Interactions Including Wave-
3. Energy Extraction. Cambridge University Press, Cambridge.

- **Tidal Systems**

1. Baker AC (1981) Tidal Power. Peter Peregrinus Ltd.

Course Number and Title: OCN 312: Marine Ecological & Ecosystem Modeling
Credit Hours: 2

Introduction to the Course:
This course aims to provide an understanding of the patterns of abundance and diversity of marine plants and animals and the processes that structure these patterns. Emphasis is placed on the challenges in understanding the complexity of marine systems and the solutions to quantifying them. In addition, throughout the course students should gain an understanding of the use of coherent logical procedures and rigorous experimental design to provide practical evidence for the development of theory and solutions to environmental and conservation problems in coastal habitats. The habitats and organisms used to illustrate lectures are derived from ecological studies of subtidal rocky and coral reefs, intertidal rocky reefs, mangrove forests, salt marshes, seagrass meadows, urban structures and pelagic habitats.

Specific Objectives:

- Introduce you to the principal coastal and oceanic ecosystems.
- In each ecosystem, explore how environmental variables affect biological communities and ecological interactions.
- Introduce topical research issues on biodiversity, global climate change, and the evolution of life in the oceans.

Course Contents:

SL.	Topics	No. of Lectures
1.	What is a model? Science with Models and the Modeling Process	3
2.	What is a system? What is environment?	2
3.	How do we describe them? Interaction and incidence matrix, multiple model representations (flow-storage, entity-process, state-space).	5
MIDTERM EXAMINATION – I		
4.	Single State Variable: Abiotic vs. biotic, state behavior (initial, transient, and steady-state), growth and population regulation, differential vs. difference equations	5
5.	Two State Variables: Resource-consumer and Predator-prey interactions	5
6.	Three State Variables: chains vs. webs, exploitative and interference competition, prey choice, trophic cascades	5
MIDTERM EXAMINATION – II		
7.	Modelling ecosystem dynamics: Lotka-Voleterra models; Nutrient-phytoplankton-zooplankton (NPZ) models.	3

8.	Application to contrasting ecosystem scenarios (N. Atlantic vs N. Pacific); Role of bottom-up vs top-down processes in regulating ecosystem processes; Additional complexity: size structure, dissolved organic matter, etc.	5
9.	Role of spatial heterogeneity (patchiness). Verification, calibration & validation, quantitative and qualitative fit, sensitivity and uncertainty analysis, stability analysis.	5
10.	Model Induction with Prometheus, generic vs. instantiated entities and processes	2
MIDTERM EXAMINATION – III		
11.	Ecosystem Network Analysis: Structure and Throughflow.	2
12.	Global models: representation of biogeochemistry in general circulation models.	3
		Total= 45

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance.

Learning Outcomes:

- Be able to recognise the principal coastal and oceanic marine ecosystems at global, regional and local scales
- Have acquired a basic knowledge of the key biological, physical, chemical and evolutionary processes operating in these ecosystems
- Have acquired basic knowledge of the types of plants and animals inhabiting marine environments and their ecological and evolutionary adaptations to particular physico-chemical conditions
- Able to develop model based on specific marine ecosystem.

Type of Assessment	**Marks**
FORMATIVE	
In-Course Exam	12.5
Attendance	2.5
SUMMATIVE	
Final Examination	35

Reading Materials:

(1) John Pastor, Mathematical Ecology of Populations and Ecosystems, A John Wiley & Sons, Ltd., Publication, 2008.

(2) White, I. D., Mottershead, D. N., and Harrison, S. J. 1992. Environmental Systems, 2nd Edition. Chapman & Hall, London. 616 pp

Course Number and Title: OCN 313: Population Dynamics of Marine Organisms
Credit hours: **2**

Introduction to the Course: To understand the drivers of change in coastal marine ecosystems, which lie at the interface between land and sea. It helps to inform the management of harvested marine species, and predicts how populations will respond to natural perturbations, climate change, and degradation of natural ecosystems.

Specific Objectives: Objectives of this course are: Define the goals of Population Dynamics of Marine Organisms as a science. Explain the different model and challenges of this course. Learn and estimate based on surveys.

Course Contents:

SL.	Topics	No. of Lectures
1.	Introductory Material: course goals -what is fishery? -history of fisheries management -what is a model? -A general review of concepts of population and stock, types of fishery resources. -Fisheries data (types, quality and availability), survey methods.	3
2.	Population Growth: rates of increase (finite versus instantaneous); derivation; models -Individual growth models -Other nonlinear models on life history or fishery processes: maturity, discarding, selectivity modeling -Individual growth curve comparison and the non-linear parameter estimation method; fitting models to data (OLS, MLE, Model error structure), Abundance Estimation based on surveys -Basic population dynamics and Mortality estimation (age/length composition, tagging) -Elementary population growth (exponential, logistic) with and without catch data -Production model with parameter estimation method.	5
3.	Somatic growth: age and growth estimation techniques -reporting fish growth -models of fish length and weight -condition indices -comparison of growth rates using linear and nonlinear methods.	2
MIDTERM EXAMINATION – I		
4.	Mortality: finite and instantaneous rates -fishing and natural mortality expression -conditional mortality rates	3

	-compensatory versus additive mortality -estimation techniques and confidence intervals	
5.	Stock structure and abundance: -Structure and abundance. Relative abundance. Sampling surveys. -Mark-recapture methods. Depletion methods. -Factors that increase biomass. Size and growth. Growth from length-frequency data. Growth from tagging information. Growth from hard-part analyses. Reproduction. Recruitment. -Factors that decrease biomass. Age-based catch curves. Length-based catch curves. Mortality from mark-recapture data. Natural mortality.	4
6.	Stock assessment -Stock abundance and catches - dynamic production models. Equilibrium models. Non-equilibrium models. Multispecies applications. Potential yield - rough estimators. -Including growth and mortality. The effects of growth and mortality on biomass. The effects of fishing mortality on a single cohort. -Including different year classes; age-structured models. Virtual population analysis. The classical yield per recruit model. The Thompson and Bell model. -Simulation and ecosystem models. A biomass dynamic simulation model. An age-structured simulation model. Ecosystem models. Risk assessment.	5
	Population Models -equilibrium yield model -incorporating variation in models -use and misuse of stochastic models	3
MIDTERM EXAMINATION – II		
7.	Fish Population Trends -cycles in fish populations -effects of density -abiotic versus biotic influences on abundance effects -Catch-at-age analysis (Virtual Population Analysis, cohort analysis) -Catch-at-age analysis (Sequential Population Analysis, ADAPT).	2
8.	Models based on Catch-at-Age -Virtual Population Analysis -Statistical Catch-at Age model -Species interactions (competition and predator-prey models, NPZ models) -Species interaction and implication in fisheries population dynamics and management -Stock-Recruitment Theory and Practice -Life history theory and Matrix models (age, size and stage structured models); -Sensitivity/elasticity analysis for matrix models.	3
		Total= 30

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance.

Learning Outcomes: Students know about fisheries management and population growth. They will be able to explain logistics model, biomassdynamic simulation model, population model, fish population model and risk assesment. They analyse sttiatical catch-at-age model, NPZ model and predaror –prey model.

Type of Assessment	**Marks**
FORMATIVE	
In-Course Exam	12.5
Attendance	2.5
SUMMATIVE	
Final Examination	35

Reading Materials:

1. Anderson Walter s, C. J., and S. J. D. Martell. 2004. Fisheries management and ecology. Princeton University Press, Princeton, New Jersey.
2. Haddon, M. 2000. Modelling and Quantitative Methods in Fisheries. Chapman and Hall, London. ISBN 1-58488-177-1
3. Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Bulletin 191 of the Fisheries Research Board of Canada.
4. Michael King, Fisheries Biology, Assessment and Management, 2nd Edition, ISBN: 978-1-4051-5831-2, August 2007, Wiley-Blackwell.

Course Number and Title: OCN 314: Marine Biotechnology and Therapeutics
Credit hours: 3

Introduction to the Course:

Marine Biotechnology and therapeutics will join other topics to ensure the acquisition by students of basic skills in degree of Oceanography. This course is a basic training for oceanographer on the application of biotechnological tools for the analysis and management of the marine and coastal environments and for the development and practical use of the organisms from such environments.

Specific Objectives:

- To understand the scientific background of marine biotechnology and therapeutics.
- To acquire substantial knowledge of marine natural products from diverse organisms and to appreciate the importance of these in terms of chemical oceanography.
- To have an awareness of the economic, legal and practical issues relating to the exploitation of marine products.
- To understand how technological advances in cellular and molecular biology benefit marine species in terms of their individual health, as well as the health of the environment.

Course Contents:

SL.	Topics	No. of Lectures
Marine Biotechnology		
1.	Marine organisms as sources of biofuel.	3
2.	Marine microbial enzymes in the food and pharmaceutical industries; Marine enzymes with applications for biosynthesis of fine chemicals; Polysaccharide-degrading enzymes from marine bacteria; Novel enzyme discovery from marine environments; Bio-processing of marine enzymes.	2
3.	Marine bioactives as food ingredients; Marine biotechnology applications in new functional foods; Nutritional and digestive health benefits of seaweed; Nutraceutical values of bioactive marine peptides; Marine nutraceuticals in dairy products.	5
MIDTERM EXAMINATION – I		
4.	Industrial applications of marine carbohydrates; Marine natural products in the cosmeceutical industries; Biosurfactants of environmental interest from marine ecosystems.	3
5.	Marine algae biomass for removal of heavy metal ions.	1
6.	Transgenic technology in marine organisms; Novel bioreactors for culturing marine organisms; Bioprocess engineering of marine organisms.	2

Marine therapeutics		
7.	Anti-viral activities of marine polysaccharides; Marine compounds with anti-helminthic, anti-bacterial, anti-coagulant, anti-fungal, anti-protozoal, and anti-tuberculosis activities.	3
8.	Marine peptides and their anti-infective activities.	2
9.	Marine fungus and bacteria for lead compounds of pharmaceutical importance; Natural products from marine invertebrates for anti-inflammatory and chronic diseases; Marine derived anticancer therapeutics; Marine-derived polysaccharides for regulation of allergic responses; Marine anti-malarials.	4
MIDTERM EXAMINATION – II		
10.	Marine peptides and their anti-infective activities.	3
11.	Marine fungus and bacteria for lead compounds of pharmaceutical importance; Natural products from marine invertebrates for anti-inflammatory and chronic diseases; Marine derived anticancer therapeutics; Marine-derived polysaccharides for regulation of allergic responses; Marine anti-malarials.	8
12.	Anti-photoaging and photoprotective compounds derived from marine organisms.	4
MIDTERM EXAMINATION – III		
13.	Bioactive secondary metabolites from marine species; Marine biotoxins; Systems microbiology technologies for bio-discovery of marine bioactive compounds.	5
		Total= 45

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance.

Learning Outcomes:

- Understanding why the marine environment is an important biotechnological and therapeutical resource
- Appreciation of the huge diversity of marine natural products and their modes of action in novel drugs and antiinfectives.
- Understanding that novel cells and proteins can be exploited for the benefit of human medicine and diagnostics
- Critical evaluation of marine natural products in terms of potential health benefit.

Type of Assessment	**Marks**
FORMATIVE	
In-Course Exam	25
Attendance	5
SUMMATIVE	
Final Examination	70

Reading Materials:

1. Handbook of Marine Biotechnology, Editor: **Kim**, Se-Kwon, 2015, Springer.
2. Marine Biotechnology I, Editors: **Le Gal**, Yves, **Ulber**, Roland, 2005, Springer
3. Marine Biotechnology II, Yves Le Gal, Roland Ulber, 2010, Springer

Course Number and Title: OCN 315: Submarine and Underwater Communication
Credit hours: 2

Introduction to the Course:

This course is designed to introduce students with different modes of submarine and underwater communication and their necessity in present world.

Specific Objectives:

- Simple control system design methods using a variety of control strategies.
- Performance specifications.
- How to proceed towards achieving these specifications.
- The operating principles, constraints and design parameters for underwater communication and positioning system.

Course Contents:

SL.	Topics	No. of Lectures
1.	Communication network	1
2.	Optical Communication System	2
3.	Medium of Communication System: Satellite medium and submarine cable medium, Transmission Medium: Atmospheric Propagation and Fiber Optics.	3
4.	Fiber optical cable system, Fiber Optic Trans-Oceanic Cable System and Trans-Atlantic Fiber Optic Cable System.	3
5.	Fiber optical communication system.	1
MIDTERM EXAMINATION – I		
6.	Undersea Optical Filter-based Cable System	2
7.	Modulation and Demodulation in Communication	2
8.	Amplitude modulation, Frequency modulation, Phase modulation and Pulse Code Modulation	3
9.	Optical Communication with Submerged Bodies	2
10.	Propagation of Optical Signal under Water	2
11.	Attenuation and Loss	1
12.	Ground to Submerged Submarine Optical Links	1
13.	Communication Device: Source and Detectors	2
14.	Underwater Acoustic Communication	2
MIDTERM EXAMINATION – II		
15.	Principles of Underwater Sound	2
16.	Underwater Acoustic Communication Channels	2
17	Communication with Submarines	1
		Total= 30

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance.

Learning Outcomes:

1. Design and specify underwater acoustic communication/positioning systems
2. Select the appropriate technology for specific applications and environments
3. Develop network to communicate with submarines.

Type of Assessment	Marks
FORMATIVE	
In-Course Exam	12.5
Attendance	2.5
SUMMATIVE	
Final Examination	35

Reading Materials:

Undersea Fiber Communication Systems (Optics and Photonics) 1st Edition
by Jose Chesnoy (Author, Editor), Govind Agrawal (Series Editor), Ivan Kaminow (Series Editor), Paul Kelley (Series Editor)

Underwater Electroacoustic Transducers designs.Softcover. 429 pages. ISBN: 9780932146724

Introduction to the Theory and Design of Sonar Transducers, Hardcover. 202 pages. ISBN: 9780932146229

Underwater Electroacoustic Measurements, Hardcover. 341 pages. ISBN: 9780932146199

Matched Field Processing for Underwater Acoustics, Hardcover. 228 pages. ISBN: 9789810210595

Principles of Underwater Sound, Third edition, Hardcover. 444 pages. ISBN: 9780932146625

Transducers and Arrays for Underwater Sound, Hardcover. 630 pages. ISBN: 9780387329406

Underwater Acoustic System Analysis, Second Edition, Softcover. 489 pages. ISBN: 9780932146632

Sonar Engineering Handbook, Softcover. 216 pages. ISBN: 9780932146595

Ambient Noise in the Sea, Hardcover. 205 pages. ISBN: 9780932146137

Sound Propagation in the Sea, Hardcover. 225 pages. ISBN: 9780932146083

Physics of Sound in the Sea, Hardcover. 577 pages. ISBN: 9780932146244

Mechanics of Underwater Noise, Hardcover. 375 pages. ISBN: 9780932146168

Side Scan Sonar Record Interpretation, Softcover. 146 pages. ISBN: 9780932146502

Applied Acoustics, Hardcover. 190 pages. ISBN: 9780932146182

ECM and ECCM Techniques for Digital Communication Systems, Hardcover. 178 pages. ISBN: 9780932146324, Peninsula Publishing of Los Altos Hills, California, USA.

Course Number and Title: OCN 316: Geophysical Fluid Dynamics
Credit hours: 3

Introduction to the Course: This course is concerned with the mathematical modelling of various phenomena observed in geophysical flows (i.e., those in the Earth's atmosphere and ocean, and upon the planetary surface). The focus is on waves and flowing currents, and how these are related to vertical density variations within the fluid and to the rotation of the Earth.

Specific Objectives: For students with a basic training in mathematical fluid dynamics, this syllabus will provide the necessary additional knowledge and mathematical techniques to understand and model geophysical flows. These ideas are central to further study in environmental and climate sciences.

Course Contents:

SL.	Topics	No. of Lectures
1.	Introduction, Purposes and value of geophysical fluid dynamics	2
2.	Fluid dynamics fundamentals: the Eulerian and Lagrangian perspective	3
3.	Fluid dynamics continued, Introduction to stratification	2
4.	The equation of state, entropy, stratification, sound, buoyancy frequency	3
MIDTERM EXAMINATION – I		
5.	Inertia gravity waves, introduction to rotation, and working on the sphere	4
6.	Geophysical Fluid Dynamics: They key approximations	3
7.	The Shallow Water Equations	3
8.	Energy Conservation	3
9.	Wave Basics	2
MIDTERM EXAMINATION – II		
10.	Geostrophic Adjustment and Balance	4
11.	The Quasi-Geostrophic Equations	2
12.	Rossby Waves	3
13.	Barotropic Instabilities, “Stirring” and Jets	3
14.	The two-layer equations, Continuous stratification	3
MIDTERM EXAMINATION - III		
15.	Baroclinic Instability	3
16.	Turbulence Basics	2
		Total= 45

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance.

Learning Outcomes: An awareness of various flow regimes in geophysical fluid dynamics; An understanding of the underlying physical processes that lead to these flows; The ability to construct and analyse idealized mathematical models of these processes; An appreciation of the relevance and limitations of these mathematical models.

Type of Assessment	**Marks**
FORMATIVE	
In-Course Exam	25
Attendance	5
SUMMATIVE	
Final Examination	70

Reading Materials:

(1) Cushmin-Roisin, Benoit, 1994: *Introduction to Geophysical Fluid Dynamics*, Prentice Hall.
(2) Pedlosky, J., *Geophysical Fluid Dynamics*, 1979, Springer-Verlag
(3) Salmon, Rick, 1998: Lectures on Geophysical Fluid Dynamics. Oxford University Press.
(4) Gill, A. E., *Atmosphere - Ocean Dynamics*, 1982, Academic Press
(5) Marshall, J., and R. A. Plumb, *Atmosphere, Ocean, and Climate Dynamics*, 2008, Acad. Press
(6) Batchelor, G. K., *An Introduction to Fluid Dynamics*, 1967, Cambridge University Press
(7) Lighthill, J., *Waves in Fluids, 1978*, Cambridge University Press
(8) Whitham, G. B., *Linear and Nonlinear Waves*, 1974, John Wiley and Sons
(9) Lindzen, R. S., *Dynamics in Atmospheric Physics*, 1990, Cambridge University Press
(10) Kundu, P. K., and I. M. Cohen, *Fluid Mechanics*, 2nd Edition, 2002, Academic Press
(11) Tritton, D. J., *Physical Fluid Dynamics*, 2nd Edition, 1988, Oxford University Press
(12) Holton, J. R., *An Introduction to Dynamic Meteorology*, 4th Edition, 2004, Academic Press.

Course Number and title: OCN-317: Coastal and Marine Aquaculture
Credit hours: 2

Introduction to the Course:

In Oceanography, knowledge of coastal and marine aquaculture has lots of importance to imply them in the field. It is essential to study different culture techniques to enhance production, to solve the constraints of a culture method as well as to improve management practices.The topic of coastal aquaculture is considered as a number of key biological research themes in this discipline including nutrition, reproduction, genetics and disease. In addition, the knowledge applies biological principles to production systems for finfish, crustacea and molluscs. Impacts of aquaculture on environment will also be discussed. This course consists of lectures and laboratory-based sessions which aim to develop practical skills and techniques in the relevant research themes.

Specific Objectives:

- To make the students familiar with scope and importance of coastal and marine water aquaculture
- To acquire knowledge on various culture techniques of finfish, crustacean and mollusks, live food etc.
- To understand the impact of aquaculture on environment and how to mitigate the impacts.
- To gain laboratory and field level experiences on constructing coastal and marine fish farms, hatcheries, larvi culture, disease management etc.

Course Contents:

SL.	Topics	No. of Lectures
1.	Introduction: Present status of brakish water aquaculture of Bangladesh and globe, Scope, trends and potential of coastal aquaculture in Bangladesh, Social and economic importance of coastal aquaculture in Bangladesh.	3
2.	Construction of coastal fish farms: site selection, phases of construction of coastal fish farms, various farming systems.	2
3.	Crustacean farming: Design, Operation and Management of shrimp hatchery, farming techniques of shrimp traditional, extensive, semi-intensive and intensive methods. Culture of mud crab and fattening. Origin and history of prawn culture in Bangladesh, Design, Operation and Management of prawn hatchery, prawn monoculture, carp-prawn polyculture, rice-prawn sub-system.	5
MIDTERM EXAMINATION – I		
4.	Molluscan farming: Life cycle Pila, culture of Pila, green mussel, oyster	3

	and clams.	
5.	Finfish farming: Biology, Hatchery Design, Seed Production and Hatchery Technique, Culture of Seabass, lizaparsia and spotted grouper.	4
6.	Culture of live food: Culture of algae, rotifers and brine shrimp.	4
7.	Mangrove fisheries: introduction, classification, mangrove ecosystem, thesundorban mangrove, coastal aquaculture and sundorban.	4
MIDTERM EXAMINATION – II		
8.	Impacts of coastal aquaculture and Sundarban: Impact of shrimp farming on coastal environment and socio-economics of Bangladesh.	5
		Total= 30

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance.

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

- know the present status of brackish water aquaculture and mariculture of the world; scope, socio-economic importance of coastal aquaculture in Bangladesh
- understand various farming systems as well as the construction of coastal fish farm; Know about Cage, Pen and raft culture
- demonstrate cultivation of shrimp species and Crab fattening
- culture marine finfishes (seabass, seabream and yellowtail, etc.), algae, rotifers, brine shrimp (*Artemia*), Diatom, Copepods,*Cylops*, *Daphnia* and *Moina*
- Improve knowledge about mangrove ecosystem, energy flow in mangrove swamp, impact of deforestation; present prospect of fish and shellfish culture in mangrove areas
- assess impact of coastal aquaculture on environment, waste water discharge, its quality and quantity; impacts of effluents on ecosystems, chemical degradation of soil and water.

Type of Assessment	**Marks**
FORMATIVE	
In-Course Exam	12.5
Attendance	2.5
SUMMATIVE	
Final Examination	35

Reading Materials:

1. P. Kungvankij, L.B. Tiro, Jr., B.J. Pudadera, Jr., and I.O. Potesta. 1985. Biology and Culture of Sea Bass (Latescalcarifer). NETWORK OF AQUACULTURE CENTRES IN ASIA.

2. P.Kungvankij, L.B. Tiro, Jr., B.J. Pudadera, Jr., I.O. Potestas, K.G. Corre, E. Borlongan, G.A. Talean, L.F. Bustilo, E.T. Tech, A. Unggui, T.E. Chua. 1985. Shrimp Hatchery Design, Operation and Management. NETWORK OF AQUACULTURE CENTRES IN ASIA.
3. P. Kungvankij, T.E. ChuaB.J.,Pudadera, L.B. Tiro, Jr., G. Corre, I.O. Potestas, E. Borlongan, G. A. Taleon, Alava and J. N. Paw. 1986. SHRIMP CULTURE: POND DESIGN,OPERATION AND MANAGEMENT. Training Manual Series No.2.
4. Patrick Lavens and Patrick Sorgeloos. 1996. Manual on the Production and Use of Live Food for Aquaculture. FAO FISHERIES TECHNICAL PAPER 361.
5. FAO. 2003. Farming freshwater prawns A manual for the culture of the giant river prawn (Macrobrachiumrosenbergii). FAO FISHERIES TECHNICAL PAPER 428.
6. Jerry, Dean R. 2014. *Biology and Culture of Asian SeabassLatescalcarifer.* CRC Press, Boca Raton, FL, USA.

Santhanam R., Ramanathan N. and Jogathoesan G. 1990. Coastal Aquaculture in India. CBS Publishers & Distributors.

Seventh Semester

Course Number and Title: OCN 401: Global Climate Change
Credit Hours: 3

Introduction to the Course:

Climate change is the biggest challenge of our time, and climate science is critical to finding solutions. How can we make the best decisions about our present and future? By taking this course, students can be part of the global conversation. This course will enable students to understand the Earth's changing climate, and its consequences, a scientific challenge of enormous importance to society. This course will also give the knowledge to practice communicating about climate change.

Specific Objectives:

- Understand the key scientific concepts of global climate change.
- Explain the major symptoms of global climate change.
- Analyze the causes of climate change and see how human activities affect the climate.
- Show the consequences of global climate change for ecosystems and human society.
- Recognize the moral principles, goals, and virtues needed for making sound policy and lifestyle responses to global climate change.
- Describe why and how the challenge of global climate change is raising spiritual questions.
- Plan and execute an environmental action that addresses climate change in their community.
- Investigate a case study that illustrates the impact of climate change on a community of our human population.

Course Content:

SL.	Topics	No. of Lectures
1.	Introduction: Climate and Climate Change. Overview of global climate change issues; plus, a look at the science	2
2.	Role of the Sun on Climate	3
3.	Paleoclimatology, Past Climates and Classification Schemes	2
4.	Climate Regulators and Feedback Loops	3
MIDTERM EXAMINATION – I		
5.	Observations of Climate Change. What causes climate to change? How does the climate system respond to input?	4
6.	Impacts of Climate Change. What are the potential consequences, risks,	3

	and uncertainties of climate change?	
7.	Climate Change and Extreme Weather Events. Hot politics.	5
8.	Climate Modeling and Future Scenarios	3
MIDTERM EXAMINATION - II		
9.	Vulnerability and Adaptation. Cool farming.	3
10.	Energy Sources and the Energy in Things.	5
11.	Mitigating Climate Change.	4
12.	Panels, protocols and the 5th IPCC Report	3
MIDTERM EXAMINATION – III		
13.	Societal Impacts and Communicating Climate Change	3
14.	Sustainability Initiatives and Career Considerations Staying "Climate Smart ".	2
		Total= 45

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance.

Learning Outcomes:

After studying this course, students will be able to:

- Explain that patterns of global warming in the past century can only be reproduced by considering both natural and human influences on climate
- describe the relationship between the geological and climatic development of the Earth
- explain the basic physical principles of the global climate system
- give an account of natural climatic and environmental changes which have occurred over different time scales
- describe current energy politics and energy systems related to climate change
- account for the effect of climate change on society and how society works with the effects of climate change and climate adaptation

Assesment:

Type of Assessment	**Marks**
FORMATIVE	
In-Course Exam	25
Attendance	5
SUMMATIVE	
Final Examination	70

Reading Materials:

1. Global Climate Change, Turning Knowledge into Action by David Kitchen
2. Climate change: The Science of Global Warming and our Energy Future by Edmond Mathez, Columbia University Press, 2009; ISBN: 0231146426.
3. Climate Change: Picturing the Science by Gavin Schmidt, Joshus Wolfe, and Jeffery D. Sachs, W.W. Norton & Company, 2009; ISBN: 0393331253.
4. Big Coal: The Dirty Secret Behind America's Energy Future by Jeff Goodell, Houghton Mifflin Company, April 2007
5. The Prize: The Epic Quest for Oil, Money, and Power by Daniel Yergin, Simon & Schuster, 1993
6. Cape Wind: Money, Celebrity, Class, Politics, and the Battle for Our Energy Future on Nantucket Sound by Wendy Williams and Robert Whitcomb, Public Affairs, 2007.
7. Climate Change 2007: The Physical Science Basis: Summary for Policymakers [Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (This Summary for Policymakers was formally approved at the 10th Session of Working Group I of the IPCC, Paris, February 2007.)], (Geneva, Switzerland, IPCC, 2 February 2007).
8. Hell and High Water: The Global Warming Solution (New York, Harper Perennial, 2008)
9. Avoiding Dangerous Climate Change (Cambridge, Cambridge University Press, 2006).
10. The Discovery of Global Warming (Cambridge, Harvard University Press, 2003).

Course Number and Title: OCN402: Coastal Zone Management
Credit Hours: 2

Introduction to the Course:
This course will teach students about the need for Coastal Zone Management and how to implement this CZM. This will involve application of skills in reconciling conflicting demands arising from different stakeholder groups and their needs and demands in the coastal zone.

Specific Objectives:
The objectives of the course is to provide advanced knowledge in coastal zone management by developing understanding of how the coast works, (physio-chemical processes) what ecosystems occur there, and how humans interact with these. The threats and opportunities related to human occupation of and utilization of the coast are studied and the options for managing/regulating these interactions are assessed.

Course Content:

SL.	Topics	No. of Lectures
1.	Concept and characteristics of coast, Resources of coast: eco-sensitive areas (ESAs) of coast	3
2.	**Coastal physical process:** Coastal morpho dynamics, natural behavior of coastal area, important physical aspects, observed on the coasts which are vital for a correct coastal zone management.	2
3.	**Institutions and organizations in coastal zone:** Stakeholders of coastal resources, role of civil society and stakeholder participation in coastal zone management. Role of IGOs, NGOs and GOs in coastal zone management of Bangladesh	5
	MIDTERM EXAMINATION – I	
4.	**Vulnerability in coastal zone:** Coastal vulnerability; Ballast water problem and impacts of alien species in coastal ecosystem. Coral reefs ecosystems and problems. Vulnerability assessment and fishermen welfare; Types of coastal hazard; Global-scale vulnerability assessment, Risk assessment and management; Decision making based on outputs from vulnerability and risk assessments.	5
5.	Coastal Biodiversity	2
6.	Coastal Resource Economics	2
7.	Coastal Engineering	2
8.	Coastal Hazards: types, causes and consequences	2
9.	Coastal management: hard engineering and soft engineering techniques	2
	MIDTERM EXAMINATION – II	
10.	Coastal Environmental Impact Assessment: Global and Bangladesh context	2
11.	**Integrated coastal zone management (ICZM):** Concept of EEZ. Method,	3

	principles, policy and planning for sustainable development. Legislations for dispute settlement in coastal zone. History, objectives, goals and important articles of United Nations Convention on Law of the Sea (UNCLOS). EEZ (exclusive economic zone) of Bay of Bengal. Concept of ICZM. Evaluation of integrated Coastal Zone Management (ICZM) in Bangladesh and other countries; Issues and challenges and conflict of managements of coastal zone and deep sea.	
		Total= 30

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance.

Learning Outcomes:

Students will gain an understanding of:

1. The unique management demands of the coastal zone as the interface between land and sea
2. The vulnerability of the coastal zone to human activities
3. Principles and techniques used to identify conflicting needs associated with the coast
4. The complex linkages between cause and effect when dealing with coastal problems
5. Methods to identify priority action areas to address coastal problems

Assesment:

Type of Assessment	Marks
FORMATIVE	
In-Course Exam	12.5
Attendance	2.5
SUMMATIVE	
Final Examination	35

Reading Materials:

1. Coastal Zones and Estuaries
   Editors: Federico Ignacio Isla, and Oscar Iribarne,
   eISBN: 978-1-84826-016-0, ISBN: 978-1-84826-466-3
2. Volume 1: Land Cover, Land Use and the Global Change
   eISBN: 978-1-84826-235-5, ISBN: 978-1-84826-685-8
3. Volume 2: Land Evaluation
   eISBN: 978-1-84826-236-2, ISBN: 978-1-84826-686-5
4. Volume 3: Land Use Planning
   eISBN: 978-1-84826-237-9, ISBN: 978-1-84826-687-2
5. Volume 4: Land Use Management and Case Studies
   eISBN: 978-1-84826-238-6, ISBN: 978-1-84826-688-

Course Number and Title: OCN 403: Coastal and Marine Pollution
Credit Hours: 3

Introduction to the Course:

The course provides the students an overview of various topics relevant to the pollution of the marine and coastal environment by different polluting agents. Based on this knowledge the students will be able to trace and evaluate possible disturbances of the biogeochemical cycles caused by human activities in the coastal zone.

Specific Objectives:

Objective of the course is to inform the students about the methodologies and techniques used for the assessment/evaluation of marine pollution, and in general to be well informed on the major environmental issues that threaten marine and coastal areas. In parallel the course will provide to student's knowledge of the various policies, laws and regulations developed for the protection and/or conservation of the "good environmental status" of the marine environment.

Course Content:

SL.	Topics	No. of Lectures
1.	**Introduction to aquatic pollution: g**eneral introduction to aquatic pollution; introduction to toxicants - metals, pesticides, POPs, lethal and sub-lethal effects of pollutants.	10
	MIDTERM EXAMINATION – I	
2.	**Sources and types of coastal and marine pollution: p**oint &non-point source of pollution including sewage, industrial effluents, oil, agricultural runoff, radioactive and hazardous waste, substances, thermal pollution, desalination plants, cooling plantsetc. Types of pollutants including Organochlorine Pesticides, Organophosphorus Pesticides, Heavy Metals, Persistent Organic Pollutants (POPs), DDT, PCBs, HCH, HCB, Dirty Dozens, Pthalates, Endocrine Disrupting Chemicals (EDCs), Polycyclic Aromatic Hydrocarbons (PAHs), Petroleum, Oils, Hydrocarbons, Chlorinated Diberizofurans, Dioxin, MBT and TBT.	10
3.	**Mechanism of toxicity by pollutants in coastal and marine biota and ecosystems:** Fate of wastes and pollutants. Routes of various pollutants circulation in aquatic ecosystems and possible mechanisms of its toxic action on living organisms. Fate and transport, bioavailability, and modifying factors of water pollutants.	5
	MIDTERM EXAMINATION - II	
4.	**Effects of pollution on coastal and marine systems:** Principles and methods for the study of toxicity effects. Acute and chronic toxicity, lethal and sub-lethal responses. Static Bioassays, Flow through technique, LC50, LD50, Acute and long-term toxicity. Bioaccumulation, Bioconcentration Factor (BCT). Effects of pollutants on biotic	15

	community, mutagenicity, genotoxicity. Chromosomal aberration, apoptosis, commet assay, micronucleus assay, imposex, safe level of pesticides for water, sediment and aquatic animal especially fish. Toxicological case studies. Genetic damage and molecular response to pollution, Molecular process and physiological response to pollution, Public health effects; Effects of bioaccumulation in fish, shellfish and other aquatic organisms.	
MIDTERM EXAMINATION – III		
5.	**Pollution management:** Monitoring of aquatic pollution, different monitoring programs, Pollution Prevention and control, indicator species and their role. Marine Pollution monitoring and assessment, Management of Marine Pollution. Aquatic pollution regulations and their implications for coastal and marine sector.	5
		Total= 45

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance.

Learning Outcomes:

- Be familiar with the basic sources and sinks of chemicals, their distributions and their variability in the oceanic system
- Demonstrate fluency to read, analyses and synthesize marine pollution literature
- Know the basic techniques and practices for the monitoring of pollution in the coastal marine environment
- Apply methodologies and techniques to assess/evaluate marine and coastal pollution
- Know the various policies, laws and regulations relevant to the protection and/or conservation of "good environmental status" of marine waters

Assesment:

Type of Assessment	**Marks**
FORMATIVE	
In-Course Exam	25
Attendance	5
SUMMATIVE	
Final Examination	70

Reading Materials:

1. R. B. Clark (2001) Marine Pollution, Oxford University Press, NY.
2. D. W. Hawker (2009) Water Pollution Chemistry Lecture Notes.
3. P. D. Vowles and D.W. Hawker (2009) Water Pollution Chemistry Laboratory and Workshop Manual.
4. Connell, D.W. (1997) Basic Concepts of Environmental Chemistry, Lewis Publishers, Boca Raton, Fl.

5. David J. Hoffman, Barnett A. Rattner, G. Allen Burton Jr., and John Cairns Jr. (2002) Handbook of Ecotoxicology, Second Edition.
6. Environmental Toxicology. 2002. D.A. Wright and P. Welbourn. Cambridge University Press, New York, NY.
7. Fundamentals of Ecotoxicology, 2nd Edn. 2003. M.C. Newman & M.A. Unger, Lewis Publishers, Florida.

Course Number and Title: OCN 404: Marine Spatial Planning & Ocean Governance
Credit hours: 2

Introduction to the Course:

The Marine Spatial Planning & Ocean Governance course introduces ocean-interested early career professionals to ocean policy and governance, and how science influences public policy decisions at the international, national, and state levels. Participants learn about pressing challenges to ocean health, and together with leaders in ocean science and policy, examine how scientists (e.g., social, economic, natural) and researchers can do work within the policy-making process to address these challenges.

Specific Objectives:

Provide insight into the structure and practice of ocean governance in the Bangladesh at multiple scales. Explain best practices in ocean governance and policy, and how science and application of these practices have trended over time. Introduce the basics of environmental law and policy, discussing how it is or may be relevant to students' current and future work.

Course Content:

SL.	Topics	No. of Lectures
1.	Nature and History of Ocean Governance	3
2.	Principles and Concepts of Sustainable Ocean Governance, Integrated Coastal Zone Management, Ecosystem Based Management and Zoning, Precautionary and Polluter Pays Principles	7
	MIDTERM EXAMINATION – I	
3.	Marine Spatial Planning (MSP) System as a tool for Sustainable Ocean Governance	4
4.	MSP and Various Uses and Interests Relating to the Ocean Environment	2
5.	MSP in Transboundary Context	2
6.	Principles of Maritime Delimitation	2
7.	Control of Marine Pollution, Land Based Sources of Marine Pollution, Vessel Based Sources of Marine Pollution, Dumping and Other Sources of Marine Pollution	5

MIDTERM EXAMINATION – II		
8.	Conservation of Marine Biodiversity	2
9.	Marine Scientific Research	3
		Total= 30

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance.

Learning Outcomes:

After studying these course students will learn Conserve and sustainably use the oceans, seas and marine resources for sustainable development, Peaceful societies for sustainable development, access to justice for all, effective, accountable and inclusive institutions at all levels and integrated maritime policy.

Assesment:

Type of Assessment	Marks
FORMATIVE	
In-Course Exam	12.5
Attendance	2.5
SUMMATIVE	
Final Examination	35

Reading Materials:

1. Daud Hassan, Tuomas Kuokkanen and Niko Soininen (eds) *Transboundary Marine Spatial Planning and International Law* (Routledge Publishing, UK, 2015).
2. Daud Hassan, *Protecting the Marine Environment from Land Based Sources of Pollution: Towards and Effective International Cooperation* (Ashgate Publishing Ltd, UK, 2006).
3. Butler William E. (ed), *The World Ocean: international Legal Regime* (Eleven International Publishing, 2010)

Course Number and Title: OCN405: Coastal Landscape and GIS
Credit Hours: 3

Introductionto the Course:
The course has been introduced to give students more detailed idea about coastal landscapes and teach them the use of GIS in relevant field. Geological Oceanography and Satellite Oceanography courses are the pre-requirements of this course.

Specific Objectives:
1. To know about different coastal zones.
2. To have idea about coastal resources and their use.
3. To know about different processes working on the coasts and the consequences resulting from this process.
4. To know details about coastal pollutions
5. To have a basic idea about Geographic Information System (GIS)

Course Content:

SL.	Topics	No. of Lectures
1.	Concept of coast and coastal zone: beach, surf zone, off shore, coastal water, estuaries, wet lands, lagoons	3
2.	Coastal resources: distribution, status and importance of coastal resources to environment	3
3.	Coastal Eco-Sensitive Areas: dunes, mangrove forests, coral reefs, sea grass, fisheries	3
4.	Importance of coastal habitats	1
MIDTERM EXAMINATION – I		
5.	Wave dynamics-wave theory, wave energy, and wave decay	2
6.	Coastal process: erosion and deposition; features,	2
7.	Coastal pollution, Coastal land use, Coastal Engineering	2
8.	Coastal Hazards: types, causes and consequences, Concept of management and planning	3
9.	Coastal management: hard engineering and soft engineering techniques	2
10.	Coastal Environmental Impact Assessment: Global and Bangladesh context	2
11.	Coastal zone management: method, principles, policy and planning for sustainable development	2
MIDTERM EXAMINATION - II		
12.	Policy, legislation and organizations pertaining to coastal resource conservation and management	3
13.	Integrated Coastal Zone Management: Background of ICZM in Bangladesh	2
14.	An introduction to Regional Landscape Planning, Sustainable Tourism, Marine Sanctuaries	3

15.	Coastal Development and Facility Design, Site Inventory and Analysis Techniques	2
16.	Regional climate, geology, hydrology and land use, coastal processes and landforms, land use conflicts and management challenges	2
17.	Marine Planning and Conservation, Marine Architecture site construction details: marinas, docks, anchorage, Geoarchaeology and Site Formation Processes	3
MIDTERM EXAMINATION – III		
18.	Remote Sensing and GIS Methods, Nature of Geographic Information, GIS/GPS systems applied to insular environments, GIS Mapping and Data Collection via GPS, creating layers, Regional Map Development	5
		Total= 45

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance.

Learning Outcomes:

1. Understand coastal landscapes and able to make plan for sustainable coastal land use management.
2. Aware of sources of coastal pollution and able to identify the sources and take necessary steps to minimize the pollution.
3. Understand the characteristics of different coastal hazards and able to take necessary steps to minimize the loss.
4. Able to solve different types of problems using GIS in coastal area.

Assesment:

Type of Assessment	**Marks**
FORMATIVE	
In-Course Exam	25
Attendance	5
SUMMATIVE	
Final Examination	70

Reading Materials:

1. Aberg, A., and C. Lewis, eds. (2000). *The Rising Tide: Archaeology and Coastal Landscapes* (Oxford: Oxbow).
2. Beatley, Timothy, David Brower, and Anna Schwab. 2002. *An Introduction to Coastal Zone Management*. Island Press
3. Bernhardson, T., 1999, *Geographic Information Systems: An Introduction*, New York: John Wiley & Sons.
4. Bonham-Carter, G.F., 1994, *Geographic Information Systems for Geoscientists: Modelling with GIS*, New York, Pergamon.
5. Burrough, P.A. and McDonnell, R.A., 1998, Principles of Geographical Information Systems, Oxford Unviersity Press

6. Clarke, K.C., 2003, Getting Started with Geographic Information Systems (4th Edition), Prentice Hall
7. Viders, Hillary. 1995. *Marine Conservation for the 21st Century*. Best Publishing: Flagstaff, Arizona
8. Whelan, Tenise. 1991. *Nature Tourism, Managing for the Environment*. Covelo, California: Island Press
9. Wouk. Herman. 1965. *Don't Stop the Carnival*. Garden City, N.Y.: Doubleday

Course Number and Title: OCN406: Coastal and Offshore Structures
Credit hours: 3

Introduction to the Course:
The course is based on developing an understanding of the theory and application of waves, tides and sediment transport and their application in the nearshore coastal zone. Other topics include nearshore processes, statistical modelling of return periods, offshore outfalls, beach protection, wave generation, harbor design, and coastal management.

Specific Objectives:
The course objective at acquainting the student of construction engineering to the knowledge of fundamental and methods of designing coastal protection structures and shoreline facilities. Further the course introduces the students to the principles of coastal zone management and construction aspects of major structures.

Course Content:

SL.	Topics	No. of Lectures
1.	Introduction, Definition and catalog of marine structures, Design criteria and methods of marine structure. General requirement for the design of marine structure.	7
2.	Material for marine structure (steel; concrete, rock and sand)	3
	MIDTERM EXAMINATION – I	
3.	The topics covered in the unit include wave mechanics, wave forecasts, wave forces on offshore and coastal structures, structural responses to wave loading, near shore hydrodynamic processes, dynamics of sediment transports, and the design of coastal and offshore structures such as breakwaters, platforms and pipelines.	7
4.	Sea Wall Design	2
5.	Wave Breaking	2
6.	Wave Run-up	2
7.	Vertical Walls	2
	MIDTERM EXAMINATION - II	
8.	Rubble Mound Structures	3
9.	Rock armour Layers	2
10.	Run-up	2
11.	Overtopping	2
12.	Structural Aspects	2
13.	Wave Loading on Cylinders	2
14.	The Morison Regime	2
	MIDTERM EXAMINATION – III	
15.	The Diffraction Regime	2

16.	Vortex Shedding	1
17.	Trends of research in marine structure	2
		Total= 45

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance.

Learning Outcomes:

- Be familiar with key coastal processes affecting the design of coastal structures;
- Be aware of the types and breadth of coastal structures in use;
- Have hands-on experience of key input parameters, application of prediction tools, and understand levels of confidence for their calculations;
- Understand the significance of different sources of guidance, including recent research results;
- Be able to devise alternative solutions with confidence by understanding key coastal process, and by their experience of the main prediction methods.

Assesment:

Type of Assessment	**Marks**
FORMATIVE	
In-Course Exam	25
Attendance	5
SUMMATIVE	
Final Examination	70

Reading Materials:

1. Ships and Offshore Structures (Vol. 1 – 2), Editors: JeomKee Paik, eISBN: 978-1-78021-008-7, 978-1-78021-009-4, ISBN: 978-1-78021-508-2, 978-1-78021-509-9
2. Geophysics and Geochemistry (Vols. 1-3), Editor: Jan Lastovicka, Institute of Atmospheric Physics, Academy of Sciences of the Czech Republic, Czech Republic. eISBN: 978-1-84826-245-4, 978-1-84826-246-1, 978-1-84826-247-8, ISBN: 978-1-84826-636-0, 978-1-84826-656-8, 978-1-84826-662-9
3. Oceanography (Vols. 1-3), Editors: Jacques C.J. Nihoul,Chen-Tung Arthur Chen, eISBN: 978-1-90583-962-9, 978-1-90583-963-6, 978-1-90583-964-3 ISBN: 978-1-84826-962-0, 978-1-84826-963-7, 978-1-84826-964-4
4. Civil Engineering (Vols. 1-2), Editors: Kiyoshi Horikawa,QizhongGuo, eISBN: 978-1-905839-73-5, 978-1-905839-74-2 ISBN: 978-1-84826-973-6, 978-1-84826-974-3
5. Structural Engineering and Structural Mechanics, Editor: Xila S. Liu,
6. Structural, Geotechnical and Earthquake Engineering (Vols. 1-2), Editor: Sashi K. Kunnath, eISBN: 978-1-78021-016-2,978-1-78021-017-9

ISBN: 978-1-78021-516-7,978-1-78021-517-4

7. Hydraulic Structures, Equipment and Water Data Acquisition Systems (Vols. 1-4) Editors: Jan Malan Jordaan,Alexander Bell,
eISBN: 978-1-84826-049-8, 978-1-84826-050-4,978-1-84826-051-1, 978-1-84826-192-1
ISBN: 978-1-84826-499-1, 978-1-84826-500-4,978-1-84826-501-1, 978-1-84826-642-1

8. Water Resources Management (Vols. 1-2), Editors: Hubert H.G. Savenije and Arjen Y. Hoekstra,eISBN: 978-1-84826-177-8, 978-1-84826-224-9, ISBN: 978-1-84826-627-8, 978-1-84826-674-2

9. Water Resources Management (Vols. 1-2), Editors: Hubert H.G. Savenije and Arjen Y. Hoekstra,eISBN: 978-1-84826-177-8, 978-1-84826-224-9, ISBN: 978-1-84826-627-8, 978-1-84826-674-2

Course Number and Title: OCN – 407 Statistical Techniques for Oceanographer
Credit hours: 3

Introduction to the Course:
A course dealing with statistical concepts including measures of central tendency and dispersion, probability distributions, the Central Limit Theorem, Sampling, Estimation, Hypothesis testing, Analysis of Variance, Correlation and Regression analysis, Multiple Regression and Statistical Forecasting.

Specific Objectives:
Students can identify the population of interest, parameter, sample and statistics from a study. Distinguish between an observational study and an experiment. Decide what graphs are appropriate for displaying quantitative and categorical variables. Identify shape of a distribution of data – right skew, left skew, or symmetric) when presented with a histogram. From a numerical description of a variable, predict what shape the histogram would most likely take. Explain how mean and median are related for different distribution shapes (right skew, left skew, and symmetric). Understand difference between subjective, relative frequency, and classical probabilities and be able to identify which approach was used to assign a probability in a given scenario. Identify from a probability scenario events that are simple, complementary, mutually exclusive, and independent. Explain the difference between events that are mutually exclusive and independent.

Course Content:

SL.	Topics	No. of Lectures
1.	Definition, scope and importance of statistics in oceanography.	3
2.	Presentation of data: Introduction	2
3.	Types of data, tabulation of data, frequency and frequency distribution, construction of frequency distribution table.	5
MIDTERM EXAMINATION – I		
4.	Graphical Representation: Introduction of graph, types of graphs.	2
5.	Measures of Central Tendency.	2
6.	Measures of Dispersion, Different types of dispersion.	2
7.	Moments, Skewness and Kurtosis.	2
8.	Correlation and Regression.	1
9.	Correlation: Coefficient of correlation, Different types of correlation, Simple correlation, Rank correlation, Coefficient of determination.	3
10.	Regression: Regression coefficient, Simple regression, Multiple regression, Polynomial Regression.	3
MIDTERM EXAMINATION - II		
11.	Probability Distribution	1
12.	Basic concept of probability, Related mathematics, Elementary Probability and Conditional probability.	4
13.	Probability distribution, Random variable & Expected value.	3

14.	Properties, constants and significance of Binomial distribution, Poisson distribution, Exponential distribution and Normal distribution. Experimental designs: CRD, CRBD, Latin square and split plot designs.	5
15.	Data Transformations	2
MIDTERM EXAMINATION – III		
16.	Test statistics: a) T-tests: One Sample Hypothesis, two and paired sample hypotheses, b) ANOVA (multiple sample hypothesis) - single factor ANOVA, two factor ANOVA, Nonparametric ANOVA.	3
17.	Multiple Comparisons: The Tukey Test, DMRT, Newman-Keuls test.	2
		Total= 45

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance.

Learning Outcomes: How to calculate and apply measures of location and measures of dispersion -- grouped and ungrouped data cases. How to apply discrete and continuous probability distributions to various ocean related problems. Compute and interpret the results of Bivariate and Multivariate Regression and Correlation Analysis, for forecasting and also perform ANOVA and T-test. Further, understand both the meaning and applicability of a dummy variable and the assumptions which underline a regression model. Be able to perform a multiple regression using computer software. Perform Test of Hypothesis as well as calculate confidence interval for a population parameter for single sample and two sample cases.

Assesment:

Type of Assessment	**Marks**
FORMATIVE	
In-Course Exam	25
Attendance	5
SUMMATIVE	
Final Examination	70

Reading Materials:

1. Hoshmand, R.A. 1994. Experimental research design and analysis A practical approach for Agricultural and natural Sciences. CRC press.
2. Zar, J.H. 1984. Biostatistical Analysis. 4th Edition. Prentice-Hall INC.
3. Dytham, C. 1999. Choosing and using Statistics: A Biologist's Guide. Blackwell.

Eighth Semester

Course Number and Title: OCN 411: Mathematical Modeling in Oceanography
Credit hours: 3

Introduction to the Course:
This course is an introductory course on Mathematical Modelling. It is designed for students studying mathematical sciences (i.e., Mathematics and Oceanography). It may, however, be useful to students in sciences, oceanography and other related fields. It introduces students to basic concepts in mathematical modelling.

Specific Objectives: The objectives of this course are to: Enable students understand how mathematical models are formulated, solved , and interpreted. Make students appreciate the power and limitations of mathematics in solving practical real-life problems. Equip students with the basic mathematical modelling skills.

Course Contents:

SL.	Topics	No. of Lectures
1.	Chapter 1: Oceanography 1.1: Introduction 1.2: Topography 1.3: The Parameters of state of sea water 1.4: The Equation of state of sea water	6
2.	1.5: The Representation of the process of mixing on the temperature salinity (TS) diagram 1.6: T-S curve of the waters of the oceans 1.7: The line integral in the T-S plain	4
MIDTERM EXAMINATION – I		
3.	Chapter 2: Hydrodynamic Equations of the sea 2.1: The Momentum Equation 2.2: Gravitational Forces 2.3: The Continuity Equation 2.4: Effects of Spin 2.5: The Coriolis force and Tidal Force 2.6: Total Potential Caused by the Gravity 2.7: Internal Forces in a Viscous Fluid (p-115, Introduction to physical oceanography, stewart) 2.8: The Salinity Equation 2.9: Wave Dynamics	15
MIDTERM EXAMINATION - II		
4.	Chapter 3: Numerical Simulation of a Large-Scale Atmospheric and Oceanic Circulation 3.1: Introduction 3.2: A Large-Scale Dynamics of the Atmosphere and Ocean	9

	3.3: Integral Laws of Conservation 3.4: The Symmetrized Form of the Equations of the Atmosphere Dynamics and the Evolutionary Formulation of the Problem in the Ocean Dynamics	
5.	Chapter 4: Material in Sea Water 4.2: The Major Constituents 4.3: The Dissolved Gases 4.4: The Nutrients 4.5: The Trace Elements 4.6: Salinity Variations	6
MIDTERM EXAMINATION – III		
6.	Chapter 5: Mathematical Model for Evaluating the Mass of Mangrove Forest along Coast Line of Indus Delta 5.1: Introduction 5.2: Mathematical Modeling 5.3: Results and Discussion	5
		Total= 45

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance.

Learning Outcomes:
Understand what a mathematical model is and explain the series of steps involved in a mathematical modelling process. State and explain the different classifications of mathematical models stating examples in each classes. Explain the essential features of a good model and discuss the benefits of using a mathematical model. Identify some simple real-life problems that can be solved using mathematical models, model the problem(s), solve the resulting problem, and interpret the solution. Mention and discuss some applications of mathematical modelling in solving problems in physical, biological, chemical and geological sciences. Acquire basic mathematical modelling skills that will enable them carry out simple modelling tasks individually or as a group.

Assesment:

Type of Assessment	**Marks**
FORMATIVE	
In-Course Exam	25
Attendance	5
SUMMATIVE	
Final Examination	70

Reading Materials:

1. Modeling Methods for Marine Science by David M. Glover, William J. Jenkins, Scott C. Doney
2. The Equations of Oceanic Motions by Müller, Peter
3. Dynamics and Modelling of Ocean Waves by G. J. Komen, L. Cavaleri, M. Donelan, K. Hasselmann, S. Hasselmann, P. A. E. M. Janssen
4. An Introduction to the Chemistry of the Sea by Pilson, M.E.Q. Prentice Hall, Ne\N, Jersey. USA, *1998.*

5. Mathematical Models (Vols. 1-3)
   Editor: Jerzy A. Filar,
   Jacek B. Krawczyk,
   eISBN: 978-1-84826-242-3, 978-1-84826-243-0, 978-1-84826-244-7
   ISBN: 978-1-84826-695-7, 978-1-84826-696-4, 978-1-84826-697-1
6. Computational Models (Vols. 1-2)
   Editors: Vladimir V. Shaidurov,
   Olivier Pironneau,
   eISBN: 978-1-84826-035-1, 978-1-84826-036-8
   ISBN: 978-1-84826-485-4, 978-1-84826-486-1

Course Number and Title: OCN 412: Paleontology & Paleo-Oceanography
Credit hours: 3

Introduction to the Course:
With this course plan, students will get to learn about paleontology as a science. They will discuss the history, objectives, and challenges of paleontology, and construct past history of oceanography through studying paleontology.

Specific Objectives:
1. Define the goals of paleontology as a science 2. Explain the methods and challenges of paleontology 3. Think critically about the analysis of paleontological evidence 4. Learn the use of paleontology in paleo-oceanography.

Course Content:

SL.	Topics	No. of Lectures
1.	**Invertebrate Paleontology:** Introduction; Scope; Comprehensive study of Morphology, Classification, Taxonomy, Ecology, Distribution, and Evolutionary History of the following phyla and classes: (a) Phylum-Mollusca (Classes-Pelecypoda, Gastropoda, Cephalopoda); (b) Phylum-Brachipoda (Class-Articulata); (c) Phylum-Coelenterata (Class-Anthozoa); (d) Phylum-Arthropoda (Class-Trilobita). Stratigraphic and Spatial Distribution of Fossils; Role, Significance and importance of fossils in Stratigraphic Correlation and in Palaeogeography.	10
MIDTERM EXAMINATION – I		
2.	**Vertebrate Paleontology** Introduction and Scope; Classification and Morphology of Vertebrate Fauna; Study of some Geologically important classes such as Agnatha, Placodermi, Sharks, Bony Fishes, Amphibians, Reptiles, and Mammals. Evolutionary history of Dinosaur, Horse, Elephant and Man.	15
MIDTERM EXAMINATION - II		
3.	**Micropaleontology** Introduction and Scope, History of Micropaleontology and its significance; Methods of collection of samples, separation and study of microfossils; Study of Morphology and classification, evolution, ecology and stratigraphic importance of some Common Animal and Plant Microfossils Study of some important Animal Microfossils (Microfauna) such as Foraminifera, Ostracoda, Radiolaria. Microfossils of 'unknown affinities'; Discoastereriod; Hystrachospherids; Chitinozon;	15
MIDTERM EXAMINATION – III		
4.	Microfossils (Microflora) such as Diatoms, Coccoliths, Charophyts, Dinoflagellates, palynology, Importance of Micropalaeotology in	5

	Hydrocarbon Exploration.	
		Total= 45

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance.

Learning Outcomes: 1. Students will acquire an understanding of the discipline of paleontology. 2. Students will acquire an understanding of the concept of natural selection. 3. Students will become familiar with the methods and techniques used in the study of fossils. 4. Students will become familiar with the evolutionary history, morphology, and classification of the major invertebrate fossil taxa. 5. Students will become familiar with the evolutionary history, morphology, and classification of the major vertebrate fossil taxa. 6. Students will become familiar with the evolutionary history, morphology, and classification of the major plant fossil taxa.

Assesment:

Type of Assessment	**Marks**
FORMATIVE	
In-Course Exam	25
Attendance	5
SUMMATIVE	
Final Examination	70

Reading Materials:

1. Ager, D.V. Principles of Paleoecology
2. Brasier, M.D. Microfossils
3. Cushman, J.A. Foraminifera
4. Markhovan, F.P. C.M.V. Post Paleozoic Ostracods (Vol 1 & 2)
5. Pokomy, V. Principles of Zoological Micropaleontology (Vol 1 & 2)
6. Bignott. Elements of Micropaleontology
7. Colbert, E.W. Evolution of Vertebrates
8. Laporte, L.F. Evolution and the Fossil Record
9. Moore, R.C. et al. Invertebrate Fossils
10. Romer, A.S. Vertebrate Paleontology
11. Shrock, R.R. &Twenhofel, W.H. Principles of Invertebrate Paleontology
12. Wood, H. Paleontology

Course Number and Title: OCN 413: Evolution and Earth's Biosphere
Credit hours: 2

Introduction to the Course:
The biosphere contains all the planet's living things. This sphere includes all of the microorganisms, plants, and animals of Earth. This course will introduce students to the evolution of earth's biosphere.

Specific Objectives:
1. Understand the concept of the biosphere and the current relationship between the physical and biological environments
2. Describe the parallel history of geological and biological evolution of planet Earth
3. Identify some of the effects of human impacts on biodiversity and ecosystem function, the complex ecological responses to these and the means of assessing and mitigating such responses
4. Recognize how oceanographers can contribute to the management, regulation and protection of the environment as well as in education and research

Course Content:

SL.	Topics	No. of Lectures
1.	**Uniqueness of habitable Earth**: Distance from sun, presence on the surface of liquid water, segregation of the earth into core, mantle, crust, ocean, atmosphere, tectonic activity, the preservation of the atmosphere.	3
2.	**Origin of Life**: Prokaryotes and eukaryotes. Theories about the origin of life. Evidence for life on the early earth, and evidence for atmospheric modification by simple life forms.	4
3	**Origin of complex life**: Evolution of eukaryotes and metazoans. Relationship between evolution, radiation and the earth's atmosphere.	3
	MIDTERM EXAMINATION – I	
4.	**The Cambrian Explosion**: Rise of predation, skeletons, major biological processes, diversification and evolution.	2
5.	**The invasion of the land**: Implications for atmospheric composition and the Carbon Cycle. Major faunal innovation - faunas which have sequentially dominated the earth over the last 550 million years	3
6.	**Dinosaurs:** Dominance era, variations & adaptations. A global environmental process. Background and mass extinctions.	3
7.	**Rise of mammals**: Terrestrial ecosystems and implications for Si and C cycles.	2
8.	**Biosphere**s, the process, types and distribution of life. Animal distributions in earth surfaces; Zoogeographical regions; Island fauna; issues of global climate changes and its impacts on life.	3

9.	**Impact of life on the planet**: Gaia hypothesis, atmospheric control, the impact of biota on physical weathering, biota as a flux and sink for important chemical compounds.	2
MIDTERM EXAMINATION – II		
10.	**Glaciations and timescales of climatic change:** The Climate System; structure, composition and circulation of the atmosphere and of the ocean.	2
11.	**Glacial-interglacial cycles and millennial timescale climate variability** Cooling from the Cretaceous into the modern 'icehouse'; glacial-interglacial cycles of the past 2 million years and the role of orbital forcing; millennial timescale variability during the last glacial-interglacial cycle; climate of the Holocene.	3
		Total= 30

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance.

Learning Outcomes:

- Appreciate the importance of the biosphere in the Earth System
- Explain a range of feedbacks between the biosphere and other components of the Earth system
- Analyse cause and effect in atmosphere-biosphere interactions
- Evaluate the role of atmosphere-biosphere interactions in the climate system
- Explain the role of carbon dioxide and photosynthesis in biosphere-atmosphere interactions

Assesment:

Type of Assessment	**Marks**
FORMATIVE	
In-Course Exam	12.5
Attendance	2.5
SUMMATIVE	
Final Examination	35

Reading Materials:

1. Begon, M, Harper JL and Townsend CR. 1999. Ecology.
2. Darlington. PE. 1957. Zoogeography
3. Donald Prothero and Robert Dott Jr. 2009. Evolution of the Earth.
4. Odum E.P. 1973. Fundamentals of Ecology (2007 reprints)

Course Number and Title: OCN414: Law of the Sea and Maritime Boundary
Credit hours: 3

Introduction to the Course:
To familiarize with the main thematic/sectoral issues in the law of the sea over the last half century, e.g. some or all of fisheries, deep seabed mining and maritime boundary delimitation.

Specific Objectives:
The objective of the course is to give a broad overview of the law on maritime boundary delimitations, such as the cardinal principles applicable to the law on maritime boundary delimitation, the principal relevant circumstances, and the role of international court and tribunals in the development of the law on maritime boundary delimitations.

Course Content:

SL.	Topics	No. of Lectures
1.	Evolution/ Historical Development of Law of the Sea.	5
2.	Maritime Zones: Rights and obligations under international law.	5
	MIDTERM EXAMINATION – I	
3.	Baseline: Legal Requirements and International Practices. Case Study: Analysis of Bangladesh's baseline	5
4.	Maritime Boundary: Delimitation and Delineation. Practical: Methods and application of relevant factors	3
5.	Maritime Resources: living and non-living	2
6.	Continental Shelf and Deep Sea-bed -- Legal Regime Practical: Modus Operandi of the UN for delineation of UNCLOS Art 76 continental shelf	5
	MIDTERM EXAMINATION - II	
7.	Dispute Resolution Case Study: Bangladesh	5
8.	Joint Development Practical: Hypothetical Project Work	5
9.	Marine Environment	5
	MIDTERM EXAMINATION – III	
10.	Marine Scientific Research and Transfer of Technology.	5
		Total= 45

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance.

Learning Outcomes:
Demonstrate a comprehensive understanding of the main principles of Law of the Sea and its sources. Understand the legal framework provided by UNCLOS regarding the maritime zones. Examine the relevant provisions on baselines and its importance. Understand the concept of equitable division of maritime spaces. Discuss dispute resolution scenarios among coastal States including their causes and consequences. Understand the role of

international courts and jurisdictions on the development of maritime boundary delimitation law.

Assesment:

Type of Assessment	**Marks**
FORMATIVE	
In-Course Exam	25
Attendance	5
SUMMATIVE	
Final Examination	70

Reading Materials:

1. UNCLOS 1982

Course Number and Title: OCN 415: Marine Biodiversity and Conservation
Credit hours: 3

Introduction to the Course:
This course will provide students an understanding of marine biodiversity and importance of its conservation. They will also learn how marine biodiversity is threatened and what can be done to protect it.

Specific Objectives:
1. To help students develop an understanding of the major issues in marine biodiversity research and its conservation 2. To show students how biodiversity is measured and what are the major patterns of diversity 3. To develop an understanding of the terms structural and functional biodiversity and the relationship between the two 4. To discuss and debate issue concerning conservation of marine biodiversity

Course Content:

SL.	Topics	No. of Lectures
1.	**Biodiversity:** Basic concepts, importance and conservation needs. Species diversity, Biological and phylogenetic species concept. Basic concepts of speciation, species extinction. Concept of genetic diversity, gene and germ-plasm banks.	10
	MIDTERM EXAMINATION – I	
5.	**Introduction to classification of marine animals of Bangladesh**: Principles of classification and nomenclature of marine plants and animals. Diversity of marine Mollusca, crustaceans, fishes, birds, reptile and mammals. Marine animal food and fisheries. Economic importance of marine wild life.	5
6.	**Biodiversity assays**: Assessment of biodiversity. Various species diversity indices and theoretical interpretations.	3
7.	**Biodiversity conventions**: International and national efforts to conserve biodiversity (Kyoto protocol, Ramseur convention, CBD, NBCF, etc.), Socio-cultural aspects of biodiversity. Biotechnological needs for biodiversity conservation. Traditional knowledge and biodiversity conservation. Concepts of Marine protected areas. Ecological critical area and coastal and marine protected areas, Wild life sanctuaries, National Parks and Biosphere Reserve.	7
	MIDTERM EXAMINATION - II	
12.	**Protecting biodiversity**: Factors for decline of biological diversity. Ecotourism and its impact. Approaches for conservation of biological diversity. Concept of threatened species. Threatened and endangered coastal and marine animals of Bangladesh. IUCN red listing. Protection of wild flora, fauna and natural habitats of coastal and marine Bangladesh.	10
13.	**Conservation**: Principles of conservation biology, *Ex situ* and In situ methods of conservation, Genetical and evolutionary principles in	5

	conservation.	
MIDTERM EXAMINATION – III		
18.	**Bangladesh Hot spots**: The Sundarbans reserve forest, NijhomDwip and Saint Martin's Island ecosystem and biodiversity.	5
		Total= 45

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance.

Learning Outcomes:
1. Describe the development of ideas on what is meant by the term marine biodiversity and conservation 2. Should know how marine biodiversity is measured and over different scales 3. Be familiar with the major patterns of marine biodiversity 4. Understand the factors which control patterns of marine biodiversity such as geological and evolutionary history 5. Understand the difference between species-accumulation and species area relationships 6. Gain an understanding of the key conservation issues for marine biodiversity 7. To increase presentation and scientific debating skills related to issues concerning marine biodiversity and conservation.

Assesment:

Type of Assessment	**Marks**
FORMATIVE	
In-Course Exam	25
Attendance	5
SUMMATIVE	
Final Examination	70

Reading Materials:

1. Anne Elizabeth Maczulak 2020. Biodiversity: Conserving Endangered Species

2. IUCN 2010. Red Data Book

3. MacClaurin J and Sterelny 2008. What is Biodiversity?National Academy Press. 1988.

4. Biodiversity: Structure and Function (Vols. 1-2). Editors: Wilhelm Barthlott, Rheinische Friedrich-WilhelmsK. Eduard Linsenmair, Stefan Porembski,
   eISBN: 978-1-905839-34-6, 978-1-905839-35-3
   ISBN: 978-1-84826-934-7, 978-1-84826-935-4
5. Biodiversity Conservation and Habitat Management (Vols. 1-2)
   Editors: Francesca Gherardi, Claudia Corti, and Manuela Gualtieri,
   eISBN: 978-1-905839-20-9, 978-1-905839-21-6
   ISBN: 978-1-84826-920-0, 978-1-84826-921-7

Course Number and Title: OCN 416: Research Methodology
Credit Hours: 3

Introduction to the Course:

This course provides students with an introduction to quantitative and qualitative research methods. The course provides a foundation for further learning in specific research methods. It is primarily designed for BS final year students of oceanography so that they could apply this knowledge in the upcoming higher-level research.

Specific Objectives:

At the end of this course, the students should be able to:

1. Understand some basic concepts of research and its methodologies
2. Identify appropriate research topics
3. Select and define appropriate research problem and parameters
4. Prepare a project proposal (to undertake a project)
5. Organize and conduct research (advanced project) in a more appropriate manner
6. Write a research report and thesis
7. Write a research proposal

Course Content:

SL.	Topics	No. of Lectures
1.	Introduction: Definition, objectives, significance and types of research	3
2.	The research process: an eight-step model	3
3.	Reviewing the literature	2
4.	Formulating a research problem	2
MIDTERM EXAMINATION – I		
5.	Identifying variables	2
6.	Constructing hypothesis	2
7.	Research design: definition, concept of research design, function of a research design, types of study designs, experimental research designs CRD, RCBD and Latin square design, selecting a study design.	8
8.	Measurement and Scaling: classifications of measurement scales, scaling, basis of classification and scaling techniques.	3
MIDTERM EXAMINATION - II		
12.	Methods of data collection: introduction, experiments and surveys, structured and semi-structured surveys, development of questionnaire, collection of primary data, collection of secondary data, case study method.	6
13.	Sampling: introduction, concept of sampling, principles of sampling, types of sampling, survey versus census.	3

14.	Social and participatory methods: PRA/PLA, Matrices, group methods, surveys and interviews, visualizing and diagramming, temporal methods, spatial methods.	3
15.	Writing a research proposal: Introduction, Materials and Methods, Review of literatures, Work plan and activity chart, financial summary.	3
MIDTERM EXAMINATION – III		
18.	Writing a research report: thesis, scientific papers, booklet and leaflet.	5
		Total= 45

Instructional Strategies: Lecture, Discussion, Question-Answer, Class Performance.

Learning Outcomes:

By the end of the module, students will be able to: -

- Describe a range of quantitative and qualitative research designs used in research and identify the advantages and disadvantages associated with these designs.
- Choose appropriate quantitative or qualitative method.
- Write a research proposal suitable for submission to a research funding body.
- Students will be familiar with ethical issues in educational research, including those issues that arise in using quantitative and qualitative research.
- Students will know the primary characteristics of quantitative research and qualitative research

Assesment:

Type of Assessment	**Marks**
FORMATIVE	
In-Course Exam	25
Attendance	5
SUMMATIVE	
Final Examination	70

Reading Materials:

1. Day, Robert A. 1995. How to write and publish a scientific paper. Cambridge University Press. 4th Edition.
2. Huda, Enamul. 1999. People's participation in development Application of PRA/PLA and training (in Bangla).
3. Kothari, CR and Garg, G. 2015.Research methodology methods and techniques. New age International (P) Limited, New Delhi, India.
4. Kumar, Ranjit. 2014. Research methodology. Pearson, India.
5. Niogy, MozammelHaque and Babul, Mahmud Hasan. 2004. PRA/PLA Theory and application (in Bangla). Saki Publications club.
6. Participatory Methods in Community-based Coastal Resource management. Volume 2 Tools and methods. 1998. IIRR.