

**INSTITUTE OF MARINE SCIENCES**  
**Faculty of Marine Sciences and Fisheries**  
 University of Chittagong, Chattogram 4331

**Syllabus for the B.Sc. (Honours) in Marine Science**

Academic Year: 2023—2024 & 2024—2025

Total Marks: 4000, Total Credits: 160

**NOTES:**

Grading of courses, GPA calculations, promotion to the next higher classes at the end of the 1st, 2nd and 3rd year examinations, pass/fail at the end of 4-year program, improvements, and all relevant matters will be governed by the clauses laid out in the respective ordinance.

**Year-wise distribution of marks** (figures within parenthesis indicate credit)

Year	Theory	Practical	Sessional	Viva-voce	Term paper	Total
First	550 (22)	250(10)	50 (2)	50 (2)	-	900 (36)
Second	625 (25)	225 (09)	50 (2)	50 (2)	-	950 (38)
Third	650 (26)	250 (10)	50 (2)	50 (2)	-	1000 (40)
Fourth	700 (28)	250 (10)	50 (2)	50 (2)	100 (4)	1150 (46)
<b>Total</b>	<b>2525 (101)</b>	<b>975 (39)</b>	<b>200 (8)</b>	<b>200 (8)</b>	<b>100 (4)</b>	<b>4000(160)</b>

**Year-wise distribution of courses**

FIRST YEAR			
Course#	Course title	Marks	Credits
<b>Theoretical</b>			
MS-101	Marine and Estuarine Ecology	75	3
MS-103	Marine Microbiology	50	2
MS-105	Planktology	75	3
MS-107	Biochemistry and Physiology of Marine Organisms	75	3
MS-109	Marine Invertebrates	75	3
MS-111	Ichthyology and Systematics	75	3
MS-113	Coastal and Marine Botany	75	3
MS-115	Communicative English	50	2
<b>Subtotal</b>		<b>550</b>	<b>22</b>
<b>Practical</b>			
MS-102	Marine and Estuarine Ecology Practical	25	1
MS-104	Marine Microbiology Practical	25	1
MS-106	Planktology Practical	25	1
MS-108	Biochemistry and Physiology of Marine Organisms Practical	50	2
MS-110	Marine Invertebrates Practical	50	2
MS-112	Ichthyology and Systematics Practical	50	2
MS-114	Coastal and Marine Botany Practical	25	1
<b>Subtotal</b>		<b>250</b>	<b>10</b>
Sessional		50	2
<i>Tutorial</i>		15	
<i>Collection &amp; Slides</i>		10	
<i>Practical Notebook</i>		10	
<i>Excursion/Field report</i>		15	
Viva-voce		50	2
<b>Total</b>		<b>900</b>	<b>36</b>

SECOND YEAR			
Course#	Course title	Marks	Credits
<b>Theoretical</b>			
MS-201	Physical Oceanography	100	4
MS-203	Chemical Oceanography	75	3
MS-205	Biodiversity and Conservation	50	2
MS-207	Hydrography and Navigation	75	3
MS-209	Aquaculture	100	4
MS-211	Aquaculture Planning and Engineering	50	2
MS-213	Seafood Processing Technology	75	3
MS-215	Mathematics	100	4
<b>Subtotal</b>		<b>625</b>	<b>25</b>
<b>Practical</b>			
MS-202	Physical Oceanography Practical	50	2
MS-204	Chemical Oceanography Practical	25	1
MS-206	Biodiversity and Conservation Practical	25	1
MS-208	Hydrography and Navigation Practical	25	1
MS-210	Aquaculture Practical	50	2
MS-212	Aquaculture Planning and Engineering Practical	25	1
MS-214	Seafood Processing Technology Practical	25	1
<b>Subtotal</b>		<b>225</b>	<b>9</b>

Sessional	50	2
<i>Tutorial</i>	15	
<i>Collection &amp; Slides</i>	10	
<i>Practical Notebook</i>	10	
<i>Excursion/Field report</i>	15	
Viva-voce	50	2
<b>Total</b>	<b>950</b>	<b>38</b>

### THIRD YEAR

Course#	Course title	Marks	Credits
<b>Theoretical</b>			
MS-301	Statistics	100	4
MS-303	Geological Oceanography	75	3
MS-305	Marine Pollution	75	3
MS-307	Remote Sensing	50	2
MS-309	Geographic Information Systems	50	2
MS-311	Integrated Coastal Zone Management	100	4
MS-313	Fluid Dynamics and Sediment Transport	75	3
MS-315	Wetland and Lake Management	50	2
MS-317	Marine Affairs	75	3
	<b>Subtotal</b>	<b>650</b>	<b>26</b>
<b>Practical</b>			
MS-302	Statistics Practical	50	2
MS-304	Geological Oceanography Practical	25	1
MS-306	Marine Pollution Practical	25	1
MS-308	Remote Sensing Practical	25	1
MS-310	Geographic Information Systems Practical	25	1
MS-312	Integrated Coastal Zone Management Practical	50	2
MS-314	Fluid Dynamics and Sediment Transport Practical	25	1
MS-316	Wetland and Lake Management Practical	25	1
	<b>Subtotal</b>	<b>250</b>	<b>10</b>
Sessional	50	2	
<i>Tutorial</i>	15		
<i>Collection &amp; Slides</i>	10		
<i>Practical Notebook</i>	10		
<i>Excursion/Field report</i>	15		
Viva-voce	50	2	
<b>Total</b>	<b>1000</b>	<b>40</b>	

### FOURTH YEAR

Course#	Course title	Marks	Credits
<b>Theoretical</b>			
MS-401	Meteorology and Ocean Forecasting	75	3
MS-403	Mangroves Ecosystem and Management	75	3
MS-405	Fisheries Resources Assessment and Management	75	3
MS-407	Fish and Shellfish Health Management	75	3
MS-409	Fish and Shellfish Nutrition	75	3
MS-411	Fish Breeding and Genetics	75	3
MS-413	Environmental Impact Assessment and Management	75	3
MS-415	Fish Pharmacology	75	3
MS-417	Research Methodology	100	4
	<b>Subtotal</b>	<b>700</b>	<b>28</b>
<b>Practical</b>			
MS-402	Meteorology and Ocean Forecasting Practical	25	1
MS-404	Mangroves Ecosystem and Management Practical	25	1
MS-406	Fisheries Resources Assessment and Management Practical	25	1
MS-408	Fish and Shellfish Health Management Practical	25	1
MS-410	Fish and Shellfish Nutrition Practical	25	1
MS-412	Fish Breeding and Genetics Practical	25	1
MS-414	Environmental Impact Assessment and Management Practical	25	1
MS-416	Fish Pharmacology Practical	25	1
MS-418	Research Methodology Practical	50	2
	<b>Subtotal</b>	<b>250</b>	<b>10</b>
MS-499	Research Project	100	4
Sessional	50	2	
<i>Tutorial</i>	15		
<i>Practical Notebook</i>	10		
<i>Internship</i>	25		
Viva-voce	50	2	
<b>Total</b>	<b>1150</b>	<b>46</b>	
<b>GRAND TOTAL</b>		<b>4000</b>	<b>160</b>

## DETAILED SYLLABUS

FIRST YEAR			
Course#	Course title	Marks	Credits
<b>Theoretical</b>			
MS-101	Marine and Estuarine Ecology	75	3
MS-103	Marine Microbiology	50	2
MS-105	Planktology	75	3
MS-107	Biochemistry and Physiology of Marine Organisms	75	3
MS-109	Marine Invertebrates	75	3
MS-111	Ichthyology and Systematics	75	3
MS-113	Coastal and Marine Botany	75	3
MS-115	Communicative English	50	2
<b>Subtotal</b>		<b>550</b>	<b>22</b>
<b>Practical</b>			
MS-102	Marine and Estuarine Ecology Practical	25	1
MS-104	Marine Microbiology Practical	25	1
MS-106	Planktology Practical	25	1
MS-108	Biochemistry and Physiology of Marine Organisms Practical	50	2
MS-110	Marine Invertebrates Practical	50	2
MS-112	Ichthyology and Systematics Practical	50	2
MS-114	Coastal and Marine Botany Practical	25	1
<b>Subtotal</b>		<b>250</b>	<b>10</b>
Sessional		50	2
Tutorial		15	
Collection & Slides		10	
Practical Notebook		10	
Excursion/Field report		15	
Viva-voce		50	2
<b>Total</b>		<b>900</b>	<b>36</b>
<b>MS-101</b>		<b>MARINE AND ESTUARINE ECOLOGY</b>	
		<b>75(3)</b>	

### Rationale

Marine and Estuarine ecology is the study of the relationship of marine and estuarine organisms to their environment and the effect of these relationships to their distribution and abundance. This course is designed to provide basic understanding of ecology and ecosystem concepts, focusing on the salt-water and brackish water ecosystems. Target students do not need any special background preparation other than higher secondary level science courses.

### Objectives

This course is intended to provide the student with a general understanding of the ecological processes that determine the structure and dynamics of populations and communities in marine and estuarine ecosystems; and to teach them how to conduct ecological research to reveal such processes. Aspects of oceanography and sea water properties necessary to understand how marine creatures survive and reproduce will be introduced first. Next, we will discuss physiological function and reproduction. We will introduce the organisms living in open waters and then we will cover coastal marine habitats. Significance will be a synthesis of how the overall ocean influences the diversity of marine life.

### Learning outcomes

Having successfully completed this module, students will be able to:

- Understand ecology and ecosystem concepts
- Recognize major salt-water ecosystems, their characteristics, and biological communities
- Understand the interactions of the living organisms with their habitats and physical-chemical factors
- Prepare for more in-depth courses, e.g. Chemical oceanography, Marine microbiology, Planktology, and Biological oceanography

### **Course contents**

1. Fundamental concepts and definitions: Ecology, Marine ecology, Ecosystem, Biotic & Abiotic components of an ecosystem, Trophic levels
2. Marine ecosystem:
  - 2.1 Overview of the marine environment: oceans and salt-water lakes, dimensions and distribution, importance of the marine ecosystems
  - 2.2 Zonation of the marine environment: Benthic and Aquatic (pelagic) compartments
3. Estuarine ecosystem: definition, classification/types and distribution
4. Abiotic factors/variables in the marine environment:
  - 4.1 Physical processes and forces: Wave, Tide, Current, Pressure, Light
  - 4.2 Chemical factors: Salinity, Dissolved Oxygen, pH, Nutrients
5. Biological communities
  - 5.1 Primary producers: Major groups and types, Occurrence, and Production mechanism of (i) Phytoplankton, (ii) Macrophytes (Algae, Seagrass, Mangrove), and (iii) Chemosynthetic microorganisms.
  - 5.2 Consumers: Major groups and types, Occurrence, and Food sources of (i) Zooplankton, (ii) Sessile animals, and (iii) Larger animals.
  - 5.3 Decomposers: types, occurrence, and decomposition mechanism & its significance.
  - 5.4 Trophic levels, Food cycle and food web, Nutrient recycling
  - 5.5 Adaptation of marine plants and animals to (i) Salinity in general, (ii) Low light, high pressure and food shortage in the deep sea, (iii) Wave action, Tidal variation and Substrate types in intertidal areas (rocky, sandy and muddy), (iv) Flootation of pelagic and swimming animals
6. Special marine ecosystems: Occurrence & geographic distribution, Salient features, Biological communities of (i) Intertidal area, (ii) Coral reef, (iii) Mangrove, (iv) Sea-grass beds and salt-marshes
7. Natural and anthropogenic threats to marine ecosystem, and its protection/conservation

### **Recommended books**

1. Mitra A, Zaman S. 2016. Basics of Marine and Estuarine Ecology, Springer India. 481p.
2. Speight M, Henderson P. 2010. Marine Ecology: Concepts and Applications, 3rd edition, Wiley-Blackwell. 276p.

- Barnes RSK, Hughes RN. 1999. An Introduction to Marine Ecology, 3rd edition, Willey-Blackwell Publishing. 286p.
- Tait RV, Dipper FA. 1998. Elements of Marine Ecology, Butterworth-Heinemann. 462p.

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<b>MS-102</b>	<b>MARINE AND ESTUARINE ECOLOGY PRACTICAL</b>	<b>25(1)</b>
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- Preparation of Model showing zonation of the sea
- Museum study of marine organisms
- Laboratory practices in determination of various ecological parameters
- Determination of DO consumption of selected aquatic species
- Qualitative ecological study of selected aquatic species
- Collection and identification of marine fauna from muddy, sandy and rocky shores
- Study of ecological parameters in the marine environment.

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<b>MS-103</b>	<b>MARINE MICROBIOLOGY</b>	<b>50(2)</b>
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Rationale

Marine microbiology is an exciting and fast-moving field of Marine Science. It is now more important than ever as a means to realize the importance of marine microorganisms in global biogeochemical cycling, marine food webs, biotechnology, interactions with other marine life, and as agents of diseases. Application of this knowledge has profound implications for human welfare and the future health of our biosphere.

Objectives

The objective of this module is to provide an introduction to the identification, biology and ecology of marine microbes (bacteria, viruses, fungi), and their function and importance in marine environments.

Learning outcomes

Having successfully completed this module, students will be able to:

- Acquire basic knowledge about microbes inhabiting marine environments, and their physiology, biology, activity, interactions and ecology
- Isolate, cultivate and identify microbes from marine environments
- Understand the microbiology of the deep sea and marine extreme environments
- Confident in applying the marine microbiology concepts to new areas

**Course contents**

- General concept and historical development of marine microbiology
- Morphology, structure and classification of microorganisms
- Marine microbial ecology
- Effects of the environment on microbes – temperature, pressure, salinity, radiation, moisture, hydrogen ion concentration, redox potential, gases
- Physiology of microorganisms
- Respiration, fermentation, product of enzymes, enzymatic reactions, staining properties of bacterial cell, bacterial spores, reproduction
- Microbial nutrition and growth – physical and chemical requirements, growth of bacterial cultures
- Microbial interaction with other organisms–symbiosis, poisoning, diseases
- Deep sea and hydrothermal vent microorganisms
- Marine viruses and their ecological effects
- Microbial transformations of matters in ocean and associated nutrient cycle, carbon cycle
- Microbial pollution of the environment
- Microbiological spoilage of fish and seafood products
- Economic importance of microorganisms

**Recommended books**

- Munn C. 2020. Marine Microbiology: Ecology and Applications, Taylor & Francis. 418 pp.
- Castro P, Huber M. 2019. Marine Biology, 11th edition, McGraw-Hill. 496p.
- Tortora GL, Funke BR, Case CL. 2018. Microbiology: An Introduction, 13th edition. 960p.
- Cappuccino JG, Welsh CT. 2017. Microbiology: A Laboratory Manual (global edition). 560p.
- Kirchman DL. 2008. Microbial Ecology of the Oceans, John Wiley & Sons. 593p.
- Austin B. 1988. Marine Microbiology, Cambridge University Press. 222p.

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<b>MS-104</b>	<b>MARINE MICROBIOLOGY PRACTICAL</b>	<b>25(1)</b>
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- Microscopy and bacterial staining
- Preparation of different types of culture media
- Techniques of isolation, culture and identification of microorganisms
- Qualitative and quantitative study of microorganisms from water, sediment, fisheries products
- Microbial growth study in relation to temperature, salinity, pH
- Biochemical activities of microorganisms

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<b>MS-105</b>	<b>PLANKTOLOGY</b>	<b>75 (3)</b>
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Rationale

Planktons are the diverse multitudes of living creatures drifting in the aquatic environment. Phytoplankton, through primary production, plays an essential role in food web dynamics and biogeochemical cycles across the oceans and other water bodies. On the other hand, zooplankton communities comprise countless tiny aquatic animals and their gametes, embryos, larvae, and juveniles. Both phytoplankton and zooplankton are also the largest suppliers of fossil fuels. Planktology, thereby, is one of the significant studies for understanding the fundamentals of food web systems, nutrient cycles, carbon sequestration, plankton-fisheries-human relationship, ocean health and productivity in world's aquatic ecosystems.

Objectives

This course aims to provide basic information on the planktonic realm of the aquatic environments along with the fundamental concept of ecological and economic roles of plankton. The objective of this course is to offer an introduction to the intricate trophic relationships among organisms, primary production, environmental drivers of planktonic distribution and their impacts in the oceans and other water bodies across the world.

#### Learning Outcomes

Upon completion of the course, students will be able to:

- Appreciate the significance of plankton
- Understand classification, morphology and physiology of plankton
- Comprehend the key factors governing temporal and spatial distribution of plankton
- Know about primary productivity and its measurements
- Understand plankton-fisheries-human relationship
- Conduct study through collection, preservation and identification of plankton
- Know about different culture techniques of commercially important plankton

#### **Course Contents**

1. Definition, classification and importance of plankton
2. Phytoplankton
  - 2.1 Definition, classification, morphology and physiology
  - 2.2 Factors affecting the growth, distribution and seasonal succession of phytoplankton
  - 2.3 Primary productivity and its measurements
  - 2.4 Factors affecting primary production of aquatic environment
  - 2.5 Seasonal and non-seasonal blooms, causes and impacts of harmful algal blooms
3. Zooplankton
  - 3.1 Definition and classification of zooplankton
  - 3.2 Factors affecting the growth, distribution and seasonal changes of zooplankton
  - 3.3 Geographical distribution of zooplankton
  - 3.4 Vertical distribution and migration of Zooplankton
  - 3.5 Food and feeding habit of zooplankton
4. Fish-plankton relationship
5. Plankton collecting methods, preservation techniques and equipments
6. Determination of plankton biomass, occurrence, abundance and distribution
7. Culture techniques of commercially important phytoplankton and zooplankton

#### **Recommended books**

1. Suthers IM, Rissik D, Richardson A. 2019. *Plankton: a guide to their ecology and monitoring for water quality*, 1st edition, CRC Press. 248p.
2. Castellani C, Edwards M. 2017. *Marine Plankton: A practical guide to ecology, methodology, and taxonomy*, Oxford University Press, Oxford. 704p.
3. Sardet C. 2015. *Plankton: Wonders of the Drifting World*, University of Chicago Press. 224p.
4. Sommer U. 1989. *Plankton Ecology: Succession in Plankton Communities*, Berlin: Springer-Verlag. 369p.
5. Raymount JEG. 1980. *Plankton and Productivity in the Oceans*, Pergamon Press. 496p.
6. Newell GE, Newell RC. 1977. *Marine Plankton: a Practical Guide*, 5th edition, London: Hutchinson & Co. Ltd. 207p.

<b>MS-106</b>	<b>PLANKTOLOGY PRACTICAL</b>	<b>25 (1)</b>
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1. Collection, preservation, identification and estimation of plankton
2. Laboratory culture of phytoplankton and zooplankton
3. Preparation of slides with plankton
4. Determination of aquatic primary productivity
5. Determination of zooplankton biomass
6. Salinity tolerance of plankton

<b>MS-107</b>	<b>BIOCHEMISTRY AND PHYSIOLOGY OF MARINE ORGANISMS</b>	<b>75(3)</b>
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#### Rationale

Study on Biochemistry and Physiology of Marine Organisms provides understanding of commercial marine fisheries resources in terms of biology, nutritional and aquaculture perspectives. Accurate information on the biochemical composition is essential for the preservation and processing of marine fisheries products.

#### Objectives

The objective of this course is to study marine commercial resource biochemistry, physiology and concepts of endocrinology which will provide valuable insights to inform marine resource conservation and management.

#### Learning outcomes

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

- Basic concepts of marine organisms' physiology, biochemistry and endocrinology
- Marine organisms' response mechanism in natural ecosystem
- Hormones and aquaculture

## Course Contents

1. Introduction to Biochemistry: Proteins; Amino acids; Fish proteins:: Fish lipids auto-oxidation, rancidity, anti-oxidants.
2. Enzymes: Classification; Factors influencing enzyme activity. Role of enzymes in metabolic activity.
3. Biological Oxidation: Metabolism of carbohydrates, proteins and lipids with reference to marine organisms.
4. Physiology of digestion.
5. Reproductive physiology: Spermatogenesis, oogenesis.
6. Maturation of the gonad in response to gonadotropin: Vitellogenesis, Oocyte maturation and Ovulation.
7. Respiration physiology: Structure and chemical composition of respiratory pigments, gas exchange concept.
8. Physiology of excretion: Excretion: Excretion in fish, Structure of kidney, Osmoregulation.
9. Neuro-secretions in finfishes and shellfish.
10. Moulting and growth in decapod crustaceans; regulating factors.
11. Neuro-hormones, endocrine glands and their functions in finfish and shellfish.

## Recommended books

1. Rodwell VW, Bender DA, Kennelly PJ, Botham KM, Weil PA. 2018. *Harper's Illustrated Biochemistry*, 31st Edition, McGraw-Hill Education. 382p.
2. Samantaray K. 2015. *Physiology o finfish and shellfish*, New India Publishing Agency.
3. Samantaray K. 2012. *Principles of biochemistry with special reference to fishes*, Narendra Publishing House.
4. Farrell A. 2011. *Encyclopedia of Fish Physiology: From Genome to Environment*, Academic Press. 2272p.
5. Val A, de Almeida e Val VMF, Randall D. 2005. *Fish Physiology: The Physiology of Tropical Fishes*, Academic Press. 400p.

MS-108	BIOCHEMISTRY AND PHYSIOLOGY OF MARINE ORGANISMS PRACTICAL	50(2)
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1. Oxygen consumption of any fish
2. Biochemical analysis of any marine fish: Protein, Fat, Ash/Minerals and Carbohydrate, Carbohydrate Content Analysis

MS-109	MARINE INVERTEBRATES	75(3)
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### Rationale

Marine invertebrates are one of the dominant groups of living communities, which can be classified under the major taxonomic groups of Porifera, Cnidaria, Mollusca, Arthropoda, Echinodermata, and many other minor phyla. The marine world is largely dominated by marine invertebrates and therefore there is great importance given to the process of dividing and classifying the millions of different species. This is done via the ever increasingly complex world of taxonomy. The practical knowledge and skills acquired by taking this course are relevant to many areas of employment such as invertebrate zoology, ecology, aquarium biology, conservation, environmental and resource management planning, biomedical research etc.

### Objectives

The key objective of the module is to introduce the students to the taxonomy, diversity, biology, ecology and the various aspects of the systematics, anatomy, physiology and adaptation of the major phyla of marine invertebrates to appreciate the diversity of body plans and the ecological roles these animals play in benthic and pelagic ecosystems of the coastal and marine environment.

### Learning outcomes

Upon successful completion, students will have the knowledge and skills to:

- Understand the use of classificatory schemes and taxonomic guides
- Recognize key marine invertebrate phyla from their external and internal morphologies and characteristic body plans
- Identify and name common marine invertebrates
- Understand the diversity of marine organisms
- Describe the life history and organ system of the major invertebrate phyla.
- Understand the functional biology of marine invertebrates and their contribution to ecological functioning of marine ecosystems
- Compare the interrelationship of invertebrate structure, function, physiology and ecology
- Choose and use literature and other resources to identify marine invertebrates
- Acquire field and laboratory-based practical skills: principally recording information in the form of annotated diagrams/photographs and use of both stereo and compound microscopes.
- Safety awareness and skills: principally, collection of field samples and handling of preserved material in a safe manner.

## Course Contents

1. Classification of marine invertebrates
  - 1.1 Identification
  - 1.2 Classification
  - 1.3 Taxonomy
2. Major Invertebrate Phyla
  - 2.1 Salient features
  - 2.2 External characteristics
  - 2.3 Internal characteristics
3. Anatomy of major marine invertebrates
  - 3.1 Protozoa
  - 3.2 Porifera
  - 3.3 Coelenterate
  - 3.4 Ctenophore
  - 3.5 Rotifer
  - 3.6 Annelida
  - 3.7 Mollusca
  - 3.8 Arthropoda
  - 3.9 Echinodermata
4. Marine invertebrates biology
  - 4.1 Digestive system
  - 4.2 Reproductive system
  - 4.3 Respiratory system
  - 4.4 Circulatory system

- 4.5 Excretory system
5. Tropical, Polar and deep-sea Invertebrates
6. Climate change and marine invertebrates
7. Invertebrates inventory in the Bay of Bengal
8. Distributional pattern of major phyla in the marine environment
9. Ecology of different marine invertebrates

#### Recommended books

1. Pechenik JA. 2015. *Biology of the Invertebrates*, McGraw-Hill Education. 625p.
2. Brusca RC. 2016. *Invertebrates*, Sinauer Associates. 1128p.
3. Kotpal RL. 2013. *Modern Textbook of Zoology: Invertebrates*, Rastogi Publications. 470p.
4. Ehrlich H. 2010. *Biological Materials of Marine Origin: Invertebrates*, Springer. 594p.
5. Moore J. 2006. *An Introduction to the Invertebrates*, Cambridge University Press. 339p.
6. Friese UE. 1996. *Marine Invertebrates*, TFH Publications. 240p.

MS-110	MARINE INVERTEBRATES PRACTICAL	50(2)
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1. Collection, preservation and identification of invertebrates
2. Study of external morphological features of microscopic marine invertebrates
3. study of external and internal anatomy of higher marine invertebrates
4. Museum study of marine invertebrates-corals, sea urchin, sea anemones, crustaceans, molluscs, polychaetes etc.

MS-111	ICHTHYOLOGY AND SYSTEMATICS	75(3)
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#### Rationale

Ichthyology, scientific study of fishes, including, as is usual with a science that is concerned with a large group of organisms, a number of specialized sub-disciplines: *e.g.*, taxonomy, anatomy, physiology, behavioral science, ecology, and evaluation. Application of these knowledge can help: (1) to find ways to improve fisheries or aquaculture; (2) to determine the effects of human activities on aquatic environments; and (3) to test ideas in rapidly developing fields, such as ecology, physiology, behavior, and evolution. Because of the great importance of fishes as human food, the study of ichthyology also has economic importance.

#### Objectives

The objective of this course is to provide an introduction to the anatomy, physiology, behavior, ecology, evolution, and taxonomy of fishes.

#### Learning outcomes

During the course, students will be able to:

- Know the ideas and principles underlying modern biological classification and its application to living fish groups
- Describe how the aquatic environment shapes all aspects of the biology of fish species
- Explain how anatomy relates to function across major organ systems in fishes
- Describe the basic function and organization of fish organ systems
- Know major features of existing fish diversity (e.g. number of species, main lineages), its evolution (e.g. timing), geographic distribution and classification
- Enhance skills at collecting and identifying local fish species

#### Course contents

##### Ichthyology

1. Introduction to Ichthyology, importance and methods of the study of fishes, opportunities of Ichthyology
2. Evolutionary history of fishes and other chordates
3. Classification of chordates with special reference to fishes
4. Habitat, movement, skeleton, skin, alimentary system, circulation, excretory system, nervous system, gonads & gonadal development etc of Ascidia, amphioxus, petromyzon
5. Geographical distribution of fishes
6. Organ systems of fish
  - 6.1 The skeleton: Notochord and vertebral column, Skull, Pectoral and Pelvic fins, Dermal skeleton, Teeth
  - 6.2 The Musculature: Somatic musculature, Visceral musculature
  - 6.3 The body cavity
  - 6.4 The digestive system: divisions of digestive tract, Large bladder, Webberain apparatus
  - 6.5 The Urogenital organs: Kidney, Gonads, Cloaca, Genital organs, Secondary sex-characters
  - 6.6 Circulatory system: Blood, Structure and function of the blood vessels, Blood vessels system, Blood purification
  - 6.7 Respiratory system: Gills, Accessory respiratory organs, Gas-exchange method
  - 6.8 Sensory organs
  - 6.9 Nervous system: central nervous, peripheral nervous system, cranial and bronchial nerves
  - 6.10 Integumentary system: skin, epidermis, dermis
7. Osmoregulation
8. Migration
9. Birds (gulls, pelicans, gannets, cormorants, albatross, petrels): Classification, distribution and economic importance.
10. Reptiles (turtles, snakes): Classification, distribution and economic importance.
11. Mammals (wheels, dolphins, porpoise, seal): Classification, distribution and economic importance.

##### Systematics

1. History, importance and scope of fisheries Systematics.
2. Taxonomic characters in fishes.
3. Collection and identification of fish.
4. Taxonomic keys.
5. Types, theories, categories and basis of classification.
6. Species concept and speciation.
7. Zoological nomenclature, synonyms, synonymy, law of priority, the type of method.
8. Origin and evolution of fishes.
9. Adaptive radiation in fishes.

10. Zoogeographical distribution of fishes.

**Recommended books**

1. Holyoak AR. 2013. *Ichthyology: A Laboratory Manual*, CreateSpace Independent Publishing Platform. 62p.
2. Helfman G, Collette BB, Facey DE, Bowen BW. 2009. *The Diversity of Fishes: Biology, Evolution, and Ecology*, Wiley-Blackwell. 737p.
3. Moyle PB, Cech JJ. 2004. *Fishes: An Introduction to Ichthyology*, 5th Edition, Pearson. 752p.
4. Kapoor BG, Khanna B. 2004. *Ichthyology Handbook*, Springer-Verlag Berlin. 1059p.
5. Lagler KF, Bardach JE, Miller RR, Passino DRM. 1977. *Ichthyology*, Wiley. 528p.

MS-112

ICHTHYOLOGY AND SYSTEMATICS PRACTICAL

50(2)

**Ichthyology**

1. Collection, preservation and identification of chordates
2. Study external and internal anatomy of chordates
3. Study of external morphology of fishes
4. Dissection and study of the basic organ systems of fish-skeletal alimentary, circulatory, nervous, respiratory excretory and reproductive system
5. Museum study of vertebrates-Reptiles, fishes and birds.

**Systematics**

1. Total, standard forked anal, fin lengths, eye diameter and their ratios; number of fin rays in different fins, fin ray/ Taxonomic formulae.
2. Identification of fishes using taxonomic key.
3. Development of taxonomic key.
4. Preparation of zoogeographical map and fish distribution.
5. Preparation of phylogenetic tree.

MS-113

COASTAL AND MARINE BOTANY

75(3)

**Rationale**

Coastal and marine flora are integral part of marine environment and have significant contribution in terms of ecosystem goods and services. Basic concept on the diversity, distribution and identification of major marine and estuarine plant communities such as algae, sea grass, salt marsh and mangroves is prerequisite for understanding their ecological roles and inter-relationships. There are ranges of man-made and natural threats for these ecosystems which are important to understand in their conservation management. Further, in Bangladesh, commercial culture of seaweeds and other marine plants need to be encouraged to maximize their direct and indirect uses and thus strengthen our national economy.

**Objectives**

To familiarize students with the diversity of marine and estuarine microalgae, macro-algae, submerged and emergent vascular plants with their distribution, classification, identification, and ecology. In addition, students will learn about the ecological roles of locally occurring marine and estuarine microalgae, macro-algae, submerged aquatic vegetation, and common marsh and dune angiosperms.

**Learning outcomes**

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

- Biology, diversity and evolution of coastal and marine plants
- Their distribution and ecology
- Seaweed flora and their habitat in St. Martin's island
- Role of algae and other plant communities in coastal and marine ecosystems
- Human impacts and commercial uses
- Practical skills in identifying common seaweeds and estuarine plants
- Practical skills in processing, preserving and culturing estuarine and marine plants
- Current research themes on coastal and marine botany

**Course contents**

1. Basic concepts and classification of marine flora (Thallophyta, Pteridophyta and Angiosperms).
2. Plant zonation in the coastal ecosystem
3. Algal communities
  - 3.1 Algal formation, types, physiology, distribution and ecology of marine algae (Green, Brown and Red algae)
  - 3.2 Importance and uses of marine algae
  - 3.3 Life cycle and reproduction of commercially important marine algae
  - 3.4 Culture of Sea weeds (*Gracilaria*, *Sargassum*, *Hypnea*, *Catenella*, *Enteromorpha*)
  - 3.5 Toxic algae and their impact.
  - 3.6 Marine seaweeds in the coastal water of Bangladesh
  - 3.7 St. Martin's Island
  - 3.8 Mangrove area
4. Seagrass communities
  - 4.1 Classification of seagrass, Morphology, Anatomy and physiology
  - 4.2 Adaptation and ecological roles
  - 4.3 Causes of seagrass losses
  - 4.4 Importance of seagrass.
5. Salt-marsh communities
  - 5.1 Definition of salt-march
  - 5.2 Adaptations (Morphological & Anatomical)
  - 5.3 Requirements for the development of salt-marsh
  - 5.4 Ecological roles
  - 5.5 Importance and uses of salt-marsh

6. Forest Ecosystem
  - 6.1 Inland forest: ecology, diversity and distribution
  - 6.2 Coastal forest: ecology, diversity and distribution of Mangroves
  - 6.3 Mangrove species and associates
  - 6.4 Physiology, adaptations, requirements of mangrove plants
  - 6.5 Role of mangrove ecosystem: goods and services
  - 6.6 Conservation challenges
  - 6.7 Terms in plant biodiversity: biodiversity index, species composition, species richness, species dominance, temporal and spatial distribution

#### Recommended books

1. Titlyanov EA, Titlyanova TV, Li X, Huang H. 2016. *Coral Reef Marine Plants of Hainan Island*, Academic Press. 254p.
2. Beer S, Björk M, Beardall J. 2014. *Photosynthesis in the Marine Environment*, Wiley.
3. Dawes CJ. 2008. *Marine Botany*, 2nd Edition, Wiley. 496p.
4. Dring MJ, 1991. *The Biology of Marine Plants*, Cambridge University Press. 208p.
5. Chapman VJ, Chapman DJ. 1980. *Seaweeds and their uses*, Chapman and Hall.
6. Islam AKMN. 1976. *Contribution to the study of the Marine Algae of Bangladesh*, Bibliotheca Phycologica Band.

<b>MS-114</b>	<b>COASTAL AND MARINE BOTANY PRACTICAL</b>	<b>25(1)</b>
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1. Identification and preservation of sea grass and marine seaweeds
2. Culture of marine seaweeds
3. Qualitative and quantitative analysis of marine flora

<b>MS-115</b>	<b>COMMUNICATIVE ENGLISH</b>	<b>50 (2)</b>
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#### Rationale

Communicative English is an approach and learning process to enhance communication skills in English, which is remarkably necessary in the realm of education, research, business and almost every aspect of human life. It provides the methodical development of essential aptitude in practical interactions and effective conversations for both the written and verbal communications.

#### Objectives

This course aims to offer learning from real life interactions, which facilitate the reinforcement of values and qualities of the respective studies. It imparts fundamental techniques of improving English linguistic skills and exploring the communicative approach effectively.

#### Learning outcomes

Upon completion of the course, students will be able to:

- Develop a spontaneous approach to English learning
- Strengthen the vocabulary or lexical range
- Explore the techniques of effective conversations
- Express ideas and information independently in verbal and written forms

#### **Course contents**

1. Functional Grammar
  - 1.1 Parts of Speech, Articles, Tense, voice, Narration, Appropriate preposition, Syntax and corrections
2. Developing Reading Skills
  - 2.1 Methods of developing reading skills
  - 2.2 Practicing reading comprehension using different reading selections from science, history, linguistics or other areas
  - 2.3 A training on summarizing and finding main points of text
3. Developing Writing Skills
  - 3.1 Writing free and guided composition
  - 3.2 Letter and essay writing
  - 3.3 Translation from Bangla to English and English to Bangla
  - 3.4 Use of countable and non-countable nouns
  - 3.5 Should/would/so/too, either/neither; real/unreal conditions, have/get, subjective, inclusive, problem verbs (rise, raise, lie, sit), gerunds, dangling participles, redundancy and parallel structure in formal written English
4. Developing Speaking Skills
  - 4.1 Practicing speaking English on the situation which may be encountered in everyday life and education

#### **Recommended books**

1. Chowdhury MYA, Hossain MM. *Advanced Learner's Functional English*.
2. Wren and Martin. *English Grammar & Composition*.
3. Ullah MK. *A Potential Communicative English Grammar & Composition*.

**SECOND YEAR**

Course#	Course title	Marks	Credits
<b>Theoretical</b>			
MS-201	Physical Oceanography	100	4
MS-203	Chemical Oceanography	75	3
MS-205	Biodiversity and Conservation	50	2
MS-207	Hydrography and Navigation	75	3
MS-209	Aquaculture	100	4
MS-211	Aquaculture Planning and Engineering	50	2
MS-213	Seafood Processing Technology	75	3
MS-215	Mathematics	100	4
<b>Subtotal</b>		<b>625</b>	<b>25</b>
<b>Practical</b>			
MS-202	Physical Oceanography Practical	50	2
MS-204	Chemical Oceanography Practical	25	1
MS-206	Biodiversity and Conservation Practical	25	1
MS-208	Hydrography and Navigation Practical	25	1
MS-210	Aquaculture Practical	50	2
MS-212	Aquaculture Planning and Engineering Practical	25	1
MS-214	Seafood Processing Technology Practical	25	1
<b>Subtotal</b>		<b>225</b>	<b>9</b>
Sessional		50	2
	<i>Tutorial</i>	15	
	<i>Collection &amp; Slides</i>	10	
	<i>Practical Notebook</i>	10	
	<i>Excursion/Field report</i>	15	
Viva-voce		50	2
<b>Total</b>		<b>950</b>	<b>38</b>

<b>MS-201</b>	<b>PHYSICAL OCEANOGRAPHY</b>	<b>100(4)</b>
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**Rationale**

At the core of marine science education lies solid understanding of the oceans and seas, and their various phenomena. Such understanding is essential for not only being able to comprehend physical, chemical, geological and biological processes and phenomena, but also for expanding knowledge on related aspects, such as marine environment or marine fisheries. Separate courses on physical oceanography, chemical oceanography, geological oceanography and biological oceanography are required.

**Objectives**

This course is designed to provide basic understanding of physical properties, forces, processes and dynamics in the ocean in a descriptive oceanography approach. Target students do not need any special background preparation other than higher secondary level science courses and basic math skills.

**Learning outcomes**

Upon completion of the course, students will be able to:

- Recognize in general the scope of ocean science and its different branches, and in particular of physical oceanography
- Understand fundamental physical properties, forces and phenomena in the ocean
- Appreciate the connections of physical ocean to climate systems, biological communities, and human societies
- Understand methods of oceanic measurement and monitoring
- Prepare for more advanced oceanography courses

**Course contents**

1. Basic concepts: Oceanography and Marine Science, branches of Oceanography, Physical Oceanography and its scope, brief history of Oceanography, general settings & dimensions in the ocean, space and timescales of physical oceanographic phenomena
2. Physical properties of seawater and typical distribution of water characteristics
  - 2.1 Molecular structure and unique characteristics of water, seawater vs. freshwater
  - 2.2 Pressure and depth in ocean
  - 2.3 Thermal properties of seawater: temperature, heat and potential temperature, freezing and sea ice
  - 2.4 Salinity and electrical conductivity
  - 2.5 Density; effects of temperature, salinity and pressure on density; stability, TS diagram
  - 2.6 Typical surface and vertical distribution of temperature, salinity, pressure in the ocean; thermocline, halocline, pycnocline, mixed layer; temporal variations
3. Sound and light: acoustic and optical properties of seawater; propagation, attenuation & extinction of sound & light in ocean; color of the sea; ocean-color measurement and optical oceanography; sound-pollution in the ocean
4. Conservation of volume and mass, salt and energy; budget and flux: heat budget, heat transport, buoyancy flux
5. Ocean Wave
  - 5.1 Types (classification) of waves
  - 5.2 Wave parameters, spectrum of surface waves, wave energy
  - 5.3 Wind generated waves, propagation of surface waves in shallow water
  - 5.4 Other waves: rogue wave, tsunami, storm surge, seiches, internal wave
6. Ocean currents
  - 6.1 Wind driven surface circulation or currents, global surface ocean currents
  - 6.2 Thermohaline circulation
  - 6.3 Vertical circulation: upwelling and sinking
  - 6.4 Other currents: rip current, tidal current, gyres and eddies
7. Astronomical Tides
  - 7.1 Causes of tide: gravitational potential of celestial bodies, atmospheric anomalies

- 7.2 Types of tides
- 7.3 Tidal datum: sea-levels, sea-level rise
- 8. Special topics: tropical cyclone, monsoon, ENSO, IOD
- 9. Observational methods in Oceanography
  - 9.1 Oceanographic instruments and platforms
  - 9.2 Data analytical methods, software tools

#### Recommended books

1. Talley LD, Pickard GL, Emery WJ, Swift JH. 2011. *Descriptive Physical Oceanography: an introduction*, 6th edition. Elsevier/Academic Press. 555p.
2. Garrison T. 2009. *Essentials of Oceanography*, 5th edition, Brookes/Cole. 434p.
3. Pinner PR. 2009. *Introduction to Oceanography*, 6th edition, Jones & Bartlett. 626p.
4. Reddy MPM. 2001. *Descriptive Physical Oceanography*, A.A. Balkema Publishers. 440p.

<b>MS-202</b>	<b>PHYSICAL OCEANOGRAPHY PRACTICAL</b>	<b>50(2)</b>
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1. Measurement of seawater properties: salinity, electrical conductivity (EC), density
2. Calculation of various water properties from known parameters: salinity, EC, density,  $\sigma_t$  and  $\sigma_{s,t,p}$ , sound velocity, pressure, depth, specific heat, adiabatic lapse rate, freezing point, potential temperature, potential density, temperature of maximum density etc.
3. Use of TS diagram to (i) derive salinity, density and temperature, (ii) to examine water masses and their mixing
4. Making profiles: temperature, salinity, density, electrical conductivity etc.
5. Interpretation of profiles and distribution maps: temperature, salinity, density, EC etc.
6. Problems relating to wave theory and wave parameters
7. Tide, tidal datum and sea-level

<b>MS-203</b>	<b>CHEMICAL OCEANOGRAPHY</b>	<b>75(3)</b>
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#### Rationale

The organic and inorganic chemistry of seawater and marine sediments cannot be isolated from the processes on atmosphere, biosphere and in the earth's crust beneath the ocean. In this sense Chemical Oceanography is the most interdisciplinary of all the sub-disciplines of ocean sciences which lead to the chemical oceanographers not only to understand the composition of seawater, its processes and cycles, and the chemical interaction of seawater with the atmosphere and sea floor but also enable to explore the effect of ocean on climate or to identify potentially beneficial ocean resources such as natural products that can be used as medicines.

#### Objectives

The major objectives of this course are to introduce the students to the fundamentals of chemical oceanography, principles and applications that ultimately train up the students with the opportunities to develop skill and undertake responsibilities for chemical oceanographic data parameter design, acquisition, processing and interpretation along with preparing themselves for advanced study in the respective field of arena.

#### Learning outcomes

Upon completion of the course, students will be able to:

- Gain a broad overview on central elements of chemical oceanography;
- Develop an understanding of the chemical properties of the marine environment such as salinity, dissolved gases and water molecules, and the effects related to these properties;
- Know about the chemical substances in the ocean and the processes that govern the distribution of chemical substances in the water column and the sediment;
- Familiar with the behaviour of dissolved gases in the ocean and their impact on ocean anoxia and carbonate chemistry;
- Aware of the biogeochemical cycles of the major nutrients within the oceans;
- Understand the theory and applications of the Chemical Oceanography method of marine exploration;
- Determine the Chemical Oceanography parameters appropriate for any specialized sea-borne exploration scheme;
- Undertake/supervise a Chemical Oceanography survey and make use of state-of-the-art equipment's appropriate for industrial operations;
- Undertake advance research studies in chemical oceanographic methodologies.

#### **Course Contents**

1. Chemistry of water and sea water
2. Major and minor elements in sea water
3. Composition of sea water
  - 3.1 Constancy of composition
  - 3.2 Factors influencing composition of sea water
4. Chemistry of air-sea interface
5. Trace elements and their biological roles.
6. Nutrients in the sea
  - 6.1 Nitrogen,
  - 6.2 Phosphorous and
  - 6.3 Silicon cycles
7. Dissolved gasses in sea water
8. The carbon dioxide & carbonates system
9. Solubility of salts in seawater
10. The oxidation-reduction potential of seawater. (pH, Eh, etc.)
11. Inorganic agencies effecting the composition of sea water
12. Biological and chemical aspects of dissolved organic material in sea water
13. Radioactive and stable isotopes
14. Marine natural product chemistry
15. Basic idea about chromatography
16. Theory and principle of TLC, GLC, HPLC column
17. Preparation of artificial sea water
18. Geochemistry and marine environment
19. Chemical features of Indian Ocean and Bay of Bengal

20. Greenhouse gases and its effects in the Bay of Bengal

**Recommended books**

1. Millero FJ. 2013. *Chemical Oceanography*, Fourth Edition, CRC Press. 594p.
2. Chester R, Jickells TD. 2012. *Marine Geochemistry*, 3rd edition, Wiley-Blackwell.
3. Steele J, Thorpe S, Turekian K. 2009. *Marine Chemistry & Geochemistry*, Academic Press. 647p.
4. Gianguzza A, Pelizzetti E, Sammartano S. 2002. *Chemistry of Marine Water and Sediments*, Springer-Verlag Berlin Heidelberg. 513p.
5. Hester RE, Harrison RM. 2000. *Chemistry in the Marine Environment*, Royal Society of Chemistry. 112p.
6. Wangersky PJ. 2000. *Marine Chemistry*, The Handbook of Environmental Chemistry Series (Book 5), Springer. 229p.

MS-204	CHEMICAL OCEANOGRAPHY PRACTICAL	25(1)
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1. Volumetric analysis
  - 1.1 Acid base titrations
  - 1.2 Oxidation Reduction titrations
2. Precipitation titrations
3. Preparation of standard for sea water
4. Determination of pH, Eh, minor, trace and major elements of sea water and sediments
5. Determination of Carbonates, bicarbonates and hydrocarbon
6. Determination of Nitrate, phosphate and silicate etc.

MS-205	BIODIVERSITY AND CONSERVATION	50(2)
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Rationale

Marine biodiversity has the great potentiality to transform medicine, industry, environmental remediation, and energy production, but it is being threatened by pollution, habitat destruction, fishing, and climate change. Therefore the UN Convention on Biological Diversity's Strategic Plan (2011-2020) calls for 10% of ocean area to be protected by 2020 where currently less than 3% area is protected. The marine graduates who will successfully complete this module and thus acquire in depth knowledge on research tools and techniques on marine biodiversity and conservation can prepare themselves to achieve the above goals for sustainable development of the ocean.

Objectives

To equip students with advanced knowledge on marine biodiversity and conservation biology facilitating them to become proactive, creative and able to do research independently to apply knowledge in practice for protection, conservation of marine biodiversity and resources for sustainable management of the ecosystems.

Learning outcomes

Upon completion of the course, students will be able to:

- Define key terms relevant to biodiversity and conservation.
- Know different methods of measuring biodiversity, the value of biodiversity and types and major threats to biodiversity.
- Know the importance of understanding the legal context for conservation management.
- Know the main elements of the legal framework that underpins biodiversity conservation nationally and internationally.
- Know the various national and international categories and designations that can apply to protected areas, and how they affect biodiversity conservation.
- Apply the knowledge in general communication for public extension.

**Course contents**

Biodiversity

1. Introduction: Definition and concepts, Genetic, species and ecosystem biodiversity.
2. Measuring Biodiversity: Number and differences, Surrogacy, Richness, and Evenness.
3. The Value of Biodiversity: Ecological value, Ethical value.
4. Threats to Biodiversity: Extinctions, Extinctions of the Past, Human-caused extinctions: Extinction rates, Vulnerability of extinctions, Causes of extinctions: exploitation, habitat destruction, degradation and pollution, biological invasions.

Conservation

1. Definition and Concepts, Importance of Conservation, The Rise of Modern Conservation
2. Approaches of Conservation: Various approaches to biodiversity conservation.
3. Biodiversity conservation inside Protected Areas: Establishing Protected Areas, Designing Protected Areas, Measuring Protected Areas, Protected Areas and people
4. Biodiversity conservation outside Protected Areas
5. Legal Instruments Relevant to Biological Diversity in Bangladesh,
6. Major International Conventions: Convention on Biological Diversity, Convention on Migratory Species, Convention on International Trade in Endangered Species of Wild Fauna and Flora, World Heritage Convention.

**Recommended books**

1. Gouilletquer P, Gros P, Boeuf G, Weber J. 2014. *Biodiversity in the Marine Environment*, Springer Netherlands. 214p.
2. Gaston KJ, Spicer JL. 1998. *Biodiversity: An introduction*, Blackwell Science.
3. Rosenzweig ML. 1995. *Species diversity in space and time*, Cambridge University Press.
4. Wilson EO, Peter FM. 1998. *Biodiversity*, National Academic Press, Washington.
5. Barbier EB, Burgess LJC, Folke C. 1994. *Paradise lost? The ecological economics of biodiversity*, Earthscan, London.
6. Ricklefs RE, Schuller D. 1993. *Species diversity in ecological communities: Historical and geographical perspectives*, Chicago University Press.

MS-206	BIODIVERSITY AND CONSERVATION PRACTICAL	25(1)
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1. Taxonomic study of flora and fauna in a specific area
2. Identification of threatened species/groups of plants and animals
3. Estimation of various Biodiversity indices
4. Practices of different tools and techniques used in biodiversity research.

Rationale

Hydrography is of increasing importance in all fields of maritime activity, which makes it a career of the future. The main sectors concerned are harbour and coastal construction, the offshore industry. Firsthand knowledge is prerequisite for the maritime professionals.

Objectives

Students will study in depth the different sensor systems used in hydrography: single and multi-beam echo-sounders, positioning systems, and inertial systems etc. which require in-depth knowledge of their functioning. They shall discover the products of Hydrography: methods for managing and processing bathymetric data, digital elevation models, and marine charts. The alternation between lectures and hydrographic surveys planning at sea and Navigational systems will be introduced.

Learning outcomes

Upon completion of the course, students will be able to:

- Understand the basic concept of hydrography and maritime navigation
- Gain knowledge on global coordinate systems
- Understand cartography and projections
- Conduce topographic survey using the most up-to-date equipment
- Conduct hydrographic survey using the most up-to-date equipment
- Assess coastal processes and protection measures

**Course contents**

1. Brief history of Hydrography, importance of Hydrography, fields of competence associated with Hydrography
2. Principles of hydrographic surveying: Survey specification and planning, data gathering, processing, analysis, quality and etc
3. Positioning: The earth, datum, coordinates systems, principles of cartography and projections; positioning methods (GNSS, electromagnetic, acoustic and optical techniques).
4. Horizontal and vertical control methods of Hydrography
5. Instruments used to establish horizontal and vertical control
6. Depth determination: Acoustic and Motion sensors, Transducers, Acoustic systems and non acoustic systems
7. Seafloor classification and feature detection: Seafloor feature detection, seafloor characterization
8. Water levels and flow: Tides and water levels and flow, water level flow and tidal currents
9. Topographic surveying: Topography, coastline delineation and aids to navigation positioning, Remote sensing tools used for topographic surveying
10. Hydrographic practice: Hydrographic survey planning, survey reconnaissance, data acquisition, coastline delineation and data processing
11. Hydrography of the Bay of Bengal
12. Coastal erosion, artificial nourishment and planning of coast protection.
13. Coastal and offshore engineering processes and problems
14. Sea-walls, break-water, jetties and groins
15. Coastal protection processes from hydrographic movements

**Recommended books**

1. Gao C, Zhao G, Fourati H. 2019. *Cooperative Localization and Navigation: Theory, Research, and Practice*, 1st edition, CRC Press. 660p.
2. Uncles R, Mitchell S. 2017. *Estuarine and coastal hydrography and sedimentology*, Cambridge University Press. 362p.
3. Burch D. 2015. *Celestial Navigation: A Complete Home Study Course*, 2nd edition. Starpath Publications, Seattle.
4. Weintrit A. 2013. *Advances in marine navigation: Marine Navigation and Safety of Sea Transportation*, CRC Press. 313p.
5. de Jong CD, Lachapelle G, Elema IA, Skone S. 2006. *Hydrography*, VSSD Publishes. 364p.
6. Briggs J. 2004. *Target Detection by Marine Radar*, The Institution of Engineering and Technology. 739p.

1. Collecting, recording and analyzing the hydrographic data using appropriate techniques in the field and laboratory.
2. Preparation of hydrographic charts and interpretation.

Rationale

Modern aquaculture has been evolved through development of cost effective farming practices using scientific principles. Globally, the activities greatly contributing to food security, protein supply, cash income and employment. It also ensures sustainable use of land and water resources. Therefore, it is necessary to train students with a thorough knowledge of the underlying scientific principles of aquaculture for better socioeconomic benefits.

Objectives

The objective of this course focuses on the concepts of aquaculture, selection of suitable sites and species, design and construction of pond, water and soil quality parameters, balanced feed for farming species, product safety and traceability, and economic appraisal.

Learning outcomes

Having successfully completed this course student will be able to:

- Understand the principles of aquaculture
- Select suitable sites and species for farming
- Maintain and manage water quality
- Acquire knowledge about feed composition, formulation and requirements for the cultured species
- Operate environment-friendly aquaculture practices

**Course contents**

1. Principles of aquaculture
  - 1.1 Aquaculture systems
  - 1.2 Aquaculture types
  - 1.3 Level of aquaculture
  - 1.4 Status and trend of food production

2. Soil and water quality
  - 2.1 Physicochemical characteristics
  - 2.2 Biological characteristics
  - 2.3 Pollution
  - 2.4 Water quality control
3. Selection of farming site
  - 3.1 Basic criteria
  - 3.2 Multi-criteria method
  - 3.3 Site suitability scales
4. Selection of cultivable species
  - 4.1 Biological characteristics
  - 4.2 Consumer preferences
  - 4.3 Market value
5. Pond design and construction
  - 5.1 Layout of pond
  - 5.2 Major components and features
6. Pond preparation and management
  - 6.1 Treatment and fertilization
  - 6.2 Water regulation
  - 6.3 Fry stocking and acclimatization
7. Feed and feeding management
  - 7.1 Natural feed
  - 7.2 Supplemental and formulated feeds
  - 7.3 Feed preparation
  - 7.4 Feeding plan
  - 7.5 Feed performance evaluation
8. Integrated aquaculture
  - 8.1 Rice-shrimp/prawn
  - 8.2 Sea salt-shrimp/seabass
  - 8.3 Mangrove-shrimp/crab
  - 8.4 Multi-trophic (fish/molluscs/seaweeds)
9. Pond harvesting techniques
  - 9.1 Partial harvest
  - 9.2 Complete harvest
10. Organic aquaculture
11. Best management practices (BMPs) for shrimp, seabass, crab, seaweeds
12. Product quality, safety and traceability
13. Economics and financing of aquaculture

#### Recommended books

1. Goddek S, Joyce A, Kotzen B, Burnell GM. 2019. *Aquaponics food production systems: Combined aquaculture & hydroponic production technologies for the future*. Springer. 619p.
2. Lembo G, Mente E. 2019. *Organic Aquaculture: Impacts and Future Developments*, Springer International Publishing. 211p.
3. Lucas JS, Southgate PC. 2019. *Aquaculture: Farming Aquatic Animals and Plants*, Wiley-Blackwell. 664p.
4. Gasco L, Gai F, Maricchiolo G, Genovese L, Ragonese S, Bottari T, Caruso G. 2018. *Feeds for the Aquaculture Sector*, Springer Briefs in Molecular Science. 111p.
5. Hai FI, Visvanathan C, Boopathy R. 2018. *Sustainable Aquaculture*. Springer. 332p.
6. Engle CR, Quagraine KK, Dey MM. 2017. *Seafood and aquaculture marketing handbook*, 2nd edition, Wiley-Blackwell. 468p.
7. Pillay TVR, Kuttu MN. 2005. *Aquaculture: Principles and Practices*, Wiley-Blackwell. 640p.

MS-210	AQUACULTURE PRACTICAL	50(2)
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1. Water and soil analysis of aquaculture pond
2. Design and layout of aquaculture farm
3. Feed preparation and calculation of feeding ration
4. Study tour to observe culture methodology of finfish and shellfish in the coastal areas
5. Calculation of feeding ration and practice of different feeding methods
6. Determination of water budget for aquaculture pond

MS-211	AQUACULTURE PLANNING AND ENGINEERING	50(2)
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#### Rationale

A good plan in aquaculture can identify potential problems that guide to minimize risks and reduce mistakes. The planning process addresses available resources, necessary training and piloting exercise before commercial investment. Moreover, integration of engineering knowledge in pond design, construction, dike height and slope, water control gates, aeration and water filtration can ensure a successful aquaculture venture.

#### Objectives

The objective of this course is to provide concepts of planning and engineering approaches of hatchery infrastructure; pond and dike construction; water control structures; water pumps, filtration and aerator system in aquaculture.

#### Learning outcomes

Having successfully completed this module students will be able to:

- Understand planning steps required before starting a new aquaculture venture
- Formulate operational plans for hatchery and grow out farm
- Determine the requirements of aerator and water pump for aquaculture
- Analyze cost-benefit analysis of hatchery and grow out farming
- Develop plans to test strengths and weaknesses of different aquaculture models

## Course contents

1. Aquaculture planning
  - 1.1 Major aspects of aquaculture planning
  - 1.2 Basic data required for planning
  - 1.3 Planning of small-scale rural aquaculture
  - 1.4 Planning of large-scale aquaculture
  - 1.5 Training of personnel, research support and extension services
  - 1.6 Economic appraisal of an aquaculture farm, legal provisions for aquaculture
2. Aquaculture engineering
  - 2.1 Water sources and quality for aquaculture, fluid behavior, water volume measurement
  - 2.2 Design and construction criteria of pond, tank, raceway and other impoundment
  - 2.3 Pumps – classification, installation, operational mechanism, capacity and characteristics
  - 2.4 Embankment, dyke and water control structure– material analysis and costing, design and layout
  - 2.5 Construction of small-scale and large-scale hatchery and facilities
  - 2.6 Different categories of filter and aerators for aqua-farms
  - 2.7 Economic aspects of farm construction

## Recommended books

1. Lekang O. 2020. *Aquaculture Engineering*, 3rd edition, Wiley. 544p.
2. Lawson TB. 1995. *Fundamentals of Aquacultural Engineering*, Springer. 364p.
3. Nash C. 1995. *Aquaculture Sector Planning and Management*, 1st edition, Wiley. 320p.
4. Yoo KH, Boyd CE. 1994. *Hydrology and Water Supply for Pond Aquaculture*, Springer. 483p.
5. Pillay, TVR. 1989. *Planning of Aquaculture Development: An Introductory Guide*, Wiley. 72p.

MS-212	AQUACULTURE PLANNING AND ENGINEERING PRACTICAL	25(1)
<ol style="list-style-type: none"><li>1. Design and layout of hatchery and grow out systems</li><li>2. Survey and identification of construction materials</li><li>3. Construction of sluice gate, dyke and canals</li><li>4. Estimation of building and construction materials</li><li>5. Cost estimation of hatchery facilities and grow out farms</li></ol>		

MS-213	SEAFOOD PROCESSING TECHNOLOGY	75(3)
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### Rationale

Proper handling and preservation of fish and fishery products is one of the crying needs in seafood processing industries of the world. Maintenance of quality from catch to consumer is of prime importance in order to compete in the global seafood trade. The seafood processing plants of Bangladesh are high-investment export based industries, require skilled manpower and abide by compliance issues such HACCP, EU directives and USFDA guidelines. Therefore, building-up knowledge base, skill development, use of modern technologies, and consistent implementation of international standard for seafood quality can only bring us competence to sustain in the global market.

### Objectives

To introduce the students with various categories of seafood, handling procedures and processing technologies in Bangladesh and other countries. Further, this course is aimed to build a clear understanding on different packaging methods, production of value added products, storage and transportation techniques of seafood. In addition, the students will be able to develop knowledge on quality and safety requirements of processed seafood.

### Learning outcomes

Upon completion of the course, students will be able to learn:

- Basics of fish spoilage and its prevention
- Post-mortem changes taking place in fish muscle
- Hygienic handling of fish and shrimp on board fishing vessel and on shore
- the principle of chilling
- Different preservation methods: freezing, drying, salting, smoking, canning, irradiation
- Practical skills in assessing fresh fish and spoiled fish
- Practical skills in icing of fish
- Practical skills in determining the changes in fish muscle during freezing and in the cold storage
- Practical skills in microbial and chemical methods of quality determination
- Importance of maintaining personal hygiene and sanitation
- Techniques of raw fish/processed fish transportation
- Seafood quality and its applications: HACCP and relevant quality control system
- Status of Bangladesh in seafood/fishery products export

## Course contents

1. Basic concept of seafood and quality
  - 1.1 Varieties of seafood (fish, crustaceans and mollusks)
  - 1.2 Sources of raw materials (wild caught and aquaculture species)
  - 1.3 Definition of quality and its implication
  - 1.4 Quality determining tests of seafood (sensory, microbial and chemical )
2. Spoilage of fish and its control
  - 2.1 Characteristics of fresh fish
  - 2.2 Freshness test by subjective method
  - 2.3 Post-mortem changes in fish (autolysis, rigor-mortis)
  - 2.4 Bacterial spoilage of fish and shellfish (process of spoilage, common pathogens and their acceptable range in processed seafood)
  - 2.5 Control methods (time-temperature, cold chain)
3. Handling of seafood products
  - 3.1 Handling of raw, processed and live seafood
  - 3.2 Hygiene and sanitation practices (worker and working environment)

- 3.3 Chilling of fish (principle, forms and quantity of ice, time duration)
- 3.4 Handling on board of fishing vessel, landing site, factory and in retail market
- 3.5 Disposal of waste parts
4. Seafood processing and preservation techniques
  - 4.1 Basics of preservation technique
  - 4.2 Methods of processing (grading, degutting, beheading, de-scaling, filleting, peeling, cooking)
  - 4.3 Preservation techniques in use (Freezing, Drying, Salting, Canning, Smoking and Irradiation)
  - 4.4 Value added seafood (novel products)
  - 4.5 Fish waste utilization
5. Packing methods of seafood
  - 5.1 Purpose, principle and type of packing
  - 5.2 Packing material
  - 5.3 Labeling
  - 5.4 Branding
6. Seafood storage and transport
  - 6.1 Time- temperature control
  - 6.2 Shelf life for different products
  - 6.3 Challenges in retaining product quality
7. Seafood processing plant
  - 7.1 Factory lay-out and process flow-chart
  - 7.2 Receiving unit
  - 7.3 Production unit
  - 7.4 Cold storage
  - 7.5 Equipment's and lab facilities
  - 7.6 Disposal of raw materials
8. Food safety issues and regulations in seafood industry
  - 8.1 CODEX alimentarius (fish and fishery products)
  - 8.2 HACCP (principle, plan, application)
  - 8.3 Cleaning and sanitizing agents
  - 8.4 Food safety standards (ISO 9000, BSTI)
  - 8.5 Food safety act'1997
9. Global trade of seafood
  - 9.1 Leading seafood exporting countries
  - 9.2 Trade barrier tariff (TBT)
  - 9.3 World Trade Organization and its rules
  - 9.4 Detention and rejection of seafood
  - 9.5 Prospects and challenges in seafood trade with reference to Bangladesh
10. Traceability of seafood
  - 10.1 Definition and implication
  - 10.2 Assessment of traceability
  - 10.3 Advantages and disadvantages

#### Recommended books

1. US FDA. 2019. *Fish and Fishery Products Hazards and Controls Guidance*, 4th edition, US FDA Center for Food Safety and Applied Nutrition. 501p.
2. Borda D, Nicolau AI, Raspor P. 2018. *Trends in Fish Processing Technologies*, CRC Press. 356p.
3. Gokoglu N, Yerlikaya P. 2015. *Seafood Chilling, Refrigeration and Freezing: Science and Technology*, Wiley-Blackwell. 248p.
4. Boziaris IS. 2014. *Seafood Processing: Technology, Quality and Safety*, Wiley. 510p.
5. Kim SK. 2014. *Seafood Science: Advances in Chemistry, Technology and Applications*, CRC Press. 606p.
6. Bremner HA. 2002. *Safety and Quality Issues in Fish Processing*, CRC Press. 528p.
7. Hall GM. 1997. *Fish Processing Technology*, Springer. 302p.
8. Bauman HE (auth.), Pearson AM, Dutson TR (eds.). 1995. *HACCP in Meat, Poultry, and Fish Processing*, Springer. 409p.

MS-214

SEAFOOD PROCESSING TECHNOLOGY PRACTICAL

25(1)

1. Freshness test of fish and fishery products by organoleptic method
2. Microbial assessment of raw materials and finished products
3. Assessment of chemical quality in raw condition and in storage
4. Estimation of quantity of ice for chilling raw materials
5. Processing of fish and shell fish (filleting, brining, deveining etc.)
6. Preservation of fish and shellfish by different methods (smoking, drying, salting)
7. Preparing HACCP plan with FDA guide

MS-215

MATHEMATICS

100(4)

#### Rationale and objectives

This course provides students with the opportunity to develop their knowledge, understanding and skills in mathematics and working mathematically in the field of environment and marine science. Students have the opportunity to develop ways of thinking and use mathematics as a powerful way of viewing and modelling the world to investigate patterns, order, generality and uncertainty.

#### Course Contents

1. Algebra
  - 1.1 Set theory: Sets, Null sets, subsets, disjoint sets, Universal sets, powerset, Venn-diagrams, basic set operations such as union, intersection, difference, complements
  - 1.2 Theory of equation: Relation between roots and co-efficient, increasing and decreasing of roots, sum of power of roots, formation of equation, Idescartes rule of sign
  - 1.3 Matrix: Definition of different matrices, rule of multiplication of matrices, adjoint matrix, inverse matrix, hermitian matrix, orthogonal matrix, solution of linear equations

2. Differential Calculus: Functions, limit, exponential function, derivative & higher order derivatives, rule of differentiation of standard functions, partial and total differentiation, change of variables
3. Integral Calculus: Integrals of standard functions, exponential functions, definite integrals, double integrals (concept of surface and area)
4. Differential Equations: Ordinary differential equation of 1st & 2nd order
5. Logarithms: Definitions, derivatives, Basis of natural logarithms
6. Vector Analysis: Vector & Scalars, rectangular co-ordinate system, components of vectors, laws of vector algebra, scalar field, vector field, gradient, divergent & curl-of-scalar and vector functions

**Recommended books**

1. Sharma BD. 2014. *Differential Equations*, New Delhi: Kedar Nath Ram Nath. 124p.
2. Lipschutz S, Lipson ML. 2013. *Schaum's Outline of Linear Algebra*, Fifth Edition, The McGraw-Hill Companies, Inc.
3. Mohammad et al. 1995. *A Text Book on Differential Calculus*.
4. Flanders H, Price JJ. 1978. *Calculus with Analytic Geometry*, New York: Academic Press.
5. Bell et al. 1976. *Algebraic and arithmetic structures: A concrete approach for elementary school teachers*, Free Press.
6. Calloway JM. 1964. *Fundamentals of Modern Mathematics*, Addison-Wesley Pub. Co.

THIRD YEAR			
Course#	Course title	Marks	Credits
<b>Theoretical</b>			
MS-301	Statistics	100	4
MS-303	Geological Oceanography	75	3
MS-305	Marine Pollution	75	3
MS-307	Remote Sensing	50	2
MS-309	Geographic Information Systems	50	2
MS-311	Integrated Coastal Zone Management	100	4
MS-313	Fluid Dynamics and Sediment Transport	75	3
MS-315	Wetland and Lake Management	50	2
MS-317	Marine Affairs	75	3
Subtotal		650	26
<b>Practical</b>			
MS-302	Statistics Practical	50	2
MS-304	Geological Oceanography Practical	25	1
MS-306	Marine Pollution Practical	25	1
MS-308	Remote Sensing Practical	25	1
MS-310	Geographic Information Systems Practical	25	1
MS-312	Integrated Coastal Zone Management Practical	50	2
MS-314	Fluid Dynamics and Sediment Transport Practical	25	1
MS-316	Wetland and Lake Management Practical	25	1
Subtotal		250	10
Sessional		50	2
	<i>Tutorial</i>	15	
	<i>Collection &amp; Slides</i>	10	
	<i>Practical Notebook</i>	10	
	<i>Excursion/Field report</i>	15	
Viva-voce		50	2
Total		1000	40

MS-301	STATISTICS	100(4)
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#### Rationale

Statistics is the science of learning from data, an exciting field about the thrill of discovery, learning, and challenging assumptions. Statistical knowledge helps selecting the proper methods to collect the data, employ the correct analyses, and effectively present the results. In fact, it allows to evaluate research hypothesis based on quantitative evidence and help to differentiate between reasonable and dubious conclusions. Statistical analyses are widely used in almost all fields including marine science to make sense of the vast amount of data that are available.

#### Objectives

The objective of this course is to provide an introduction for constructing the study design, selecting and measuring the variables, devising the sampling technique and sample size, cleaning the data, and determining the analysis methodology among numerous other issues. Another objective of the course is to design a statistical hypothesis on issues related to coastal & marine investigations and conduct appropriate test for drawing valid inference about the population characteristics.

#### Learning outcomes

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

- Understand data characteristics for applying descriptive statistics or inferential statistics.
- Demonstrate the ability to apply fundamental concepts in exploratory data analysis.
- Design sampling methods for obtaining data whilst avoiding common design flaws that incur bias, inefficiency and confounding.
- Demonstrate an understanding of the basic concepts of probability and the sampling distribution of a statistic, and in particular describe the behaviour of the sample mean.
- Demonstrate the procedure of testing hypothesis for drawing valid inference about the population characteristics.
- Understand the foundations for classical inference involving confidence intervals and level of significance.
- Apply and interpret basic summary and modelling techniques for bivariate data and use inferential methods in the context of simple linear models with normally distributed errors.
- Apply non-parametric tests and their interpretation of results.
- Understand the basic concept of time series analysis

#### **Course contents**

1. General introduction
2. Presentation of data.
  - 2.1 Introduction,
  - 2.2 Types of data, tabulation of data, frequency and frequency distribution, construction of frequency distribution table
3. Graphical Representation
  - 3.1 Introduction of graph, types of graphs
4. Measures of Central Tendency
5. Measures of Dispersion
  - 5.1 Introduction, different types of dispersion
6. Moments, Skewness and Kurtosis
  - 6.1 Introduction, Definition and types of Skewness and Kurtosis, Absolute and relative measures of Skewness, Measures of Kurtosis, Use of Moments in Skewness and Kurtosis
7. Correlation and Regression
  - 7.1 Correlation: Coefficient of correlation, Simple correlation, Rank correlation, Coefficient of determination
  - 7.2 Regression: Regression coefficient, Simple regression, Multiple regression, Polynomial Regression
  - 7.3 Use of regression and correlation analysis: Limitations and Errors
8. Probability Distribution
  - 8.1 Basic concept of probability, Related mathematics, Elementary Probability and Conditional probability
  - 8.2 Probability distribution, Random variable & Expected value in Decision making

- 8.3 Properties, constants and significance of Binomial distribution, Poisson distribution and Normal distribution
9. Sampling
  - 9.1 Introduction to sampling, population and sample, types of sampling- Judgment sampling and Probability sampling
  - 9.2 Random sampling: simple random sampling, stratified random sampling, systematic sampling and their uses, Sample estimates and its variances, Standard errors of estimates, Sampling and non-sampling errors
10. Basic ideas of test
  - 10.1 Introduction: hypothesis, null hypothesis, alternative hypothesis, level of significance, confidence limit
  - 10.2 't' distribution, properties of 't' distribution application of 't' distribution, 't' tests
  - 10.3 The  $\chi^2$  distribution, constants of  $\chi^2$  distribution,  $\chi^2$  test, conditions for applying  $\chi^2$  tests, uses of  $\chi^2$  tests
  - 10.4 The F distribution, some special characteristics of F distribution, application of F tests, Analysis of variance, Assumption of analysis of variance, techniques of analysis of variance, techniques of analysis of variance one way and two way classification models for ANOVA.
11. Experimental design
  - 11.1 Introduction, Phases of experimental design
  - 11.2 Randomized block design
  - 11.3 The Latin square design
12. Test of significance
  - 12.1 Introduction, hypothesis, null hypothesis, alternate hypothesis, level of significance, one tailed and two tailed test, power of a test, construction of confidence intervals.
  - 12.2 Special applications: Tests about means, proportions & correlation coefficient, Test of goodness of fit, independence & homogeneity, Test in regression analysis
13. Non parametric tests: Introduction, advantage of non-parametric tests, rank sum test, Mann-Whitney test, Spearman's rank Correlation, Kolmogorov-Smirnov sample test, Wilcoxon Signed Rank test
14. Time series and forecasting
  - 14.1 Introduction, utility and components of time series analysis, measurements of trends, Graphic method, methods of semi averages, methods of moving averages, the methods of least squares, second degree parabola, exponential trends, growth curves, measurement of seasonal variations

#### Recommended books

1. Oleksy A. 2018. *Data Science with R A Step By Step Guide With Visual Illustrations and Examples*, Andrew Oleksy. 201p.
2. Montgomery DC. 2017. *Design and Analysis of Experiments*, 9th Edition, Wiley. 749p.
3. Salkind NJ. 2017. *Statistics for people who (think they) hate statistics: Using Microsoft Excel 2016*, SAGE Publications. 546p.
4. Pallant J. 2016. *SPSS Survival Manual: A Step by Step Guide to Data Analysis Using IBM SPSS*, Open University Press. 368p.
5. Bailey NTJ. 1995. *Statistical Methods in Biology*, Cambridge University Press.
6. Rao CR, Chakraborty R. 1991. *Handbook of Statistics 8: Statistical Methods in Biological and Medical Sciences*, North-Holland / Elsevier. 552p.
7. Mustafa MG. 1989. *Methods of Statistics*.

MS-302	STATISTICS PRACTICAL	50(2)
<ol style="list-style-type: none"> <li>1. Graphical representation of data, measures of location, dispersion, moments, Skewness, Kurtosis.</li> <li>2. Calculation of single correlation coefficient, simple regression coefficient, scatter diagram, multiple and polynomial analysis.</li> <li>3. Analysis of variance: one way and two way</li> <li>4. Problems on 't' test, F test, <math>\chi^2</math> test</li> <li>5. Time series analysis linear trend line, polynomial trend line, moving average method, seasonality analysis           <ol style="list-style-type: none"> <li>5.1 Problems on different types of tests: Tests about means, proportions &amp; correlation coefficient</li> <li>5.2 Test of goodness of fit, independence &amp; homogeneity</li> <li>5.3 Test in regression analysis</li> </ol> </li> <li>6. Special tests           <ol style="list-style-type: none"> <li>6.1 DMRT for growth performance test</li> <li>6.2 Non-parametric tests: Chi-square test, K related test</li> </ol> </li> <li>7. Trend analysis and seasonal variation test of supplied data</li> </ol>		

MS-303	GEOLOGICAL OCEANOGRAPHY	75(3)
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#### Rationale

This course will cover the formation of ocean basins; the role of mid-ocean ridges in basin scale processes; structure and geological processes at continental margins; sedimentary processes within and on the boundaries of ocean basins; and the past history and impact of sea level change. Emphasis will be placed on the use of these techniques in both research-led and commercially-led environments. Experience collecting data at sea and practical analysis of example datasets will be included.

#### Objectives

1. To know the ocean basins and its fracture systems, origin and its composition
2. To understand the marine sediments and mineral deposits and plate tectonics

#### Learning outcomes

Having successfully completed this module, student will be able to demonstrate knowledge and understanding of:

- Have a solid grounding in marine geology.
- Understand the framework provided by Plate Tectonics.
- Be able to describe sediments found in different water depths and settings, and understand the sedimentary processes leading to their deposition.
- Be able to 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.

#### Course contents

1. Introduction
  - 1.1 Brief history of marine Geology and geological time scale
  - 1.2 Early mapping, positioning and sampling techniques
2. General Geological and physiographic features of the Earth
  - 2.1 Shape and dimension: hypsometry, relative distribution of land and sea
  - 2.2 crust and the interior of the Earth: Continental and Oceanic crust, Isostasy

3. Plate tectonics
  - 3.1 Concepts; principles; plate boundaries; plate motion; causes of plate motion
  - 3.2 Continental drift and sea floor spreading: conceptual development, evidences, opposition
  - 3.3 Tectonics as an explanation of major Earth features and processes
4. Physiographic features of the Ocean and Ocean basins
  - 4.1 Large scale features: ridge, trench, fracture zone, fault, sea mount, island arc, aseismic ridge, abyssal hill, guyot, abyssal plain and others
  - 4.2 Features associated with continental margin: terrace, shelf, slope, rise, depressions, canyons, troughs
  - 4.3 Near shore and other features: Reef, coral island, atoll, sedimentary formations and others
5. Marine sedimentation: definitions, sources of sediment, transport of sediment, settling, deep sea deposits, classification of sediments, calcification
6. Basins of the Indian Ocean and Bay of Bengal: general morphology, physiography and bathymetry, tectonics, sedimentology
7. Coastal geomorphology & landforms, coast classification

#### Recommended books

1. Pickering KT, Hiscott RN. 2016. *Deep Marine Systems-Processes, Deposits, Environments, Tectonics and Sedimentation*, American Geophysical Union and Wiley. 675p.
2. Seibold E, Berger W. 2017. *The Sea Floor: An Introduction to Marine Geology*, Springer.
3. Nairn AEM. 2013. *The Ocean Basins and Margins: The Indian Ocean*, Springer.
4. Seibold E, Berger WH. 2010. *The Sea Floor: An Introduction to Marine Geology*, Springer.
5. Davidson-Arnott R. 2009. *Introduction to Coastal Processes and Geomorphology*, Cambridge University Press.
6. Robertson KG (auth.), Hailwood EA, Kidd RB (eds.). 1990. *Marine Geological Surveying and Sampling*, Springer, 168p.

MS-304	GEOLOGICAL OCEANOGRAPHY PRACTICAL	25(1)
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1. Study of Earth's inner structure and geophysical aspects, tectonic features using map, software, etc.
2. Study of geological time scale, reconstruction of paleo-Earth
3. Study of coastal landforms of Bangladesh
4. Study of Bathymetric and physiographic maps
5. Sediment Texture analysis

MS-305	MARINE POLLUTION	75(3)
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#### Rationale

The course provides updated information and knowledge on various aspects of marine pollution with the ways and methods of prevention. It presents an integrated approach, analyzing various sources of pollution, describing best practices for minimizing contamination, responding to emergencies and compliance requirements with related management strategies.

#### Objectives

The objective of this course is to focus environment pollution concepts, sources of pollutants with their fate and effects on marine water, sediment and biota. The course is designed to investigate pollution issues, international legal framework on marine pollution, management strategies and contingency planning to minimize the environmental impact of industrial, agricultural, sewage and shipping activities.

#### Learning outcomes

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

- Characterize sources and effects of pollutants on marine environment
- Examine pathways of contaminants through marine ecosystems and food webs
- Understand the methods used to assess and quantify marine pollution
- Understand fundamentals of marine environment protection
- Manage land-based and ship-born pollutants

#### Course contents

1. Definition of pollution, types, contamination and sources of air pollution, water pollution, coastal and deep sea pollution, effect of pollutants on organism
2. Air Pollution
  - 2.1 Definition, major sources of air pollution, effect of air pollution on human beings. Green-house gases: sources, effect on global warming and sea-level changes
  - 2.2 Atmosphere and its function: Gas laws governing the behaviour of pollutants in atmosphere. Natural and anthropogenic sources of atmospheric pollutants; Significance of pollutants and their reactions in the atmosphere
  - 2.3 Transport and dispersion of pollutants – effects of meteorological and topographic functions. Effects of pollutants; sampling of gaseous and particulate pollutants – their analysis and control. Air quality standards and criteria
3. Water Pollution: Types, sources and consequences of water pollution. Ecological and biological aspects of water pollution. Types and characteristics of domestic, industrial and agricultural waste and their effects on water bodies
4. Sewage: Definition of sewage, sources and types of sewage, Characteristics of sewage, Sewage treatment, Eutrophication and its effect. Solid waste disposal problem and its management in urban area
5. Industrial Wastes: Sources of effluents, nature of effluents of some industries, Effects of effluents on aquatic ecosystem, Waste treatment: Primary treatment, Secondary treatment and Tertiary treatment
6. Heavy Metals: Introduction, Sources of heavy metals, Effects of heavy metals on aquatic ecosystem. Bioaccumulation and biomagnification of lead, cadmium, chromium & mercury
7. Agro-Chemicals: Introduction, types of agrochemicals, Uses of Agrochemicals, Effects of agrochemicals on biota, Bio-accumulation and biomagnification of organochlorine pesticides (DDTs) in food chain and its impact on living ecosystem
8. Oil Pollution: Definition of oil, types of hydrocarbon, sources of hydrocarbon, fate of oil on the surface water of the ocean, impact of oil on marine ecosystem, Removal technique of oil from surface water of the ocean
9. Toxicology: Introduction, principles and concepts, classification and sources of toxic substances. Pathways of toxic substances into ecosystem. Effect of toxic substances – emphasis on physiological effects

#### Recommended books

1. Seinfeld JH. 1998. *Atmospheric Chemistry and Physics*, John Wiley & Sons.
2. APHA. 1996. *Standard Methods for the Examination of Water & Wastewater*.
3. Mishra SR. 1996. *Assessment of Water Pollution*, APH Pub. New Delhi.

4. Lyons T, Scott B. 1992. *Principles of Air Pollution Methodology*, CBS Pub. & Distributions.
5. Bridgman H. 1990. *Global Air Pollution*, John Wilay & Sons.
6. Haslam SM. 1990. *River Pollution: An Ecology Perspective*, CBS Pub. & Distributor.
7. Tripathi Ak. 1990. *Water Pollution*, Astish Pub. New Delhi.

MS-306

## MARINE POLLUTION PRACTICAL

25(1)

1. Assessment of Physico-chemical condition: DO, BOD<sub>5</sub>, COD, pH, S%<sub>o</sub>. Nutrients, Organic matter
2. Spectrophotometric analysis of organic and inorganic matters in water
3. Selected biological methods for the assessment of marine pollution; Bioassay test on shrimp, mollusk and fish
4. Physicochemical & Biological test of water quality
5. Determination of some trace elements
6. Determination of benthos from polluted area
7. Comparative study of organisms between polluted and unpolluted areas
8. Determination of Lethal Concentration/Dosage (LC<sub>50</sub>/LD<sub>50</sub>)

MS-307

## REMOTE SENSING

50(2)

Rationale

The course introduces remote sensing principles and its wider applications. It enables students to search and analyze satellite imagery from spatial data portals of relevant agencies and organizations (e.g. USGS, NASA, NOAA, and FAO) in the context of marine and coastal ecosystems.

Objectives

The objective of this course is to focus basic concepts of satellite technology and real world applications. The course is designed to prepare students with an understanding of the tools and techniques used to display, process, and analyze remotely sensed data for marine science, fisheries and aquaculture planning.

Learning outcomes

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

- Understand the role of satellite technology in marine and coastal resources management
- Search and use satellite imagery
- Process remotely sensed data to make it useful in geographic information systems
- Extract information from remotely sensed data using a variety of manual and automated techniques
- Communicate findings from the analysis of remotely sensed data through written words and graphical products

**Course contents**

1. Introduction to remote sensing: definitions, techniques, sensors, vehicles, applications
2. Physical principles of remote sensing: radiation principles, electromagnetic spectrum, atmospheric interferences
3. Remote sensing systems: active and passive sensors, monochromatic and multispectral remote sensing, airborne and satellite remote sensing, LIDAR remote sensing, RADAR interferometry
4. Remote sensing of water and hydrosphere:
  - 4.1 Surface water biophysical characteristics, applications: water surface area, water constituents (organic and inorganic), water depth (bathymetry), water surface temperature, water color & Chlorophyll, turbidity measurement
  - 4.2 Remote sensing of precipitation
  - 4.3 Remote sensing of aerosols, clouds, water vapour and snow
  - 4.4 Water quality modeling using remote sensing and GIS
5. Remote sensing of the coast and the oceans:
  - 5.1 Shoreline detection and coastal change
  - 5.2 Ocean scatterometry: wind and current
  - 5.3 Oceanic productivity
  - 5.4 Sea Surface Temperature (SST), Sea Surface Height (SSH), Sea Surface Salinity (SSS)
  - 5.5 Coral reef remote sensing
  - 5.6 Some ocean and coastal remote sensing satellites & systems: CZCS, NOAA/AVHRR, TOPEX/POSEIDON, ADEOS/OCTS, OCISAT, WINDSCAT, Aquarius
6. Remote sensing data and data analysis:
  - 6.1 Characteristics of remote sensing data: format, spatial resolution, radiometric resolution (bit depth), temporal resolution (acquisition interval), spectral resolution (bands);
  - 6.2 Data acquisition, pre-processing: radiometric correction, geometric correction, image enhancement
  - 6.3 Image classification: supervised and unsupervised classification, ground truthing, classification accuracy, feature extraction, post classification, GIS data creations, mapping
  - 6.4 Data extraction, model building and model verification

**Recommended books**

1. Goodman et al. 2013. *Coral Reef Remote Sensing: A Guide for Mapping, Monitoring and Management*, Springer.
2. Rees WG. 2013. *Physical Principles of Remote Sensing*, Cambridge University Press.
3. Barale et al. 2010. *Oceanography from Space, Revisited*, Springer.
4. Robinson IS. 2010. *Discovering the Ocean from Space: the unique applications of Satellite Oceanography*, Springer.
5. Wang Y. 2009. *Remote Sensing of Coastal Environments*, CRC Press.
6. Jensen JR. 2006. *Remote sensing of the Environment: An Earth Resource Perspective*, Pearson. 592p.
7. Lilles and TM, Keifer RW. 1994. *Remote Sensing and Image Interpretation*, 3rd edition, Willey.

MS-308

## REMOTE SENSING PRACTICAL

25(1)

1. Remote sensing image analysis: geometric correction/registration, classification & post-classification
2. Studying various ocean remote sensing products: SST, SSH, SSS, Ocean Color, etc.
3. Studying changes in coastline and bathymetry
4. Water quality mapping and modeling
5. Monitoring Sea Surface Temperature (SST), Chlorophyll, Salinity, Turbidity, etc.
6. Case studies (about 50% of the lab sessions)

Rationale

Geographic Information Systems (GIS) is an effective tool for mapping and understanding the natural and artificial environments including trends and phenomena. Students can find multiple uses of GIS and relevant technologies in marine and coastal applications during the course of their study and subsequent applications of acquired knowledge.

Objectives

Objective of the course is to provide a basic, practical understanding of GIS concepts, techniques and real world applications, with hands-on experience of creating, manipulating and analyzing geographic information in a GIS environment. No specific background preparation is needed other than higher secondary science.

Learning outcomes

Upon completion of the course, students will be able to:

- Recognize the role of GIS as an analytical tool in marine and coastal applications
- Gain fundamental concepts of geographic data in general and GIS data in particular
- Be able to use GPS and one or more software platforms for GIS analyses
- Be able to collect and create data, analyze and produce maps for research and academic assignments

**Course contents**

1. Introduction to GIS
  - 1.1 General introduction and definitions
  - 1.2 GIS requirements (hardware, software, manpower)
  - 1.3 GIS and related technologies (Remote Sensing, GPS, Computerized Cartography, photogrammetry)
  - 1.4 Applications of GIS
  - 1.5 Future directions of GIS (WebGIS, OpenGIS)
2. Mapping and scales
  - 2.1 Types of Maps
  - 2.2 Map scale
  - 2.3 Coordinates and projection systems
3. GIS data structure
  - 3.1 Characteristics and sources of GIS data
  - 3.2 Raster and vector data model: basic understanding
  - 3.3 Understanding layers and attribute
4. Images and rasters/grids
  - 4.1 Understanding rasters: raster properties – pixels, resolution, color depth, storage requirement and compression, histogram; advantages and disadvantages
  - 4.2 GIS specific raster/grid manipulation: buffering, recalculation, reclassification, thinning, attribute manipulation, 3D modeling & analyses
  - 4.3 Fundamentals of RS specific image manipulation
5. Vectors
  - 5.1 Understanding vectors: topologies – point, line, polygon; storage requirement; advantages and disadvantages
  - 5.2 Vector manipulation: overlay, buffer, geometric modeling
6. Attributes and database
  - 6.1 Built-in attributes, raster and vector case, manipulating attributes
  - 6.2 External data sources, manipulating external database, linking with GIS
7. Marine and Coastal applications of GIS

**Recommended books**

1. Iliffe J. 2000. *Datums and Map Projections for Remote Sensing, GIS and Surveying*. Whittles Publishing. 150p.
2. Burrough PA, McDonnell RA. 1998. *Principles of Geographical Information Systems*, Oxford University Press. 333p.
3. Heywood I, Cornelius S, Carver S. 1998. *An Introduction to geographical Information Systems*, Longman. 279p.
4. Chrisman N. 1997. *Exploring Geographic Information Systems*, John Wiley & Sons. 298p.
5. Korte GB. 1992. *The GIS Book*, 3rd edition, Onward Press. 220p.
6. Star J, Estes J. 1990. *Geographic Information Systems: An Introduction*, Prentice-Hall. 303p.

1. Field data collection using GPS, collecting positing information on Google Maps/Earth
2. Creating vector GIS data in Google Earth and QGIS
3. GIS attribute data exercise
4. Converting GIS data formats (KML, SHP)
5. Converting vector data geometry (point, line, polygon)
6. Basic GIS analyses (geoprocessing)
7. Making map in QGIS

Rationale

The coastal zone is subjected to a multitude of uses that affect the environment and its resources and may cause conflicts as a result of competition for coastal space. Therefore, an integrated management is necessary to ensure rational resource use, alleviate conflicts among users and protect the coastal environment. The coastal ecosystems of Bangladesh include mangroves, saltmarshes, estuaries, sand dunes, beaches, coral reefs and seagrasses. These ecosystems are widely distributed and provide not only direct economic benefits, but also indirect services to the society.

Objectives

The objective of the course is to understand the concept of integrated coastal zone management for sustainable resources management. It emphasizes coastal resource uses, management issues, conflicts among users, coordination and integration attitudes, reviews national and international policy issues with relevant tools and techniques that are important on the daily work of a coastal zone manager.

### Learning outcomes

Upon completion of the course, students will be able to:

- Understand the basic concepts of integrated coastal management and related activities
- Learn about the importance of coastal resources on environment, economy and society
- Identify and prioritize challenges to sustainable coastal resources utilization
- Develop sustainable plan on coastal issues which reflects stakeholders' views
- Communicate and facilitate the need to work in a coordinated and integrated manner to address coastal issues

### **Course contents**

1. Introduction and Concepts
  - 1.1 Definitions of ICZM
  - 1.2 Boundaries of the coastal zone
  - 1.3 View of coastal zone as a system
  - 1.4 Characteristics of the coastal zone
  - 1.5 Dimensions of ICZM
  - 1.6 Major functions of ICZM
2. Multiple uses of the Coastal Zone
  - 2.1 Capture fisheries
  - 2.2 Aquaculture and mariculture
  - 2.3 Sea salt production
  - 2.4 Coastal agriculture
  - 2.5 Wet meadows and livestock
  - 2.6 Port operation and shipping
  - 2.7 Tourism and recreation
  - 2.8 Industrial development
  - 2.9 Urban settlement
  - 2.10 Shore protection
  - 2.11 Extraction industries
3. Coastal Zone Management Issues
  - 3.1 Environmental issues
  - 3.2 Climate change issues
  - 3.3 Economic issues
  - 3.4 Social issues
  - 3.5 Horizontal and vertical integration
4. Legislation and policy framework
  - 4.1 International framework
  - 4.2 Regional framework
  - 4.3 National policy document
5. Tools and Techniques for ICZM
  - 5.1 Capacity need assessment
  - 5.2 Stakeholder participation
  - 5.3 Landscape and resource analysis
  - 5.4 Coastal resilience mapping
  - 5.5 Satellite technology
  - 5.6 Geographic information systems (GIS)
  - 5.7 Land/water use zoning
  - 5.8 Environmental Impact Assessment
  - 5.9 Economic analysis
  - 5.10 Measurable indicators
6. ICZM Planning Cycle
  - 6.1 Classifying coastal management plans
  - 6.2 Designing a coastal planning framework
  - 6.3 ICZM plans described by geographical coverage
  - 6.4 Planning processes
7. Implementation of ICZM plan in Bangladesh
  - 7.1 Coordination among government agencies/departments
  - 7.2 Public participation
  - 7.3 Identify coastal management actions
  - 7.4 Implementation process
  - 7.5 Establishing an administrative structure
  - 7.6 Monitoring and evaluation

### **Recommended books**

1. Ahlhorn A. 2018. *Integrated Coastal Zone Management: Status, Challenges and Prospects*, Springer. 210p.
2. Clark JR. 2018. *Coastal Zone Management Handbook*, Chapman and Hall/CRC. 717p.
3. Moksness E, Dahl E, Stottrup JG. 2013. *Global Challenges in Integrated Coastal Zone Management*, Wiley-Blackwell. 260p.
4. Bartlett DJ, Smith JL. 2005. *GIS for coastal zone management*, CRC Press. 349p.
5. Kay R, Alder J. 2002. *Coastal Planning and Management*, CRC Press. 400p.
6. Cicin-Sain B, Knecht RW. 1998. *Integrated Coastal and Ocean Management: Concepts and Practices*, Island Press. 517p.
7. UNESCO. 1997. *Methodological guide to Integrated Coastal Zone Management*. UNESCO-IOC Manuals and guides volume 36. 49p.
8. ESCAP/UN, 1987. *Coastal Environmental Management Plan for Bangladesh*. Economic and Social Commission for Asia and the Pacific (ESCAP) of the UN, Bangkok.

1. Integration among community groups, sectors/departments/agencies
2. Land use zoning for aquaculture, mangrove afforestation, sea salt production, agriculture, wet meadow and livestock and coastal tourism development
3. ICZM plan formulation
4. ICZM plan implementation practices

**Rationale**

This course focuses on the transport of mass and momentum in natural fluid systems and physical processes related to the dynamic feedback between flowing water and movable sediment in rivers and estuaries. It is designed as an entry-level graduate course in fluid mechanics for students studying in engineering and earth science disciplines. The first two thirds of the course are devoted to developing a foundation in basic incompressible fluid mechanics with an emphasis on turbulent channel flow. The course looks briefly at the watershed system as a whole and then narrows down to focus primarily on the coupling of the water and sediment phases within the channel and open ocean.

**Objectives**

The objective of this course is to provide access to the empirical and theoretical background that forms the modern basis for evaluating and understanding sediment transport systems. Students who fully participate and complete this course can expect to be prepared to conduct scientific and professional research regarding the sedimentary evolution of Earth's surface, its stability, and its dominant processes.

**Learning outcomes**

The aim of the course is to provide engineers working in the coastal environment with the understanding of wave and sediment processes and their effects on the morphology of beaches and coastlines. We will explore the dynamics of the near shore environment in detail, including consideration of wave boundary layer processes and sediment particle dynamics and examine how these can be considered using engineering models.

**Course Contents**

1. The physics of the fluids: Fluid properties, fluid statics, pressure variations, hydrostatic force (curve & plane surface), buoyancy.
2. Hydrodynamics: Types of flow, continuity equation, equation of motion, momentum equation, real fluid flow, energy losses.
3. Open channel flows:
  - 3.1 Type of channel: non-uniform flow, gradually varied flow, unsteady non-uniform flow.
  - 3.2 Steady uniform flow, boundary layer and boundary roughness, velocity distribution, bed shears and shear velocity.
  - 3.3 Secondary flow, resistance equation.
4. Sediment movement: Sediment properties, viscosity of the dilute suspensions, fall velocity, initiation of movement, bed forms influences ripples and dunes.
5. Bed forms and bed roughness: Types of bed forms, dimensions of bed forms, effective bed roughness.
6. Sediment transport:
  - 6.1 Modes of particle motion, types of load: bed load transport and suspended load transport, total load transport, transport measurements.
  - 6.2 Sediment transport and deposition in the Bay of Bengal.

**Recommended books**

1. Fallavotti G. 2002. *Foundations of Fluid Dynamics*, Springer.
2. Mayele R. 2000. *Principle of Fluid Flow and Sediment Transport*, CRT Press.
3. Shyy W, Narayanan R. 1999. *Fluid Dynamics at Interfaces*, Cambridge University Press.
4. Acheson DJ. 1992. *Elementary Fluid Dynamics*, Oxford University Press.

1. Flow observation: Open channel flow, Hydraulic jump, Flow distribution
2. Flow measurement: use of current meter in natural conditions, construction of velocity graphs
3. Sediment movement: Initiation of movement, justification of erosion and stable condition
4. Bed form observation: Different structures in the channel floor, roughness.
5. Field observation: Erosion-deposition characterization of the tidal flat
6. Preparation of bathymetric charts and interpretation.
7. Measurement of sediment movement.

**Rationale**

Bangladesh is blessed with a large number of wetlands of various kinds which have significant ecosystem functions. Therefore to sustain and restore wetlands, their resources and biodiversity for future generations through research, information exchange and conservation activities in the country and worldwide the proposed course is really time demanding. The major topics of wetland and lake management course will be very much appropriate for students planning careers in natural resource management while working in consulting, industry, government, or a non-profit organization.

**Objectives**

The purpose of this course is to improve students understanding of the physical, chemical, and biological components of different types of wetland and lake ecosystems and thus to develop an ability to understand issues related to best practices in wetland and lake ecosystems management, and preparation of management plans for conservation action.

**Learning outcomes**

- On successful completion of the course, students will be able to:
- Understand the characteristics, types, functions and values of different wetlands and lakes;
  - Classify inland and coastal wetlands from an ecosystem perspective;
  - Understand the physical, chemical and biological aspects of different wetlands and lakes;
  - Identify the biological components of various wetlands and lakes including biodiversity;
  - Critically analyze wetland management policies, regulations and challenges;
  - Conduct in-depth analysis on existing problems and prospects;
  - Address potential conflicts for sustainable use of wetlands and lakes;
  - Understand different aspects of wetland management planning that will aid governance

**Course contents**

1. Definition, Types & Characteristics
  - 1.1 Definition and Classification of Lakes and Wetlands
  - 1.2 Origin and Morphology of Lakes and Wetlands

- 1.3 Characteristics of Wetland
- 1.4 Importance of Wetlands
2. Distribution of Lakes and Wetlands
  - 2.1 Geographic Distribution of Major Lakes and Wetlands Systems
  - 2.2 Distribution of Wetlands in Bangladesh
3. Dynamics & Ecological Aspects of Tropical Wetlands
  - 3.1 Ecological Characteristics of Freshwater and Coastal Wetlands
  - 3.2 Pedological, Hydrological and Biological Elements and Processes, and their Interactions
4. Bio-Diversity of Freshwater and Coastal Wetlands
  - 4.1 Floral Diversity
  - 4.2 Faunal Diversity
5. Wetlands and Fisheries
  - 5.1 Fisheries Significance of Inland and Coastal Wetlands
  - 5.2 Production Enhancement of Artificial Lakes: Open-water Stocking in Lakes and Reservoirs
6. Issues of Wetland Management in Bangladesh
  - 6.1 Inventory of Resources, Assessment, Problems & Management Measures
  - 6.2 Socio-Economic Issues in Wetland Management
  - 6.3 Wetland Policies, Rules and Regulations in Bangladesh
  - 6.4 Institutional Aspects of Wetland Management in Bangladesh
  - 6.5 Threats to Wetland ecosystems
  - 6.6 Conservation of Wetlands in Bangladesh
7. Conventions and Laws on Wetlands
  - 7.1 Laws on Wetlands in Bangladesh
  - 7.2 Wetland Management and International Perspective
  - 7.3 RAMSAR Convention,1971 on Wetland Management

#### Recommended books

1. Mitsch WJ, Gosselink JG. 2015. *Wetlands*, 5th edition, Wiley. 736 p
2. Kar D. 2013. *Wetlands and Lakes of the World*, Springer. 700p.
3. Varis et al. 2008. *Management of Transboundary Rivers and Lakes*, Springer. 316p.
4. Jørgensen et al. (eds.). 2005. *Lake and Reservoir Management*, Academic Press. 514p.
5. BCAS/NACOM. 2000. *Wetlands of Bangladesh*.
6. Maitland PS, Morgan NC. 1997. *Conservation Management of Freshwater Habitats: Lakes, Rivers and Wetlands*, Springer. 233p.

<b>MS-316</b>	<b>WETLAND AND LAKE MANAGEMENT PRACTICAL</b>	<b>25(1)</b>
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1. Mapping of Major Wetlands in Bangladesh
2. Zonation of Wetland and Lake Ecosystems
3. Inventory of Flora and Fauna and their Reporting
4. Identification of Flora and Fauna
5. Preparation of Suitable Management Models of Wetlands and Lakes in Bangladesh.

<b>MS-317</b>	<b>MARINE AFFAIRS</b>	<b>75(3)</b>
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#### Rationale

The oceans and coasts are immensely significant ecologically and economically, however, the marine and coastal spaces are mostly vulnerable to overexploitation of its resources, climate consequences, geopolitical complexity and other anthropogenic pressures. Marine Affairs offers an interdisciplinary education in ocean and coastal management, which is necessary to recognize and address relevant issues at national, regional and global scales for sustainability.

#### Objectives

The major objective of this course is to provide the basic and stimulating concepts to understand the equitable and sustainable use of the diverse coastal and ocean environments of the world. Additionally, it provides a solid foundation on the legal, political, socioeconomic, and environmental implications of management choices and how they impact on coastal and marine systems.

#### Learning outcomes

Upon completion of the course, students will be able to –

- know about the legal regime of coastal and ocean systems
- realize the multiple uses of coastal and marine spaces
- understand the importance of marine resources to human well-being
- comprehend the multidimensional factors influencing governance and management efforts
- communicate effectively with professionals in various fields of marine sciences and affairs

#### Course Contents

1. Law of the Sea
  - 1.1 Introduction to UNCLOS, its background and importance
  - 1.2 Miscellaneous national and international sources of maritime law
2. Maritime Zones: Delimitation and General Provision
  - 2.1 Territorial sea and contiguous zone
  - 2.2 Exclusive economic zone
  - 2.3 Continental shelf
  - 2.4 Areas beyond national jurisdiction
3. Key Issues of Maritime Affairs
  - 3.1 Basic concepts on blue economy and SDG-14
  - 3.2 Marine fisheries
  - 3.3 Conservation of marine biodiversity
  - 3.4 Protection of the marine environment
  - 3.5 Maritime transport
  - 3.6 Marine renewable and non-renewable resources

- 3.7 Marine genetic resources and BBNJ
- 3.8 Marine and coastal tourism
- 4. Maritime Defense and Law enforcement
  - 4.1 Military use of the seas
  - 4.2 Roles and jurisdiction of Bangladesh Navy and Bangladesh Coast Guard

**Recommended books**

1. Patil et al. 2018. *Toward a Blue Economy: A Pathway for Sustainable Growth in Bangladesh*, Washington, DC: The World Bank Group.
2. Monaco A, Prouzet P. 2015. *Governance of Seas and Oceans*, John Wiley & Sons.
3. Paula J. 2015. *Regional State of the Coast Report: Western Indian Ocean*, Nairobi: United Nations Environment Programme.
4. Chang Y. 2012. *Ocean Governance: A Way Forward*, Springer.
5. Smith HD. 2004. *The Oceans: Key Issues in Marine Affairs*, Springer.
6. Churchill RR, Lowe AV. 1999. *The Law of the Sea*, Manchester University Press.

FOURTH YEAR			
Course#	Course title	Marks	Credits
<b>Theoretical</b>			
MS-401	Meteorology and Ocean Forecasting	75	3
MS-403	Mangroves Ecosystem and Management	75	3
MS-405	Fisheries Resources Assessment and Management	75	3
MS-407	Fish and Shellfish Health Management	75	3
MS-409	Fish and Shellfish Nutrition	75	3
MS-411	Fish Breeding and Genetics	75	3
MS-413	Environmental Impact Assessment and Management	75	3
MS-415	Fish Pharmacology	75	3
MS-417	Research Methodology	100	4
	<b>Subtotal</b>	<b>700</b>	<b>28</b>
<b>Practical</b>			
MS-402	Meteorology and Ocean Forecasting Practical	25	1
MS-404	Mangroves Ecosystem and Management Practical	25	1
MS-406	Fisheries Resources Assessment and Management Practical	25	1
MS-408	Fish and Shellfish Health Management Practical	25	1
MS-410	Fish and Shellfish Nutrition Practical	25	1
MS-412	Fish Breeding and Genetics Practical	25	1
MS-414	Environmental Impact Assessment and Management Practical	25	1
MS-416	Fish Pharmacology Practical	25	1
MS-418	Research Methodology Practical	50	2
	<b>Subtotal</b>	<b>250</b>	<b>10</b>
MS-499	Research Project	100	4
	Sessional	50	2
	<i>Tutorial</i>	15	
	<i>Practical Notebook</i>	10	
	<i>Internship</i>	25	
	Viva-voce	50	2
	<b>Total</b>	<b>1150</b>	<b>46</b>
	<b>GRAND TOTAL</b>	<b>4000</b>	<b>160</b>

MS-401	METEOROLOGY AND OCEAN FORECASTING	75 (3)
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#### Rationale

Meteorology is a branch of the atmospheric sciences which basically includes atmospheric physics and chemistry with a major focus on the troposphere, where most weather takes place. Meteorologists use scientific principles to observe, analyze, and predict the local and global weather with an emphasis on atmospheric research and operational weather forecasting. Besides, ocean forecasting deals primarily with ocean dynamics, waves, storm surges and ecosystems.

#### Objectives

The objective of this course is to provide a comprehensive introduction to weather processes, climatic conditions and application of meteorological data with a focus on forecasting. It also offers an understanding of the interactions between Earth's atmosphere and its oceans.

#### Learning outcomes

Upon completion of the course, students will be able –

- To know about the aspects of weather and climate
- To comprehend the nature of Earth's atmosphere
- To understand the physical and chemical processes in weather events
- To understand various applications of meteorology and forecasting
- To comprehend the air-sea interactions
- To know about the global climates

#### **Course Contents**

1. Introduction to meteorology
  - 1.1 Aspects of meteorology
  - 1.2 Basic elements of weather
  - 1.3 Weather and climate
2. Earth's atmosphere
  - 2.1 Atmospheric composition
  - 2.2 Structure of the atmosphere
3. Energy, temperature and heat
  - 3.1 Heat transfer in the atmosphere
  - 3.2 Radiation and temperature
  - 3.3 Temperature and seasonal variations
4. Humidity, condensation and clouds
  - 4.1 Hydrologic cycle
  - 4.2 Humidity
  - 4.3 Evaporation, condensation and saturation
  - 4.4 Condensation nuclei and clouds
  - 4.5 Cloud types
  - 4.6 Stability and cloud development
5. Precipitation
  - 5.1 Precipitation processes
  - 5.2 Precipitation types
  - 5.3 Measuring precipitation
6. Air pressure and winds

- 6.1 Atmospheric pressure
- 6.2 Forces influencing winds and air motions
- 6.3 Scales of atmospheric motion
- 6.4 General circulation of the atmosphere
- 6.5 Atmosphere-ocean interactions
7. Air masses and fronts
  - 7.1 Air masses, their types and processes
  - 7.2 Fronts and their categories
  - 7.3 Mid-latitude cyclones
8. Weather observation and forecasting
  - 8.1 Weather observations
  - 8.2 Acquisition of weather information
  - 8.3 Weather forecasting tools and methods
9. Ocean forecasting
  - 9.1 Introduction to operational oceanography
  - 9.2 Fundamentals of ocean models
  - 9.3 Satellite measurements for ocean forecasting
  - 9.4 In-situ observations
  - 9.5 Data assimilation and management
10. Global climates: Classification and patterns
11. Climatology of Bangladesh and the Bay of Bengal

#### Recommended books

1. Ahrens CD, Henson R. 2018. *Essentials of Meteorology: An Invitation to the Atmosphere*, Boston: Cengage Learning.
2. Shonk J. 2013. *Introducing Meteorology: A Guide to Weather*, Dunedin Academic Press Ltd.
3. Spellman FR. 2013. *The Handbook of Meteorology*, Lanham: Scarecrow Press, Inc.
4. Barry RG, Chorley RJ. 2010. *Atmosphere, Weather and Climate*, Oxon: Routledge.
5. Pinardi N, Woods J. 2002. *Ocean Forecasting: Conceptual Basis and Applications*, Springer.
6. Chassignet EP, Verron J. 2006. *Ocean Weather Forecasting: An Integrated View of Oceanography*, Springer.
7. Oliver JE, Hidore JJ. 2002. *Climatology: An Atmospheric Science*, Prentice Hall.

<b>MS-402</b>	<b>METEOROLOGY AND OCEAN FORECASTING PRACTICAL</b>	<b>25 (1)</b>
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1. Geo-referencing of weather spot in the global scale
2. Measurement of wind speed, direction and record keeping
3. Measurement of humidity, precipitation and evaporation rate
4. Interpretation of weather data, different data sources
5. Modeling climate data and forecasting – a simple model practice
6. Analysis of tropical storms and computation of wind speed in the storm field
7. Preparation of weather summaries and forecasts

<b>MS-403</b>	<b>MANGROVES ECOSYSTEM AND MANAGEMENT</b>	<b>75 (3)</b>
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#### Rationale

Mangrove ecosystems serve as the buffer between land and sea having numerous benefits. Though mangroves offer a wide range of ecosystem services, they face constant threats and stresses of various magnitudes globally. Hence, management of mangrove ecosystems and conservation of its biodiversity are critical to achieve the sustainability objectives at local, national and international levels.

#### Objectives

The objective of this course is to offer a fundamental background on the biogeography, ecosystem services and environmental processes in mangrove vegetations across the world. It aims to provide stimulating concept and analytical understanding to contribute to strategic decisions for biodiversity conservation, sustainable resource utilization, mitigation of anthropogenic stresses and improvement of community livelihood in the mangrove-dominated areas.

#### Learning outcomes

Upon completion of the course, students will be able to:

- Understand the biogeography of mangroves
- Appreciate the ecological processes and significance of mangrove ecosystems
- Comprehend the geomorphology and hydrodynamics of mangrove forests
- Recognize the threats and challenges to mangrove ecosystems
- Understand different aspects of sustainable mangrove management

#### Course contents

1. Introduction
  - 1.1 Definition, types and significance of mangrove
  - 1.2 Global distribution
2. Mangrove and its environment
  - 2.1 Adaptation to saline water
  - 2.2 Reproductive adaptations
  - 2.3 Nutrients and its recycling
3. Mangrove community structure
  - 3.1 Species zonation
  - 3.2 Terrestrial components: Mangrove-associated plants and fauna
  - 3.3 Marine components: Algae, fish and other fauna
4. Sediments and geomorphology of mangroves
  - 4.1 Sedimentation
  - 4.2 Shoreline progradation and mangrove succession
  - 4.3 Environmental settings
5. Hydrodynamics in mangrove ecosystem
  - 5.1 Tidal circulation and asymmetry

- 5.2 Exchange with the nearshore zone
- 5.3 Groundwater flow
- 5.4 Climatic and tidal influences
- 5.5 Links between physical and biochemical processes
6. Mangrove Management
  - 6.1 Integrated Planning for Mangrove Management
  - 6.2 Mangrove Conservation and Plantation
  - 6.3 Mangrove Assessment and Monitoring
  - 6.4 Mitigation of deforestation and other threats to mangrove forests
  - 6.5 Mangrove eco-tourism
7. Studies on Sundarbans
  - 7.1 Geographic context
  - 7.2 Biodiversity of Sundarbans
  - 7.3 Ecosystem services of Sundarbans
  - 7.4 Management strategies for sustainable exploitation of aquatic resources of Sundarbans
8. Case Studies on mangrove management
  - 8.1 Mangrove ecosystem of Malaysia: status, challenges and management strategies
  - 8.2 Distribution and current status of mangrove forests in Indonesia
  - 8.3 Mangrove forests in Thailand
  - 8.4 Philippines' mangrove ecosystem: status, threats and conservation

#### Recommended books

1. Sen HS. 2019. *The Sundarbans: A Disaster-Prone Eco-Region: Increasing Livelihood Security*, Springer.
2. DasGupta R, Shaw R. 2017. *Participatory Mangrove Management in a Changing Climate: Perspectives from the Asia-Pacific*, Springer.
3. Pancel L, Köhl M. 2016. *Tropical Forestry Handbook*, Springer.
4. Hogarth PJ. 2015. *The Biology of Mangroves and Seagrasses*, Oxford University Press.
5. O'Donnella, Wodon Q. 2015. *Climate Change Adaptation and Social Resilience in the Sundarbans*, Routledge.
6. Faridah-Hanum et al. 2014. *Mangrove Ecosystems of Asia: Status, Challenges and Management Strategies*, New York: Springer.
7. Vannucci M. 2004. *Mangrove Management and Conservation: Present and Future*, Tokyo: United Nations University Press.

MS-404	MANGROVES ECOSYSTEM AND MANAGEMENT PRACTICAL	25 (1)
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1. Identification of mangrove fauna and flora
2. Identification of different adaptive features of mangrove plants
3. Determination of soil composition of mangrove area
4. Estimation of organic matters in mangrove sediment
5. Determination of key nutrients of mangrove ecosystem
6. Estimation of biodiversity of mangroves

MS-405	FISHERIES RESOURCES ASSESSMENT AND MANAGEMENT	75 (3)
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#### Rationale

Among all the exploited natural resources, fisheries is among the largest. Fisheries sector plays a vital role in the national economy of Bangladesh. Responsible fisheries resource management is a prerequisite to sustain ecosystem, ensure nutrition security, and enhance livelihood and income. The magnitude, dynamics and resilience of fish stocks pose great challenges to their assessment and management, which require specialized training and education.

#### Objectives

The objective of this course is to provide insight into fisheries management perspectives in tropical ecosystems in terms of estimating the stock abundance and drawing management plan for optimum harvest of the resources. Besides, this course is intended to offer knowledge on sound stock assessment strategies, fish population dynamics and fisheries economics to the learners.

#### Learning outcomes

At the end of the course module, students will learn:

- Basic concepts of fisheries resources, fish stocks and their inherent characteristics
- Fish/shellfish stock assessment tools and techniques to predict the changes in stock and size of yields as function of both fishery dependent as well as fishery independent factors
- Fisheries economics
- Fisheries resource management planning

#### **Course contents**

1. Fisheries resources of Bangladesh
  - 1.1 Concept, Exploration, Exploitation, Fisheries Biodiversity, Statistics, Pelagic and Demersal marine fishery resources
  - 1.2 History and status of marine fisheries resource exploitation in Bangladesh
  - 1.3 Fishing grounds and other important marine fishing zones of Bangladesh
  - 1.4 Artisanal fisheries: Concepts and components of artisanal fisheries
2. Fishing crafts and gears of Bangladesh: Types, Design and Selectivity of gears and crafts used in Bangladesh
3. Fish stock assessment
  - 3.1 Concepts of stock and stock assessment; types and objectives of stock assessment
  - 3.2 Stock assessment methods: Sampling, direct enumeration, mark recapture method, survey removal method, catch and effort method, swept area method, deck sampling method, acoustic method, egg production method etc.
4. Fish population dynamics
  - 4.1 Fundamental concepts of fish population dynamics
  - 4.2 Length weight relationship, isometric growth, correlation, coefficient of correlation and regression
  - 4.3 Growth estimation: Estimation of growth parameters, Von Bertalanffy growth parameters, Ford-Walford plots
  - 4.4 Reproduction and recruitment: GSI, HSI, Condition factor, relative condition factor, gonad maturation stages, Timing of reproduction, length at sexual maturity ( $L_m$ ), timing of recruitment, length at recruitment ( $L_r$ )
  - 4.5 Mortality estimation: Definition, causes and effects, estimation of mortality ( $Z$ ), catch curves (basic principles), Age-based and Length-based plots, Beverton and Holt equation, Powell-Wetherall method
  - 4.6 Virtual population analysis

5. Fish yield models
  - 5.1 Basic concepts, Determination of MSY,  $f_{MSY}$ , MEY,  $f_{MEY}$  etc.
  - 5.2 Yield per recruit model
  - 5.3 Biomass model
6. Recruitment and selectivity
7. Fisheries economics
  - 7.1 Concepts of fisheries economics; types, purpose and uses
  - 7.2 Bioeconomic fisheries model concepts
  - 7.3 Economics in the fish market
8. Fisheries management
  - 8.1 Concept, scope and objectives
  - 8.2 Data and information requirement and analysis
  - 8.3 Fisheries management planning and strategies
  - 8.4 Fisheries management system; International, regional and national perspectives
  - 8.5 Small-scale Fisheries (SSF) management: Concept, complexity and dynamics of SSF

#### Recommended books

1. Svein J. 2019. *Life Above Water*, TBTI Global Book Series, Essays on Human Experiences of Small-Scale Fisheries.
2. Stamatopoulos C. 2002. *Sample-based Fishery Surveys – A Technical Handbook*, FAO Handbook, FAO Fisheries Technical Paper, No. 425.
3. Hilbom R, Walter CG. 2001. *Quantitative Fisheries Stock Assessment Methods*.
4. King M. 2001. *Fisheries Biology, Assessment and Management*.
5. Punt and Hilbom. 2001. *BAYES-SA – Bayesian Stock Assessment Methods in Fisheries*, Users' Manual.
6. Sparre PJ. 2000. *Manual on sample-based data collection for fisheries assessment, Examples from Vietnam*, FAO Fisheries Technical Paper. No. 398.
7. Spare and Venema. 1998. *Introduction to Tropical Fish Stock Assessment – Part 1 (Manual) and Part 2 (Practical)*, FAO Technical Paper, No. 306 (1 & 2).

MS-406	FISHERIES RESOURCES ASSESSMENT AND MANAGEMENT PRACTICAL	25 (1)
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1. Observation of different types of crafts and gears used in Bangladesh (Bay of Bengal and inland capture fisheries), field visit
2. Biostatistics of fisheries (correlation, regression and length-weight relationship)
3. Sampling (Fish sampling and measurement)
4. Growth estimation (Growth parameters, VBGP, Cohort analysis)
5. Mortality estimation ((Beverton and Holt's Z estimation, Powell-Wetherall method)
6. Determination of MSY,  $f_{MSY}$ , MEY,  $f_{MEY}$  etc.
7. Cost revenue and effect relationship

MS-407	FISH AND SHELLFISH HEALTH MANAGEMENT	75(3)
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#### Rationale

Increasing farming intensity in response to growing demand for fisheries commodities has challenged aquaculture in many ways, particularly with diseases. Proper understanding of diagnostic and control measures of pathogenic organisms is essential to overcome the adverse impact of diseases in aquaculture and to make the activity profitable.

#### Objectives

The objective of this course is to introduce students with the basic principles of aquatic health management, host defense system, and to impart knowledge on preventive and remedial measures for maintaining healthy aquaculture stocks.

#### Learning outcomes

Having successfully completed this module students will be able to:

- Understand the basic principles of fish and shellfish health management
- Characterize and diagnose common diseases in aquaculture
- Undertake appropriate modes of treatment of microbial and parasitic diseases
- Outline the biosecurity regime in aquaculture systems, in view of the prevailing national and international quarantine standards, and disease surveillance and reporting

#### Course contents

1. Diseases and principal pathogens in aquaculture
2. Microbial diseases
  - 2.1 Bacteria – anaerobic, Gram-positive & Gram-negative bacteria; *Pseudomonas*; *Vibrio*
  - 2.2 Virus – viral erythrocytic necrosis (VEN), infections pancreatic necrosis (IPN), infectious Hematopoietic necrosis virus (IHNV), Viral hemorrhagic septicemia (VHS), baculovirus penaei (BP), yellow head baculovirus (YBV), lymphoid organ virus (LOV), lymphocystis
  - 2.3 Fungi – *Ichthyophomus hoferi*, other fungal pathogens
3. Parasitic diseases
  - 3.1 Protozoa – Sarcocystis, Apicomplexa, Ciliophora
  - 3.2 Platyhelminthes – Monogenea, Digenea, Cestoda
  - 3.3 Nematode – Nematoda, Acanthocephala
  - 3.4 Crustacea – Copepoda, Isopoda
4. Diagnosis of pathogen
  - 4.1 Clinical sign
  - 4.2 Post-mortem
  - 4.3 Histopathological & bacteriological examination
  - 4.4 Serology
5. Pathogen control measures
  - 5.1 Chemicals
  - 5.2 Medication
  - 5.3 Mechanical & biological control
  - 5.4 Extermination & disinfection

6. Host defense mechanism
  - 6.1 Response to stressors
  - 6.2 Inflammation & wound repair
  - 6.3 Immune response to foreign antigen
7. Biosecurity measures, disease surveillance and reporting
8. Fish and shellfish diseases in Bangladesh
9. Socioeconomic effects of disease outbreaks

#### Recommended books

1. Austin B, Newaj-Fyzul A. 2017. *Diagnosis & Control of Diseases of Fish & Shellfish*, Wiley.
2. Galina J. 2017. *Fish Diseases: Prevention & Control Strategies*, Academic Press.
3. Austin & Austin. 2016. *Bacterial Fish Pathogens: Disease of Farmed and Wild Fish*, Springer.
4. Plumb & Hanson. 2010. *Health Maintenance & Principal Microbial Diseases of Cultured Fishes*, John Wiley & Sons.
5. Woo PTK. *Fish Diseases & Disorders: Vol. 1 (2006), 2 (2010), 3 (2011)*; CABI Publishing.

MS-408	FISH AND SHELLFISH HEALTH MANAGEMENT PRACTICAL	25(1)
<ol style="list-style-type: none"> <li>1. Collection of parasites from fish and shellfish specimens</li> <li>2. Preservation of parasites and preparation of permanent slides</li> <li>3. Isolation and identification of pathogens from farmed species and environmental samples</li> <li>4. Clinical examination of diseased fish and shellfish</li> <li>5. Examination of blood parasites</li> </ol>		

MS-409	FISH AND SHELLFISH NUTRITION	75(3)
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#### Rationale

Adequate nutrition is essential for maintaining good health of aquaculture stocks. The chemical and physical properties affect the appearance, taste, smell, texture, preparation process and shelf-life of feed. Thus, nutrient requirements, feeding habits, preference of food, frequency and time of feeding are important for grow out pond management.

#### Objectives

The objective of this course is to provide students with the basic concepts of nutrition including nutrient requirements, nutrient chemistry, feed & ration formulation, practical feeding.

#### Learning outcomes

Having successfully completed this course students will be able to:

- Understand nutritional requirement of cultivable fish and shellfish species
- Formulate balanced diet for farmed species
- Formulate on-farm feed with locally available ingredients
- Test the quality of feed ingredients and feeds

#### Course contents

1. Basic concept of nutrition, fate of ingested nutrients
2. Protein and amino-acids nutrition
  - 2.1 Classification, functions, total protein requirements, factors affecting the requirements
  - 2.2 Qualitative & quantitative requirements of amino-acids, dietary non-protein nitrogen
  - 2.3 Evaluation of protein quality, deficiency symptoms
3. Lipids & fatty acid nutrition
  - 3.1 Classification, functions, essential fatty acids, fatty acids requirements, biosynthesis
  - 3.2 Structure, function and requirement of phospholipids; deficiency symptoms
4. Carbohydrates nutrition
  - 4.1 Classification, biological significance, functions, carbohydrate utilization by fish
  - 4.2 Fiber and their nutritive role, requirements of carbohydrate in diet, protein sparing effects
5. Vitamins nutrition
  - 5.1 Classification, biological functions, dietary sources, requirements
  - 5.2 Factors affecting requirements; stability & availability of vitamins; deficiency symptoms
6. Minerals nutrition
  - 6.1 Classification, function, nutritional value of minerals
  - 6.2 Dietary sources of individual minerals, dietary mineral requirements
7. Anti-nutritional factors, classification, anti-nutritional factors & its presence in aqua-product
8. Feed additives, aqua-feed nutraceuticals
9. Conventional and unconventional feed ingredients; proximate composition; international coding
10. Diet formulation, feed manufacturing process, storage, quality evaluation
11. Feeding methods, feed loss, feed derived wastes
12. Feeding management – feeding ration, feeding frequency, feeding period

#### Recommended books

1. Gasco et al. 2018. *Feeds for the Aquaculture Sector*, Springer.
2. Holt J. 2011. *Larval Fish Nutrition*, Wiley-Blackwell.
3. Webster & Lim. 2002. *Nutrient Requirements and Feeding of Finfish for Aquaculture*, CABI.
4. Guillame et al. 2001. *Nutrition and Feeding of Fish and Crustaceans*, Springer.
5. Webster & Lim. 2001. *Nutrition and Fish Health*, CRC Press.
6. Hertrampf & Pascual. 2000. *Handbook on Ingredients for Aquaculture Feeds*, Springer.

MS-410	FISH AND SHELLFISH NUTRITION PRACTICAL	25(1)
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1. Identification of feed ingredients, their physical characteristics, proximate composition
2. Formulation of a balanced diet for fish and shrimp, proximate composition
3. Hydro-stability test for a compound feed; estimation of protein quality (PER, NPU)
4. Estimation of acid value, per-oxide & iodine value of fat; crude fiber content of feed
5. Analysis of anti-nutritional and toxic substances in feed ingredients

Rationale

There is an increasing application of genetics and biotechnological tools in fisheries and aquaculture, particularly in characterizing genetic diversity of wild fish stocks, and genetic improvement of cultured stocks. This knowledge is key for domestication of stocks with good traits and adopting broodstock management strategies to overcome the negative effects of inbreeding and unintentional selection.

Objectives

The objective of this course is to provide students with the basic concepts of applied genetics relating to management of fish stocks, conservation of genetic resources & selective breeding in aquaculture.

Learning outcomes

Having successfully completed this module students will be able to:

- Understand the principles of genetics and its role in conservation of fish genetic resources
- Identify analytical genetic technologies relevant to fisheries and aquaculture
- Distinguish population genetic, quantitative genetic and the techniques
- Apply the principles and practices of selective breeding in aquaculture

**Course contents**

1. Introduction to genetics: Phenotype, genotype, molecular genetics (DNA molecule, replication of DNA, RNA, chromosomes, protein synthesis), cell division (mitosis, meiosis, location of genes), genetic code, dominant and additive gene expression, Mendelian traits in fish
2. Population genetics: Hardy-Weinberg equilibrium, inbreeding, crossbreeding, selection, mutation & sexual reproduction, genetic drift, migration, genetic distance & population divergence
3. Reproductive traits and genetic structure in aquatic organisms: Reproductive cycle, sex determination, sex ratio, sexual characteristics, egg & sperm production, fertilization, hormone induced sex reversal & ovulation, cryopreservation of gametes & gene banking, alleles & genotypes, allozymes, mtDNA & microsatellite variation
4. Application of fish biotechnology: Crossbreeding, hybridization, polyploidy, sex reversal & breeding, gynogenesis, and rogenesis
5. Fish genetic resources of Bangladesh; genetic considerations in open water stocking
6. Gene-transfer technique – DNA construction, transgene delivery, transgene integration, detecting integration & expression of the transgene, performance of transgenesis, gene cloning
7. Design of breeding programs: Maintenance of additive genetic variance, inbreeding & risk, mating design, selection, selection & mating, progeny testing, connectedness, small- and large-scale breeding program
8. Biotechnology in aquaculture – DNA markers, linkage maps, QTL, marker-assisted selection
9. Safety and ethics in biotechnology, existing legislation, codes of practice for biotechnology
10. Constraints and limitations of genetic biotechnology

**Recommended books**

1. Griffiths et al. 2015. *Introduction to Genetic Analysis*, Freeman/Worth.
2. Dunham. 2011. *Aquaculture and Fisheries Biotechnology: Genetic Approaches*, CABI.
3. Beaumont et al. 2010. *Biotechnology & Genetics in Fisheries & Aquaculture*, Wiley-Blackwell.
4. Shah MS. 2010. *Genetics of Aquaculture and Fisheries Management*, Khulna University.
5. Gjedrem. 2005. *Selection and Breeding Programs in Aquaculture*, Springer.
6. Carvalho & Pitcher. 1995. *Molecular Genetics in Fisheries*, Springer.

1. Extraction of DNA, RNA and protein
2. Isolation of chromosomal or genomic DNA; DNA cloning
3. DNA amplification by polymerase chain reaction (PCR)
4. Agarose gel electrophoresis for separating and identifying DNA fragments
5. Identification of fish mutant; embryonic development in fish and shellfish species
6. Sex determination and progeny testing

Rationale

EIA has been considered as a decision aid rather than a decision-making tool. The course focuses practice in environmental assessment at both the project level (environmental impact assessment) and the strategic level (strategic environmental assessment). It explains a thorough grounding in environmental assessment procedures and practice, followed by an introduction to the environmental management aspects.

Objectives

The objective of the course is to provide understanding of EIA and confidence with its application and limitations. The course is designed to prepare students on the role of EIA in decision-making process, strengths of EIA in regard to environmental management, technical and social/political limitations of EIA and can determine how EIA processes are useful in academic and professional careers.

Learning outcomes

Upon completion of the course, students will be able to:

- Understand basic concepts and principle of EIA
- Understand the screening process
- Know the options for estimating environmental and social impacts
- Know the format of an EIA Report
- Know the factors that assist/detract the usefulness of the EIA Report
- Understand the purpose of developing follow-up procedures
- Prepare environmental management plan (EMP) of an industry

**Course contents**

1. Introduction: History of EIA, Definition of Environmental Impact Assessment
2. Major issues of the EIA process
3. Methodological aspect of EIA
  - 3.1 Preliminary activities

- 3.2 Scoping methods in EIA
- 3.3 Baseline studies in EIA Process
4. The EIA process adopted in Asia and the Pacific region
5. EIA and international/bilateral development and donor agencies
6. EIA study in development projects
7. Major development activities
  - 7.1 Flood protection embankment
  - 7.2 Coastal aquaculture developments
  - 7.3 Solid waste disposal areas
  - 7.4 Green-house gases
  - 7.5 Industrial impacts
  - 7.6 Health impacts (Risk assessment)
  - 7.7 Impact of Farakka-Barrage on coastal region of Bangladesh
8. Guidelines of developing countries

#### Recommended books

1. Wood C. 2002. *Environmental Impact Assessment*, 2nd edition, Routledge.
2. Glassman et al. 1998. *Introduction to Environmental Impact Assessment*, UCL Press.
3. Walther D. P. 1996. *Environmental Impact Assessment (EIA)*, Mc-Graw Hill Co.

<b>MS-414</b>	<b>ENVIRONMENTAL IMPACT ASSESSMENT AND MANAGEMENT PRACTICAL</b>	<b>50(2)</b>
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1. Case studies
2. Study of flood protection embankment
3. Marine activities (coastal deforestation, shrimp farming)
4. Solid-waste disposal in Urban area
5. Industrial impacts
6. Health impacts (Risk assessment).

<b>MS-415</b>	<b>FISH PHARMACOLOGY</b>	<b>75(3)</b>
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#### Rationale

A greater knowledge of medicinal treatments is essential for the prevention and treatment of fish diseases. This module covers the basic information of different therapeutics and prophylactics used in aquaculture, principles of pharmacokinetics and dynamics, and the techniques in pharmacology. Such an understanding is also important to regulate the use of drugs, antibiotics and chemicals in aquaculture from the view-point of fish health, consumer and environmental safety.

#### Objectives

This module will equip students with the knowledge of basic principles of veterinary pharmacology, pharmacodynamics, pharmacokinetics (absorption, distribution, metabolism, elimination) of aquaculture drugs, and their applications in relation to the drug effects and mechanisms of action.

#### Learning outcomes

Having successfully completed this module students will be able to:

- Understand how pharmacological agents (antibacterial agents, antiparasitic agents and anaesthetics) work and behave in the fish body
- Know about breeding induction agents, immunostimulants, vaccines, probiotics and their mode of action
- Learn different methods of administering drugs to fish
- Know which dose and drug to use as anaesthetics
- Understand environmental concerns of aquaculture drugs

#### **Course contents**

1. Introduction to Pharmacology, Pharmacological terms and definitions, sources of drugs.
2. Principles of drug activities, pharmacokinetics, absorption, mechanism of action, distribution, metabolism, excretion of drugs.
3. Pharmacodynamics, concept of drug receptor, dose response relationship, half-life and withdrawal period, factors affecting drug effect and dosage, mechanisms of drug resistance.
4. Antibacterial (tetracyclines, penicillins, macrolides, sulfonamides, potentiated sulfonamides, quinolones and fluoroquinolones), antiviral, antiprotozoal, antiparasitic and antihelmintic agents. Externally applied antimicrobial agents.
5. Probiotics, Immunostimulants, Vaccines and their mode of action.
6. Breeding induction agents, Sex control, Osmoregulators
7. Anesthesia and anaesthetics.
8. Antiseptic and disinfectant.
9. Methods of drug administration. Safety of aquaculture medicines and the law.
10. Proper use of the drugs, chemicals and antibiotics, considering food safety and GAP system in the steps of aquaculture.
11. The possible effects of drugs on the environment near aquaculture farms.

#### **Recommended books**

1. Richard et al. 2005. *Pharmacology*, Lippincott Williams and Wilkins. 552p.
2. Brown KMT. 2000. *Applied Fish Pharmacology*, Aquaculture Series 3; Kluwer Academic Publishers. 309p.
3. Noga EJ. 1996. *Fish Disease Diagnosis and Treatment*, Mosby-Year book Inc. 367p.
4. Stoskoipf MK. 1993. *Fish Medicine*, W B Saunders Company Philadelphia. 882p.

<b>MS-416</b>	<b>FISH PHARMACOLOGY PRACTICAL</b>	<b>25(1)</b>
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1. AntibioGram preparations; Antibiotic residual assays; studies on histopathological changes caused due to chemotherapy. Probiotics, immunostimulants, vaccines, important anaesthetics and their mode of action.

<b>MS-417</b>	<b>RESEARCH METHODOLOGY</b>	<b>100(4)</b>
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#### Rationale

Research methodology course takes a step-by-step approach on research concepts, *hypothesis*, scientific methods, *research design*, *sampling techniques*, *data collection*, *data analysis*, and *research report* and presentation (*Term paper/Thesis*). The course also focuses participatory

approach including surveys, interviews, focus groups, participant observation, and textual analysis. This course equips students with the necessary knowledge and skills to complete term paper and thesis for Bachelor and Master's degrees.

### Objectives

The objective of this course is to understand research terminology, quantitative and qualitative methods, analytical techniques, literature review process, presentation format, and dissemination options. The course is designed to prepare students with knowledge and ability to undertake research projects and can determine how research findings are useful in academic and professional careers.

### Learning outcomes

Upon completion of the course, students will be able to:

- Understand basic concepts of research and research methodology
- Select research topics with problem and parameters
- Perform literature reviews using print and online databases
- Use relevant quantitative and qualitative methodologies and techniques for data analysis
- Plan, design and execute Bachelor and Masters research

### **Course contents**

1. Introduction
  - 1.1 Fundamental concepts of research
  - 1.2 Steps of conducting a research
  - 1.3 Motivation in research
  - 1.4 Types of research
  - 1.5 Identification of research problem/question
  - 1.6 Reviewing literatures
2. Hypotheses and variables
  - 2.1 Definition of hypothesis
  - 2.2 Types of hypothesis
  - 2.3 Formulation of research hypotheses
  - 2.4 Variables in hypothesis
  - 2.5 Types of variables
  - 2.6 Errors in hypothesis
  - 2.7 Hypothesis/theory building process
3. Research design
  - 3.1 Design of experiment
  - 3.2 Principles and importance of replication
  - 3.3 Questionnaire design for survey
4. Data collection
  - 4.1 Collection methods (observation, interview, questionnaire, experiment, case study)
  - 4.2 Sampling design
  - 4.3 Types of sampling
  - 4.4 Probability and non-probability sampling
  - 4.5 Sampling error and sample size
5. Participatory approach (PRA/RRA)
  - 5.1 Concepts and importance
  - 5.2 Sustainable livelihood frameworks
  - 5.3 Specific tools and techniques (Resource mapping, wealth ranking, seasonal calendar, historical trends, transect analysis, daily activity, problem tree, Venn diagram, etc)
6. Data analysis
  - 6.1 Quantitative data analysis
  - 6.2 Qualitative data analysis
  - 6.3 Mixed methods data analysis
7. Writing research proposal
  - 7.1 Developing an outline
  - 7.2 Key elements - introduction, objective, rationale
  - 7.3 Experimental method, measurement
  - 7.4 Results, outputs and measurable indicators
8. Writing term paper, thesis and articles
  - 8.1 Structure and organization
  - 8.2 Sections/chapters
  - 8.3 Use of text, tables and graphics
  - 8.4 Plagiarism concern
  - 8.5 Citations and bibliography
9. Research outreach
  - 9.1 Oral presentation
  - 9.2 Poster presentation
  - 9.3 Extended abstract
  - 9.4 Policy documents
  - 9.5 Press and media briefing

### **Recommended books**

1. Bairagi V, Munot MV. 2019. *Research Methodology: A Practical and Scientific Approach*, CRC Press. 321p.
2. Jain S. 2019. *Research Methodology in Arts, Science and Humanities, Society Publishing*. 250p.
3. Niaz M, Rivas M. 2016. *Students' Understanding of Research Methodology in the Context of Dynamics of Scientific Progress*, Springer. 69p.
4. Saris WE, Gallhofer IN. 2014. *Design, Evaluation, and Analysis of Questionnaires for Survey Research*, Wiley. 376p.
5. Betz F. 2011. *Managing Science: Methodology & Organization of Research*, Springer. 420p.
6. Kothari CR. 2009. *Research Methodology: Methods and Techniques*, New Age Publications (Academic). 414p.
7. Kumar R. 2005. *Research methodology: A step-by-step guide for beginners*, SAGE publications. 344p.

1. Research proposal writing
2. Research design, sampling design, and sampling protocol
3. Practices in data analyses and interpretation
4. Oral and poster presentation