Bangabandhu Sheikh Mujibur Rahman Maritime University, Bangladesh (BSMRMU)

Faculty of Earth and Ocean Science
Department of Marine Fisheries and Aquaculture

Course Curriculum for
B.Sc. (Honours) in Marine Fisheries Programme

Effective from the Academic Session: 2019–2020

AUTHOROTY OF PUBLICATION

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PREAMBLE

Program Description

1. Bangladesh has coastline of 710 km along the north and north-east part of the Bay of Bengal. It has internal estuarine water area of 25124 square kilometers up to 10 fathoms depth from the baseline, territorial waters of 9054.94 sq. km, continental shelf of 8506.15 sq. km and Exclusive Economic Zone (EEZ) 1,18,813 sq. km under national economy and jurisdiction. All these areas of Bay of Bengal offer potential resources specially fishes and shellfish for the country.

2. The Bachelor of Science (Honours) in Fisheries is an Under Graduate degree program that deals with the study on different aspect of marine fisheries to ensure blue economy from sea resources of Bangladesh. The course provides scientific-technical training and the methodology necessary for fishery research, aquaculture, stock assessment and management, marine fishing operation, fish processing, operation and maintenance of commercial fishing, processing establishments and their concerned issues in fisheries sciences.

Program Educational Objectives

3. Bachelor of Science (Honors) in Marine Fisheries is a fully integrated professional course of study for the persons willing to prepare themselves for variety of careers in the Fishing sectors, Fish Processing Plants, Aquaculture Farms and Hatcheries, Integrated Costal Management, Marine Spatial Planning, fisheries research etc. The duration of this course is 4 (Four) years. In this period students learn how to maximize the proper and sustainable utilization of marine living resources. Students will get sufficient practical knowledge regarding Marine Resources during their research project at final year.

The Aim of Bachelor of Science (Honors) in Marine Fisheries Program

4. Provide and equip students with knowledge, understanding, proficiencies, skills, competences, attitudes and values to qualify and prepare them for marine fisheries sector, fish processing, aquaculture farms and hatcheries as well as any managerial position in maritime domain and also to produce graduates who are qualified to pursue a professional career or advanced studies in a related field of specialization.

5. All courses are compulsory.

6. After successful completion of Bachelor of Science (Honors) in Marine Fisheries course, students can accommodate themselves into the commercial Fishing industry, Fish Processing Industry, Fish/shrimp hatchery, Aquaculture Farm, Coastal and Marine Tourism Industry, Government organization and NGO's in various capacity as well as may serve themselves as a freelance Consultants.

COURSE CURRICULUM

General Information

1. **Name of the Programme** **B.Sc. in Marine Fisheries**

2. **Duration of the Programme** B.Sc. in Marine Fisheries is a 4 years full time regular undergraduate programme. This programme is divided into eight semesters of 6 months each (2 semesters in each year). The duration of each semester is 26 weeks. In each semester, 15 weeks are dedicated for classroom learning, while remaining weeks are utilized for make-up classes, mid-term examination, preparatory leave, final examination and other curricular and co-curricular activities. Distribution of weeks is as follows:

a.	Classes	15 weeks
b.	Mid Term Examinations	02 weeks
c.	Preparatory Leave	02 weeks
d.	Term Final Examination	03 weeks
e.	Recess	04 weeks

3. **Credits of the Programme 150** Credits

Admission Criteria

4. Applicants must fulfil the admission requirements as prescribed by Bangabandhu Sheikh Mujibur Rahman Maritime University, Bangladesh (BSMRMU). To be eligible for admission in the programme, a candidate must pass SSC/ Dakhil and HSC/Alim examinations or its equivalent in Science discipline. The minimum requirements for admission in this programme are as follows:

a. Applicants who have passed HSC or equivalent examination in the current year or one year before the notification for admission are eligible to apply.

b. Applicants must have passed SSC/equivalent examination and HSC/ equivalent examination from Board of Intermediate and Secondary Education/ Madrasa Education Board/ Technical Education Board in Science group with minimum GPA 4.00 in a 5-point scale. Applicants must have Biology in HSC.

c. In HSC/Alim/equivalent examination the applicant must have obtained minimum "A" grade in any two (02) subjects from Mathematics, Physics, Chemistry, Biology and English with minimum "B" grade in rest of the Courses.

d. Applicants with GCE must have passed minimum five subjects in O level including Physics, Chemistry, Mathematics and at least two subjects in A level including Physics and Mathematics. Applicants must also have Biology

in A level. However, an applicant having more than two 'C' grades in O level and/or more than one 'C' grade in A level shall not be eligible for admission.

e. Foreign applicants shall apply through their respective embassy. Educational qualifications are same as applicable for Bangladeshi students.

Admission Test

5. The admission notice shall be circulated usually in the month of August/September of each year through media advertisement, BSMRMU website and notice board. The procedure for admission in B.Sc. in Marine Fisheries programme is as follows:

a. Written Admission Test: An eligible candidate have to sit for a written admission test of 100 marks. The current HSC syllabus shall be the syllabus of the admission test.

b. Marks Distribution of Written Admission Test: Syllabus of the admission test shall that be of the current HSC Syllabus. Subjects of the written examination and mark distributions are given below:

1. Mathematics	:	20 marks
2. Physics	:	20 marks
3. Chemistry	:	20 marks
4. Biology	:	20 marks
5. English	:	20 marks
Total	:	100 marks

c. Final Selection: Candidates will be selected finally on the basis of their combined marks obtained in the written admission test (100), HSC/equivalent examination (60) and SSC/equivalent examination (40). Final merit list along with waiting list will be published on BSMRMU notice board as well as on BSMRMU website.

d. Registration/Admission in the Programme:
After final selection, selected candidates shall be registered with the programme in accordance with the procedures as laid down by BSMRMU. The candidates have to go through a medical checkup at BSMRMU designated Medical Centre to ascertain their medical fitness. The selected candidates shall have to collect Admission Form from Admission Section and complete admission and registration formalities within the given time frame by paying required fees.

e. Cancellation of admission:(i) If any candidate fails to complete admission formalities within the prescribed date and time his/her selection will be cancelled automatically; (ii) If any student does not attend the class within two weeks of commencement of classes, his/her admission will be cancelled automatically.

Grading System

6. Letter grades and corresponding grade points will be awarded in accordance with the provisions (unified UGC grading system) shown below:

Grade	Grade points	Numerical Markings
A+	4.0	80% and above
A	3.75	75% to below 80%
A-	3.50	70% to below 75%
B+	3.25	65% to below 70%
B	3.00	60% to below 65%
B-	2.75	55% to below 60%
C+	2.50	50% to below 55%
C	2.25	45% to below 50%
D	2.00	40% to below 45%
F	0.00	below 40%
I	Incomplete	-
W	Withdrawn	-
X	Thesis continuation	-
E	Expelled	Due to exam offence

Conduct of Courses

7. In a semester, teacher/teachers shall be assigned to plan and teach a particular course. The following guidelines shall be followed to conduct the courses:

a. At the beginning of the semester, the course teacher will prepare a course outline incorporating the course syllabus, performance evaluation and grading system (as laid down in the policy), list of suggested text books/references, and a tentative schedule of classes, examinations and events.

b. **Assignment of Credits.** The assignment of credits to theoretical course is different from that of laboratory course, which is stated as follows:

1) For theoretical courses one lecture of 60 minutes per week per term is equivalent to one credit.
2) For laboratory courses three class hours per week per term is equivalent to one credit.
3) Credits are also assigned to thesis work taken by the students. The amount of time assigned to such work may vary depending on the thesis.

c. A thesis work shall be assigned, either individually or in groups on any issue pertaining to the course.

d. A number of individual and group assignments, presentations, etc. Shall be assigned to students as per the course requirements.

Performance Evaluations

8. **Theory Courses:** Forty percent (40%) of marks of theoretical course shall be allotted for continuous assessment, i.e. quizzes, class tests, home assignments, class evaluation, class

participation, mid-term exam etc. Term Final Examination is conducted centrally by BSMRMU. Term Final Examination will be normally of 3-hour duration. Distribution of marks for a given course is as follows:

a.	Class Attendance	05%
b.	Class Participation/Observation	05%
c.	Term Paper/Assignment	05%
d.	Class Tests/Quiz	10%
e.	Mid Term Examination (01 Exam)	15%
f.	Term Final Examination	60%

The number of quizzes/class tests of a theory course shall be *n+1*, where *n* is the number of credit hours of the course. Evaluation of performance in quizzes/class tests will be based on the best *n* quizzes.

The scheme of continuous assessment that a particular teacher wishes to follow for a course will be announced as course outline on the first day of the term. The performance of a student will be evaluated in terms of two indices, viz. Semester Grade Point Average (SGPA), and Cumulative Grade Point Average (CGPA).

9. Lab Courses: The distribution of marks for Lab courses is given below:

a.	Lab test	40%
b.	Assignment / Report	20%
c.	Viva/Presentation	10%
d.	Quiz	10%
e.	Attendance	10%
f.	Class Performance / Observation	10%

10. Field Trip

The distribution of marks for field trip is given below:

a.	Evaluation of students' participation:	50%
b.	Report Submission:	30%
c.	Presentation:	20%

The requirements for promotion to the next term

11. The requirements for promotion to the next term are as follows:
    a. A student has to take the required courses for a particular term/level as per the syllabus of the programme.
    b. A student shall be promoted to the second term of each level, irrespective of his/her results in the first term of the level provided he/she does not have ‘F’ grades in more than two subjects including backlog subjects (if any).

Credit Earned

12. The Courses in which a student has obtained 'D' or a higher Grade shall be counted as credits earned by him/her. Any course in which a student has obtained 'F' grade shall not be counted towards his/her earned credits. 'F' grade must be cleared within designated period.

Degree Requirements

13. Degree requirements are as follows:

a. Completion of courses for the minimum required credits of 150 in maximum period of six academic years.
b. Appearing at the final examination in all the required courses as per syllabus of the programme.
c. Successful completion of defence of thesis paper.
d. Scoring a CGPA 2.20 or above.

Retaking a Course

14**.** It is expected that students will obtain degree by clearing the entire offered courses of specified credit hours as per the syllabus within six academic year's period. In case of failure to do so by any student the following guiding policies shall be adopted:

a. A student obtaining F grade in a course may be allowed to repeat the course with the prior approval of Head of the Department on the recommendation of the course coordinator. Such approval shall be reported to the BUGSR and academic council (AC).
b. Two courses of any semester may be repeated for improvement with the prior approval of the Head of the Department on the recommendation of the course coordinator. Such approval shall be reported to the BUGSR and AC.

Course Designation System

15. Each course is designated by a maximum of four-letter code identifying the department offering the course followed by a four-digit number having the following interpretation:

a. The first digit corresponds to the year/level in which the course is normally taken by the students.
b. The second digit corresponds to the semester/ term in which the course is normally taken by the students.
c. The last two digits denote various courses, where an odd number is used for theoretical courses and an even number for Laboratory/Practical course

Semester Wise Distribution of the Courses

16. Distribution of the courses is given below:

First Semester (Year-1, Semester-1)					
Theory					
Sl. No.	**Course Code**	**Course Title**	**Credit**	**Contact Hours**	**Marks**
1.	MFS 1101	বাংলাভাষা	3	42	
2.	MFS 1103	Bangladesh Studies	3	42	
3.	MFS 1105	Marine Ecology	3	42	
4.	MFS 1107	Marine Invertebrates	3	42	
5.	MFS 1109	Marine Botany	2	28	
6.	MFS 1111	Communicative English	2	28	
Total of Theory			**16**	**224**	
Lab/ Practical					
1.	MFS 1106	Marine Ecology Lab	1.5	42	
2.	MFS 1108	Marine Invertebrates Lab	1.5	42	
Total of Lab/Practical			**3**	**84**	
Total of 1st Semester			**19**	**308**	

Second Semester (Year-1, Semester-2)					
Theory					
Sl. No.	**Course Code**	**Course Title**	**Credit**	**Contact Hours**	**Marks**
1.	MFS 1201	Fundamentals of Oceanography	3	42	
2.	MFS 1203	Ichthyology and Marine Vertebrate	3	42	
3.	MFS 1205	Limnology	2	28	
4.	MFS 1207	Marine Microbiology	2	28	
5.	MFS 1209	Fisheries Mathematics	2	28	
6.	MFS 1211	Chemistry	2	28	
Total of Theory			**14**	**196**	
Lab/ Practical					
1.	MFS 1202	Fundamentals of Oceanography Lab	1.5	42	
2.	MFS 1204	Ichthyology and Marine Vertebrate Lab	1.5	42	
3.	MFS 1212	Chemistry Lab	1	28	
4.	MFS 1214	Field Trip / Study tour	1		
5.	MFS 1216	Viva -Voce	1		
Total of Lab/Practical			**6**	**112**	
Total of 2nd Semester			**20**	**308**	

Third Semester (Year-2, Semester-1)					
Theory					
Sl. No.	**Course Code**	**Course Title**	**Credit**	**Contact Hours**	**Marks**
1.	MFS 2101	Aquaculture	3	42	
2.	MFS 2103	Mariculture	2	28	
3.	MFS 2105	Planktology	3	42	
4.	MFS 2107	Marine Fish diversity and Systematic	3	42	
5.	MFS 2109	Wetland and Lake Management	2	28	
6.	MFS 2111	Society Culture and Fisheries	2	28	
Total of Theory			**15**	**210**	
Lab/ Practical					
1.	MFS 2102	Aquaculture Lab	1.5	42	
2.	MFS 2106	Planktology Lab	1.5	42	
Total of Lab/Practical			**3**	**84**	
Total of 3rd Semester			**18**	**294**	

Fourth Semester (Year-2, Semester-2)					
Theory					
Sl. No.	**Course Code**	**Course Title**	**Credit**	**Contact Hours**	**Marks**
1.	MFS 2201	Fisheries Genetics and Biotechnology	2	28	
2.	MFS 2203	Aquaculture Nutrition	3	42	
3.	MFS 2205	Fish Diseases	3	42	
4.	MFS 2207	Marine Environment and pollution Management	2	28	
5.	MFS 2209	Fish Harvesting and Handling	2	28	
Total of Theory			**12**	**168**	
Lab/ Practical					
1.	MFS 2204	Aquaculture Nutrition Lab	1.5	42	
2.	MFS 2206	Fish Diseases Lab	1.5	42	
3.	MFS 2210	Fish Harvesting and Handling Lab	1	28	
4.	MFS 2212	Field Trip/ Study tour	1		
5.	MFS 2214	Viva-Voce	1		
Total of Lab/Practical			**6**	**112**	
Total of 4th Semester			**18**	**280**	

Fifth Semester (Year-3, Semester-1)					
Theory					
Sl. No.	**Course Code**	**Course Title**	**Credit**	**Contact Hours**	**Marks**
1.	MFS 3101	Biostatistics	3	42	
2.	MFS 3103	Fish Population Dynamics	3	42	
3.	MFS 3105	Fish Feed Technology	3	42	
4.	MFS 3107	Aquaculture Planning and Engineering	2	28	
5.	MFS 3109	Fisheries Biochemistry	2	28	
6.	MFS 3111	Sedimentology	2	28	
Total of Theory			**15**	**210**	
Lab/ Practical					
1.	MFS 3104	Fish Population Dynamics Lab	1.5	42	
2.	MFS 3106	Fish Feed Technology Lab	1.5	42	
3.	MFS 3108	Aquaculture Planning and Engineering Lab	1	28	
4.	MFS 3110	Fisheries Biochemistry Lab	1	28	
Total of Lab/Practical			**5**	**140**	
Total of 5th Semester			**20**	**350**	

Six Semester (Year-3, Semester-2)					
Theory					
Sl. No.	**Course Code**	**Course Title**	**Credit**	**Contact Hours**	**Marks**
1.	MFS 3201	Basic Seamanship and Navigation	3	42	
2.	MFS 3203	Biodiversity and Conservation	3	42	
3.	MFS 3205	Remote Sensing and GIS	2	28	
4.	MFS 3207	Post-Harvest Technology	2	28	
5.	MFS 3209	Fish Breeding and Hatchery Management	3	42	
Total of Theory			**13**	**182**	
Lab/ Practical					
1.	MFS 3202	Basic Seamanship and Navigation Lab	1.5	42	
2.	MFS 3206	Remote Sensing and GIS Lab	1	28	
3.	MFS 3208	Post-Harvest Technology Lab	1	28	
4.	MFS 3210	Fish Breeding and Hatchery Management Lab	1.5	42	
5.	MFS 3212	Field Trip/Study tour	1		
6.	MFS 3213	Viva-Voce	1		
Total of Lab/Practical			**7**	**140**	
Total of 6th Semester			**20**	**322**	

Seven Semester (Year-4, Semester-1)					
Theory					
Sl. No.	**Course Code**	**Course Title**	**Credit**	**Contact Hours**	**Marks**
1.	MFS 4101	Value Added Fishery product	2	28	
2.	MFS 4103	Coastal Zone Management	2	28	
3.	MFS 4105	Fisheries Economics, Marketing and Extension	3	42	
4.	MFS 4107	Fisheries Resource Management	2	28	
5.	MFS 4109	Research Methodology	3	42	
Total of Theory			**12**	**168**	
Lab/ Practical					
1.	MFS 4102	Value Added Fishery Product Lab	1	28	
2.	MFS 4112	Research Project (Carry upto Eight Semester)	6		
Total of Lab/Practical			**7**	**28**	
Total of 7th Semester			**19**	**196**	

Eight Semester (Year-4, Semester-2)					
Theory					
Sl. No.	**Course Code**	**Course Title**	**Credit**	**Contact Hours**	**Marks**
1.	MFS 4201	Climate Change and Fisheries	3	42	
2.	MFS 4203	Mangrove Ecology and Management	2	28	
3.	MFS 4205	Quality Control and Bio safety	3	42	
4.	MFS 4207	Fisheries Conservation and Laws	3	42	
5.	MFS 4209	Environmental Impact Assessment and Management Plan	3		
Total of Theory			**14**	**196**	
Lab/ Practical					
1.	MFS 4204	Mangrove Ecology and Management Lab	1	28	
2.	MFS 4210	Viva-Voce	1		
Total of Lab/Practical			**2**	**28**	
Total of 8th Semester			**16**	**224**	

FIRST YEAR

FIRST SEMESTER

Course Code & Title:	Credit:3
MFS 1101: বাংলাভাষা	

শিক্ষার যুক্তি	উচ্চ শিক্ষা গ্রহণকারী শিক্ষার্থী-দর বাংলা ব্যাকরণ, বাংলা সাহিত্য এবং বাংলা-দ-শর ইতিহাস, সংস্কৃতি, কৃষ্টি ও মূল্যবোধের উপর মৌলিক জ্ঞান অর্জন এবং প্রাত্যহিক জীবনে সে জ্ঞান নির্ভুলভাবে প্রয়োগে সহায়তা করা।
শিক্ষার উদ্দেশ্য	● বাংলা ভাষা শেখার ও বাংলা সাহিত্য-ক জানার ইতিবাচক ম-নাভাব তৈরি। ● বাংলা-দশ এবং বাঙালির ইতিহাস ও সংস্কৃতি সম্প-র্ক সম্যক ধারণা প্রদান। ● বাংলা ব্যাকরণ ও নির্মিতি সম্প-র্ক সামগ্রিক ধারণা প্রদান। ● দৈনন্দিন জীব-ন শুদ্ধরু-প বাংলা ভাষার প্র-য়াগ।
শিক্ষার ফল	-কার্সটি সফলভা-ব সম্পন্ন করার মধ্য-ম শিক্ষার্থীরা যা শিখ-ত পার-বঃ ● বাংলাদেশের সামাজিক, ঐতিহাসিক ও সাংস্কৃতিক অনুষঙ্গের সঙ্গে বাংলা সাহি-ত্যর সং-যাগ স্থাপন কর-ত পার-ব।

Syllabus Contents:

১। কবিতা

মাইকেল মধুসূদন দত্ত	-	"বঙ্গভাষা"
রবীন্দ্রনাথ ঠাকুর	-	"নির্ঝরের স্বপ্নভঙ্গ"
কাজী নজরুল ইসলাম	-	"আজ সৃষ্টি-সুখের উল্লা-স "
হাসান হাফিজুর রহমান	-	"অমর একু-শ "
শামসুর রহমান	-	"তোমাকে পাওয়ার জন্য হে স্বাধীনতা"

২। প্রবন্ধ

বঙ্কিম চন্দ্র চট্টোপাধ্যায়	-	"বাঙ্গালা ভাষা"
রবীন্দ্রনাথ ঠাকুর	-	"সভ্যতার সংকট"
কবীর চৌধুরী	-	"আমা-দর আত্মপরিচয়"

৩। ছোটগল্প ও অন্যান্য রচনা

রবীন্দ্রনাথ ঠাকুর	-	"পোস্ট মাস্টার"
রোকেয়া সাখাওয়াত হোসেন	-	"অবরোধ বাসিনী"
হাসান আজিজুল হক	-	"ঘর-গরস্থি"
জাহানারা ইমাম	-	একাত্তরের দিনগুলি

৪। নাটক

মুনীর চৌধুরী	-	কবর

৫। বাংলা ব্যাকরণ ও নির্মিতি

বাংলা ধ্বনি/ বাগ্ধ্বনি, বর্ণ, অক্ষর, বাংলা ধ্বনির উচ্চারণ স্থান ও রীতি, বাংলা উচ্চারণ, বাংলা ভাষার প্রয়োগ ও অপপ্রয়োগ: সন্ধি,সমাস, প্রত্যয়, উপসর্গ, সাধু / চলিত রীতি, প্রমিত বাংলা বানানের নিয়ম, বিরাম চিহ্নের ব্যবহার, বাক্য প্রকরণ।

ভাষণ, প্রতিবেদন, পত্র-লিখন ও আবেদনপত্র রচনা।

৬। **বাংলাদেশ এবং বাঙালির ইতিহাস ও সংস্কৃতি**

বাংলা নামের উদ্ভব ও বিবর্তন, বাঙালির ইতিহাস ও সংস্কৃতির স্বরূপ, বাঙালির প্রাগৈতিহাসিক পটভূমি, বাঙালির সংস্কৃতির উৎস, বাঙালির সংস্কৃতির ইতিহাস, ১৯৪৭-এ ভারত বিভক্তি, রাষ্ট্রভাষা আন্দোলন, যুক্তফ্রন্ট ও একুশ দফা, ১৯৫৪-এর নির্বাচন ও যুক্তফ্রন্টের পরিণতি, পাকিস্তা-নর অধীন পূর্ব বাংলার রাজনৈতিক-সামাজিক-অর্থনৈতিক দুরবস্থা, ৬ দফা ও স্বায়ত্তশাসনের আন্দোলন, আগরতলা ষড়যন্ত্র মামলা, ১১ দফা ও ১৯৬৯-এর গণঅভ্যুত্থান, সত্তরের সাধারণ নির্বাচন, নির্বাচনোত্তর ষড়যন্ত্র ও একাত্তরের অসহযোগ আন্দোলন, ৭-ই মার্চ বঙ্গবন্ধুর ভাষণ, ২৫ শে মার্চ পাকিস্তানি বাহিনীর গণহত্যার সূচনা, বাঙালির প্রতিরোধ সংগ্রাম, প্রবাসী বাংলাদেশ সরকার, মুক্তিযুদ্ধ ও স্বাধীন বাংলাদেশের প্রতিষ্ঠা।

Recommended Text(s):

১। রবীন্দ্রনাথ ঠাকুর	-	গল্পগুচ্ছ
২। রোকেয়া সাখাওয়াত হোসেন	-	অবরোধবাসিনী
৩। হাসান আজিজুল হক	-	হাসান আজিজুল হকের নির্বাচিত গল্প
৪। জাহানারা ইমাম	-	একাত্তরের দিনগুলি
৫। মুনীর চৌধুরী	-	কবর
৬। বঙ্কিম চন্দ্র চট্টোপাধ্যায়	-	নির্বাচিত প্রবন্ধ
৭। রবীন্দ্রনাথ ঠাকুর	-	নির্বাচিত প্রবন্ধ
৮। মাইকেল মধুসূদন দত্ত	-	চর্তুদশপদী কবিতাবলী
৯। রবীন্দ্রনাথ ঠাকুর	-	সঞ্চয়িতা
১০। কাজী নজরুল ইসলাম	-	সঞ্চিতা
১১। হাসান হাফিজুর রহমান	-	কাব্যসমগ্র
১২। শামসুর রাহমান	-	বন্দী শিবির থেকে
১৩। নীহাররঞ্জন রায়	-	রবীন্দ্র সাহিত্যের ভূমিকা
১৪। অরুণ কুমার মুখোপাধ্যায়	-	কালের পুত্তুলিকা
১৫। জীনাত ইমতিয়াজ আলী	-	ধ্বনিবিজ্ঞানের ভূমিকা
১৬। মোহাম্মদ মনিরুজ্জামান	-	নজরুল সমীক্ষণ
১৭। আবদুল মান্নান সৈয়দ	-	শুদ্ধতম কবি
১৮। মোহাম্মদ জয়নুদ্দীন	-	মুনীর চৌধুরীর সাহিত্যকর্ম
১৯। হুমায়ুন আজাদ	-	শামসুর রাহমান/ নিঃসঙ্গ শেরপা
২০। অধীর দে	-	আধুনিক বাংলা প্রবন্ধ সাহিত্যের ধারা
২১। অরবিন্দ পোদ্দার	-	বঙ্কিম-মানস
২২। রফিকউল্লাহ খান	-	বাংলাদেশের কবিতা: সমবায়ী স্বতন্ত্রস্বর
২৩। সাঈদ-উর রহমান	-	পূর্ব বাংলার রাজনীতি-সংস্কৃতি ও কবিতা
২৪। সুভাষ ভট্টাচার্য	-	আধুনিক বাংলা প্রয়োগ অভিধান
২৫। আহমদ শরীফ, আনিসুজ্জামান ও অন্যান্য	-	বাংলা ভাষার প্রয়োগ ও অপপ্রয়োগ
২৬। বাংলা একা-ডমি	-	প্রমিত বাংলা বানানের নিয়ম
২৭। মাহবুবুল হক	-	বাংলা বানানের নিয়ম
২৮। আনন্দ পাবলিশার্স	-	তিষ্ঠ ক্ষণকাল
২৯। যতীন সরকার	-	গল্পে গল্পে ব্যাকরণ
৩০। সুবল দাস বণিক	-	ছড়ায় ছড়ায় শুদ্ধ বানান
৩১। অতুল সুর	-	বাঙলা ও বাঙালীর বিবর্তন
৩২। আহমদ শরীফ	-	বাঙলা, বাঙালী ও বাঙালীত্ব
৩৩। আবুল কাসেম ফজলুল হক	-	মুক্তিসংগ্রাম
৩৪। আহমদ রফিক ও বিশ্বজিৎ ঘোষ	-	ভাষা আন্দোলনের পঞ্চাশ বৎসর
৩৫। মঈদুল হাসান	-	মূলধারা '৭১

৩৬। ড. মো.মাহবুবর রহমান - বাংলাদেশের ইতিহাস ১৯৪৭-৭১
৩৭। ড. আশফাক হোসেন - বাংলাদেশের ইতিহাসের রূপরেখা
৩৮। গোলাম মুরশিদ - হাজার বছরের বাঙালি সংস্কৃতি
৩৯। নীহাররঞ্জন রায় - বাঙালীর ইতিহাস (অদি পর্ব)
৪০। বাংলা একা-ডমি - ব্যবহারিক বাংলা অভিধান
৪১। যতীন সরকার - ভাষা-জ্যাতি

Course Code & Title: **MFS 1103: BANGLADESH STUDIES**	**Credit:3**

Rationale	This course has been designed to learn the biography of the father of the nation, Bangabandhu Sheikh Mujibur Rahman, and his contribution to the emergence of Bangladesh and the visionary steps to the maritime affairs of Bangladesh. Besides learning oceanography, it is important to know about the maritime vision of Bangladesh as a far-sighted maritime country.
Objectives	• To introduce the students about the early life and education, political involvement of Bangabandhu including the Bengali Language Movement, Six Point Movement, Anti Ayub Movement, 1970 elections and civil disobedience. • To enlighten the students about the contributions of the Father of the Nation to the governing and reconstructing measures for Bangladesh. • To learn about the insight of Bangabandhu on maritime affairs of Bangladesh, and the geopolitical importance of the Bay of Bengal. • To learn the Territorial Waters and Maritime Zones Act, l974.
Learning Outcomes	On successful completion of this unit, students should be able to: • Address the biography of Bangabandhu Sheikh Mujibur Rahman and his far-sighted contribution to the establishment of Bangladesh. • Demonstrate the major events i.e., Bengali Language Movement, Six Point Movement, Anti Ayub Movement, 1970 elections and civil disobedience which finally pave the path to the emergence of Bangladesh as an independent country. • Conceptualize how to reconstruct a collapsed nation and learn to provide the maritime policy for the blue growth of Bangladesh • Imply the further maritime affairs and maritime acts of the Bay of Bengal.

Syllabus Contents:

1. Early life and education
   1.1 Personal life, family, and relatives
2. Political involvements and activism in British India
   2.1 Early political career

2.2 Bengali language movement
2.3 The founding of the Awami League
2.4 Six-point movement
2.5 Anti-Ayub movement
2.6 1970 elections and civil disobedience
2.7 7th March Speech of Sheikh Mujibur Rahman
2.8 Bangladesh Liberation War
2.9 Provisional Government of Bangladesh

3. Establishment of Bangladesh
4. Governing Bangladesh
   4.1 Struggle for national reconstruction
   4.2 Economic policies
   4.3 Foreign policies
5. Assassination
6. Maritime vision and policies for Bangladesh
   6.1 Bangabandhu's role in the rehabilitation, reformation & development of shipping & marine sector of Bangladesh
      6.1.1 Establishment of Bangladesh Shipping Corporation in 1972
      6.1.2 Establishment of Marine Fisheries Academy in 1973
      6.1.3 Commencement of Oil & Gas exploration in Bay of Bengal in 1973
      6.1.4 Promulgated Petroleum Act 1974
   6.2 Territorial Waters and Maritime Zones Act, l974
   6.3 Promulgated Petroleum Act, 1974

Recommended Text(s):

1. Mujibur Rahman, Sheikh (2012). The Unfinished Memoirs. Dhaka: The University Press Limited. ISBN 9789845061100.
2. Kādira, Muhāmmada Nūrula (2004). Independence of Bangladesh in 266 days: history and documentary evidence. Dhaka: Mukto Publishers. ISBN 978-984-32-0858-3.
3. Karim, SA (2008). Sheikh Mujib: triumph and tragedy. The University Press Limited. ISBN 9789840517374.
4. Milam, William B. (2009). Pakistan and Bangladesh: Flirting with Failure. Columbia University Press. ISBN 978-0-231-70066-5.
5. Kaushik, S. L.; Patnayak, Rama (1995). Modern Governments and Political Systems: governments and politics in South Asia.
6. Frank, Katherine (2001). Indira: The Life of Indira Nehru Gandhi. HarperCollins. ISBN 978-0-395-73097-3.
7. Ahmed, Moudud (1983). Bangladesh: Era of Sheikh Mujibur Rahman. University Press Limited. ISBN 9789845062268.
8. Ahmed, Salahuddin (2003). Bangladesh: Past and Present. New Delhi: A.P.H. Publishing Corporation. ISBN 9788176484695.
9. Enayetur Rahim and Joyce L. Rahim, ed. (2013). Bangabandhu Sheikh Mujibur Rahman and Struggle for Independence: UK Foreign and Commonwealth Office, De-classified Documents, 1962-1971. Hakkani Publishers. ISBN 978-7-02-140067-5.
10. Meghna Guhathakurta and Willem van Schendel (2013). The Bangladesh Reader: History, Culture, Politics. Duke University Press. ISBN 9780822353188.
11. Islam, Maidul (2015). Limits of Islamism. Cambridge University Press. ISBN 9781107080263.

12. Jahan, Rounaq (2000). Bangladesh: promise and performance. Zed Books. ISBN 9781856498258.
13. M. Uddin, Sufia (15 December 2006). Constructing Bangladesh: Religion, Ethnicity, and Language in an Islamic Nation. ISBN 9780807877333.
14. Gupta, Jyoti Sen (1981). Bangladesh, in Blood and Tears. Naya Prokash.

Course Code & Title:	**Credit:3**
MFS 1105: MARINE ECOLOGY	

Rationale	This course has been designed to learn the processes of marine environment and its components. Different marine and coastal habitats and their organisms are important components of the marine ecosystems. So, this course is very necessary to the sustainable management of the biological resources of the ocean.
Objectives	• To introduce the students about zonation and different biotic and abiotic factors of the Ocean. • To clarify the students about different habitats e.g., coastal, freshwater and marine ecosystems. • To learn about the different kinds of food chains in the marine environments and the flow of energy from producers to the higher trophic levels. • To learn the factors those are responsible to the distribution of different aquatic organisms. • To provide the intrinsic knowledge on the ecosystem and species distributions in the Bay of Bengal.
Learning Outcomes	On successful completion of this unit, students should be able to: • Define different ecological terms and marine divisions. • Identify the factors those control the marine life in various aquatic habitats. • Demonstrate the energy flow in the marine environment from the producers to the consumers. • Visualize the biotic and abiotic factors and their role in the distribution of the living resources of the Bay of Bengal.

Syllabus Contents:

1. Definition, scope and type of ecology
2. Marine environment: general concepts, the open ocean, coastal water, the floor of the sea
3. Coastal habitats: estuaries, coral reef, beaches, islands, salt marshes, and dunes & shingle
4. Major ecological divisions of marine habitat
5. Comparative study of the fauna of freshwater, brackish water and marine ecosystems
6. Faunal characteristics of sandy, muddy and rocky shores
7. Factors controlling the adaptation and distribution of marine organisms
8. Food chain, food webs and ecological niche in marine environment, energetic of a marine ecosystem

9. Ecology of the Bay of Bengal and its major estuaries, ecological model of abiotic and biotic, components, case study of an ecosystem
10. Concepts of Biodiversity: Introduction, Definition, types, patterns, factors causing loss of Biodiversity.

Recommended Text(s):

1. Marine Ecology, by RV Tait
2. Introduction to Marine Science, by McKa
3. Fundamentals of Ecology, by EP Odum
4. Sorokin, Yuri I. Coral Reef Ecology, Springer, ISSBN: 978-3-642-80046-7

Course Code & Title:	**Credit:1.5**
MFS 1106: MARINE ECOLOGY (LAB)	

Rationale	This course has been designed to learn about the species which exit in different marine habitat and to identify them. Collection and preservation of marine species are very important to develop a museum of marine organisms. So, this course will help the students to get an overview about the marine organisms and their interactions to the biotic and abiotic factors.
Objectives	• To create a list of marine organisms of different ecosystems. • To determine different aquatic parameters those are responsible to the distribution of different aquatic organisms. • To demonstrate the identifying characteristics of marine species of different locations. • To know about the species distribution in the Bay of Bengal.
Learning Outcomes	On successful completion of this unit, students should be able to: • Determine different aquatic parameters that are lined to the marine life. • Identify the species by qualitative study. • Differentiate the organisms of various habitats in the Bay of Bengal.

Syllabus Contents:

1. Preparation of Model showing zonation of the sea
2. Museum study of marine organisms
3. Laboratory practices in determination of various ecological parameters
4. Determination of DO consumption of selected aquatic species
5. Qualitative ecological study of selected aquatic species
6. Collection and identification of marine fauna from muddy, sandy and rocky shores
7. Study of ecological parameters in the marine environment.

Recommended Text(s):

1. Marine Ecology, by RV Tait
2. Introduction to Marine Science, by McKa
3. Fundamentals of Ecology, by EP Odum
4. Sorokin, Yuri I. Coral Reef Ecology, Springer, ISSBN: 978-3-642-80046-7

Course Code & Title:	Credit:3
MFS 1107: MARINE INVERTEBRATES	

Rationale	This course is designed to get the knowledge about the marine invertebrate organisms. These organisms are a crucial part of ocean. So, to understand these organisms and their functions are important in oceanography.
Objectives	• To learn about various phylum of invertebrate organisms. • To develop the knowledge on diversity and classification of the organisms. • To get the understanding of internal and external structure and functionality of the organisms.
Learning Outcomes	Having successfully completed this course, students will be able to: • Understand the diversity of marine invertebrate organisms. • Understand the taxonomy and classification process. • Know the structure, function and evolutionary trend of the marine invertebrate organisms.

Syllabus Contents:

1. Classification of marine invertebrates.
   1.1 Identification
   1.2 Classification
   1.3 Taxonomy
2. Salient features of major invertebrates.
3. Study of different phyla of marine invertebrates.
   3.1. External characteristics
   3.2. Internal characteristics
4. Anatomy of major marine invertebrates.
   4.1. Protozoa
   4.2. Porifera
   4.3. Coelenterate
   4.4. Ctenophore
   4.5. Rotifer
   4.6. Annelida
   4.7. Mollusca
   4.8. Arthropoda
   4.9. Echinodermata
5. Organ systems of major marine invertebrates.
   5.1. Digestive system
   5.2. Reproductive system
   5.3. Respiratory system
   5.4. Circulatory system
   5.5. Excretory system

6. Distributional pattern of major phyla in the marine environment.
7. Ecology of different marine invertebrates.

Recommended Text(s):

1. A manual of practical zoology: Invertebrate, by P. S. Verma, S Chand (2010), ISBN:8121908299.
2. Practical invertebrate zoology, edited by R. P. Dales, John Wiley & Sons (1981).
3. General zoology, by T. I. Storer and R. L. Usinger, McGraw-Hill, ISBN: 0070617805.
4. Zoology, by E. L. Cockrum and W. J. McCauley, 1965.
5. Marine fauna and flora of Burmuda by W. Sterrer, Wiley, ISBN: 0471823368.

Course Code & Title:	**Credit:1.5**
MFS 1108: MARINE INVERTEBRATES (LAB)	

Rationale	This course provides the practical experience to understand different aspects of marine invertebrate species.
Objectives	• To recognize the body of major phyla. • To understand the external and internal characteristics of species. • To know the classification of species.
Learning Outcomes	Having successfully completed this course, students will be able to: • Recognize different marine invertebrate species. • Explain the internal and external characteristics. • Know the classification of species.

Syllabus Contents:

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, mollusca , polychaetes etc.

Course Code & Title:	**Credit:2**
MFS 1109: MARINE BOTANY	

Rationale	This course provides the overview knowledge on various types of marine photosynthetic plants and their biodiversity in different communities in the coastal and marine ecosystems.
Objectives	• To learn about various phylum of marine flora/plants. • To develop the knowledge on diversity and classification of the marine plants and different algal communities. • To get the understanding of internal and external structure and functionality of the marine flora.

	• To know about the
Learning Outcomes	Having successfully completed this course, students will be able to: • Understand the diversity of marine flora/plants. • Understand the taxonomy and classification of marine plants and different algal communities. • Know the structure, function and evolutionary trend of the marine flora.

Syllabus 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
     - 3.6.1 St. Martin's Island
     - 3.6.2 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 Types of forest, forest ecology, abundance and distribution of different forest
   - 6.2 Adaptations, requirements and role of mangrove forest
   - 6.3 Biodiversity of mangrove ecosystem
     - 6.3.1 Species composition and diversity
     - 6.3.2 Temporal and spatial distribution
     - 6.3.3 Species richness
     - 6.3.4 Community dominance
     - 6.3.5 Coefficient of similarity

Recommended Text(s):

1. Contribution to the study of the Marine Algae of Bangladesh, by AKMN Islam. Biblotheca Phycologica Band. 19. 1976.
2. Marine Botany, by Dawson, 1976.
3. The Biology of Marine Plants, by MJ Dring, Cambridge University Press. 1996.
4. Seaweeds and their uses, by VS Chapman and DJ Chapman, Chapman and Hall, 1980.

Course Code & Title:	Credit:2
MFS 1111: COMMUNICATIVE ENGLISH	

Rationale	This course will provide fundamental aspects of reading, writing, listening and speaking skills. The course will help students to develop their language and communication skills through interactive participation in the class. Students will practice brainstorming, free-writing, paragraph and argumentative essay writing. In addition, they will practice listening and speaking activities. By attending this course student can build up communicative skills which they can utilize in their academic as well as professional life.
Objectives	• To improve academic writing in English. • To improve students' reading skills and understanding of short texts. • To enrich students' vocabulary. • To develop listening skills. • To improve grammatical accuracy. • To develop speaking skills.
Learning Outcomes	Having successfully completed this course, students will be able to: • Utilize the strategies of free hand writing in other courses. • Speak more accurately and fluently. • Communicate with native and nonnative speakers more efficiently. • Find out key ideas reading long texts. • Write grammatically correct sentences. • Improve critical thinking skills.

Syllabus Contents:

1. **Functional Grammar**
   Right forms of verbs, use of tenses, Parts of Speech, Articles, use of active and passive voice, Appropriate preposition, Use of modal verbs, Subject verb agreement, Narration, Transformation, Conditionals, Tag questions, Error corrections.

2. **Developing Reading Skills**
   Reading strategies (skimming, scanning, predicting, guessing etc.), Methods of developing reading skills, practicing reading comprehension using different reading

selections from science, history, linguistics or other areas, reading to summarize the main points of text, reading to improve linguistic skills and expand vocabulary.

3. **Developing Writing Skills**
   Writing strategies: free-writing, brainstorming, mind mapping/clustering, narrowing the focus etc. Paragraph writing: organizing a paragraph: topic sentence, detailed sentences, logical orders and conclusions. Writing different types of essays: narrative/descriptive, argumentative, cause effect, exploratory, Letter and email writing, Translation from Bangla to English and vice versa.

4. **Developing Speaking Skills**
   Practicing speaking English on everyday life situation, Guided conversations (greetings, requesting, apologizing), Two- minute impromptu talks, Preparing and presenting talks on a given theme, Oral presentation, responding to audio/video clips, Learning IPA symbols.

5. **Developing Listening Skills**
   Listening for main ideas/key information, listening for specific details, listening and note-taking, listening to news, broadcasts and songs.

Recommended Text(s):

1. Headway (Upper Intermediate), by Liz and John Soars, Oxford University Press, ISBN: 0194335593.
2. English Grammar & Composition, by Wren and Martin, S. Chand & Co. Ltd, ISBN: 8121900093.
3. Friends' Language Grammar, Reading Comprehension, Writing Composition by Prof. Ataul Haque, Prof. Jahurul Islam, Dr. Binoy Barman.
4. Mastering Language Skills, by S. M. Amanullah.

SECOND SEMESTER

Course Code & Title: MFS 1201: FUNDAMENTALS OF OCEANOGRAPHY	Credit:3

Rationale	This course provides an introduction to the ocean science in order to understand physical, geological, biological and chemical aspects of oceanography.
Objectives	• To understand the origin of ocean study and the changes through time. • To investigate the broad-scale features and dynamics of the Earth's oceans. • To know about different aspects of world ocean. • To know about the operations and safety aspect of onboard research vessel at sea.
Learning Outcomes	Having successfully completed this course, students will be able to: • Collect and integrate information about ocean science. • Know the different branches of oceanography and the relationship between each other. • Introduce themselves with the contemporary works and institutions of oceanography around the world. • Aware the different operational and safety aspect of research vessel at sea.

Syllabus Contents:

1. **Introduction to Chemical Oceanography:** History of Physical and Chemical Oceanography, Scope, Physical characteristics of oceans.
2. **Major and Minor Constituents of Seawater:** Major constituents of seawater, Concentrations and residence times of major constituents, Trace metals and minor elements, Various patterns of distribution of minor elements, Special cases of Mercury and Iron, Speciation.
3. **Salinity and Conductivity of Seawater:** Salinity, Solubility of salts, Constancy of composition, Variations in salinity, Chemical and physical methods for salinity measurement, Relation between conductivity and salinity, Relation between salinity and density.
4. **Dissolved Gases:** Simple gas laws, Solubility of gases in water, Sources of dissolved gases, Atmospheric exchange by diffusion, The carbonate system, Alkalinity and control of pH, Some minor gases, Rate of oxygen consumption, Anoxic oxidation, Dissolved gases as tracers, Air-sea interaction.
5. **Nutrients:** Phosphorous and its forms of occurrence in seawater, Oceanic distribution of Phosphorous, Phosphorite minerals, Nitrogen and its chemical forms, Nitrogen fixation, Denitrification, Nitrogen cycles, Dissolved organic nitrogen, Silica: forms, occurrence and solubility, Nutrients other than Phosphorous, Nitrogen and Silicon.
6. **Dissolved and Particulate Organic Compounds in Seawater:** Sources of organic matter, Dissolved and Particulate Organic Matter, Kinds of organic compounds in seawater, Concentration and age of marine organic matter.

7. Physical properties of sea water
   7.1 Pressure and depth, units, accuracy and precision
   7.2 Temperature, heat and potential temperature
   7.3 Concept of salinity
   7.4 Electrical conductivity
   7.5 Density, potential density and neutral density, TS diagram
   7.6 Distribution of temperature, salinity, conductivity, pressure etc. in ocean: Surface distribution, Vertical distribution and profiles, Meridional distribution
8. Sound and light in sea water: Propagation, attenuation, extinction, color of sea
9. Freezing, Sea Ice and ice bergs
   9.1Freezing point and temperature of maximum density, effect of salinity, freezing in shallow seas and lakes, properties of sea ice
10. Water, salt and heat budget and flux
    10.1. Hydrologic cycle
    10.2 Conservation of Mass, Salt and Energy
    10.3 Heat fluxes and heat balance
11. Ocean Wave
    11.1 Wave parameters, Spectrum of surface waves
    11.2 Classification of waves
    11.3 Wind waves and swells
    11.4 Wave theories: Small amplitude wave theory
    11.5 Wave refraction, diffraction, reflection
    11.6 Rossby wave and Kelvin wave
12. Ocean circulation
    12.1 Wind driven surface circulation: wind stress, Coriolis force, Ekman's spiral and net transport, major ocean currents
    12.2 Vertical circulation: Upwelling and sinking
    12.3 IOD
13. Astronomical Tides
    13.1 Causes of tide: centrifugal force and gravitational attraction, tidal potential
    13.2 Effects of sun-moon system on tide: distance, declination and nutation, diurnal inequality
    13.3 Types of tide
    13.4 Tidal datums
14. Dynamics of physical Oceanography
    14.1 Classification of forces and types of motion in the sea
    14.2 Kinematics of fluid flow, equation of continuity and applications
    14.3 Equation of motion in oceanography

Recommended Text (s):

1. Introduction to Ocean sciences, by D.A. Segar, W.W. Norton & Company (2^{nd} edition), ISBN: 0-393-92629-x.
2. Essentials of Oceanography, by Alan P. Trujillo, Harold V. Thurman, Pearson (11^{th} edition,) ISBN: 1-292-04100-5.

3. Investigation Oceanography, by Keith. A. Sverdrup, R.M. Kudela, Mcgraw-hill, ISBN: 978-0-07-802291-3.
4. Oceanography: An invitation to Marine Science, by Tom Garrison and Robert Ellis.
5. Chemical Oceanography, Frank J. Millero; CRC Press, 2013.
6. Chemical Oceanography, Ronald Cohn; Saunders College Publishing/Harcourt Brace, 2012.
7. An Introduction to the Chemistry of the Sea, Michael E. Q. Pilson, 2nd Edition, Cambridge University Press, 2013.
8. Chemical Oceanography and Marine Carbon Cycle, Steven Emerson; 1st edition, Cambridge University Press; 2008.
9. Marine Chemistry, by Martin; 2nd edition, New York, M. Dekker, 1972.
10. Chemical Oceanography, Riley; 2nd edition, ELSEVIER.
11. Synthesis of Marine Natural Products, Volume 1, Kim Albizati; V.A.; Springer (1992).
12. Terpenoids (Bioorganic Marine Chemistry); Martin; M.R. Agharahimi.
13. The Oceans: Their Physics, Chemistry, and General Biology, by H. U. Sverdrup, M. W. Johnson, R. H. Fleming, Prentice Hall (1942), ISBN: 0136303501.
14. General Oceanography: An Introduction by Dietrich, Kalle, KraussandSiedler, John Wiley &Sons (1980, Second Edition).
15. Descriptive Physical Oceanography, by G. L Pickard, Elsevier Science Ltd, ISBN: 0080379524.
16. Introduction to Physical Oceanography, by RH Stewart, University Press of Florida (2009), ISBN: 1616100451.
17. Principles of Physical Oceanography, by G. Neumann, Prentice-Hall, ISBN: 0137097417.
18. Elements of Physical Oceanography, by H. J. McLellan, Pergamon Press, ISBN: 0080113206.
19. Elements of Physical Oceanography, by John Steele, Academic Press, ISBN: 0080964850.
20. Physical oceanography of coastal and shelf seas, by B Johns, Cambridge University Press, ISBN: 0521701481.

Course Code & Title	**Credit: 1.5**
MFS 1202: FUNDAMENTALS OF OCEANOGRAPHY (LAB)	

Rationale	To understand sea water properties applying different quantitative analysis processes and analysis the composition of seawater.
Objectives	• To provide basic knowledge of chemical processes in the ocean. • To introduce students with methods to undertake analysis of sea water properties. • To be able to determine amount of dissolved substances in sea water. • To be able to know physical characteristics of ocean.
Learning Outcomes	Having successfully completed this course, students will be able to: • Determine Chemical and Biochemical Oxygen Demand in seawater. • Determine amount of dissolved salts as carbonates, nitrates, phosphates, silicates etc. • Compare between the properties of seawater and pure water. • Determine physical properties of sea water.

Syllabus Contents:

1. Determination of chloride from sea water using precipitation titration
2. Determination of Dissolved Oxygen (DO) in sea water sample
3. Determination of Biochemical Oxygen Demand (BOD) from sea water
4. Determination of Chemical Oxygen Demand (COD) from sea water
5. Comparison of hardness between sea water and river water
6. Spectroscopic determination of iron (Fe^{2+}) from sea water
7. Determination of phosphate as ammonium magnesium phosphate hexahydrate using gravimetric analysis
8. Analysis (Qualitative and Quantitative) of sea water properties:
    a) Total dissolved solid
    b) Halides
    c) NO_3^-
    d) NO_2^-
    e) NH_4^+
    f) CO_3^{2-}
9. Determination of physical properties of sea water.

Recommended Text(s):

1. An Introduction to the Chemistry of the Sea, Michael E. Q. Pilson, 2nd Edition, Cambridge University Press, 2013.
2. Vogel's Textbook of Quantitative Inorganic Analysis, Revised by Bassett & Jeffery; Fourth Edition.
3. Chemical Oceanography, Frank J. Millero; CRC Press, 2013.
4. Seawater: Its Composition, Properties and Behaviour, John Wright and Angela Colling, Second Edition; Butterworth-Heinenmann, 2003.

Course Code & Title:	**Credit:3**
MFS 1203: ICHTHYOLOGY AND MARINE VERTEBRATE	

Rationale	This course is designed to get the knowledge about the marine fishes and other vertebrate organisms. These organisms are a crucial part of ocean and main sources of the biological resources in the ocean. So, to understand these organisms and their functions are important in oceanography.
Objectives	• To learn about various marine fish as well as other vertebrates. • To develop the knowledge on diversity, classification and evolution of the organisms. • To get the understanding of internal and external structure and functionality of the organisms. • To understand the ecology and different processes such as: feeding, reproduction, behavior, migration, osmoregulation, etc.

Learning Outcomes	Having successfully completed this course, students will be able to: • Understand the diversity of marine fishes and other vertebrates. • Understand the taxonomy and classification process. • Know the structure, function and evolutionary trend of the marine vertebrate organisms. • Determine the ecology and different processes such as: feeding, reproduction, behavior, migration, osmoregulation, etc.

Syllabus Contents:

1. Introduction to Aquatic Vertebrates and Ichthyology, importance and methods of the study of fishes, opportunities of Ichthyology
2. Evolutionary history of Aquatic vertebrates, mainly 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, Gental 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.
12. Systematics: History, importance and scope of fisheries Systematics.
    - 12.1 Taxonomic characters in fishes and other vertebrates.
    - 12.2 Collection and identification of fish.
    - 12.3 Taxonomic keys.

12.4 Types, theories, categories and basis of classification.

12.5 Species concept and speciation.

12.6 Zoological nomenclature, synonyms, synonymy, law of priority, the type of method.

12.7 Origin and evolution of fishes.

12.8 Zoogeographical distribution of fishes.

Recommended Text (s):

1. Ichthyology, by CF Lagler et al
2. Chordate Zoology, by Storer and Usinger
3. Chordate Zoology, by Velly and Walker
4. Principles of Animal Taxonomy, George Gaylore Simpson, 1969, Columbia University Press.
5. Methods and Principles of Systematic Zoology, E. Mayer, 1953. McGraw Hill Book Co. NY.
6. Animal Species and Evaluation. E.Mayer (1966). McGraw Hill Book Co. New York.
7. Theory and Practice of Animal Taxonomy (4th edn.), V.C. Kapoor, 1998, Oxford & IBH Publishing Co. Pvt. Ltd.
8. Functional Anatomy of the Vertebrates: An Evolutionary Perspective, by K. Liem, W. Bemis, W. Walker, L. Grande, Brooks Cole (3rd Edition, 2000).
9. Vertebrate Life, by F. H. Pough, C. M. Janis, J. B. Heiser, Pearson (9thEdition, 2012).

Course Code & Title:	Credit:1.5
MFS 1204: ICHTHYOLOGY AND MARINE VERTEBRATE (LAB)	

Rationale	This course provides the practical experience to understand different aspects of marine fishes and other vertebrate species.
Objectives	• To recognize different species of marine vertebrates (Fish, Birds, Snakes, etc.). • To understand the external and internal characteristics of species. • To know the classification and characteristics of species.
Learning Outcomes	Having successfully completed this course, students will be able to: • Recognize different marine vertebrate species (Fish, Birds, Snakes, etc.). • Explain the internal and external characteristics. • Learn the classification and characteristics of species.

Syllabus Contents:

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.
6. Total, standard forked anal, fin lengths, eye diameter and their ratios; number of fin rays in different fins, fin ray/ Taxonomic formulae.
7. Identification of fishes using taxonomic key.
8. Development of taxonomic key.
9. Preparation of zoogeographical map and fish distribution.
10. Preparation of phylogenic tree.

Recommended Text (s):

1. Ichthyology, by CF Lagler et al
2. Chordate Zoology, by Velly and Walker
3. Vertebrate Life, by F. H. Pough, C. M. Janis, J. B. Heiser, Pearson (9thEdition, 2012)
4. Methods and Principles of Systematic Zoology, E. Mayer, 1953. McGraw Hill Book Co. NY.
5. Theory and Practice of Animal Taxonomy (4th ed.), V.C. Kapoor, 1998, Oxford & IBH Publishing Co. Pvt. Ltd.
6. Functional Anatomy of the Vertebrates: An Evolutionary Perspective, by K. Liem, W. Bemis, W. Walker, L. Grande, Brooks Cole (3rd Edition, 2000).

Course Code & Title:	**Credit:2**
MFS 1205: LIMNOLOGY	

Rationale	This course provides an introduction to the fresh water bodies especially, the lakes and inland waters in order to understand the physical, geological, biological and chemical aspects of them.
Objectives	• To develop understanding of the students on the origins of inland lentic and lotic habitats. • To understand their various physical, chemical and biological parameters those govern the lives and productivity of different lacustrine ecosystems.
Learning Outcomes	Having successfully completed this course, students will be able to: • Collect and integrate information about lacustrine science. • Know the origins of inland lentic and lotic habitat. • Demonstrate the various physical, chemical and biological parameters those govern the lives and productivity of different lacustrine ecosystems.

Syllabus Contents:

1. Limnology: Definition and objectives, history, introduction to inland waters, origin of lakes, ponds and reservoirs, lakes of Bangladesh and the world, estuaries, swamps and marshes.
2. Rivers: Definition, significance, types, origin, sources of water, rivers of Bangladesh and the world.
3. Water: Water distribution, water cycle, physico-chemical characteristics of water and their limnological significance.

4. Physical parameters of inland waters: Form of basin, water movement, light, transparency and turbidity, temperature, thermal classification of lakes, heat budget of lake.
5. Chemical parameters of inland waters: Dissolved gases- oxygen, carbon dioxide, and other gases, dissolved solids- nitrogen, phosphorus, calcium, magnesium, sodium, potassium, iron, silicon etc. and trace nutrients, total alkalinity and total hardness, pH and its effects on aquatic organisms.
6. Biogeochemical cycles: Definition, biogeochemical cycles of nitrogen, phosphorus, calcium, carbon, silicon, sulfur, iron etc.
7. Primary production: Definition, determination of primary production, factors affecting primary production.
8. Secondary production: Definition, factors influencing the secondary production in a waterbody.

Recommended Text (s):

1. Boyd, C. E. 1979. Water Quality in Warmwater Fish Ponds. Auburn University, Alabama.
2. Coker, R. E. 1954.Streams Lakes Ponds. Chapel Hill, The University of North Carolina Press.
3. Cole, G. A. 1979.Textbook of Limnology.2nd Edition. The C.V.Mosby Company St. Louis Missouri 63141.
4. Goldman, C. R. and A. J. Horne. 1983. Limnology. McGraw-Hill Book Company, New York.
5. Jorgensen, S. E. 1980. Lake Management. Pergamon Press Ltd., Oxford.
6. Kalff, J. 2002. Limnology-Inland Water Ecosystem. Prentice- Hall, Upper Saddle River, New Jersey 07458
7. Lecren, E. D. and R. H. Low-McConnel. 1980. The Functioning of Freshwater Ecosystems. IBP 22. Cambridge University Press. Cambridge, London.
8. Schwoerbel, J. 1987. Handbook of Limnology. Ellis Horwood Limited. New York.
9. Serruya, C. and U. Pollinger. 1983. Lakes of Warm Belt. Cambridge University Press, Cambridge, London.
10. Wetzel, R. G. 1983. Limnology, CBS College Publishing, The Dryden Press.
11. Rahman, M.S. 1992. Water quality management in aquaculture. BRAC Prokashana. Dhaka-1212.
12. Reid G. K. and Wood. 1976. Ecology of Inland waters and Estuaries. Reinhold Publishing Co., New York.

Course Code & Title:	**Credit:2**
MFS 1207: MARINE MICROBIOLOGY	

Rationale	This course is designed to get the knowledge about the marine microorganisms. Microorganisms have a crucial role in various biogeochemical cycles and also in ecology.

Objectives	• To get acquainted with marine microorganisms. • To understand general concept and historical development of marine microbiology. • To learn about microbial ecology and the role of microorganisms. • To understand microbial pollution and the relationship of microorganisms with other organisms.
Learning Outcomes	Having successfully completed this course, students will be able to: • Understand the diversity and role of marine microorganisms. • Learn different microbial processes of environmental and geochemical significance. • Know relationship and different between marine and terrestrial microorganisms.

Syllabus Contents:

1. General concepts and historical development of Marine Microbiology.
2. Morphology, structure Systematic study of bacteria, virus, yeasts and fungi.
3. Marine microbial ecology: effects of the environment upon microbes - Temperature, Pressure, Radiation, Moisture, Hydrogen ion concentration, Oxidation and reduction potentials, Salinity and Gases.
4. Physiology of Microorganisms: Respiration, Nutrition, Fermentation, Product on of enzymes-their nature& enzymatic reactions, Staining properties of bacterial cell, Bacterial spores, Reproduction and life cycle.
5. Role of Microorganisms in the transformation of different matters, oils and gases in the sea and associated nutrient cycle, carbon cycle and sulfur cycle.
6. Relationships and differences between marine and terrestrial microorganisms; Deep sea and hydrothermal vents, microbial toxins, food poisoning.
7. Microbial pollution of the marine environment (soil, water and live organisms).
8. Ocean acidification and rapid changes in ocean chemistry.
9. Economic importance and application of micro-organisms in Oceanography.

Recommended Text(s):

1. Marine microbial ecology, by E. J. F. Wood (1965).
2. Microbiology, by Eugene Nester et al, McGraw-Hill Science/Engineering/Math, ISBN: 0077250419.
3. The microbial world, by Stanier et al, 1970.
4. Microbial interactions, edited by JL Reissig, Springer US (1977), ISBN: 978-1-4615-9700-1.
5. Microbiology, by Michael et al, 1986.
6. Marine Microbiology, by B. Austin, CUP Archive (1988), ISBN: 0521311306.

Course Code & Title:	Credit:2
MFS 1209: FISHERIES MATHEMATICS	

Rationale	This course is designed to introduce students with the fundamental concepts of modern mathematics with a particular emphasis on the underlying foundations of mathematics. The use and understanding of mathematical theories will allow students to develop analytical skills which will form a base for further study.
Objectives	• Develop deep mathematical understanding of students. • Enable students to formulate problems and develop their problem solving skill. • Develop students' ability to reason logically and think creatively. • Provide a foundation for future learning.
Learning Outcomes	Having successfully completed this course, students will be able to: • Find roots of algebraic equations and the relation between roots and coefficients. • Determine domain and range of different types of functions. • Analyze and find limiting value of a function. • Differentiate (find derivative) any function and also apply these techniques to solve real-world problems. • Explain integration and integrating rules, apply various techniques to evaluate indefinite & definite integrals. • Solve 1^{st} order and higher order homogenous and non-homogenous differential equations. • Select and apply appropriate methods to solve differential equations. • Solve different geometrical problems.

Syllabus Contents:

1. **Theory of equation:**
   Relation between roots and coefficient, increasing and decreasing roots, Descartes rule of sign.

2. **Differential Calculus:**
   Limit, Continuity and Differentiability, Differentiation of explicit and implicit functions and parametric equations, Successive differentiation, Partial differentiation, Euler's theorem, The Chain rule.

3. **Integral Calculus:**
   Integration by parts, Standard integrals, Integration by the method of successive reduction, Definite integrals, Area between curves in cartesian and polar co-ordinates.

4. **Differential Equations:**

Definitions, Order and Degree of Differential Equations, Solution of first order differential equations by various methods, Solution of linear differential equations of higher order with constant coefficients, Variation of parameters.

5. **Exponential and Logarithmic Functions:**
   Definitions, Derivative and integrals involving logarithmic functions. Applications of logarithmic and exponential functions.

6. **Geometry:**
   Rectangular co-ordinates, Transformation of co-ordinates, other system of co-ordinates, Idea of Euclidean Geometry**,** Parametric representations of curve and surface, Arc length, Frenet formula, Geodesics.

Recommended Text(s):

1. Calculus, by Howard Anton, IRL Bivens, Stephen Davis. Wiley (10^{th} edition), ISBN: 1118137922.
2. Differential Calculus, by B. C Das, B. N Mukherjee, U. N. Dhur & Sons Pvt. Ltd (55^{th} edition), ISBN: 9380673876.
3. Integral Calculus, by B. C Das, B. N Mukherjee. (58^{th} edition)
4. Basic Algebra & Fundamentals of Mathematics, by Prof. Md. Abdur Rahman. (3^{rd} edition)
5. A First Course In Differential Equations with modeling Applications, by Dennis G. Zill.(10^{th} edition), Brooks Cole, ISBN: 1111827052.
6. A Text Book On Co-ordinate Geometry with Vector Analysis, by A. F. M. Abdur Rahman and P. K. Bhattacharjee. (11^{th} edition)
7. Differential equations, by BD Sharma.
   Ordinary & Partial Differential Equations, by M. D. Raisinghania, S Chand, ISBN: 8121908922.

Course Code & Title:	**Credit:2**
MFS 1211: CHEMISTRY	

Rationale	To develop basic knowledge about the structure, bonding and properties of matter.
Objectives	• To understand the need of Chemistry in daily life and to help students to solve analytical problems with a molecular perspective • To develop fundamentals for future courses as Chemical Oceanography, Marine Geochemistry etc.
Learning Outcomes	Having successfully completed this course, students will be able to: • Explain the structure and understand the properties of matter • Explain the bonding within atoms of a molecule and understand stoichiometry of reactions • Develop basic foundation for understanding properties and analysis of seawater.

Syllabus Contents:

1. **Structure of Atom:** Atomic theory of Matter, Classical concept of atom models, Nuclear Structure, Properties of Wave, Electromagnetic Radiation, Quantum Effects and Photons, Atomic Spectra, Bohr theory of Hydrogen atom, Quantum Mechanics, Quantum numbers, Atomic orbitals and their energies, Electronic Structure of Atoms.

2. **Periodic Table:** History of Periodic Table**,** Development of Periodic Table, Periodic law, Some periodic properties, Periodicity in the main group elements.

3. **Structure and Bonding:** An overview of Chemical Bonding, Ionic and Covalent bonds, Properties of Ionic and Covalent Compounds, Lewis Structure and Shapes of molecules, Hybridisations, Bond length and bond order, Molecular geometry and directional bonding, Molecular orbital Theory, Molecular orbital diagrams of homonuclear and hetronuclear diatomic molecules.

4. **Chemical reactions:** Classification of chemical reactions, Precipitation reactions, Acid-base reactions, Redox reactions, Balancing simple redox reactions, Addition, Substitution and Elimination reactions.

5. **Gas:** States of matter, Equation of state, Kinetic Molecular Theory, Molecular velocities, Distribution of velocities, Behaviour of Real Gases: Amagat's Curves, Van der Waals' Equation and critical phenomena.

6. **Phase Equilibriia:** Phase, Components and Degrees of Freedom, Deduction of Phase rule, Phase Diagram of water and sulphur system, Solid-liquid equilibria, Eutectic point.

7. **Acids and Bases:** Acid-base concepts, Relative Strengths of acids and bases, Molecular structure and strengths, Autoionisation of water, Solutions of strong acids and bases, pH of solutions, Acid-Base equilibria.

8. **Thermodynamics:** First law of Thermodynamics, Work and Heat, Heat of reactions, Entropy and Second law of Thermodynamics, Free energy and spontaneity, Interpretation of free energy Free energy and equilibrium constant.

9. **Chemical Kinetics**: Rate law, Determination of rate law, Molecularity and order of reactions, Factors affecting rate of reaction, Temperature dependence of reaction rates, Collision and Transition state theory, Some chain reactions and their mechanism.

10. **Organic Chemistry:** Nomenclature, Synthesis and properties of alkanes, Cycloalkanes, Alkenes, Alkynes and aromatic hydrocarbon, Derivatives of hydrocarbons, Polymer materials.

11. **Nuclear Chemistry:** Radioactivity, Nuclear bombardment reactions, Radiation and matter, Rate of radioactive decay, Energy of nuclear reactions, Application of radioactive isotopes.

12. **Electrochemistry:** Voltaic Cells-its construction and notation, Cell Potential, Standard cell potential and standard electrode potential, Some Commercial Voltaic cell, Electrolysis of molten salts, Aqueous electrolysis, Stoichiometry of electrolysis.

Recommended Text(s):

1. Introduction to Modern Inorganic Chemistry, by S.Z. Haider.
2. General Chemistry, by Ebbing & Gammon.
3. Principles of Physical Chemistry, by MM Haque & Molla.
4. Organic Chemistry, by Morrison & Boyd.
5. Essentials of Physical Chemistry, by Bahl &Tuli.

Course Code & Title:	**Credit:1**
MFS 1212: CHEMISTRY (LAB)	

Rationale	To develop basic knowledge on theories of Chemistry with practical demonstration and laboratory works.
Objectives	• To develop confidence of the students to perform qualitative and quantitative analysis with an understanding of principles and proper interpretation of experimental results. • To introduce students with contemporary instrumentation used in analytical chemistry.
Learning Outcomes	Having successfully completed this course, students will be able to: • To develop idea about the qualitative and quantitative analysis of substances • To get acquainted with different experimental methods and instrumentation • To enhance knowledge on data interpretation and analysis

Syllabus Contents:

1. Purification of commercial sodium chloride, NaCl, by re-crystallization and salting out process.

2. Preparation of Ferrous Ammonium Sulphate (Mohr's salt), $FeSO_4.(NH_4)_2SO_4.6H_2O$.

3. Qualitative analysis of few selected cations and anions from mixture of salts/from supplied solutions.

4. Preparation of a primary standard solution of oxalic acid and standardization of a supplied NaOH solution.

5. Preparation of a primary standard solution of Na_2CO_3 and standardization of a supplied HCl solution.

6. Determination of the amount of Fe (II) and Fe (III) in a given sample using a standard dichromate solution.

7. Standardization of a sodium thiosulphate solution using a standard dichromate solution and hence determination of the amount of copper (II) in a supplied solution with the standard thiosulphate solution.

8. Determination of hardness of the supplied water sample by Complexometric Method.

9. Elemental (Nitrogen, Sulphur and Halogen) analysis and melting point determination of some selected organic compounds.

10. Identification of few functional groups of some selected organic compounds.

11. Determination of the pH-neutralization curve of a strong acid by a strong base.

12. Determination of the dissociation constant of ethanoic acid by investigating its conductance behavior at different concentrations.

13. Determination of the enthalpy change for the thermal decomposition of $NaHCO_3$ into Na_2CO_3.

Recommended Text(s):

1. A Textbook of Macro and Semimicro Qualitative Inorganic Analysis, by A. I. Vogel; Fourth Edition.
2. Vogel's Textbook of Quantitative Inorganic Analysis, Revised by Bassett & Jeffery, John Wiley & Sons Inc. (Fourth Edition).
3. A Handbook of Organic Analysis, by H. T. Clarke; Fifth Edition.

SECOND YEAR

THIRD SEMESTER

Course Code & Title:	Credit:3
MFS 2101: AQUACULTURE	

Rationale	The course is designed to provide a general knowledge and interdisciplinary understanding of aquaculture specially in production of coastal and marine aquatic organisms, with focus on fishes, shrimp, crabs, mussels, clams, oysters, abalone, scallop, squid, green turtle and seaweed.
Objectives	• To acquire the fundamental knowledge of the aquaculture including site and species selection, genetics, breeding and seed production, farming techniques, farm operation and maintenance. • To understand the diseases and health management, and nutrition, feed types, main feed sources and principles for their evaluation and formation.
Learning Outcomes	Having successfully completed this course, students will be able to: • Demonstrate the fundamental knowledge on site and species selection, genetics, breeding and seed production, farming techniques, farm operation and maintenance. • Implement the diseases and health management, and nutrition, feed types, main feed sources and principles for their evaluation and formation.

Syllabus Contents:

1. **Basis of Aquaculture:**
   Scope and definition; Cultural and socio-economic basis; Biological and technological basis; Role in fishery;

2. **History and Principles of Aquaculture:**
   Origin and growth of aquaculture; Present state; History of aquaculture in Bangladesh; Aim and objectives of aquaculture; Different kinds of aquaculture

3. **Selection of Site:**
   General consideration; Basic principles for suitable farm; Selection site for different types of culture

4. **Selection of Species:**
   Biological characteristics; Economic and market consideration; Common aquaculture species

5. **Design and Construction of Aquaculture Pond:**
   Features of a fish/shrimp pond; Different kinds of pond; Physical characteristics of pond; Layout of pond; Characteristics of pond dikes; Compacting earthen dikes; Pond bottom drains; First filling of pond; Inlet structures; Outlet structures

6. **Pond Preparation and Management:**
   Improving pond water quality; Controlling water loss; Pond preparation; Liming; Fertilization; Aeration; Stocking; Control of weeds, pests and predators

7. **Water Quality Requirements and its Management:**
   Physical and chemical characteristics; Biological characteristics; Pollution and other types of water quality deterioration; Microbial pollution; Control

8. **Bottom Soil Management:**
   Pond soils and fish production; Soil texture; Organic matter; Soil acidity; Soil nutrients; Soil treatments

9. **Feeds and Feed Management**

   9.1 Types of feeds: Natural; Supplemental; Complete
   9.2 Making own feed
   9.3 Evaluating Feed Performance

10. **Pond Harvest Technique:**
    Harvesting in drainable ponds; Catching fish in undrainable ponds; Other methods; Harvesting molluscs; Harvesting cage and raceway systems

11. BMP aquaculture of – shrimp, mullet, coral, and mussel

12. **Economics and Financing of Aquaculture:**
    Economic viability; Data requirements; Assets and liabilities; Variable and fixed cost; Operating income; Analysis of data; Evaluation of farm performance

13. **Integrated Aquaculture:**
    Rationale of integrated farming; Rice-shrimp culture; Duck cum fish culture

Recommended Text (s):

1. Tropical Mariculture, edited by SS DeSilva, Academic Press, 1998
2. Coastal shrimp aquaculture in Thailand: Key issues for research, edited by PT Smith, ACIAR Technical Report 47, Australia, 1999
3. Tropical coastal aquaculture, edited by J Hambrey, AIT, 1999
4. Studies on the Fisheries Biology of the Tiger Prawn, *Penaeusmonodon* in the Phillipines, by H Motoh
5. Giant Prawn Farming, by MV New
6. Textbook of Fish Culture: Breeding and Cultivation of Fish, by JA Timmermans
7. De Silva, S.S. 1998. Tropical mariculture. Academic Press: San Diego, CA (USA)
8. Coastal shrimp aquaculture in Thailand: Key issues for research, edited by PT Smith, ACIAR Technical Report 47, Australia, 1999.
9. Timmermans, J.A. Textbook of Fish Culture: Breeding and Cultivation of Fish
10. Pillay, T.V.R. 2005: Aquaculture: Principles and Practices. Fishing News books Ltd.
11. Bardach, E.J. Rhyther, J.H. & W.O. Mc. Larney. 1972: Aquaculture. The Farming and Husbandry of freshwater and Marine organisms. John Wiley and Sons. New York: p 868.

Course Code & Title: MFS 2102: AQUACULTURE (LAB)	Credit:1.5

Rationale	The course is designed to provide a practical knowledge of aquaculture and the production of coastal and marine aquatic organisms.
Objectives	• To prepare a design an aquaculture farm and farm management techniques. • To monitor the farms, formulate the feeds and increase the production. • To collect and prepare the pituitary gland for breeding.
Learning Outcomes	Having successfully completed this course, students will be able to: • Analyze Water and soil, design farms, prepare project profile for hatchery and grow out farm. • Monitor water parameters in culture systems, formulate feed and make feeding ration. • Collect and prepare the pituitary gland.

Syllabus Contents:

1. Water and soil analysis of aquaculture farms
2. Design and layout of aquaculture farms
3. Study of development stages of commercially important shrimps and fishes
4. Practice of seed collection, sorting, preservation & transportation
5. Calculation of feeding ration
6. Study tour to observe culture methodology of fin-fish and shell fish in coastal areas of Bangladesh
7. Collection of pituitary gland & preparation
8. Practice of different feeding methods
9. Determination of water budget for aquaculture panel

Recommended Text (s):

1. Tropical Mariculture, edited by SS DeSilva, Academic Press, 1998
2. Tropical coastal aquaculture, edited by J Hambrey, AIT, 1999
3. Studies on the Fisheries Biology of the Tiger Prawn, *Penaeusmonodon* in the Phillipines, by H Motoh
4. Textbook of Fish Culture: Breeding and Cultivation of Fish, by JA Timmermans
5. De Silva, S.S. 1998. Tropical mariculture. Academic Press: San Diego, CA (USA)
6. Coastal shrimp aquaculture in Thailand: Key issues for research, edited by PT Smith, ACIAR Technical Report 47, Australia, 1999.
7. Pillay, T.V.R. 2005: Aquaculture: Principles and Practices. Fishing News books Ltd.

Course Code & Title	Credit:2
MFS 2103: MARICULTURE	

Rationale	This course is designed to get the knowledge about the aquaculture system of coastal and marine organisms. Coastal and marine water support for diverse organisms in capture fisheries. But culture of those species is also important to implement now a days.
Objectives	• The students will earn necessary knowledge in culture and management systems of different fish and shellfish in coastal and marine waters.
Learning Outcomes	Having successfully completed this course, students will be able to: • Gather more practical knowledge to operate a culture system. • Understand about more suitable environment required for culture of a specific species. • To learn about the feasibility of culture system.

Syllabus contents:

1. Introduction: History of coastal and marine aquaculture, global, regional and national importance of coastal aquaculture.

2. Site selection: General consideration; soil properties and water quality.

3. Farming techniques: Shallow water (finfish and shrimp), intertidal zone (oyster and seaweed), deep water (rafts and cages).

4. Larval rearing: Larval rearing of marine finfishes, shrimp and prawn.

5. Culture of finfishes: Pangasius catfish, tilapia, sea-bass, milkfish, mullets, yellowtail, grouper and salmon.

6. Culture of crustaceans: Crabs, shrimp, prawn and lobsters.

7. Culture of marine mollusks and seaweeds: Mussels; clams, oysters (including pearl oyster); abalone, scallops, seaweeds.

8. Mangrove forest and aquaculture: Mangrove ecosystem, energy flow in mangrove swamps, impact of deforestation and management of mangroves for sustainable aquaculture and fisheries.

Recommended Text(s):

1. Bardach, J. E. J. H. Ryther, and W. O. Mclarney. 1972. Aquaculture. John Willey & Sons. Inc. New York. 868 pp.
2. Imai, T. 1977. Aquaculture in shallow seas: Progress in shallow sea culture. Oxford. IBH Publishing Co. New Delhi, Bombay, Calcutta. 615 pp.
3. Pillay, T.V.R. 1973. Coastal Aquaculture in the Indo-pacific Region. Fishing News Books Ltd. London. 497 pp.

Course Code & Title	Credit:3
MFS 2105: PLANKTOLOGY	

Rationale	This course is designed to provide the knowledge of planktons. There are phytoplankton and zooplankton related to marine fisheries. These planktons play important contribution in the food chain. So, it is important to learn about marine planktons.
Objectives	• To learn about the classification and importance of planktons. • To understand the distribution of planktons and its relationship with seasonality. • To learn about different culture techniques. • To know about migration and productivity of plankton.
Learning Outcomes	Having successfully completed this course, students will be able to: • Identify various planktons and would be able to know their importance. • Learn about different culture techniques. • Understand distribution, migration and productivity of plankton.

Syllabus 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 in different Oceans.
   2.3. Productivity and their measurement (Lake, Estuary, Oceans).
   2.4. Factors affecting primary production of the sea, nutrients, light, temperature, micronutrients, grazing etc.
   2.5. Seasonal & non-seasonal blooms, causes of phytoplankton bloom, the problem of single species bloom.
   2.6. Culture techniques of phytoplankton *Skeletonemacostatum*, Chlorella and *Tetraselmis.*

3. **Zooplankton**

   3.1. Definition and classification of zooplankton.
   3.2. Factors affecting the growth, distribution and seasonal changes of zooplankton.
   3.3. Seasonal changes and breeding of zooplankton.
   3.4. Geographical distribution of zooplankton.
   3.5. Vertical distribution and migration of Zooplankton.
   3.6. Food and feeding habit of zooplankton.
   3.7. Culture techniques of commercially important zooplankters - Artemia, Rotifer, Copepod.

4. Phytoplankton-zooplankton relationship.

5. Fish-plankton relationship.
6. Plankton collecting gears.
7. Determination of plankton biomass, occurrence, abundance, species richness.
8. Plankton of the coastal waters of Bangladesh.

Recommended Text(s):

1. Plankton and Productivity in the Oceans, by J. E. G. Raymount, Pergamon, ISBN: 0080215513.
2. Primary Productivity in Aquatic Environment, by C. R. Goldman, University of California Press (1974), ASIN: B001P0ML4M.
3. Nature Adrift: The Story of Marine Plankton, by J Fraser, G. T. Foulis& Co. Ltd. (1962), ASIN: B0000CLHJZ.
4. The Marine and Freshwater Plankton, by CC Davis, Michigan State Univ. Press (1955), ISBN: 0870130161.
5. Marine Plankton, by G. E & R. C. Newell, 1977, ISBN: 978-1-904690-41-2.
6. Zoogeography and Diversity in Plankton, by Spoelet at, Hodder& Stoughton Educational (December 1, 1979), ISBN: 0713127899.
7. Ecology of Plankton, by A. Kumar, Daya Publishing House (June 30, 2008), ISBN: 8170353742.

Course Code & Title	Credit:1.5
MFS 2106: PLANKTOLOGY (LAB)	

Rationale	This course is designed to get the practical understanding of marine plankton – phytoplankton and zooplankton.
Objectives	• To learn about the collection techniques of plankton. • To learn about preservation, identification and estimation of planktons. • To know the process of determining the productivity and biomass.
Learning Outcomes	Having successfully completed this course, students will be able to: • Understand the diversity of marine planktons. • Collect, preserve and identify the planktons. • Determine productivity and biomass.

Syllabus Contents:

1. Preparation and handling of plankton collection equipments.
2. Collection, preservation, identification and estimation of plankton.
3. Laboratory and mass culture of Phyto/zooplankton.
4. Preparation of plankton slides.
5. Determination of productivity.
6. Determination of Zooplankton Biomass.
7. Salinity tolerance of plankton

Course Code & Title	Credit:3
MFS 2107: MARINE FISH DIVERSITY AND SYSTEMATIC	

Rationale	Diversity and systematics are major part of study in an ecosystem. Therefore, study with these is key part for coastal and marine ecosystem. The course is focused on current status and values of biodiversity, systematic classification and identification, taxonomic nomenclature, threats to aquatic biodiversity, and discusses conservation strategies and rules and regulations in real cases from local as well as other regions of the world.
Objectives	• To learn about the diversity of species. • To learn about hierarchy of organism. • To know taxonomic classification of organisms.
Learning Outcomes	Having successfully completed this course, students will be able to: • Understand the diversity of organisms. • Collect, preserve and identify different organisms. • Have broader knowledge on different threatened, endangered, critically endangered and extinct species.

Syllabus Contents:

1. Basic information on biodiversity: Definition of species, ecosystem and genetic diversity, the nature and value of biodiversity- economic and ecological.

2. Aquatic biodiversity of Bangladesh: Ecosystem diversity: inland waters - rivers, beels, haors and baors, and coast and marine - Bay of Bengal, coast, off-shore and estuaries protected areas of Bangladesh, the forests and the major hotspots

3 Species biodiversity: Aquatic animals - coastal and marine.

4. Loss of the biodiversity: Causes, natural variation in time and space, present situation, threatened aquatic species of Bangladesh and the Red List

5. Biodiversity rules and regulations and Conservation of Biological Diversity (CBD).

6. Systematics: An overview, taxonomy and systematics, terms and definitions, the role of taxonomy, category and taxon, classification and identification, hierarchy of categories, Linnean hierarchy.

7. Taxonomic characters: Morphometric, meristic, physiological, ecological, and ethological criteria for taxonomic categorization.

8. Species concepts: Typological, nominalistic and biological, difficulties in the applications.

9. Zoological nomenclature: The rules of zoological nomenclature, International Code of Zoological Nomenclature, validity of names, homonymy, synonymy.

10. Zoogeography of Fishes: Clues to geographical history of fishes, geography of freshwater and marine fishes, continental patterns.

Recommended Text(s):

1. Gaston, K. J. and J. I. Spicer. 1998. Biodiversity - An Introduction. Wiley-Blackwell. 133 pp.
2. Helfman, G. E., B. B. Collette, D. E. Facey and B. W. Bowen. 2009. The Diversity of Fishes. Wiley-Blackwell.736 pp.
3. Mayr, E. and P. D. Ashlock. 1991. Principles of Systematic Zoology. McGraw Hill College. 416 pp.
4. Patro, L. R. 2010. Aquatic Biodiversity, Discovery Publishing House Pvt. Ltd. 216 pp.

Course Code & Title	Credit:2
MFS 2109: WETLAND AND LAKE MANAGEMENT	

Rationale	To familiarized students about the structure and functioning of aquatic and wetland ecosystems for their management and wise use, and learn how to interact with stakeholders, managers and policy makers for the development of best practices.
Objectives	• Proficient with tools to conduct basic assessments for wetland management • Introduce about the policies, factors and management systems of wetland
Learning Outcomes	Having successfully completed this course, students will be able to: • Demonstrate and apply an understanding of the physical, chemical and biological structure and associated processes of wetland ecosystems. • Achieve experience in data analysis and interpretation, and it's use for management. • Integrate potentially conflicting stakeholder objectives for the sustainable use of lakes, rivers and wetlands

Syllabus 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 RAMSAR Convention,1971 on Wetland Management

Recommended Text(s):

1. Wetlands of Bangladesh, by BCAS/NACOM, 2000
2. Wetland Water and the Law, by IUCN, 1999
3. Wise use of Wetland, by RAMSAR Bureau, 1998
4. Fresh Water Ecology, by Jeffries and Mills, 1999

Course Code & Title	Credit:2
MFS 2111: SOCIETY CULTURE AND FISHERIES	

Rationale	This course is designed to have knowledge on economic analysis and cultural need of different fisheries product.
Objectives	To teach the students updated knowledge on principles, theories and practices of aquaculture and fisheries economics for sustainable management of aquatic resources towards economic benefits.
Learning Outcomes	Having successfully completed this course, students will be able to: • Have marketing knowledge of products. • Have knowledge on benefit analysis. • Have knowledge on culture related economically viable fisheries product.

Syllabus content:

1. Concepts and principles of fisheries economics: Definition and basic concepts as it relates to fisheries and aquaculture, relationship of economics with other social sciences, rationale of studying economics for the students of fisheries sciences.

2. Consumer behaviour: Utility analysis, law of diminishing marginal utility and law of equimarginal utility, indifference curve analysis, law of demand and supply, elasticity of demand.

3. Factors of production: Definition, relative importance of the factors, land, peculiarities of land, efficiency of labour, theory of population, capital and capital formation, importance of capital, steps of capital formation.

4. Theory of production: Definition, production function, law of diminishing return, production efficiency, improving production efficiency.

5. Cost and revenue concepts: Definition, different cost concepts, cost curves, revenue and revenue curves.

6. Financing in fisheries: Money, banking, credit, micro-credit and fisheries.

7. Economics of aquaculture and open-water fisheries: Fish production and its economic importance, contribution of fisheries sub-sector in the economy of Bangladesh, small-scale, subsistence and commercial fisheries, capture and culture fisheries, economic and bio-economic models of fisheries management.

8. Farm planning: Definition, steps in fish farm planning, analyzing farm enterprises, farm profitability analysis, project analysis technique.

9. Environmental aspects in fisheries.

Recommended Text(s):

1. Dewett, K. K. and A. Chand. 2001. Modern Economic Theory. S. Chand & Company Ltd., New Delhi.

2. Hill, B. 1980. An Introduction to Economics for Students of Agriculture. Pergamon Press, London.

3. Samuelson, P. A. 2005. Economics. 18th Edition. McGraw Hill, New York.

FOURTH SEMESTER

Course Code & Title	Credit: 2
MFS 2201: FISHERIES GENETICS AND BIOTECHNOLOGY	

Rationale	To understand the molecular level of work in gene manipulation to better modification of the existing species.
Objectives	• To provide basic knowledge of genetics. • To introduce students with methods of gene manipulation. • To be able to determine amount of dissolved substances in sea water. • To be able to know about new techniques in the field of biotechnology.
Learning Outcomes	Having successfully completed this course, students will be able to: • Have knowledge on basic genetics. • Have knowledge on application of fish biotechnology for diversified area. • Compare between the modified product and existing product. • Have knowledge on importance of fisheries genetics in fisheries management.

Syllabus Contents:

1. Basic genetics
   Phenotype, Genotype, Molecular genetics (DNA molecule, replication of DNA, ribonucleic acid - RNA, chromosomes, protein synthesis), Cell division (mitosis, meiosis, location of genes), Genetic code, Dominant and additive gene expression, Example of Mendelian traits in fish

2. Population genetics
   Hardy-Weinberg equilibrium, Inbreeding, Crossbreeding, Selection, Mutation and sexual reproduction, Genetic drift, Migration, Genetic distance and population divergence

3. Reproductive traits and genetic structure in aquatic animals
   Reproductive cycle, Sex determination, Sex ratio, Sexual characteristics, Egg and sperm production, Fertilization, Genetic determination of sex, Hormone induced sex reversal and ovulation, Cryopreservation of gametes and gene banking, Alleles and genotypes, Allozymes, mtDNA and microsatellite variation

4. Commercial application of fish biotechnology
   Selection, Intraspecific crossbreeding, Interspecific hybridization, Polyploidy, Sex reversal and breeding, Gynogenesis, Androgenesis

5. Genetics in fisheries management
   Fish genetic resources of Bangladesh, Genetic considerations in open water stocking

6. Gene-transfer technique in fish/shellfish
   DNA construction, Transgene delivery, Transgene integration, Detecting integration and expression of the transgene, Performance of transgenesis, Gene cloning

7. Design of breeding programs
   Maintenance of additive genetic variance, Inbreeding and risk, Mating design, Selection, Selection and mating, Progeny testing, Connectedness, Small- and large-scale breeding program

8. Modern biotechnology in aquaculture
   DNA markers, Linkage maps, Quantitative traits loci, Marker-assisted selection

9. Ethics of Biotechnology
   Ethical theory and principle, Ethical issues (food safety, health and environmental risks) in biotechnology, Existing legislation, Codes of practice for biotechnology

10. Constraints and limitations of genetic biotechnology

Course Code & Title	**Credit:3**
MFS 2203: AQUACULTURE NUTRITION	

Rationale	To understand the value of nutrition for proper growth of cultivable aquatic species.
Objectives	• To provide basic knowledge of aquaculture nutrition. • To introduce students with different supplementary food for culture system. • To be able to determine quality and quantity of supplementary food supplied to culture system. • To be able to know about new techniques of preparing supplementary food at a low cost.
Learning Outcomes	Having successfully completed this course, students will be able to: • Have knowledge on nutritional value of aquaculture food. • Have knowledge on relation between food supply and growth performance of cultured species. • Compare among the required nutrition for a particular species. • Have knowledge on importance of aquaculture nutrition for newly introduced farm for commercial purpose.

Syllabus Contents:

1. Introduction of fish nutrition and aquaculture: Origin of nutritional characteristics of fish and crustaceans; Terminology in aquaculture nutrition; Relationship between fish nutrition and fish culture.

2. Nutrition of aquatic animals: Feeding behavior and regulation of food intake; Digestive physiology and nutrient digestibility of fishes; Sources of nutrients, natural, supplementary and complete artificial diet of fish.

3.Nutritional energetic: Partitioning of energy; Energy requirements of fish; Energy retention.

4. Protein nutrition of fish and shellfish: Characteristics of protein metabolism in fish**;** Requirements of protein and essential amino acids**;** Protein deficiency symptoms**;** Evaluation of dietary protein.

5. Lipid nutrition: Lipid metabolism in fishes; Essential fatty acid requirements**;** deficiency symptoms; Importance of lipids in fish diet; Influence of dietary lipidson body composition and fish carcass quality; Evaluation of lipid quality.

6. Carbohydrate nutrition: Importance and limits of energetic role of carbohydrate; Glucose metabolism in fish; Synthesis and metabolism of glycogen; Improvement of carbohydrate utilization in fish.

7. Vitamin nutrition: Vitamin characteristics and classification; Requirements and sources**;** Deficiency symptoms.

8. Mineral nutrition: Characteristics of mineral nutrition in fish; Interactions between environment, nutritional supply and requirements; Nutritional role of macro-minerals and trace elements in fish; Deficiency symptoms.

9. Larval nutrition: Nutritional requirements of fish and shrimp larvae; Nutritional quality of live prey; Characteristics of artificial food for larvae.

10. Brood-stock nutrition: Energy partitioning for reproduction; Protein requirements for brood stock; Effect of dietary quality on reproductive output.

11. Methods used in studies on fish nutrition: Experimental methods and designs in fish nutritional studies; Performance measure; growth prediction and survival; Food utilization, temperature and water quality actors; Assessing diets and flesh quality.

Recommended Text(s):

1. Halver J. E and Hardy R. W (Editor) 2002. Fish Nutrition, Third Edition, Academic Press. USA.
2. Guillaume J, Kaushik S, Bargot P and Metailler R (Editors) 1999. Nutrition and Feeding of Fish and Crustaceans. Praxis Publishing, UK.
3. De Silva S.S and Anderson T. A 1995. Fish Nutrition in Aquaculture, Chapman and Hall, London.
4. Tacon A. G. J. 1990. Standard Methods for the Nutrition and Feeding of Farmed Fish and Shrimp. Argent Laboratories Press, Washington.
5. Lovell, T. 1989. Nutrition and Feeding of Fish. Van Nostrand Rainhod, New York.
6. Steffers W. 1989. Principles of Fish Nutrition. Ellis Horwood Limited. John Wiley and Sons New York 1384 pp.

Course Code & Title	Credit:1.5
MFS 2204: AQUACULTURE NUTRITION (LAB)	

Rationale	This course is designed for field application of outsource food supply in a culture system for proper growth of species.

Objectives	• To provide basic knowledge of field application. • To have knowledge on composition of supplementary food for all nutrition. • To be able to determine quality of food supplied to culture system.
Learning Outcomes	Having successfully completed this course, students will be able to: • Have knowledge on analysis of feed ingredients. • Know the contamination of food supplied. • Have knowledge on growth performance evaluation under different feeding practice.

Syllabus Contents:

1. Introduction to laboratory equipments and safety procedures.

2. Proximate composition analysis of feed ingredients, compounded feed, naturally produced food and carcass samples: a) moisture/dry matter, b) protein c) lipid, d) ash and e) crude fibre.

3. Techniques for faecal collection.

4. Determination of chromic oxide content in feed and faecal sample.

5. Digestibility studies of dry matter, protein and lipid content in feed.

6. Analysis of growth responses, food conversion and protein utilization.

7. Aquarium setting for nutritional studies.

8. Study of growth performances under different feeding practices in field conditions.

Recommended Text(s):

1. AOAC. 2000. Official Methods of Analysis 17th Edition, Association of Official Analytical Chemists, Washington DC. 2200 pp.
2. Guillaume, J., S. Kaushik, P. Bergot and R. Metailler. 2001. Nutrition and Feeding of Fish and Crustaceans. Praxis Publishing, Chichester, UK. 408 pp.
3. Halver, J. E. 1989. Fish Nutrition 2nd Edition. Academic Press. 388 pp.
4. Steffens, W. 1989. Principles of Fish Nutrition. Ellis Horwood Ltd., West Sussex. 384 pp.
5. Tacon, A. G. J. 1990. Standard Methods for the Nutrition and Feeding of Farmed Fish and Shrimp. Vol. I-II. Argent Laboratories Press, Redmond, Washington, USA. 454 pp.

Course Code & Title	**Credit: 3**
MFS 2205: FISH DISEASES	

Rationale	This course is designed to have proper knowledge on health management of fisheries species.
Objectives	• To provide basic knowledge on different infectious and other diseases. • To have knowledge on bacterial, viral and parasitic diseases.

	• To be able to determine the environmental stresses.
Learning Outcomes	Having successfully completed this course, students will be able to: • Identify causative agent of diseases. • Knowledge on preventive measure taken for a particular area. • Have knowledge on disease control and management.

Syllabus Contents:

1. Basics of Fish and Shellfish Health Management:
   1.1 Host-pathogen-environment relationship,
   1.2 Management of culture systems,
   1.3 Environmental stress.
2. Infectious bacterial and viral diseases:
   2.1 General characteristics,
   2.2 Epizootiology,
   2.3 Diagnosis,
   2.4 Prevention and treatment.
   Bacteria: Gram-positive bacteria, Gram-negative bacteria, Pseudomonas, Vibriosis.
   Virus: White Spot Syndrome Virus (WSSV), Monodon Baculo Virus (MBV), Hepatopoetic Parvo Virus (HPV), Yellow-head Virus (YHV), infectious hypodermal and hematopoietic necrosis virus (IHHNV), Lymphocystis, Infections pancreatic necrosis, Infectious Hematopoietic necrosis, Viral hemorrhagic septicemia.
3. Parasitic and mycotic diseases: General characteristics, Epizootiology, Diagnosis, Life cycle, Prevention and treatment.
   3.1 Protozoa: Sarcomastigophora, Apicomplesa, Cilophora
   3.2 Plathielmintties: Monogenia, Digenia, Cestoda
   3.3 Nemathelminthes: Nematoda, Acnthopcephala
   3.4 Crustacea: Copeda, Isopoda
   3.5 Fungi: *Ichtyophomus hoferi*, Other fungal pathogens
4. Non-infectious Diseases:
   Nutritional diseases, water, soil, environmental parameters and their effects on fish health. Disease in hatcheries and grow-out systems.
5. Defense system in fish and shellfish:
   5.1 Defense systems in fish,
   5.2 Innate and adaptive immunity,
   5.3 Inflammation response to diseases,
   5.4 Immune response to foreign antigens-antibody and cell mediated immunity in fish and shellfish.
6. Techniques in health management:
   6.1 Microbiological, haematological, histopathological, immunological and molecular techniques.
   6.2 Disease surveillance and reporting.
7. Disease problem and socio-economic effects:
   7.1 Principal pathogens in aquaculture
   7.2 Effects of diseases in aquaculture

7.3 Reduction in number of fish & shellfish

7.4 Effects on other species

7.5 Diseases outbreaks in aquafarm of Bangladesh

8. Disease control and management:

8.1 Environment management, chemotherapeutic agents, host management, prophylaxis-vaccines, adjuvants, immunostimulants and probiotics.

8.2 Use and abuse of antibiotics and chemicals in health management.

8.3 Fish and shrimp health and quarantine systems.

8.4 Seed certification, SPF and SPR stocks-development and applications.

8.5 Biosecurity of aquafarm.

Course Code & Title	**Credit:1.5**
MFS 2206: FISH DISEASES (LAB)	

Rationale	This course is designed to have broader knowledge on different diseases of fisheries species, their causative agent, preventive measure and proper treatment.
Objectives	• To provide basic knowledge on prompt identifying a disease. • To have knowledge on clinical examination of diseases. • To be able to identify the environmental condition responsible to be happened for a disease.
Learning Outcomes	Having successfully completed this course, students will be able to: • Make themselves skilled in field application. • Know the way of taking preventive measure for diseases. • Have knowledge on histological techniques for disease diagnosis.

Syllabus Contents:

1. Collection of parasites from hosts

2. Preservation of parasites

3. Preservation of permanent slides

4. Sampling, preparation of media and culture of pathogenic bacteria; Techniques for bacterial classification

5. Histological techniques for disease diagnosis; Molecular and immunological techniques; Biochemical tests; PCR; ELISA; Agglutination test; Challenge tests

6. Clinical examination of diseased fish & shellfish

7. Stress related study of fish and shellfish; Disease treatments

Recommended Text(s):

1. Aline, W. 1980. Fish diseases, Spranger- Verlay, Berlin Heidelberg, New York.
2. Schaperclaus, W.1986. Fish diseases (Vol. 1 & II)., Oxonian CU Press File No. 176 Pvt. Ltd.

3. Wedmeyer, G. Meyer, F.P. and Smith, L., 1999. Environmental Stress and Fish Diseases, Narendra Publishing House, Delhi. P. 192.4. Ronald J. Roberts Ed. 1989. Fish Pathology. 2nd Edition, Baillere Tindall, London.

Course Code & Title	Credit:2
MFS 2207: MARINE ENVIRONMENT AND POLLUTION MANAGEMENT	

Rationale	This course is designed for introducing students to environmental pollution and their consequence on biological diversity of species.
Objectives	• To provide basic knowledge on environmental pollution. • To have knowledge on identifying the source of pollution. • Knowledge on development activities can take to prevent pollution.
Learning Outcomes	Having successfully completed this course, students will be able to: • Aware of consequences of pollution for coastal and marine water. • Know the lethal condition of environment. • Take necessary preventive measure to minimize the pollution level.

Syllabus 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

Course Code & Title	Credit: 2
MFS 2209: FISH HARVESTING AND HANDLING	

Rationale	This course is designed for students to have basic knowledge on theory of fishing, introduce them with fishing technique, gears and crafts.
Objectives	• To provide basic knowledge on different fishing techniques. • To have knowledge on safety procedure of fish handling. • To be able to determine the quality of fish during handling.
Learning Outcomes	Having successfully completed this course, students will be able to: • Have knowledge on different methods of fish harvesting. • Know the level of fishing safe for future production. • Have knowledge on safe handling of fish.

Syllabus Contents:

1. **Introduction:** Principles and theory of fishing; history of fishing; sustainable harvest; carrying capacity; MSY; Optimum sustainable yield; maximum economic yield; modern trends in fishing; fishing techniques other than using gears.

2. **Fishing gears:** Classification materials, terminology, numbering systems; relative efficiencies of nets of different materials; net preservation; net making and mending, knot less net; use of different nets in fishing; spear-fishing, line-fishing, traps and their operation.

3. **Fishing crafts:** Trawlers, seiners, traditional and mechanized crafts and their operation in Bangladesh; deep sea, mid sea and offshore fishing.

4. **Methods of harvesting**: Harvesting of pelagic, demersal and mid-water fishes; harvesting of Shrimps; survey of fishing grounds in the Bay of Bengal, present status of fishing; problem of trash fish and joint ventures in fish harvesting.

5. **Fishery reconnaissance:** Location and detection of fish and shell fish, hydrographic observation, fishing charts, eco-sounding, infra-red photography, ghost fishing, Katha fisheries.

6. **Fish behavior:** Response to stimuli, attraction concentration, frightening by artificial lures, light and sound.

6. **Fish handling:** Handling of fresh fish and shrimps on board and shore; ideal/ Careful handling of different types of catches; sorting, washing slime, gutting, evisceration, filleting, salting, shelf life of fish, cause of fish decomposition; characteristics of fresh condition of fish, prevention of mechanical damage in fish.

Recommended Text(s):

1. Ahmed, N. 1970, Fishing Craft of East Pakistan, East Pakistan Government Press,

Dacca
2. Clusas, I.J. Sutcliffe, P.J. 1981, An introduction to fish Handling and Processing, Tropical Products Institute, London
3. Clusas, I. J. (Editor) 1985, Fish Handling, Preservation and Processing in the tropics, Part I & II, Tropical development & Research Institute London.
4. Das, B. and Bandayapaddaya, O. 2000, Fish Harvesting Technology, Bangla Academy, Dhaka.
5. Garner, J. 1988. Modern Deep-Sea Trawling Gear, Hartnolls Limited, Bodmain, Cornwall.
6. Neilsen, L. A. and Johnson, D. L 1985. Fisheries Techniques, Southern Printing Company Inc, Blacksburg, Virginia.

Course Code & Title	Credit:1
MFS 2210: FISH HARVESTING AND HANDLING (LAB)	

Rationale	This course is designed to acquaintance students with different fishing gears and handling techniques.
Objectives	• To provide basic knowledge of netting materials. • To have knowledge on safe mesh size and design for a particular species. • Knowledge on net preservation.
Learning Outcomes	Having successfully completed this course, students will be able to: • Have knowledge on preparing net, crafts and gears. • Use these net, crafts and gears for significant fishing. • Have knowledge on different knots used in fishing and net making.

Syllabus Contents:

1. Acquaintance with different types of fishing gears: Wounding gears, fish traps and nets, their identification, description, operation and significance.

2. Acquaintance with different types of fishing crafts in Bangladesh: Identification, carrying capacities, use and significance in fishing.

3. Examination and identification of different types of net materials: Yarn, strands, twine, rope, etc. and its direction. Study of count system of fishing twines.

4. Identification of different types of natural and synthetic fibres used in fishing.
5. Practice of different types of knots used in fishing and net making.

6. Practice on net making and mending.

7. Exercise on different techniques of net preservation.

8. Field visit to different fishing locations (inland and marine) to gather experience on traditional and commercial fishing operations.

Recommended Text(s):

1. Brandt, A. V. 1984. Fish catching methods of the world (3rd Edition). Fishing News (Books) Ltd. Surrey, England.

2. Deep Sea Trawling and wing Trawling. 1956. (ed.). The Gourock Ropework Co. Ltd., Port Glasgow, Scotland.

3. Fyson, J. 1985. (ed.). Design of small fishing vessels. FAO Publication. Fishing News (Books) Ltd. Surrey, England.

4. Garner, J. 1982. How to make and set nets or the technology of netting. Fishing News (Books) Ltd. Surrey, England.

5. Gerhard, K. 1973. Netting materials for fishing gear. FAO Fishing Manuals. Fishing News (Books) Ltd. Surrey, England.

6. Kristijohnsson, H. 1975. (ed.). Modern fishing of the world. Fishing News (Books) Ltd. Surrey, England.

7. Nomura, M. 1978. Outline of fishing gear and method. Kanagawa International Fisheries Training Centre. Nagai, Yokoshika-ken, Japan.

8. Sainsbury, J. C. 1975. Commercial fishing methods: an introduction to vessels and gears. Fishing News (Books) Ltd. Surrey, England.

9. Training Department, SEAFDEC. 1988. (ed.). Fishing technology outline. TD/TRB/45. October, 1988. Text Reference Book. Southeast Asian Fisheries Development Centre, Phroprudoeng, Samutpraken, Thailand.

THIRD YEAR

FIFTH SEMESTER

Course Code & Title	Credit:3
MFS 3101: BIOSTATISTICS	

Rationale	Biostatistics is designed to teach the basic principles of biostatistics with applications in public health. This course is for students who will use the knowledge they acquire to enable them to continue learning more advanced techniques in future statistical and biostatistical course work specially for fisheries interest.
Objectives	• Define the principal concepts about biostatistics • Collect data relating to variable/variables which will be examined and calculate descriptive statistics from these data. • Identify distribution form relating to the variable/variables. • Apply hypothesis testing via some of the statistical distributions.
Learning Outcomes	In this course we'll learn how to effectively collect data, describe data, and use data to make inferences and conclusions about real world phenomena. After finishing this course, student should be able to: • Recognize the importance of data collection and its role in determining scope of inference. • Demonstrate a solid understanding of interval estimation and hypothesis testing. • Choose and apply appropriate statistical methods for analyzing one or two variables. • Use technology to perform descriptive and inferential data analysis for one or two variables. • Interpret statistical results correctly, effectively, and in context. • Understand and critique data-based claims.

Syllabus Contents:

1.1 General introduction

1.2 Presentation of data

1.3 Introduction,

1.4 Types of data, tabulation of data, frequency and frequency distribution, construction of frequency distribution table

1.5 Graphical Representation

1.6 Introduction of graph, types of graphs

1.7 Measures of Central Tendency

1.8 Measures of Dispersion

1.9 Introduction, different types of dispersion

1.10 Moments, Skewness and Kurtosis

1.11 Introduction, Definition and types of Skewness and Kurtosis, Absolute and relative measures of Skewness, Measures of Kurtosis, Use of Moments in Skewness and Kurtosis

1.12 Correlation and Regression

1.13 Correlation: Coefficient of correlation, Simple correlation, Rank correlation, Coefficient of determination

1.14 Regression: Regression coefficient, Simple regression, Multiple regression, Polynomial Regression

1.15 Use of regression and correlation analysis: Limitations and Errors

1.16 Probability Distribution

1.17 Basic concept of probability, Related mathematics, Elementary Probability and Conditional probability

1.18 Probability distribution, Random variable & Expected value in Decision making

1.19 Properties, constants and significance of Binomial distribution, Poisson distribution and Normal distribution

1.20 Sampling

1.21 Introduction to sampling, population and sample, types of sampling- Judgment sampling and Probability sampling

1.22 Random sampling: simple random sampling, stratified random sampling, systematic sampling and there uses, Sample estimates and its variances, Standard errors of estimates, Sampling and nonsampling errors

1.23 Basic ideas of test

1.24 Introduction: hypothesis, null hypothesis, alternative hypothesis, label of significance, confidence limit

1.25 ‘t’ distribution, properties of ‘t’ distribution application of ‘t’ distribution, ‘t’ tests

1.26 The $\chi 2$ distribution, constants of $\chi 2$ distribution, $\chi 2$ test, conditions for applying $\chi 2$ tests, uses of $\chi 2$ tests

1.27 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.

1.28 Experimental design

1.29 Introduction, Phases of experimental design

1.30 Randomized block design

1.31 The Latin squire design

1.32 Test of significance

1.33 Introduction, hypothesis, null hypothesis, alternate hypothesis, level of significance, One tailed and two tailed test, power of a test, construction of confidence intervals.

1.34 Special applications: Tests about means, proportions & correlation coefficient, Test of goodness of fit, independence & homogeneity, Test in regression analysis

1.35 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

1.36 Time series and forecasting

1.37 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 squires, second degree parabola, exponential trends, growth curves, measurement of seasonal variations

Recommended Text(s):

1. Methods of statistics, by MG Mustafa
2. Research methodology and statistical techniques, by S Gupta
3. Statistical methods, by SP Gupta
4. Statistics for management, by RI Levin and DS Rubin
5. Designs and analysis of experiments, by DC Montgomery
6. Fundamentals of bio-statistics (biometry), by S Prasad, 1992
7. Statistical methods in biology, byNorman and Bailey, 1995
8. Biometry, by RR Sokal and FJ Rohlf, 1981

Course Code & Title	Credit: 3
MFS 3103: FISH POPULATION DYNAMICS	

Rationale	Course will demonstrate the analysis of fish population data for management purposes. Methods for estimating fish population parameters (e.g., growth, recruitment, and mortality) will be conducted. You will predict yield and catch composition for recreational and commercial fisheries, and assess effects of harvest restrictions for fisheries management problems.
Objectives	• Proficient with tools to conduct basic assessments for recreational and commercial fisheries • Demonstrate the methods used, and laboratories will provide experience in using the various assessment tools
Learning Outcomes	Having successfully completed this course, students will be able to: • Proficient in basic parameter estimation and stock assessment of fish populations • Achieve experience in data analysis and interpretation, and it's use for management • Analyze data and interpret the results to diagnose overfishing and explore how management policies can improve fisheries

Syllabus Contents:

1. Basic concepts

   1.1 Definition: fish, fisheries, population dynamics, fish population dynamics

   1.2 Morphometric/meristic characteristics related to fish population dynamics

   1.3 Distribution and abundance calculation in time and space

   1.4 The primary objectives of fish population dynamics

   1.5 The population dynamics concept

   1.6 Models

      1.6.1 Analytical models

      1.6.2 Holistic models

2. Review of biostatistics

   2.1 Mean, standard deviation and variance

   2.2 The normal distribution

   2.3 Confidence limits

   2.4 Ordinary linear regression analysis

   2.5 The correlation coefficient and functional regression

   2.6 Linear transformations

3. Estimation of population parameters

   3.1 Estimation of length weight relationship, isometric growth, determination of 'c' by linear analysis, determination of condition factor, relative condition factor etc.

   3.2 Selectivity curve, selectivity of fishing gear

4. Analysis of growth

   4.1 The von bertalanffy growth equation

   4.2 The von bertalanffy growth equation in terms of length

   4.3 The von bertalanffy growth equation in terms of weight

   4.4 Input data for the von bertalanffy growth equation

   4.5 Data from age reading and length measurement

   4.6 Calculation of von bertalanffy growth parameters using length frequency data analysis

      4.6.1 Ford-walford plots
      4.6.2 Von bertalanffy plots
      4.6.3 Chapman's plot
      4.6.4 Age at zero length in von bertalanffy growth curve
      4.6.5 Estimation of age composition from length-frequencies
      4.6.6 Bhattacharya' s method
      4.6.7 Modal progression analysis

4.6.8 Length age key

4.7 Calculation of von bertalanffy growth parameters using hard part analysis

4.8 Fitting growth curves by means of computer programs

4.8.1 Elefan i
4.8.2 The seasonalized von bertalanffy growth equation
4.8.3 The seasonalized von bertalanffy growth equation
4.8.4 Maximum likelihood methods
4.8.5 Limitations of length-frequency analysis

5. Reproduction and recruitment

5.1 Timing of recruitment
5.2 Gsi, hsi, gonad maturation stages
5.3 Gonad maturation stages
5.4 Length at first sexual maturity
5.5 Timing of recruitment
5.6 Length at recruitment
5.7 Length at first capture

6. Estimation of mortality rate

6.1 Definition, cause, types, effect
6.2 Basic principal of mortality estimation
6.3 The concept of acohort and some basic notation
6.4 The dynamics of acohort, the exponential decay model
6.5 Estimationofzfromcatchperunitofeffortdataandtheconceptofthecatchabilitycoefficient

6.5.1 Heincke's method
6.5.2 Robson and chapman's method

6.6 Estimation of z from a linearized catch curve

6.6.1 The constant parameter system
6.6.2 The linearized catch curve equation
6.6.3 The linearized catch curve based on a decomposition data
6.6.4 The linearized catch curve based on length composition data
6.6.5 The cumulated catch curve based on length composition data

6.6.5.1 The jones and vanzalinge method
6.6.5.2 Beverton and holt'sz-equation based on length data
6.6.5.3 Beverton and holt'sz-equation based on age data
6.6.5.4 Beverton and holt'sz-equation based on length-at-first-capture
6.6.5.5 The powell-wetherall method

6.7 A plotofzoneffort for separate estimates of fandm
6.8 Natural mortality

6.8.1.1 Natural mortality and longevity
6.8.1.2 Pauly's empirical formula
6.8.1.3 Rikhter and efanov's formula

7. Virtual population analysis (vpa)

7.1 Principles of virtual population analysis
7.2 Basic steps in virtual population analysis
7.3 Pope's age-based cohort analysis
7.4 Jones' length-based cohort analysis
7.5 The slicing technique

8. Life history pattern of fish

Recommended Text(s):

1. Fisheries biology, assessment and management, by Michal King, 2001, fishing news books.

2. Introduction to tropical fish stock assessment - part 1: manual, by Per Sparre and Siebren c. Venema, fao fisheries technical paper 306/1 rev. FAO 1998.

Course Code & Title	Credit:1.5
MFS 3104: FISH POPULATION DYNAMICS (LAB)	

Rationale	Course will demonstrate practical analysis of fish population data for management purposes. Methods for estimating fish population parameters (e.g., growth, recruitment, and mortality) will be conducted. You will predict yield and catch composition for recreational and commercial fisheries, and assess effects of harvest restrictions for fisheries management problems.
Objectives	• Proficient with practical use of different tools and ecosystem of assessing fish population dynamics. • Development of practical skill on the methods used which will provide experience in using the various assessment procedures.
Learning Outcomes	Having successfully completed this course, students will be able to: • Collection of data for the assessment of fish population dynamics. • Population Dynamic Analysis for fish

Syllabus Contents:

1. Observation of different types of crafts and gears used in the Bay of Bengal (field visits)

3. Observation of different type of fish landing centers and fish markets adjacent to Chittagong (field visits).

3. Length-weight relationship analysis by linear regression
4. Determination of VBGF parameters by Cohort analysis
5. Determination of GSI, HSI and K value
6. Length at first maturity.
7. Mortality estimation by length converted catch curve
8. Virtual population analysis.

Recommended Text(s):

1. Fisheries biology, assessment and management, by Michal King, 2001, fishing news books.
2. Introduction to tropical fish stock assessment - part 1: manual, by Per Sparre and Siebren c. Venema, fao fisheries technical paper 306/1 rev. FAO 1998.

Course Code & Title MFS 3105: FISH FEED TECHNOLOGY	Credit: 3

Rationale	To familiarize the students with different feedstuff of animal and plant origin, non-nutrient components and antinutritional factors of feed, commercial and farm-made feed. The students will also learn about feed formulation, manufacturing, storage and feeding regime.
Objectives	• To teach about the feed preparation techniques. • To measure and preparation of feed with different nutritional value. • Different method of storage of food. • Other necessary aspects of fish feed technology.
Learning Outcomes	Having successfully completed this course, students will be able to: • Prepare feed with different diet for fishery. • To determine and maintain quality of feed. • Different methods of storage of feed.

Syllabus Contents:

1. Materials Flow in Feed Mill:
   Receiving, processing, packaging, storage and distribution
2. Feed Milling Processes
   2.1 Grinding: hammer mills, Attrition mills, Cutters, Screening
   2.2 Mixing: Horizontal mixers, Vertical mixers, Liquid mixers, Other mixers
   2.3 Pelting: Application; Influence of feed composition; Cooling and drying; Crumbles; Screening and grading; Use of hard pellets; Hazards of feeding hard pellet; Pellet hardness and stability; Floating pellets

3. Effects of Processing on the Nutritional Value of Feed

3.1 Heat treatment
3.2 Grinding
3.3 Pelleting and crumbling
3.4 Processing to destroy naturally occurring toxins and moulds
3.5 Salmonella and others
3.6 Effects of processing on the availability and nutritional value of vitamins
3.7 Effect of processing on the availability and nutrient value of trace elements

4. Quality Control in Feed Manufacturing
   4.1 Quality control procedure: Raw materials and finished product
   4.2 Raw materials and finished product analysis: protein, fat, ash, moisture, anti-metabolites and toxin in feed
5. Antioxidants in Compound Feed
   5.1 Criteria for selecting feed antioxidants
   5.2 Commonly used feed antioxidants
   5.3 Functional effects of antioxidants
   5.4 Level of antioxidant usage in feed
6. Manufacturing Compound Feed in Developing Countries:
   Guideline; Concept; Requirements of a feed mill; Planning the project
7. Experimental Design in Diet Study
   7.1 Experiential design
   7.2 Number of observations
   7.3 Significant test between treatments
   7.4 Isocaloric and insonitrogenous diets
   7.5 Control diet
8. Storage of Feed
   Losses & deteriorative change during storage: Physical loss; Water and heat damage; Losses due to insect attach; Control of insect; Control of microorganisms; Factors effecting deteriorative processes; Rancidity

Recommended Text(s):

1. Principles of animal nutrition and feed technology by D.V. Reddy
2. Standard method for the nutrition and feeding of farmed fish and shrimp by Albert G.J. Tacon
3. Feed management in intensive aquaculture by Stephen Goddard
4. Fish feeds and feeding in developing countries by FAQ
5. Feed and feeding of fish and shrimp by Michael B. New

Course Code & Title	Credit: 1.5
MFS 3106: FISH FEED TECHNOLOGY (LAB)	

Rationale	To familiarize the students preparing different feedstuff of animal and plant origin, non-nutrient components and anti-nutritional factors of feed, commercial and farm-made feed. The students will also have practical knowledge about feed formulation, manufacturing, storage and feeding regime.
Objectives	• To give practical knowledge about the feed preparation

	techniques. • To measure and preparation of feed with different nutritional value in lab. • Learn Different method of storage of food.
Learning Outcomes	Having successfully completed this course, students will be able to: • Prepare feed with different diet for fishery. • To determine and maintain quality of feed. • Different methods of storage of feed.

Syllabus Contents:

1. Techniques of fish feed grinding, mixing and pelting
2. Nutritional value of different artificial feed
3. Practices on different storage techniques

Recommended Text(s):

1. Standard method for the nutrition and feeding of farmed fish and shrimp by Albert G.J. Tacon
2. Feed management in intensive aquaculture by Stephen Goddard
3. Fish feeds and feeding in developing countries by FAQ
4. Feed and feeding of fish and shrimp by Michael B. New

Course Code & Title	Credit: 2
MFS 3107: AQUACULTURE PLANNING AND ENGINEERING	

Rationale	As planning a good aquaculture system is a prerequisite of successive culture of species. Therefore, this course is designed to acquire more knowledge on structural framework of a culture system.
Objectives	• To learn about the major aspects of culture system. • To learn about site selection criteria. • To learn about the suitability of a species for a specific site.
Learning Outcomes	Having successfully completed this course, students will be able to: • Plan and design a culture system • Introduce new species in culture method • Have broader knowledge on management practice of a system

Syllabus content:

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 service
1.6 Economic appraisal of an aquaculture farm, Legal provisions for aquaculture promotion

2. Aquaculture Engineering
   2.1 Water source and quality for aquaculture, fluid behavior, direct volume measurement system
   2.2 Definition, classification, installation, operational, operational mechanism, capacity, number, retirement of pumps, design and constructional criteria of pond, tank, raceway and other impoundment
   2.3 Material analysis and costing, design and construction of embankments, dykes and water control structures layout and construction of small scale and large scale hatchery and facilities types, function and uses of different categories of filter and aerators for aquafarms
   2.4 Economic aspects of farm construction

Course Code & Title	**Credit:1.5**
MFS 3108: AQUACULTURE PLANNING AND ENGINIEERING (LAB)	

Rationale	This course is mainly designed to focus on field implementation for the country. As we have small scale culture system operational in coastal and marine water.
Objectives	• To learn about the total estimation for a system. • To learn about grow out method of a farm. • To have knowledge on survey system.
Learning Outcomes	Having successfully completed this course, students will be able to: • Design a culture system. • Have capacity in estimating cost benefit. • Have broader knowledge on different species to be introduce in culture system.

1. Survey and identification of construction materials
2. Planning and drawing of foundation, brick walls columns, lintels beams floor etc. of sluice gate, dyke and canals
3. Estimation of building and construction materials
4. Estimation of hatchery building and grow out farms.

Recommended Text(s):

1. Fundamentals of Aquaculture Engineering, by TB Lawson
2. Planning and management for sustainable coastal aquaculture development, GESAMP, 1999
3. Coastal planning and management, by R Kay and J Alder, 1999

Dynamics of Pond Aquaculture, by HS Igna and CE Boyd

Course Code& Title	Credit:2
MFS 3109: FISHERIES BIOCHEMISTRY	

Rationale	Course will demonstrate the analysis of fishery biochemical composition analysis with different biochemical components, their structure and functions and flow of genetic information.
Objectives	• Proficient with different biochemical composition of fishery and their role. • Genetically information transfer procedures through biochemical components.
Learning Outcomes	Having successfully completed this course, students will be able to: • Describe the biochemistry of fishery resources and their significance • Structure and function of different biochemical components.

Syllabus Contents:

1. Introduction to Biochemistry and Biochemical Research Literature
2. Cells: The Bio of Biochemistry; Water; pH and Buffer
3. Energy: Energy Reactions, Cellular Phosphorylations and Electron Transport, Energy Efficiency, Thermodynamics, Metabolic Controls
4. Definition, classification and biological significance of lipids, fatty acids: structure, properties and chemical reactions; Saponification, iodine number and peroxide value of fats
5. Structure and Function: Proteins, Nucleic Acids, Carbohydrates, Lipids, Membranes and Transport, Vitamins and Cofactors
6. Catalysis: Activation Energy, Enzyme Catalysis, Enzyme Kinetics, Enzyme Inhibition, Control of Enzymes
7. Flow of Genetic Information: DNA Replication, DNA Repair, Transcription, Regulation of Transcription, RNA Processing and Translation
8. Metabolism: Overview of Metabolic Concepts, Glycolysis, Fermentation, and Gluconeogenesis, Citric Acid and Glyoxylate Cycles, Acetyl-CoA and Cholesterol Metabolism, Fatty Acid Oxidation and Synthesis, Carbohydrate Storage and Breakdown, Pentose Phosphate Pathway, Amino Acid Metabolism and Catabolism
9. Structure, functions and properties of nucleic acids; Structure of purines, pyrimidine; DNA and RNA; Watson and Crick mode l of DNA.

Recommended Text(s):

1. Biochemistry and Molecular Biology of Fishes by Hochachka
2. Principles of Biochemistry by David L. Nelson and Michael M. Cox
3. Fish Physiology by William Stewart Hoar and D. J. R and all

Course Code& Title	Credit:1
MFS 3110: FISHERIES BIOCHEMISTRY (LAB)	

Rationale	Course will demonstrate the practical analysis procedure of fishery biochemical composition analysis with different biochemical components, their structure and functions and flow of genetic information
Objectives	• Qualitative and quantitative analysis of different biochemical substances • To learn about different biochemical techniques
Learning Outcomes	Having successfully completed this course, students will be able to: • Measure qualitative and quantitative analysis of different biochemical substances • To analyze different biochemical techniques.

Syllabus Contents:

1. Extraction and purification of proteins and lipids Isolation, purification and Characterization of nucleic acids
2. Qualitative and quantitative analysis of proteins, lipids, carbohydrates and nucleic acids.
3. Quantitative estimation of biomolecules by spectrophotometric methods
4. Biochemical Techniques: Cell Disruption and Fractionation, Chromatography, Electrophoresis, Blotting, DNA Techniques

Recommended Text(s):

1. Biochemistry and Molecular Biology of Fishes by Hochachka
2. Principles of Biochemistry by David L. Nelson and Michael M. Cox
3. Fish Physiology by William Stewart Hoar and D. J. R and all

Course Code & Title	Credit:2
MFS 3111: SEDIMENTOLOGY	

Rationale	This course is designed to get the knowledge about sediment. Bay of Bengal receives huge quantity of sediments from the river system. The understanding of sediment dynamics is important in the overall study of the ocean.
Objectives	• To learn about different types of sediments. • To know about sediment transport and deposition. • To understand the relationship between sedimentation and evolution.
Learning Outcomes	Having successfully completed this course, students will be able to: • Understand different types of sediments. • Learn the process of sediment transportation and deposition at different environmental composition. • Know different bed forms. • Understand the relationship between sedimentation and evolution.

Syllabus Contents:

1. The physics of the fluids:
   1.1. Fluid properties, fluid statics, pressure variations, hydrostatic force (curve & plane surface), buoyancy.
2. Hydrodynamics:
   2.1. 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:
   4.1. Sediment properties, viscosity of the dilute suspensions, fall velocity, initiation of movement, bed forms influence ripples and dunes.
5. Bed forms and bed roughness:
   5.1. 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.
   6.3. Marine Sedimentary and Environmental Evolution.

Recommended Text(s):

1. Elementary Fluid Dynamics, by D.J. Acheson, Oxford University Press (1992), ISBN: 019 8596790.
2. Fluid Dynamics at Interfaces, by W. Shyy, R. Narayanan, Cambridge University Press (1999).
3. Principle of Fluid flow and Sediment Transport by R. Mayele, CRT Press, Frankfort, Germany (2000).
4. Foundations of Fluid Dynamics, by G. Fallavotti, Springer Publications (2002), ISBN: 978-3-540-41415-5.
5. Global sedimentology of the ocean: an interplay between geodynamics and paleo-environment, by Christian M Robert, Elsevier Science, ISBN: 0444518177.
6. Sedimentology and stratigraphy, by Gary Nichols, Wiley-Blackwell, ISBN: 1405135921.
7. Sedimentology and sedimentary basins: from turbulence to tectonics, by Mike R Leeder, Wiley-Blackwell, ISBN: 1405177837.
8. Sedimentology and petroleum geology, by Knut Bjorlykke, Springer, ISBN: 978-3-540-17691-6.
9. Sedimentology: process and product, by M.R. Leeder, Springer, ISBN: 978-94-009-5986-6.
10. Sedimentary basins: evolution, facies and sediment budget, by Gerhard Einsele, Springer, ISBN: 3540544496.

SIX SEMESTER

Course Code & Title	Credit: 3
MFS 3201: BASIC SEAMANSHIP AND NAVIGATION	

Rationale	The course introduces students to basic knowledge on a fishing vessel, ships organizations, ships parts and their role, Navigation at sea and maintenances of ships.
Objectives	The course wills enhance student's knowledge of fishing vessel's navigation procedures, maintenances during onboard, onshore, on the sea, on the river, at the port to avoid any maritime accidents.
Learning Outcomes	Having successfully completed this course, students will be able to: • From this subject student will learn about nautical knots and rigging, mooring and anchoring procedures, • port operation procedures • safe working practice, routine deck maintenances and seafarer's safety • social responsibilities onboard ship. • Basic Navigation procedures at the sea

Syllabus Contents:

Seamanship:

1. Fundamental of Seamanship and Basic sea terminology.
   1.1.Nautical and Shipping terminology.
   1.2. The names and functions of various parts of the ship; for example, decks, compartments, ballast tanks, bilges etc.
   1.3. Anchor and Cables - various parts, marking on cable and operations.
   1.4. Knowledge of the compass card and its use.
   1.5. Method of reporting approximate bearing of an object in degrees or points on the bow.
   1.6. Method of reading of Draft markings of vessel.
   1.7. Method of Anchor Cable marking.
2. Nautical Knots, bends and hitches.
   2.1. Cordage, Types of rope.
   2.2. Use and care of rope.
   2.3. Characteristics of ropes.
   2.4. Nautical knots, bends and hitches and their use onboard ship.
   2.5. Whipping. Splicing. Rope and wire stoppers.
   2.6. Rigging boson's chair and stage hitch.
3. Relevant sections of Marine Notices.
   3.1. Code of Safe Working Practices for Merchant Seamen.
   3.2. Maintenance equipment. Safety precautions while working onboard.

3.3. Guidelines relating to safe working practices and safe movement aboard ship.

3.4. Working at a height or over side.

3.5. Personal Protective equipment and clothing.

3.6. Risk assessment. Permit to work procedures.

4. Personal Safety and Social Responsibilities

4.1 Types of emergencies and actions to take.

4.2 Emergency signals and use of safety equipment.

4.3 Value of drills and training.

4.4 Importance of safe working practices.

4.5 Effective communication.

4.6 Precautions on entering enclosed spaces.

4.7 Use of Lock-out/Tag-out system.

4.8 Pollution prevention.

4.9 Drug and alcohol policy.

Recommended Text(s):

1. Theory and Practice of seamanship ---Danton G.
2. Seamanship Notes ------Kemp and Young
3. Nicholls Seamanship -----Brown Son and Ferguson
4. Seamanship Technique -------D.J. HOUSE.

Navigation:

1. Mercator's Chart and Gnomonic or Great Circle Sailing Charts, Plain charts, Scales, Graduation, Scale or Natural Scale, Nautical Mile, Knot, Instruction, Measuring Distance.

2. The Log: Plotting and Taking of Positions, Positions on Plans, Conventional Signs and Abbreviations, Soundings, Metric Charts.

3. Coastal Aids to Navigation: Lighthouses, Light Vessels, Buoys, Radio and Radar Stations, Fog Signals.

4. Directions: Bearings and Courses; True, Magnetic and Compass, Pylorus, Gyro Compass

5. The Compass Rose: Taking off and laying down Courses and Bearing, Courses to Steer, Course to steer to counteract a Current, Leeway.

6. Position on a chart by simultaneous cross bearing, by bearing and range
7. Position Lines and Fixes: Running Fix, Leeway, Types of Running Fix, Cocked hat, Dead Reckoning Position and Estimated Position.

8. Elementary Knowledge of passage planning and execution; Landfalls in thick and clear weather; The selection of suitable anchorage, approaching anchorage and entering narrow channel waters; The use of clearing marks and horizontal and vertical angles.

9. Radio Bearings: Errors and Adjustments of Radio Bearings - use of Radio Bearings - Long Distance Radio Bearings.

10. Knowledge of IALA system of Buoyage

11. Theory of tides: Definitions of tidal levels. Ships' under keel clearances. Find the times and heights of tides using Standard Ports using the Admiralty Tide Tables Volume 1. Calculate tidal heights based on Standard Ports. Tidal stream Atlases.

Recommended Text(s):

1. Chartwork-Capt. S.S. Chaudhari
2. Chartwork for Mariners- Capt. Puri, S.K
3. Voyage Planning and Chartwork-Capt. M.V.Naik and Capt.Varty
4. Nicholls Concise Guide Volume I- Brown Son and Ferguson
5. Marine Chartwork- Moore, D.A
6. A Seaman's Guide to Basic Chartwork Morgans -Technical Books 1985, Latest Ed., Southsea [ISBN: 0948254017]

Course Code & Title	Credit:1.5
MFS 3202: BASIC SEAMANSHIP AND NAVIGATION (LAB)	

Rationale	The course introduces students to basic practical knowledge of a fishing vessel, Navigation, ships organizations, ships parts and their role and maintenances of ships.
Objectives	The course will give student a handful practical knowledge on fishing vessel's Navigation, maintenances during onboard, onshore, on the sea, on the river, at the port to avoid any maritime accidents.
Learning Outcomes	Having successfully completed this course, students will be able to: • From this subject student will learn nautical knots and rigging, mooring and anchoring procedures, • safe working practice, routine deck maintenances and seafarer's safety • Demonstrate basic passage planning and monitoring using the ship simulator. • Calculate times and heights of tides and ships under keel clearances at European Standard Ports

Syllabus Contents

1. Practical training on different knots and rigging procedures.
2. Training on deck maintenance.
3. Introduction of different seamanship gears.
4. practical seamanship practices
5. Anchoring and mooring procedures
6. Practical passage plan and navigation
7. Practical navigational practices

Recommended Text(s):

1. Theory and Practice of seamanship ---Danton G.
2. Seamanship Notes ------Kemp and Young
3. Nicholls Seamanship -----Brown Son and Ferguson
4. Seamanship Technique -------D.J. HOUSE.
5. An Introduction to Coastal Navigation - a seaman's guide -Morgan Technical Books Ltd. 1985, Latest Ed., All, Morgan technical Books Ltd. Gloucestershire, UK [ISBN: 0948254025

Course Code & Title	Credit:3
MFS 3203: BIODIVERSITY AND CONSERVATION	

Rationale	Marine environment is rich in biodiversity. The course has been designed to understand this biodiversity which have great ecological value.
Objectives	• To learn about the value of biodiversity. • To know the biodiversity measurement processes. • To understand the treats and conservation techniques.
Learning Outcomes	Having successfully completed this course, students will be able to: • Understand the concept of biodiversity. • Measure biodiversity and formulate conservation procedure. • Importance, threats and conservation of marine biodiversity.

Syllabus Contents:

Biodiversity

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

Conservation

1. Definition and Concepts
2. Importance of Conservation
3. The Rise of Modern Conservation

4. Approaches of Conservation
5. Biodiversity conservation inside Protected Areas
   5.1. Establishing Protected Areas
   5.2. Designing Protected Areas
   5.3. Measuring Protected Areas: Protected Areas and people
6. Biodiversity conservation outside Protected Areas
7. International Agreements on Biodiversity Conservation

Recommended Text(s):

1. Biodiversity: An introduction, by K.J. Gaston and J.I. Spicer, Blackwell Science (1998), ISBN: 1-4051-1857-1.
2. Species diversity in space and time, by M.L. Rosenzweig, Cambridge University Press (1995), ISBN: 0883853396.
3. Species diversity in ecological communities: Historical and geographical perspectives, by R. E. Ricklefs and D. Schulter, *University* Of Chicago *Press*(1st edition, 1994), ISBN: 9780226718231.
4. Biodiversity, by E.O. Wilson and F.M. Peter, National Academic Press (1998), ISBN: 0-309-03783-2.

Course Code& Title	Credit: 3
MFS 3205: REMOTE SENSING AND GIS	

Rationale	This course aims at introducing concept, principles and applications of Geographic Information Systems (GIS). Course also aims to develop the skill of using software and other tools of GIS and RS in fishery students.
Objectives	• provides students foundations of Remote Sensing (RS) theory, RS image processing techniques and applications • provides students foundations of GIS theory, GIS data processing techniques and applications
Learning Outcomes	Having successfully completed this course, students will be able to: • Explain and communicate the concept of various kind of maps and geospatial data • Develop, edit and update geospatial data • Create digital maps, apply projections and other characteristics of mapping • Integrate various kind of data from various sources and analyze the same using GIS concept and tools • Apply the knowledge and skill for various applications

Syllabus 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

7. Introduction to GIS

   7.1 General introduction and definitions
   7.2 GIS requirements (hardware, software, manpower)
   7.3 GIS and related technologies (Remote Sensing, GPS, Computerized Cartography, photogrammetry)
   7.4 Applications of GIS
   7.5 Future directions of GIS (WebGIS, OpenGIS)
   7.6 GIS theories

8. Mapping and scales

8.1 Types of Maps
8.2 Map scale
8.3 Coordinates and projection systems

9. GIS data structure

9.1 Characteristics and sources of GIS data
9.2 Raster and vector data model: basic understanding
9.3 Understanding layers and attribute

10. Images and rasters/grids

10.1 Understanding rasters: raster properties – pixels, resolution, color depth, storage requirement and compression, histogram; advantages and disadvantages
10.2 GIS specific raster/grid manipulation: buffering, recalculation, reclassification, thinning, attribute manipulation, 3D modeling & analyses
10.3 Fundamentals of RS specific image manipulation

11. Vectors

11.1 Understanding vectors: topologies – point, line, polygon; storage requirement; advantages and disadvantages
11.2 Vector manipulation: overlay, buffer, geometric modeling

12. Attributes and database

12.1 Built-in attributes, raster and vector case, manipulating attributes
12.2 External data sources, manipulating external database, linking with GIS

Recommended Text(s):

1. Remote sensing of the Environment: An Earth Resource Perspective, by John J. Jensen, Prentice-Hall, 2000.
2. Physical Principles of Remote Sensing, 3rd Ed., by W.G. Rees, Cambridge University Press, 2013.
3. Coral Reef Remote Sensing: A Guide for Mapping, Monitoring and Management, by J.A. Goodman et al. Springer 2013.
4. Remote Sensing of Coastal Environments, by Y. Wang. CRC Press, 2009.
5. Oceanography from Space, Revisited, by V. Barale et al. Springer, 2010.
6. Discovering the Ocean from Space: the unique applications of Satellite Oceanography, by Ian S. Robinson. Springer, 2010.
7. Remote Sensing and Image Interpretation 3rd Ed., by T.M. Lillesand & R.W. Keifer. John Willey & Sons, 1994.
8. Geographic Information Systems: an introduction, by J Star and J Estes. Prentice-Hall, NJ. 1990

Course Code & Title	Credit:1
MFS 3206: REMOTE SENSING AND GIS (LAB)	

Rationale	This course aims at give practical knowledge of applications of Geographic Information Systems (GIS). Course also aims to develop the skill of using software and other tools of GIS and RS in fishery students.
Objectives	• provides students practical knowledge of Remote Sensing (RS) theory, RS image processing techniques and applications • provides students practical knowledge foundations of GIS theory, GIS data processing techniques and applications
Learning Outcomes	Having successfully completed this course, students will be able to: • Explain and communicate the concept of various kind of maps and geospatial data • Develop, edit and update geospatial data by own. • Create digital maps, apply projections and other characteristics of mapping. • Integrate various kind of data from various sources and analyze the same using GIS concept and tools Apply the knowledge and skill for various applications

Syllabus Contents:

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)
7. Using QGIS
8. Raster data processing: creating, using and analyzing raster data
9. Vector data processing: data creation, digitization, geoprocessing,
10. Attribute/data processing: creating and editing attribute data, analyzing GIS data using attributes
11. Using GPS, importing location data into GIS
12. Case studies (about 50% of the lab sessions)

Recommended Text(s):

1. An Introduction to geographical Information Systems, by I Heywood, S Cornelius and S Carver. Longman, 1998.
2. The GIS Book (Third Edition), by GB Korte, P.E. Onward Press, 1992.

3. Exploring Geographic Information Systems, by N Chrisman. John Wiley & Sons, 1997.
4. Principles of Geographical Information Systems, by PA Burrough and RA McDonnell. Oxford University Press, 1998.
5. Understanding GIS: The ARC/INFO Method (Third Edition). ESRI, 1995.
6. Datums and Map Projections for Remote Sensing, GIS and Surveying. By J Iliffe. Whittles Publishing, 2000.

Course Code & Title	Credit:2
MFS 3207: POST-HARVEST TECHNOLOGY	

Rationale	The course has been designed to teach about different post-harvest techniques of fisheries in different ways used in modern world and also in effective way in context of Bangladesh.
Objectives	• To learn about the spoilage procedure of fisheries. • To know about the different preservation techniques. • To understand the different rules and standards for preservation.
Learning Outcomes	Having successfully completed this course, students will be able to: • Process different fishery in standard procedure. • Learn about different preservation procedures as per international standard.

Syllabus Contents:

1. Microbiology of fish spoilage
2. Assessment and control of Fish and Shellfish quality
3. Wet fish and shellfish handling and preparation
4. Fish and shellfish preservation techniques: Chilling, Freezing, Salting, Drying, Smoking, Canning, Fermentation, Irradiation
5. Modern packing methods: Modified-atmosphere packaging of fish and fishery product
6. Processing facilities: Processing plant, Cold storage, Supply and ingredients, Equipment and Lab facilities
7. Transportation and storage of raw fish and finished products
8. Live fish/crab transportation
9. Code of practices for fish and fishery products, CODEX alimentarius.
10. HACCP and quality assurance of seafood, ISO-9001, GAP, GMP, GVP
11. Cleaning and sanitizing agents for seafood processing plants
12. Food safety issue, sanitary and phytosanitary (SPS) agreements, food safety act.
13. Trade barrier tariff (TBT) and WTO rules.
14. Detention and rejections of seafood in international trade.

Recommended Text(s):

1. Fish processing technology, by G.M. Hall, Springer publication 2009
2. Textbook of Fish processing technology, by K Gopakumar, Indian Council of Agricultural Research, New Delhi.
3. Fish inspection and quality control, edited by R Kreuzer, FAO, 1971

Course Code & Title	Credit:1
MFS 3208: POST-HARVEST TECHNOLOGY (LAB)	

Rationale	The course has been designed to teach in hand about different post-harvest techniques of fisheries in different ways used in modern world and also in effective way in context of Bangladesh.
Objectives	• To see about the spoilage procedure in of fisheries in situ. • To know about the different preservation techniques by hand. • To practice different rules and standards for preservation.
Learning Outcomes	Having successfully completed this course, students will be able to: • Process different fishery in standard procedure in lab and commercial environment. • Learn about different preservation procedures as per international standard.

Syllabus Contents:

1. Inspection of Fish and shellfish quality
2. Microbial assessment of raw material and finished product
3. Preservation of fish and shellfish by different methods

Recommended Text(s):

1. Fish curing and processing, by AD Merindol, 1969
2. Fish handling and processing, edited by Burgess et al, 1967
3. Methods of assessment of fish production in fresh waters, edited by WE Ricker, 1971

Course Code & Title	Credit: 3
MFS 3209: FISH BREEDING AND HATCHERY MANAGEMENT	

Rationale	The course has been designed to understand the reproduction of fisheries in culture and captive condition in comparison to natural condition and operation of hatcheries.
Objectives	• To learn about the fishery reproduction processes. • To know the Genetics of fisheries and their different breeding techniques • Operating techniques of hatcheries

Learning Outcomes	Having successfully completed this course, students will be able to: • Analyze different fisheries reproductive techniques • To breed fishery in different conditions. • Operation techniques of hatcheries successfully.

Syllabus Contents:

Breeding

1. Reproduction in fishes
   1.1. Introduction
   1.2. sexuality in fishes
   1.3. sexual dimorphism
   1.4. reproductive cycle
   1.5. control of reproduction
2. Fish Reproductive endocrinology
   2.1. Introduction
   2.2. Anatomy of the pituitary and hypothalamus
   2.3. Gonadotropin-releasing hormone
   2.4. Effect of GnRH on GtH release
   2.5. Inhibition of GtH release
   2.6. Fish GtHs and their actions
   2.7. Maturation of the gonads
   2.8. Oogenesis, yolk formation, ovulation, gamete maturation and release in male fishes
3. Basic genetics:
   3.1. Introduction,
   3.2. Genes, effects of genes
   3.3. Single gene trait, quantitative trait, qualitative traits,
   3.4. Genetic variance, heritability and hybridization.
4. Inbreeding: Genetic relationships, inbreeding, effective population size, effect of inbreeding on genetic variance, inbreeding depression.
5. Cross breeding, Pure Breeding,
6. Selection breeding: Introduction, Natural selection, Artificial selection, Response to selection, Selection differential.

Hatchery management

1. Breeding Criteria of Marine Species under Controlled Conditions
   1.1 Taxonomy and Morphology
   1.2 Life history
   1.3 Food and feeding habits
   1.4 Sex Determination and Sexual Maturity
   1.5 Fecundity and Spawning
   1.6 Embryonic and Larval Development
3. Hatchery Facilities and Equipment

   2.1 Holding tanks: Brood stock tanks; Spawning tanks; Incubation tanks; Larval rearing tanks; Overhead tanks
   2.2 Other accessories (pump, aerator, blower, scooping net, plankton net, sieve net)

4. Hatchery Design (Fin fish and Shell fish)
    3.1 Criteria for selection of suitable site
    3.2 Hatchery size
    3.3 Financial analysis
5. Water Quality Management
    4.1 The chemistry of water
    4.2 Water quality parameters (pH, S‰, DO, temperature, nutrients)
    4.3 Sources of water (fresh water, salt water)
    4.4 Plankton activity
    4.5 Filtration and water treatment: Mechanical filters; Gravitational filters; Biological filters; Chemical filters; Disinfection; Aeration; Degassing
6. Hatchery Techniques
    5.1 Brood stock collection
    5.2 Brood stock maintenance
    5.3 Spawning and fertilization
    5.4 Incubation and hatching
    5.5 Larval rearing
    5.6 Feed management
    5.7 Harvest and transport of fry
    5.8 Phytoplankton culture
    5.9 Rotifer culture
    5.10 Artemia nauplii production

Recommended Text(s):

1. Al-hajj, A. B. and A. S. D. Farmaer. 1984. Shrimp Hatchery Manual. Safut. Kuwit for Institute for Scientific Research.
2. BAFRU (Bangladesh Agricultural and fisheries Resources Unit). 1990. A guide to Shrimp and Prawn Hatchery Techniques in Bangladesh. Stirling, Scotland, HAFRU/ Institute of Aquaculture.
3. Billard, R. 1995. Culture. Praxis Publishing, Chichester, UK.
4. Black, K. D and A. D. Pickerin. 1998. Biology and Cultivation of Fish. Fishing News Books Ltd. Faroham, Surrey. England.
5. Chondar, S. L. 1994. Induced Carp Breeding. 3rd Edition. CBS Publishers and Distributers. 142 pp.
6. Text book of fish culture: Breeding and cultivation of fish, M. Huet (1979). Chapter 1. Fishing News Books Ltd. Surrey, England.
7. Aquaculture Engineering. F, W. Wheaton (1987). Robert E. Keieger Pnbi., Florida.

Course Code & Title	Credit: 1.5
MFS 3210: FISH BREEDING AND HATCHERY MANAGEMENT (LAB)	

Rationale	The course has been designed to have practical skill on the reproduction of fisheries in culture and captive condition in comparison to natural condition and operation of hatcheries.
Objectives	• To learn about the fishery reproduction processes by hand. • To learn different breeding techniques of fishery. • Operating techniques of hatcheries**.**
Learning Outcomes	Having successfully completed this course, students will be able to: • Application of different fisheries reproductive techniques • To breed fishery in different conditions. • Real time operation techniques of hatcheries successfully.

Syllabus Contents:

1. Drawing the layout of typical fish and shrimp hatchery.
2. Selection of breeders, handling and management.
3. Sex identification and selection of the ready-to-spawn breeders.
4. Collection of PG, preparation of PG and HCG extracts.
5. Dose calculation of inducing agents, injection, stripping and fertilization.
6. Use of incubators for hatching of eggs.
7. Incubation of fertilized eggs in different types of incubators.
8. Study of fertilization, hatching and survival rates.
9. Field visit to commercial fish and shrimp hatcheries.

Recommended Text(s):

1. Lee C. S., M. S. Su and I. C. Liao. 1991. Finfish Hatchery in Asia (Proceedings of Finfish Hatchery in Asia'91). Tungakang Marine Laboratory, Taiwan.
2. Piper, R. G., I. B. McElwan, L. E. Orme, J. P. McCraren, L. G. Fowler and J. R. Leanard. 1998. Fish Hatchery Management. US Department of Interior Fish and Wildlife Service, Washington D.C.
3. Woynarovich, E. and L. Horvath. 1984 The Artificial Propagation of Warm-water Finfishes, a manual for extension. FAO Fisheries Technical Paper 201.
4. Fishery Science: Its methods and appilcations. GA. Rounsefell and W. H. Everhart (1953). John Wiley and Sons. Inc. New York,
5. Prawn hatchery Design and Operation: E.T. Quinition, 1989. SEAFDEC Aqua Ext. Man. 9.

FOURTH YEAR

SEVEN SEMESTER

Course Code & Title	Credit: 2
MFS 4101: VALUE ADDED FISHERY PRODUCT	

Rationale	This Subject will introduce the learners to the quality of a fishery product. The theoretical knowledge of quality, assessment of quality measures, quality management in the industrial level and different aspect of quality assurance. Student will also learn about the sanitation in the processing industries and some modern method to quality control.
Objectives	• to know the quality in fishery products • to know the methodology of quality assessment • to know modern approach of quality control
Learning Outcomes	Having successfully completed this course, students will be able to: • identify the quality of a fishery product • understand the methodology of quality control in industrial level • demonstrate the modern method of quality control

Syllabus Contents:

1. Introduction: Concept of quality; various aspects of fish quality- intrinsic quality, quality deterioration, extrinsic quality defect; factors affecting fish quality, quality attributes.

2. Quality programme: Definition and types, responsibilities of quality programmes, quality control and quality assurance, purpose and functional responsibilities.

3. Industrial quality management: Good manufacturing practices (GMP), standard operating procedures (SOP) and sanitary sanitation standard operating procedures (SSOP) of fish processing industries.

4. Methods of assessing quality of fish for consumption: Sensory methods, mechanical or instrumental methods and laboratory methods-chemical/biochemical analysis and microbiological analysis.

5. Raw material and finished product quality: Intrinsic quality of seafood, maintaining raw material quality, types and requirements of finished products, end product specification, ensuring proper specification, design and content of finished products.

6. Modern approach to quality-HACCP: Principles, aims, HACCP program, steps of HACCP implementation, hazard, sources and categories of hazards, HACCP plant and worksheet, problems of HACCP implementation.

7. Quality deterioration and defect in fishery products: Chilled fish, frozen fish, smoked fish, dried and salted fish, canned fish, marinades and heat processed fish, fish flavor and quality.

8. Organization of quality control: Objectives and importance, industrial quality control, processing specification and checking, recording, reporting and actions, personnel and their responsibilities, quality management information system (QMIS).

9. Sanitation in processing industries: Hygiene practices, cleanup procedures, water supplies, various aspects of sanitation in fish processing.

10. Aquatic animal welfare: Awareness building, fish handling, anaesthetizing, transportation of live fishes, killing of fish and crustaceans, storing live seafood, storing specific types of seafood; attitudes towards marine mammals, turtles & endangered animals, legislation.

Recommended Text(s):

1. Bonnell, A. D. 1994. Quality Assurance in Seafood Processing: A Practical Guide. Chapman & Hall, London. 208 pp.
2. Connell, J. J. 1980. Control of Fish Quality. Fishing News Books Ltd. 2nd Edition. England. 222 pp.
3. Kramer, A. and B. A. Twigg. 1966. Fundamentals of Quality Control for the Food Industry. The Avi. Publishing Co. Inc., Westport. 541 pp.
4. Seafood HACCP Alliance. 2001. HACCP: Hazard Analysis and Critical Control Point. Training Curriculum. 4th Edition.
5. Bremer, H. A. 2002. Safety and Quality Issues in Fish Processing. CRC Press, 2002 - Technology & Engineering. 507 pp.
6. Fish Inspection, Quality Control, and HACCP: A Global Focus. Proceedings of the Conference. Held May 19-24, 1996, Arlington, Virginia, USA.
7. Food and Drug Administration. 1996. Fish and Fisheries Products Hazard and Control Guide; 1st Edition.
8. Huss, H. H., L. Ababouch and L. Gram. 2003. Assessment and Management of Seafood Safety and Quality. Food and Agriculture Organization of the United Nations, Nature. 230 pp.
9. Huss, H. S. 1995. Assurance of Seafood Quality, FAO Fisheries Technical Paper 334. Technology laboratory, Technical University, Lyngby, Denmark. Royal Veterinary and Agricultural University, Copenhagen, Denmark.
10. Pau, L. F. and R. Olafsson. 1991. Fish Quality Control by Computer Vision. Food Science and Technology. Marcel Dekker, Inc., 270 Madison Avenue, New York, New York 10070.
11. Seafood Quality Determination. Proceedings of the International Symposium on Seafood Quality Determination, coordinated by the University of Alaska Sea Grant College Program, Anchorage, Alaska.
12. Shahidi, F. and B. K. Simpson. 2004. Seafood Quality & Safety: Advances in the New Millennium. Science Tech Publishing Company, St. John's NL, Canada.

Course Code & Title	Credit:1
MFS 4102: VALUE ADDED FISHERY PRODUCT (LAB)	

Rationale	This Subject will introduce the learners to the quality of a fishery product. The theoretical knowledge of quality, assessment of quality measures, quality management in the industrial level and different aspect of quality assurance. Student will also learn about the sanitation in the processing industries and some modern method to quality control.
Objectives	• to know the quality in fishery products

	• to know the methodology of quality assessment • to know modern approach of quality control
Learning Outcomes	Having successfully completed this course, students will be able to: • identify the quality of a fishery product • understand the methodology of quality control in industrial level • demonstrate the modern method of quality control

Syllabus Contents:

1. Terminologies in the quality control and quality assurance of fish and fishery products.
2. Study of the methods of assessing quality of fish and fishery products.
3. Sample collection, organoleptic, physical, biochemical evaluation of fishery products.
4. Study of statistical methods for sensory analysis experiments for quality assessment of fish and fishery products.
5. Freshness test for quality assessment of fish.
6. Hazard identification, preparation of hazard worksheet and HACCP plan.
7. Determination of detectable differences between two formulations of value-added fish products by Triangle Test and Duo-Trio Test.
8. Determination of TVB-N value of fish as quality test.
9. Group work:
   a. Study of the Practical aspects of HACCP in sea food processing Industry.
   b. Internal Quality Audit of sea food processing Industry.

Recommended Text(s):

1. Bonnell, A. D. 1994. Quality Assurance in Seafood Processing: A Practical Guide. Chapman & Hall, London. 208 pp.
2. Bremer, H. A. 2002. Safety and Quality Issues in Fish Processing. CRC Press, 2002 - Technology & Engineering. 507 pp.
3. Connell, J. J. 1980. Control of Fish Quality. Fishing News Books Ltd. 2nd Edition. England. 222 pp.
4. Fish Inspection, Quality Control, and HACCP: A Global Focus. Proceedings of the Conference. Held May 19-24, 1996, Arlington, Virginia, USA.
5. Food and Drug Administration. 1996. Fish and Fisheries Products Hazard and Control Guide; 1stEdition

Course Code & Title	Credit:2
MFS 4103: COASTAL ZONE MANAGEMENT	

Rationale	This Subject will introduce the learners to know the present status of coastal zone of Bangladesh and to impart knowledge on conservation measures. The students will be exposed in learning the recent strategies of sustainable management of coastal resources.
Objectives	• to know the existing coastal natural resources • to know different coastal zone management tools

Learning Outcomes	Having successfully completed this course, students will be able to: • demonstrate the coastal resources and its important • understand the coastal community livelihood approach • relate the management measures for coastal resources

Syllabus Contents:

1. Land-sea interaction, boundaries and extent of coastal zone, zoning of coastal areas.
2. Coastal natural resource system: land, water, animal and forest resources, critical habitat resources, ecological issues and productivity.
3. Coastal human resource systems: coastal livelihood, demography, poverty, social dynamics, assets and vulnerabilities.
4. Multiple uses of coastal zone and development impacts.
5. Coastal zone management strategies: management goals and purposes, solution through management, strategic planning and programme development.
6. Mobilization of coastal people for coastal zone management, participatory planning exercise
7. Participatory coastal resource management: community based and community participated management, fisheries co-management, linkage with different organizations and stakeholders, result-oriented monitoring and evaluation.

Recommended Text(s):

1. Clark, J.R. Soremen, J. and SChultink, G. 1993. Integrated Coastal Zone Management Strategy. Tropical Resource and Development Inc. Ganesville, Fla., Report to UNDP and Planning Commission, Bangladesh, Dhaka.
2. Clark, JR. R. (Ed). The Status of Integrated Coastal Zone Management: A Global Assessment> CAMPNET/ University of Miami/RSMS. Miami, Fla. USA.
3. Clark, J.R. 1992. Integrated Management of Coastal Zone. FAO Fisheries Technical Paper No. 327. FAO. Rome.
4. Clark, J.R. 1996. Coastal Zone Management Handbook. CRC Press LLC, N.W. Fla, USA.

Course Code & Title	Credit:3
MFS 4105: FISHERIES ECONOMICS, EXTENSION AND MARKETING	

Rationale	This Subject will introduce the learners to know the theoretical basis for fisheries extension and marketing. Student will learn the educational process in extension, different extension program. They will also learn about extension problem and conservation perspectives
Objectives	• to know about economics, extension principles and objectives • to know the educational process of extension • to know the extension problem in fisheries development
Learning Outcomes	Having successfully completed this course, students will be able to: • demonstrate the extension principles and different extension program • understand the marketing principles and different existing marketing channel

Syllabus Contents:

Fisheries Extension:

1. **Introduction:** Extension and Fisheries extension, Fisheries extension principles, levels, functions and objectives, Need for fisheries extension works for fisheries development, Gradual growth of extension work in Bangladesh.

2. **Extension as educational process:** Teaching in extension, learning in extension, principles of Learning, Behavior, Attitudes, Perception.

3. **Extension objectives:** Motivation, Need identification, Concept of need, Maslow's need theory, Change in behavior, attitude and perception.

4. **Leadership:** concept, types and groups, recognition for good leadership

5. Communication in extension for fisheries: Basic function of communication, types, models of extension communication, Barriers of communication.

6. **Extension communication methods and aids:** individual methods, group and mass methods, visual and audio-visual aids, importance and use.

7. **Extension programme:** procedures, concept, planning, implementation, evaluation, and importance.

8. **Innovation:** decision process, transfer of technologies, diffusion, adoption, factors affecting the transfer of technologies.

9. **Organization for extension work:** Main features, Categories of personnel, Supervision and co-ordination in extension work.

10. **Extension problems for fisheries development: P**ossible solution, rural youth in extension work, past and present programmes for development of fisheries and related agricultural development activities, awareness programme for bio-diversity, fishing fight.

11. **Conservation**: common property fisheries.

Fisheries Marketing:

1. **Introduction:** Marketing principles and process. Aquaculture and Fisheries Marketing concepts. Concept of product, service and brand.

2. **Market infrastructure and facilities:** Types of Markets in urban and rural areas. Marketing channels and supply chain management: Types of channels, channel management.

3. **Market equilibrium and Price analysis:** Price in perfectly competitive, Monopoly, oligopoly, and monopolistic market; Price policy models: estimation and projection of demand for and supply of Aquaculture products. Theory of distribution and factor pricing in aquaculture.

4. **Retailing and whole selling:** types, marketing decision, current trends. Advertising: Objectives, strategy, evaluating effectiveness. Sales promotion: Objectives, tools and development of the program; New product marketing strategies.

5. **Consumer behavior:** Factors affecting behavior, types of behavior and buyer decision process.

6. **Value chain analysis:** Key Elements of Value Chain Analysis; Barriers to entry, mobility and exit; Price linkages analysis; Financial Costs and Profitability; Policy Analysis Matrix; Enterprise Variations; Logistics analysis.

7. **Credits analysis**: 3`R' of the Credits; Principles of aquaculture insurance; Institutions involved in aquaculture financing.

8. **Policies, Regulation, Strategies and Research:** Policies and regulation regarding fisheries marketing in Bangladesh. Fish marketing strategies of Government organizations, private enterprise and NGO's in Bangladesh. International Seafood trade legislation. Marketing research planning and methodologies.

Recommended Text(s):

1. Mashem.M.A. 1992 Samorasaran Biggan (Extension Science). Dhaka: The Bangladesh packing Press.
2. Mosher, A.T. 1978. An Introduction Extension. New York Agricultural Development Council.
3. Oakley, P. and Garforth C. 1985. Guide to Extension Training. Rome; Food and Agriculture Organization of the United Nations.
4. Regers, E.M. 1983. Diffusion of Innovations, New York: The Free Press of Glenco.
5. Kotlar, P and Armstrong, G. 2007. Principles of Marketing. Prentice Hall, NewYork.
6. Engle, Carole Ruth, 2006. Aquaculture marketing handbook. Blackwell Publishing Ltd. UK.

Course Code & Title	Credit:2
MFS 4107: FISHERIES RESOURCES MANAGEMENT	

Rationale	This Subject will introduce the learners to know the different fisheries resources in Bangladesh. Student will learn the methodology in fish stock assessment, different fishery model and fisheries assessment and monitoring tools.
Objectives	• to know the existing fisheries resources in Bangladesh • to know fish stock assessment methodology •
Learning Outcomes	Having successfully completed this course, students will be able to: • understand the available fisheries resources in Bangladesh • demonstrate the fish stock assessment methodology

Syllabus Contents:

1. Capture Fisheries resources of Bangladesh
   1.1 Definitions: Fish, fisheries, fisheries resources, fisheries management, exploration, exploitation
   1.2 Fisheries resource statistics of Bangladesh
   1.3 Different types of fishing areas of Bangladesh (Ponds, canals, Lake, Rivers, Oxbow Lakes, Flood plains, rivers, estuaries and coastal areas)
   1.4 Marine fisheries resources of Bangladesh (Pelagic and Demersal fishery)

1.5 coastal and marine Fishing grounds of Bangladesh
1.6 Artisanal fisheries: components of artisanal fisheries

2. Fishing crafts and gears used in Bangladesh
   2.1 Active, passive and threatening fishing crafts and gears
   2.2 Types, Design, Operating techniques, Gear selectivity etc.
3. Methods of Fish stock assessment
   3.1 Definition stock, Stock assessment, different types of stock assessment
   3.2 Description of methods: 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. Population structure in space and time
   4.1 Recruitment
   4.2 Spawner and recruit relationships
   4.3 Mortality during the recruitment
   4.4 Depensation
   4.5 Regulation in fish populations
   4.6 Density-dependent habitat use
5. Surplus Yield Model
   5.1 Definition: catch, yield, biomass, effort, CPUE, equilibrium condition, breakeven point, MSY, f_{msy}
   5.2 Schaefer's model
      5.2.1 Basic assumption of Schaefer's model (surplus yield model)
      5.2.2 Principals of Schaefer's model (surplus yield model)
      5.2.3 Calculation of MSY and f_{msy} using Schaefer's model (surplus yield model)
      5.2.4 Maximum Economic Yield model (fox model)
      5.2.5 Calculation of MEY and f_{mey} using fox model
   5.3 Gulland's formula
   5.4 Cadima's formula
   5.5 *MSY* estimators based on the surplus production model
   5.6 Validation of estimates of MSY based on empirical formulas
   5.7 Munro and Thompson plot
   5.8 Standardization of effort
   5.9 The Deriso/Schnute delay difference model
6. Prediction models
   6.1 Beverton and holt's yield per recruit model
   6.2 Assumptions and models underlying the yield per recruit model
   6.3 Basic principles of yield per recruit model
   6.4 Calculation of Y/R using yield per recruit equation
   6.5 Beverton and Holt's biomass per recruit model
   6.6 Beverton and Holt's relative yield per recruit model
   6.7 Yield per recruit from length data
   6.8 Age-based Thompson and bell model
   6.9 Length-based Thompson and bell model
   6.10 Prediction of the effects of changes of mesh sizes using the Thompson and Bell method

7. Fisheries assessment and monitoring
    7.1 Steps in appraising potential fishery resources
        7.1.1 Data requirement
        7.1.2 Data collection
        7.1.3 Data analysis and stock assessment
        7.1.4 Potential yield analysis
        7.1.5 Financial analysis
    7.2 Fisheries monitoring (components)
8. Fisheries Management
    8.1 Components for management objectives and strategies
    8.2 Control points for fisheries regulations

Recommended Text(s):

1. Fisheries biology, assessment and management, by Michal King, 2001, fishing news books.
2. Introduction to tropical fish stock assessment - part 1: manual, by Per Sparre and Siebren c. Venema, fao fisheries technical paper 306/1 rev. FAO 1998. Introduction to tropical fish stock assessment - part 2: Excersise, by Per Sparre and Siebren c. Venema, fao fisheries technical paper 306/2 rev. FAO 1999.

Course Code & Title	Credit: 3
MFS 4109: RESEARCH METHODOLOGY	

Rationale	This course is designed to help the students understand the basic concepts of research and its methodologies. To carry out oceanography research the students have to learn about the fundamentals of research methodology. To be able to identify a research problem stated in a study and acquire knowledge about the overall process of designing a research study from its inception to its report.
Objectives	• To learn the basic concepts of research, types, methods, processes and so on. • To know way of designing research plan. • To learn sampling strategies and data collection methods. • To know how to check the accuracy of result and present research findings.
Learning Outcomes	Having successfully completed this course, students will be able to: • Learn about the fundamental concepts and related ideas of research methodology. • Design research plan. • Collect data using various techniques. • Check research accuracy and present research findings.

Syllabus Contents:

1. Introduction

1.1 Basic research concepts: definition of research, classical and modern research methodologies - historical and casual-comparative

1.2 Definitions of relevant concepts: empirical, systematic, controlled, critical investigation, hypothetical propositions, presumed relations, observed phenomena.

1.3 Logical steps of scientific methods: systematic & cyclic; problem identification, hypothesis formulation, developing a research plan, collecting and analyzing data, interpreting results and forming conclusions

1.4 Types of research methods: quantitative, qualitative, and mixed-method; their suitability in different research situations; methods of conducting quantitative, qualitative and mixed-method research

2.Reviewing literature

2.1 Finding literature

2.2 Electronic databases & journals

2.3 Referencing styles

3. Research design

3.1 Problem definition

3.2 Design of experiment

3.3 Principles and importance of replication

3.4 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 Sample size

4.5 Sample collection techniques of water, sediment, plankton, benthos and nekton

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. Writing research proposal

6.1 Developing an outline

6.2 Key elements - introduction, objective, rationale

6.3 Experimental method, measurement

6.4 Results, discussion, conclusion, referencing

6.5 Research extension process (workshop/seminar/journal publication)

7. Presentation Tool

7.1 Creating presentation
7.2 Showing presentation

8. Presentation Tool

8.1 Introduction to internet
8.2 Use of internet and WWW
8.3 Using search engine

Recommended Text(s):

1. Research Methods in Marine Biology, by C. Schlieper, University of Washington Press (1972), ISBN: 0295952342.
2. How to write scientific papers, Elsevier.
3. Research Methodology: Methods and Techniques, by C. R. Kothari, New Age International, ISBN: 8122415229.
4. A guide to Research Proposal and Report Writing, by A. R. Moten, Research centre, IIUM, 1998, ISBN: 9839727087.

EIGHT SEMESTER

Course Code & Title	Credit: 3
MFS 4201: CLIMATE CHANGE AND FISHERIES	

Rationale	This Subject will introduce the learners to the theoretical knowledge of weather, climate and climate change. Student will learn the process of climate change and its impact and consequences on fisheries resources, specially for Bangladesh perspectives. This course also covers the mitigation and adaptation policy of climate change.
Objectives	• to know the science behind the climate change • to know the climate change impact in fisheries sector Bangladesh • to know the consequences of climate change in ecosystem
Learning Outcomes	Having successfully completed this course, students will be able to: • know the science behind the climate change • impact and consequences of climate change • mitigation and adaptation measures of climate change

Syllabus Contents:

1. Weather and climate; Definitions of different terms related to climate change; Evidence for global climate change

2. Climate change variables and indicators:
Carbon-di-oxide and other Greenhouse gases; Temperature; Sea level change; Flood & Drought; Glacier/snow melt

3. Causes of climate change

   3.1 Natural and anthropogenic causes
   3.2 Solar insulation
   3.3 Carbon cycle
   3.4 Carbon-dioxide emission
   3.5 Volcanic activity
   3.6 Deforestation

4 Global climate change: Changes in Greenhouse gases, temperature and precipitation, sea level and snow cover, extreme climate events, Disease outbreak

5. Climate change in Bangladesh

   5.1 Climate change studies in Bangladesh
   5.2 Present and future scenario of climate change
   5.3 Extreme events, Temperature, Rainfall, flood and drought, Sea level rise, cyclone frequency & intensity

6. Climate change impacts on fisheries: Potential impacts on

6.1 Small scale and artisanal fisheries
6.2 Marine fisheries
6.3 Inland fisheries
6.4 Spawning and recruitment of Fishes and Shrimps
6.5 Fishing ground and fishing operation
6.6 Species abundance and distribution
6.7 Spatial and temporal variation of fish production

7. Impacts of climate change on aquaculture: Direct impacts on

7.1 Aquaculture production systems
7.2 Aquaculture dependent livelihoods
7.3 Fishmeal and fish oil supply
7.4 Other fed ingredients
7.5 Disease of culture species

8. Effects on ecosystem:

8.1 Primary production
8.2 Secondary production
8.3 Species invasions
8.4 Food web impacts from plankton to fish

9. Climate change impacts on water quality:

9.1 Impacts on water temperature and circulation
9.2 Nutrient concentration and loading
9.3 Oxygen concentration
9.4 Pathogenic microbes

10. Climate change impacts on fisheries resources of Bangladesh

10.1 Current state of aquaculture and fisheries of Bangladesh
10.2 Future potential impacts on aquaculture and fisheries
10.3 Economic impacts

11. Climate change mitigation and adaptation

11.1 Carbon-dioxide capture and storage
11.2 Land use change and management
11.3 Development of new technique in fisheries and aquaculture
11.4 Energy use
11.5 Aqua-food production
11.6 Aquaculture/Fisheries zoning and monitoring
11.7 Aquaculture/Fisheries insurance
11.8 Research and technology transfer

12. Climate change policy and regulations

12.1 United Nation Framework Convention on Climate Change (UNFCCC)
12.2 International Panel on Climate Change (IPCC)
12.3 International conferences and protocols: Rio 1992, Rio+10, Kyoto Protocol, Bali Road Map, Cancun Agreements, Copenhagen, Paris and beyond
12.4 Bangladesh Climate Change Strategy and Action Plan (BCCSAP)
12.5 National Adaption Plan of Action (NAPA)
12.6 Upcoming policies

Recommended Text(s):

1. Websites: UNFCCC, UNDP, IIED, SAARC, DFID, IUCN, IPCC, World Bank, ADB, etc.
2. Chowdhury, S.R., Hossain, M.S., Shamsuddoha, M. and Khan, S.M.M.H., 2012. Coastal Fishers' Livelihood in Peril: Sea Surface Temperature and Tropical Cyclones in Bangladesh. Foreign and Commonwealth Office through British High Commission and CPRD, Dhaka, Bangladesh, 66 pp.
3. Hossain, M.S., 2012. Fishermen Resilience Modeling of Hatiya. University of Chittagong, 32 pp. ISBN 978-984-33-4138-9.
4. Sterrett, C., 2011. Review of Climate Change Adaptation Practices in South Asia. Climate Concern, Melbourne, Australia, 100pp.
5. Hossain, M.S (ed.), 2009. Climate Change Resilience by Mangrove Ecosystem. PRDI, Dhaka, Bangladesh, 33 pp.

Course Code & Title	Credit:2
MFS 4203: MANGROVE ECOLOGY AND MANAGEMENT	

Rationale	This course has been designed to introduce the student about the unique mangrove ecology and their management perspectives. Student will learn the organism community and their ecological process in complex mangrove ecosystem. Importance and threats to this mangrove forest will also be introduced in this course.
Objectives	• to know the flora and fauna of a mangrove community • to know the ecological process of a mangrove forest • to know the adaptation measures of organism • to now the threats and conservation aspects
Learning Outcomes	On successful completion of this module the learners will be able to: • understand the ecological process of a mangrove forest • demonstrate the threats and conservation measures to a mangrove forest

Syllabus Contents:

1. Introduction
   1.1 Definition of mangrove
   1.2 Geographical distribution
   1.3 Mangrove flora
2. Mangrove ecosystem

2.1 Form of the mangroves: Riverine mangrove, Tide-dominated mangrove, Wave dominated mangrove, Basin mangrove
2.2 Mangrove species zonation
2.3 Siltation in mangrove forest
2.4 Food chain and energy flow

3. The mangrove community
   Algae (Phyto - benthos, seaweeds, periphyton); Fauna of mangrove roots; Invertebrates (Crustacea, mollusks, meiofauna); Fish
4. Soil of mangrove forest: Acid sulphate soil; Alluvial soil
5. Mangrove forest of Bangladesh
   5.1 The Sundarbans
   5.2 Chakana Sundarbans
   5.3 Mangrove afforestation in the coastal zone of Bangladesh
   5.4 Natural regeneration of mangroves
   5.5 Top dying disease at Sundarbans
   5.6 Effects of mangrove deforestation
6. Importance of mangroves
   6.1 Uses of mangroves: Direct & indirect uses; Mangroves and coastal protection; Ecotourism
7. Threats to mangrove forests
   7.1 Conversion of shrimp ponds
   7.2 Agricultural expansion
   7.3 Conversion to salt pans
   7.4 Construction of embankments
   7.5 Human settlement
8. Hydrodynamics of mangrove ecosystem
   8.1 Water characteristics
   8.2 Fluctuation of physico-chemical and biological parameters
   8.3 Water flow in high and low tide

Recommended Text(s):

1. The Biology of Mangrove, by PJ Hogarth. Oxford University Press, 1999.
2. Mangrove forestry in Bangladesh by NA Siddiqi, Chittagong University, 2001.
3. Mangroves of the Sundarbans, Vol. 2, Bangladesh. IUCN, 1994.
4. Ecology of mangroves, by P Hutchings and P Saenger, University of Queensland Press, 1987.
5. Mangrove vegetation, by V. J. Chapman, FL —9490 VADUZ, Germany, 1976.

Course Code & Title	Credit: 1
MFS 4204: MANGROVE ECOLOGY AND MANAGEMENT (LAB)	

Rationale	This course has been designed to introduce the student about the unique mangrove ecology and their management perspectives. Student will learn the organism community and their ecological process in complex mangrove ecosystem. Importance and threats to this mangrove forest will also be introduced in this course.

Objectives	• to know the flora and fauna of a mangrove community • to know the ecological process of a mangrove forest • to know the adaptation measures of organism • to now the threats and conservation aspects
Learning Outcomes	On successful completion of this module the learners will be able to: • understand the ecological process of a mangrove forest • demonstrate the threats and conservation measures to a mangrove forest

Syllabus Contents:

1. Participation in mangrove plantation activities
2. Identification of mangrove fauna and flora
3. Soil composition of mangrove area
4. Determination of PO_4, NO_2 and other elements of mangrove area
5. Determination of RDP

Recommended books

1. The Biology of Mangrove, by PJ Hogarth. Oxford University Press, 1999.
2. Mangrove forestry in Bangladesh by NA Siddiqi, Chittagong University, 2001.
3. Mangroves of the Sundarbans, Vol. 2, Bangladesh. IUCN, 1994.
4. Ecology of mangroves, by P Hutchings and P Saenger, University of Queensland Press, 1987.
5. Mangrove vegetation, by V. J. Chapman, FL —9490 VADUZ, Germany, 1976.

Course Code & Title	**Credit:3**
MFS 4205: QUALITY CONTROL AND BIOSAFETY	

Rationale	The objective of this course is to teach the students inspection of fish and fishery products, fish processing industry and official inspection practices in EU, India and Japan. The students will also be taught the inspection of fish and fishery products in Bangladesh and legislation related to fish inspection and quality.
Objectives	• to learn about the fish inspection and quality control measures • to know about food laws and regulations • to know about the international standard of fishery products and processing plants
Learning Outcomes	On successful completion of this module the learners will be able to: • demonstrate different fish inspection and quality control measures • know about the international standards of fishery products and a processing plant

Syllabus Contents:

1. Introduction: Organization of fish inspection and quality control, the Importance of inspection in the utilization of fishery resources, programmes of fish inspection and quality control (FIQC), organizational structure, duties and responsibilities and inspection services of FIQC.

2. Inspection of fishery products: Fresh, precooked and frozen fish, hygiene and safety aspect of fishery products.

3. Food Laws and regulations: Inspection and quality control regulations for fish and fishey products, fish feed and animal feed act, fish hatchery act, updated version as well as previous acts with amendments, EU and USFDA regulations and guidelines.

4. Traceability: Legal background, benefits and steps of implementing traceability in fish and shrimp value chain.

5. National Residue Control Plan-NRCP: Policy guideline for NRCP planning, implementation and monitoring, role of department of fisheries, Bangladesh.

6. Checklist of inspections of farms, depots and processing industries.

7. Standards of different fishery products and processing plants: CODEX standards and Bangladesh Standard specification for different fishery products.

Recommended Text(s):

1. Bonnell, A. D. 1994. Quality Assurance in Seafood Process.ing: A Practical Guide. Chapman & Hall, London. 208 pp.
2. Connell, J. J. 1980. Control of Fish Quality. Fishing News Books Ltd. (2nd Edition). England. 222 pp.
3. Kramer, A. and B. A. Twigg. 1966. Fundamentals of Quality Control for the Food Industry. The Avi. Publishing Co. Inc., Westport. 541 pp.
4. Kreuzer, R. 1971 (ed.). Fish Inspection and quality control. Fishing News Books. Ltd. London. 290 pp.

Course Code & Title	Credit: 3
MFS 4207: FISHERIES CONSERVATION AND LAWS	

Rationale	The objective of this course is to teach the students about fisheries biodiversity and conservation in Bangladesh perspectives. They will learn the different challenges and threats to fisheries conservation, different existing laws and regulation to conserve fisheries resources.

Objectives	• to know the fish biodiversity in Bangladesh • to know the challenges in fisheries conservation • to know different conservation tools through existing laws and regulation
Learning Outcomes	On successful completion of this module the learners will be able to: • understand the fish biodiversity and conservation measures in Bangladesh

Syllabus Contents:

1. Introduction

    1.1 History of fisheries conservation
    1.2 Principles of conservation
    1.3 Conservation ethic

2. Fisheries Biodiversity

    2.1 Types and components
    2.2 Measurement of biodiversity
    2.3 Species list (previous and existing)
    2.4 Abundance and distribution trends
    2.5 Threats to biodiversity

3. Fisheries conservation challenges

    3.1 Habitat degradation
    3.2 Habitat fragmentation
    3.3 Habitat alteration

4. Essential fish habitat conservation

    4.1 Establishing new populations
    4.2 Establishing protected areas
    4.3 Managing protected areas
    4.4 Ecological restoration
    4.5 Design sustainable fisheries reserve

5. Conservation and management approaches

    5.1 Gear modifications
    5.2 Habitat modifications
    5.3 Spatial and temporal control of fishing
    5.4 Restoration and sustainable development
    5.5 Community-based management
    5.6 Co-management

6. Overview of laws, acts, rules and conventions

   6.1 Biodiversity Convention 1992
   6.2 Ramsar Convention on Wetlands 1971
   6.3 UNESCO Man and the Biosphere Program
   6.4 Bangladesh Marine Fisheries Ordinance 1983
   6.5 Bangladesh Marine Fisheries Rules 1983
   6.6 Protection and Conservation of Fish Act 1950
   6.7 Protection and Conservation of Fish Rules 1985

Recommended Text(s):

1. Gene S. Helfman, Fish Conservation: A Guide to Understanding and Restoring Global Aquatic Biodiversity and Fishery Resources. Island Press; 1st edition (July 15, 2007), ISBN-10: 1559635967

Course Code & Title	Credit:3
MFS 4209: ENVIRONMENTAL IMPACT ASSESMENT AND MANAGEMENT PLAN	

Rationale	This course is designed to get the knowledge about the methodology of environmental impact assessment. It is a vital tool for marine environmental management and decision making.
Objectives	• To know about the methodology of EIA. • To understand the concepts, issues and various forms and stages of EIA process. • To know about the impacts of EIA process.
Learning Outcomes	Having successfully completed this course, students will be able to: • Explain the major principles of EIA. • Understand the different stages of EIA. • Know about the key aspects of EIA. • Access different case studies of EIA.

Syllabus 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 Text(s):

1. Global Air Pollution, by H. Bridgman, John Wiley& Sons (1994), ISBN: 0471944947.
2. Principles of Air Pollution Methodology, by T. Lyons, B. Scott, CBS Publication & Distributions, New Delhi (1992).
3. Atmospheric Chemistry & Physics, by J. H. Seinfeld, Wiley-Interscience, ISBN: 0471720186.
4. Environmental Water Pollution and its Control, by G.R. Chhatwal, M.C. Mehra, Mohan Katyal, T. Katyal, T. Nagahiro, ISBN**:** 8170412145, Anmol Pub. New Delhi.
5. Water Pollution, by A. K. Tripallhi, Astish Publications, New Delhi (1990).
6. Assessment of Water Pollution, by S. R. Mishra, APH Publications, New Delhi (1996), ISBN: 8170247101.
7. River Pollution–an Ecology Perspective, by S. M. Haslam, CBS Pub. & Distributor, New Delhi.1990, ISBN: 8123900201.
8. Standard Methods for the Examination of Water & Wastewater, by APHA, Washington. D.C.1996.