Course curriculum and syllabus

2 Years M.Sc. in

FISHERIES SCIENCE

w.e.f. 2016-2017

Vidyasagar University

Midnapore -721102

West Bengal, India

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PREFACE

The mandate of the Vidyasagar University is to plan, undertake, aid, promote and co-ordinate education, research and extension in Fisheries Science for the livelihood generation of a sizable sections of the region and our university will play a key role in fisheries education and research in the state of West Bengal, in particular and India, in general.

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GENERAL INSTRUCTIONS

1. M.Sc. in Fisheries Science course is of two years duration and is divided into four semesters consisting of 1200 Marks (Total 24 Courses; 22 Core Courses and 2 Elective Courses). Each course has 4 credits (Total 96 Credits).

2. Each semester has 300 Marks (24 credits). Semester I, II & III has 6 courses/papers each (4 Theory courses and 2 Practical courses). The Semester-IV has three theory courses and three practical courses. Each theory course is subdivided into two units of 25 marks each (2 credits). Each practical course is of 50 marks (4 credits)

3. There is Elective Course of 100 Marks in the semester – II (50 Marks = 4 credits) and Semester – III (50 Marks = 4 credits).

4. There is a special paper, 'Aquaculture' in the semester III (One Theory paper = 4 credits and one practical paper = 4 credits) and in semester-IV (One Theory paper = 4 credits and one practical paper = 4 credits). The special paper will be announced at the beginning of the third semester.

5. Each course is to be evaluated by internal assessment – 10 marks and University semester examination - 40 marks. For each course/paper, there will be two internal assessment examinations which will be evaluated by written test.

6. The students have to carry out an individual dissertation paper of 50 marks (4 credits) in the fourth semester. The dissertation paper will be evaluated by a project report, presentation of seminar followed by *viva-voce* examination.

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FRAME OF THE SYLLABUS

Curriculum for M.Sc. in Fisheries Science

TOTAL MARKS - 1200 (96 Credits)	**1st SEMESTER- 300 (24 credits)**	**6 Core courses (4 Theory + 2 Practical courses)**
	2nd SEMESTER-300 (24 credits)	**5 Core courses and 1 Elective course (4 Theory + 2 Practical courses)**
	3rd SEMESTER-300 (24 credits)	**5 Core courses and 1 Elective course (4 Theory + 2 Practical courses)**
	4th SEMESTER-300 (24 credits)	**6 Core courses (3 Theory + 2 Practical courses + 1 dissertation paper)**

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FIRST SEMESTER

300 Marks - 24 Credits

[Core courses (Theory) - 200; Core courses (Practical) - 100]

*** University Examination - 80%; Internal Assessment - 20%**

THEORY PAPER	UNIT	CREDITS	MARKS	TOPIC
FSC-101 (Core course)	UNIT-I	2	25	Freshwater Fisheries Resources
	UNIT- II	2	25	Saline water Fisheries Resources
FSC-102 (Core course)	UNIT-I	2	25	Taxonomy and Classification of fishes
	UNIT- II	2	25	Biomechanics, Distribution and Evolution of fishes
FSC-103 (Core course)	UNIT-I	2	25	Anatomy and Physiology of Fin Fishes
	UNIT- II	2	25	Anatomy and Physiology of Shell Fishes
FSC-104 (Core course)	UNIT-I	2	25	Biology, Biodiversity and Conservation
	UNIT- II	2	25	Oceanography, Remote sensing & GIS

PRACTICAL PAPER	CREDITS	MARKS	TOPIC
FSC-105 (Core course)	4	50	Based on FSC -101 (Unit – I & II) and FSC -102 (Unit – I & II)
FSC-106 (Core course)	4	50	Based on FSC -103 (Unit – I & II) and FSC -104 (Unit – I & II)

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SECOND SEMESTER

300 Marks - 24 Credits
[Core courses (Theory) - 150; Elective course (Theory) - 50;
Core courses (Practical) - 100]
*** University Examination - 80%; Internal Assessment - 20%**

THEORY PAPER	UNIT	CREDITS	MARKS	TOPIC
FSC-201 (Core course)	UNIT-I	2	25	Freshwater Ecology
	UNIT- II	2	25	Saline water Ecology
FSC-202 (Core course)	UNIT-I	2	25	Fish Breeding
	UNIT- II	2	25	Hatchery Design & Management
FSC-203 (Core course)	UNIT-I	2	25	Aquatic Pollution and Eco-toxicology
	UNIT- II	2	25	Aquatic Microbiology & Public Health Fisheries
FSC-204 (Elective course)	UNIT-I	2	25	Fundamental of Fisheries Science
	UNIT- II	2	25	Aquaculture Management

PRACTICAL PAPER	CREDITS	MARKS	TOPIC
FSC-205 (Core course)	4	50	Based on FSC -201 (Unit – I & II) and FSC -202 (Unit – I)
FSC-206 (Core course)	4	50	Based on FSC -202 (Unit – II) and FSC -203 (Unit – I & II)

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THIRD SEMESTER

300 Marks - 24 Credits

[Core courses (Theory) - 150; Elective course (Theory) - 50; Core courses (Practical) - 100]

*** University Examination - 80%; Internal Assessment - 20%**

THEORY PAPER	UNIT	CREDITS	MARKS	TOPIC
FSC-301 (Core course)	UNIT-I	2	25	Fish Pathology and Disease Management
	UNIT- II	2	25	Fish Parasitology and Immunology
FSC-302 (Core course)	UNIT-I	2	25	Genetic Engineering and Biotechniques
	UNIT- II	2	25	Fisheries Technology and Harbour Engineering
FSC-303 (Core course) Special paper: Aquaculture	UNIT-I	2	25	Aquaculture Practices
	UNIT- II	2	25	Fish Nutrition & Bioenergetics
FSC-304 (Elective course)	UNIT-I	2	25	Aquaculture Technology
	UNIT- II	2	25	Fisheries Entrepreneurship Development

PRACTICAL PAPER	CREDITS	MARKS	TOPIC
FSC-305 (Core course) General paper	4	50	Based on FSC -301 (Unit – I & II) and FSC -302 (Unit – I & II)
FSC-306 (Core course) Special paper: Aquaculture	4	50	Based on FSC -303 (Unit – I & II)

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FOURTH EMESTER

300 Marks - 24 Credits

[Core courses (Theory) - 150; Core courses (Practical) - 150]

*** University Examination - 80%; Internal Assessment - 20%**

THEORY PAPER	UNIT	CREDITS	MARKS	TOPIC
FSC-401 (Core course)	UNIT-I	2	25	Fish Processing Technology and Quality Assurance
	UNIT- II	2	25	Fisheries Extension, Economics and Marketing
FSC-402 (Core course)	UNIT-I	2	25	Fisheries Statistics and Research Methodology
	UNIT- II	2	25	Fisheries Legislation, Computer and Bioinformatics
FSC-403 (Core course) Special paper: Aquaculture	UNIT-I	2	25	Aquaculture Engineering & Environment Management
	UNIT- II	2	25	Fish Genetics and Biotechnology

PRACTICAL PAPER	CREDITS	MARKS	TOPIC
FSC-404 (Core course) General paper	4	50	Based on FSC -401 (Unit – I & II) and FSC -402 (Unit – I & II)
FSC-405 (Core course) Special paper: Aquaculture	4	50	Based on FSC -403 (Unit – I & II)
FSC-406 (Core course) Special paper: Aquaculture	4	50	Dissertation work

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1st SEMESTER

(24 credits: 300 Marks)

Core course (Theory) - 200 Marks + Core course (Practical) - 100 Marks

FSC-101

(Core course - 4 credits: 50 Marks)

[University Examination - 40 and Internal Assessment-10]

UNIT- I: Freshwater Fisheries Resources: (2 credits): 20+5 =25 Marks

1. **Fisheries resources of India**: Categorization of different freshwater fisheries resources. Present scenario and problems and prospects of inland fisheries. Trends in Indian fisheries.

2. **River, Lake & Reservoir fisheries:** Major river systems of India and their fisheries. Current status and trend of riverine fisheries. Effect of human intervention in rivers. Lake fisheries of India. Classification of reservoirs, present productivity levels and fishery potentialities. Problems and prospects of reservoir fisheries in India. Measures to increase their production and economic management of reservoirs.

3. **Cold water fisheries of India:** Coldwater resources of India. Important coldwater fish species. Status of cold water fisheries. Mahseer and trout fisheries. Problems & prospects of sports fisheries in India.

UNIT- II: Saline water Fisheries Resources: (2 credits): 20+5 =25 Marks

1. **Brackish Water Fisheries:** Brackish water fishery resources of India. Estuaries of India and their fisheries. Problems and management practices. Prospects of brackish water fisheries.

2. **Marine Water Fisheries:** Major fishing nations of the world, major fishing regions; present trend of marine capture fisheries of India; Fisheries resources of inshore, offshore and deep sea fisheries of Indian sea; Management of marine fisheries in Indian context.

3. **Commercially important finfishes and shellfishes:** Important finfish and shellfish resources in demersal and pelagic systems. Important groups of finfishes & shellfishes having commercial fishery importance.

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FSC-102

(Core course - 4 credits: 50 Marks)

[University Examination - 40 and Internal Assessment- 10]

UNIT- I: Taxonomy and Classification of fishes: (2 credits): 20+5 =25 Marks

1. **Taxonomy:** Definition and basic concepts of biosystematics & scientific nomenclature, taxonomy and classification. Classical taxonomy - morphometrics & meristics. Taxonomic keys; Modern techniques in ichthyo-taxonomy; Modern taxonomical tools; Types and molecular approaches of taxonomy.

2. **Classification:** Classification of freshwater and marine finfishes and shellfishes (Vertebrate-Sub-order; Invertebrate-Sub-class).

3. **Phylogeny:** Scope and definition. Method employed in phylogenic studies. Phylogenic tree. Fish identification and fish bar-coding.

UNIT- II: Biomechanics, Distribution and Evolution of fishes: (2 credits): 20+5 =25 Marks

1. **Biomechanics:** Body form, Swimming mechanism and buoyancy regulation - propulsive system. Swimming modes, Bioenergetics. Biorhythms and its significance.

2. **Distribution:** Zoo-geographical realms. Distribution of freshwater and marine water fishes. General accounts of Agnathan fishes, Chimeras and Dipnoans. Migration of fishes. Physiology of fish migration.

3. **Evolution of fishes:** Origin and evolution of major groups of fishes, Evolutionary strategies and morphological innovation. Evolutionary genetics. Living fossils of fishes.

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FSC-103

(Core course - 4 credits: 50 Marks)

[University Examination – 40 and Internal Assessment- 10]

UNIT- I: Anatomy and Physiology of Fin Fishes: (2 credits): 20+5 =25 Marks

1. **Digestive and Circulatory system:** Structure and physiology of digestive system; Associated digestive gland and their functions; Absorption and assimilation of nutrients; Hormones in the regulation of digestion; Factors affecting the process. Types and morphological structure of heart, blood vascular system; cardiovascular physiology & haematology of finfishes.

2. **Respiratory and Excretory system:** Types of respiratory organs, gill structure. Mechanism of gaseous exchange and their transport, Accessory respiratory organs of air-breathing fishes and their evolutionary significance. Excretory organs in finfish and their physiological functions and mechanism of excretion. Osmoregulation in finfishes. Endocrine control of osmoregulation.

3. **Reproductive and Endocrine System:** Structure and physiology of reproductive system of finfishes. Gametogenesis, Fertilization, Organogenesis and Embryonic development of finfishes. Endocrine glands of fin fishes and their hormonal regulation.

UNIT- II: Anatomy and Physiology of Shell Fishes: (2 credits): 20+5 =25 Marks

1. **Digestive and Respiratory System:** Anatomical structure and physiology of digestive and respiratory system of shell fishes. Aquatic and aerial respiratory mechanisms of prawns.

2. **Circulatory and Excretory System:** Haematology of shell fishes. Cardiovascular physiology of shell fishes. Excretory mechanism and osmoregulation of prawns.

3. **Reproductive and Endocrine System:** Anatomical structure and physiology of reproductive system of shell fishes. Embryonic development of prawn. Neuro-endocrine system of prawns. Hormonal control of reproduction in shell fishes. Environmental and exogenous hormonal stimuli.

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FSC-104

(Core course - 4 credits: 50 Marks)

[University Examination – 40 and Internal Assessment - 10]

UNIT- I: Biology, Biodiversity and Conservation: (2 credits): 20+5 =25 Marks

1. **Biology of Aquatic Resources:** Biology of commercially important freshwater, brackish water and marine finfishes & shellfishes and their sustainable management.

2. **Biodiversity:** Definition and concept; Factors influencing aquatic biodiversity; Types of biodiversity - Species diversity in different ecosystems; Genetic Diversity and Habitat Diversity; Biodiversity indices and their significance; Concepts of Index of Biotic Integrity (IBI); Global diversity patterns and loss of biodiversity; Bioindicators.

3. **Conservation:** Endangered species as per the guidelines of IUCN; Threatened aquatic species of India; Issues and strategies of conservation of aquatic species; Factors threatening indigenous species; *In-situ* and *Ex-situ* conservation. Regulations regarding introduction of exotic and invasive species and their impact on aquatic ecosystem.

UNIT- II Oceanography, Remote sensing & GIS: (2 credits): 20+5 =25 Marks

1. **Oceanography:** Definition, physical, chemical and biological and oceanographical analysis of Indian Ocean. Zonation of ocean. Ocean currents, waves and tides. Renewable and non-renewable ocean energy.

2. **Management of Ocean:** Anthropogenic activities and their monitoring and regulation through government and nongovernment organization. Sustainable management of Indian Ocean.

3. **Concept and Application of Remote Sensing and GIS:** Definition and principle of Remote Sensing and GIS. Sensing mechanism. Analysis of images and data. Fisheries forecasting system. Global Positioning System (GPS). Application of Remote Sensing and GIS in conservation and management of fish faunal diversity and exploitation of capture fisheries. Application of Remote Sensing and GIS in coastal resource management and aquaculture.

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FSC-105
PRACTICAL PAPER
(Core course - 4 credits: 50 Marks)
[University Examination – 40 + Internal Assessment-10]

[Based on FSC -101 (Unit – I & II) and FSC -102 (Unit – I & II)]

1. Identification of common finfishes available from different aquatic resources of India.
2. Identification of common shellfishes available from different aquatic resources of India.
3. Identification of Agnathan fishes, Chimera, Dipnoan and Coelacanth fishes.
4. Study the morphometry of different fishes.
5. Preparation of taxonomic key.
6. Construction of chart regarding study of the phylogenetic tree/evolutionary tree.
7. Preparation of fish bar-coding.
8. Study of Swimming mechanisms and buoyancy of fishes.
9. Visit to Freshwater areas/Brackish water areas/Marine fish landing centres to collect data.
10. Biological studies of selected finfishes and shellfishes from different aquatic resources.

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FSC-106
PRACTICAL PAPER
(Core course - 4 credits: 50 Marks)
[University Examination - 40 + Internal Assessment-10]

[Based on FSC -103 (Unit – I & II) and FSC -104 (Unit – I & II)]

1. Study of the digestive and circulatory systems of common species of finfishes.
2. Study of the urinogenital and nervous system of different species of locally available finfishes.
3. Study of the digestive and nervous system of shellfishes.
4. Accessory respiratory organs of fishes.
5. Study of the Length-Weight relationship, Relative gut length, Gastro-Somatic index of fish.
6. Study of the feeding behavior, mouth-parts modification and gut content analysis from different fish groups.
7. Study of different endocrine glands of fishes and shellfishes.
8. Analysis of different biodiversity indices. (Community analysis through community map).
9. Study of fish histology and histochemistry of different organs of fishes.
10. Study of marine / brackish water zooplankton/phytoplankton.
11. Fisheries forecasting system; Remote sensing equipment. PFZ analysis.
12. Preparation of fish-skeletons.

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2nd SEMESTER
(24 credits: 300 Marks)
Core course (Theory) - 150 Marks + Elective course (Theory) - 50 Marks
Core course (Practical) - 100 Marks

FSC-201
(Core course - 4 credits: 50 Marks)
[University Examination - 40 and Internal Assessment-10]

UNIT- I: Freshwater Ecology: (2 credits): 20+5 =25 Marks

1. **Aquatic Ecosystem:** Definition, Principles, Types and structure of aquatic ecosystems. Abiotic and biotic factors. Physico-chemical characteristics of freshwater. Classification and thermal stratification of fresh water bodies. Freshwater adaptation. Aquatic organisms and their role in carbon, nitrogen, phosphorus and sulpher cycles and their impact on aquatic habitats. Biogeochemical cycle.

2. **Wetland and Mangrove Ecosystem:** Definition, types, structure and management of wetland ecosystem. Structure and functions of mangrove ecosystem. Fisheries potentialities of wetland and mangrove ecosystem. Conservation and management of wetland and mangrove ecosystem.

3. **Ecosystem & Productivity Management**: Productivity of aquatic ecosystems - Primary, Gross and Net productivity. Biomass, Food chain, Food web, Energy flow and their model. Restoration, Management and Conservation of aquatic ecosystems for sustainable uses. Biodiversity indices and their significance.

UNIT- II: Saline water Ecology: (2 credits): 20+5 =25 Marks

1. **Estuarine Ecology:** Physico-chemical characteristics of estuarine water and soil; Origin, types & characteristics of estuaries; Major estuaries of India; Management of Indian estuary; Thermal stratification of estuary; Estuarine community and their adaptation.

2. **Marine Water Ecology:** Physico-chemical characteristics of marine water; Classification and thermal stratification of marine environment; Role of plankton in water colour development; Marine communities and their adaptation; Conservation and management of marine environment; Coral-reef ecosystem. Marine Ecology of benthic invertebrates.

3. **Coastal Ecology and Ecology of Plankton:** Structure of sea- beach, communities of sea shore. Conservation and Management of Indian Coastal resources. Ecology and Life history of Phytoplankton and Zooplankton. Indicator species, Predator and Prey relationship. Impact of grazing in the aquatic ecosystem,

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FSC-202

(Core course - 4 credits: 50 Marks)

[University Examination -40 and Internal Assessment-10]

UNIT- I: Fish Breeding: (2 credits): 20+5 =25 Marks

1. **Fish Reproduction:** Sexuality in fishes; Sexual dimorphism; Reproductive cycle; Fecundity and spawning; Courtship and mating; Style of reproduction; Environmental and Hormonal control of reproduction; Gonad anatomy and reproductive mechanisms in important finfish and shellfish species; Factors affecting maturation and spawning.

2. **Brood Husbandry:** Brood availability, transport, brood raising, captive rearing and maturation; Nutritional and environmental requirement for broodstock; Nutritional and environmental manipulation for early maturation and brood health care, stress management.

3. **Fish Breeding:** Criteria for selection of brood fish; Natural collection of seed; Bundh breeding; Hypophysation technique; Synthetic hormones and analogues for induced spawning; Multiple breeding; Artificial breeding and seed production of commercially important shellfishes; Improvement of seed quality; Cryopreservation of gametes and embryos.

UNIT- II: Hatchery Design & Management: (2 credits): 20+5 =25 Marks

1. **Design and Construction:** Types of hatchery; Criteria for site selection of hatchery; Design and construction of modern hatchery. Operation, management and hatchery technology for seed production of important finfish and shell fish species.

2. **Water Quality Management:** Monitoring of pH, temperature, dissolved oxygen, alkalinity, salinity, free CO_2 etc. in hatcheries for seed production. Aeration system and water exchange. Different chemicals and drugs used; Hatchery standards and bio-security; Sanitary and Phytosanitary (SPS) measures.

3. **Hatchery Technology & Management:** Disease management and their control in the hatchery systems; SPF and SPR; Seed certification; Better management practices (BMPs); Seed packaging and transportation methods. Economics of seed production.

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FSC-203

(Core course - 4 credits: 50 Marks)

[University Examination - 40 and Internal Assessment - 10]

UNIT- I: Aquatic Pollution and Eco-toxicology: (2 credits): 20+5 =25 Marks

1. **Aquatic Pollution:** Definition, types, sources of pollutants. Common transport process of pollutants in the aquatic environment. Toxic components and their bio-transformation. Toxic kinetics and toxic dynamics. Basic mechanisms of toxicity and toxicity study. Xenobiotics; Factors affecting xenobiotics action. Environmental risk assessment. Bioaccumulation and biomagnification. BOD and COD of different polluted water bodies. Aquatic contaminants and their biodegradation.

2. **Impact of Pollution on Aquatic Environment:** Eutrophication and their impact on aquaculture. Algal blooms. EIA and its impact on aquaculture. Impact of pollution on fish health and other aquatic plants. Effect of selected toxicants on aquatic life and detoxification.

3. **Control of Pollution:** Treatment methods of Waste water, Principles of aeration, Chlorination, Ozonation and U.V. radiation. Waste recycling and utilization in aquaculture. Design and construction of water filtration devices; Aerobic and anaerobic treatment of water. Prevention and control of different aquatic pollution. Waste disposal system in India and different parts of the World. Role of Central and State Government in pollution control.

UNIT- II: Aquatic Microbiology & Public Health Fisheries: (2 credits): 20+5 =25 Marks

1. **Aquatic Microbiology:** Types of microbes; Influence of physical, chemical and biological factors on aquatic micro-organisms. Role of microbes in regeneration of nutrients: conversion of Carbon, Nitrogen, Phosphorus and other micro-nutrients. Types, characters of psychrophilic and mesophilic bacteria. Viral interactions in aquatic system.

2. **Role of Microbes in Aquatic environment:** Freshwater microbes and their role in production of aquatic ecosystem. Studies of water and soil microbes; Types and characters of saline water microbes. Role of microbes to enhance aquaculture productivity. Microbial population in aquatic ecosystem. Concept of probiotics and prebiotics in aquaculture. Feed microbes and their impact on aquatic environment.

3. **Public Health Fishery:** Biological factors of water-self purification. Trickling filter, technical means of controlling microbial population in water. Treatment of domestic and industrial sewage for fish culture. Sewage fed fisheries in India and its impact on environment. Recycling of nutrients in aquatic systems and the role of microbes. Use of medicines and its impact on human health.

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FSC-204

(Elective course - 4 credits: 50 Marks)

[University Examination - 40 and Internal Assessment-10]

UNIT-I: Fundamental of Fisheries Science: (2 credits): 20+5 =25 Marks

1. **Know about fish:** Definition and morphometric characteristics of fishes. Commercially important fin fishes and shellfishes of Indian water.

2. **Introduction to Aquaculture:** Basics of aquaculture - definition and scope. History of aquaculture: Present global and national scenario. Aquaculture *vs* agriculture.

3. **Aquatic resources & Management:** Aquatic resources of India and their conservation and management in different water bodies.

UNIT-II: Aquaculture Management: (2 credits): 20+5 =25 Marks

1. **Types of Aquaculture:** Systems of aquaculture - pond culture, pen culture, cage culture, running water culture, Sewage fed aquaculture etc. Intensification of aquaculture system.

2. **Farming methods & management:** Management of aquaculture pond. Monoculture and polyculture. Raceway culture, integrated culture systems and sewage fed aquaculture. Backyard aquaculture. Fish for therapeutic measures. Angling as a sport.

3. **Ornamental fish culture:** Different varieties of exotic and indigenous ornamental fishes. Culture of freshwater and saline water ornamental fishes, Management of home aquaria and their accessories. Trade of ornamental fish and export potential.

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FSC-205
PRACTICAL PAPER
(Core course - 4 credits: 50 Marks)
[University Examination - 40 and Internal Assessment-10]

[Based on FSC -201 (Unit – I & II) and FSC -202 (Unit – I)]

1. Determination of productivity, soil texture, Organic Carbon, Phosphorus, Potassium, Nitrogen, C/N ratio, pH etc.
2. Study of the physico-chemical characteristics of freshwater: pH, Temperature, Dissolved Oxygen, Free CO_2, Hardness, Salinity, Alkalinity, Transparency, Turbidity etc.
3. Identification of different macrophytes collected from freshwater ecosystem.
4. Study of benthic community, aquatic insects from different aquatic ecosystems.
5. Analysis of phytoplankton and zooplankton from freshwater ecosystem.
6. Dissection & display of reproductive system (male and female) of fish.
7. Dissection and display of Pituitary gland and preparation of pituitary gland extracts and its application in fish breeding.
8. Histological & histochemical techniques to study gonads & other endocrine glands.
9. Study of the maturity stages, Gonado-somatic Index, Fecundity, ova diameter of different fishes.
10. Cryopreservation of fish gametes.

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FSC-206
PRACTICAL PAPER
(Core course - 4 credits: 50 Marks)
[University Examination - 40 and Internal Assessment-10]

[Based on FSC -202 (Unit – II) and FSC -203 (Unit – I & II)]

1. Study of toxicity bioassay technique.

2. Identification of different aquatic pollution indicator species.

3. Physico-chemical analysis of waste water: total dissolved and suspended solids, H_2S, NH_3-N, PO_4.

4. Estimation of BOD and COD in different aquatic ecosystems.

5. Isolation and culture of aquatic microbes.

6. Identification of different types of algae.

7. Gram staining.

8. Studies of soil microbes, feed microbes.

9. Hatchery layout and identification of equipment.

10. Visit to Sewage fed fish culture area/ Fish breeding Centre (Hatchery).

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3rd SEMESTER
(24 credits: 300 Marks)
Core course (Theory) - 150 Marks + Elective course (Theory) - 50 Marks + Core course (Practical) - 100 Marks

FSC-301
(Core course - 4 credits: 50 Marks)
[University Examination - 40 and Internal Assessment-10]

UNIT- I: Fish Pathology and Disease Management: (2 credits): 20+5 =25 Marks

1. **Protozoan and Viral Disease:** Causative agents, symptoms, prophylaxis and histo-pathological studies of protozoan and viral diseases of freshwater, brackish water and marine water finfish, shellfishes and ornamental fishes. Biology, morphology and clinical signs associated with viral pathogen. Non infectious diseases of shell fishes.

2. **Bacterial and Fungal Disease:** Causative agents, symptoms, prophylaxis and histo-pathological studies of bacterial and fungal diseases of freshwater, brackish water and marine water fin fish and shell fishes and ornamental fishes. Bacterial diseases of shellfish, namely; vibrosis, necrotizing hepato-pancreatitis, rickettsial diseases, mycobacteriosis. Life-cycle of shell fish parasites.

3. **Disease Management:** Principles of disease diagnosis, epidemiological and clinical diagnosis, microbiological and post mortem examination of fin fishes in fresh water, brackish water and marine water environment. Environmental impact of disease management. Aquaculture medicines and its importance in fisheries. Rules and regulation for use of aquaculture medicine.

UNIT-I I: Fish Parasitology and Immunology: (2 credits): 20+5 =25 Marks

1. **Parasitic Disease:** General characteristics; Epizootiology; Diagnosis; Life cycle of crustacean, helminthes, protozoon and metazoan parasites in freshwater and marine water fishes.

2. **Disease Control and Management:** Host-parasite interaction; Host-pathogen-environment relationship. Management of culture system and environmental stress. Prevention and control of different parasitic diseases. Pathology, treatment and control of disease caused by Protozoan, Metazoan, Acanthocephalan, Crustacean and Microsporidian Parasites.

3. **Defense System in Fin Fish and Shell Fish:** Introduction to fish immunology. Defense system in fish. Innate and acquired immunity. Cell mediated and humoral immunity. Lymphoid tissues and cellular components of immune systems. Non-specific humoral and cellular defense mechanisms. Hypersensitivity reactions. Structures and functions of antibody. Fish vaccines and strategies for fish vaccination and vaccine production.

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FSC-302

(Core course - 4 credits: 50 Marks)

[University Examination - 40 and Internal Assessment - 10]

UNIT- I: Genetic Engineering and Biotechniques: (2 credits): 20+5 =25 Marks

1. **Molecular Biology:** Structure of DNA and RNA. Genetic code, DNA replication and transcription. Translation.

2. **Biotechniques:** Centrifugation, Electrophoresis, Isoelectrofocusing, chromatography Polymerase Chain Reaction (PCR), molecular markers, RFLP, RAPD, ELISA, Northern blotting and Southern blotting.

3. **Genetic Engineering:** Principles and practices of genetic engineering; recombinant DNA technology and gene cloning methods; Gene mapping; Sequencing and DNA fingerprinting; Recombinant vaccines and transgenic fish; DNA amplification and genomic DNA library; Gene therapy.

UNIT- II: Fisheries Technology and Harbour Engineering: (2 credits): 20+5 =25 Marks

1. **Fishing Crafts and Gears:** Principles and operation of different types of Crafts and Gears used in inland and marine fishing. Design and fabrication of various fishing gears; Different types of gear materials. Traditional and mechanical vessels. Inland and marine crafts; Types of mechanization of crafts. Trawlers and technique of trawling. Preservation of Crafts and Gears.

2. **Devices and Operation System:** By-catch reduction devices; Turtle Exclusion Device (TED); Acoustics; Safety devices; Vessel Monitoring Systems; Satellite navigation systems; Advanced communication Systems.

3. **Harbour Engineering:** Principles and site selection for construction of fishing harbour. Classification and functions of fishing harbor. Design and layout of a modern fishing harbour. Harbours and their relationship with environment and fishing harbour management.

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FSC-303

SPECIAL PAPER (Aquaculture)

(Core course - 4 credits: 50 Marks)

[University Examination -40 and Internal Assessment-10]

UNIT-I: Aquaculture Practices: (2 credits): 20+5 =25 Marks

1. **Freshwater aquaculture:** Present status, problems and scope of fish and prawn farming in global and Indian perspective. Important cultivable freshwater species. Farming of commercially important finfish and shellfishes. Nursery and grow-out culture, pond preparation, stocking, feeding, water quality and disease management in the farming of important cultivable finfish and shellfish species. Stunted seed production and culture practice. Wastewater-fed aquaculture. Guidelines of sustainable aquaculture.

2. **Mariculture and brackishwater aquaculture:** Different farming systems. Important cultivable finfishes. Farming of commercially important finfish and shell fishes. Present status and scope of culture of marine mollusks in India, farming methods. Seaweed culture; emerging trends in their farming in open seas.

3. **Non-food aquaculture:** Present status, potential of aquarium fish trade; major exporting and importing countries. Species-wise contribution of freshwater and marine fishes; marketing strategies. Aquarium management. Colour enhancement. Introduction of exotic fishes and their management. Rearing of live bearer and egg laying fishes. Problems and prospects of ornamental fish culture.

UNIT-II: Fish Nutrition & Bioenergetics: (2 credits): 20+5 =25 Marks

1. **Nutritional Biochemistry & Bioenergetics:** Principles of fish nutrition, nutritional requirements of cultivable finfish and shellfish. Classification and metabolism of proteins, lipids and carbohydrates. Role of nutrients like amino acids, fatty acids, proteins, lipids, carbohydrates, vitamins and minerals. Energy requirement of fishes; Bioenergetics; Factors affecting bioenergetics of fish. Optimal foraging theory, Metabolic rate, Energy budgets, Energetic efficiency of fish production.

2. **Nutritional Physiology:** Digestion, accretions and nutrient flow; Factors affecting digestibility. Anti-nutritional factors and anti-metabolites. Microbial toxins, methods of elimination, nutrient deficiency and symptoms. Nutritional value of feed ingredients and live feed. Contribution from natural food to nutrient requirements of fish.

3. **Feed Formulations and Feed Technology:**

   Classification of feed ingredients. General principle of feed formulation; Methods of feed formulation: Pearson's method, quadratic equation linear programming, limitations. Types of feed. Hydro-stability of feed and their storage and prevention of spoilage from rancidity. Feed additives: - Classification, function, and their specific use. Feed evaluation through the study of growth performance, FCR and PER analysis.

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FSC-304

(Elective course - 4 credits: 50 Marks)

[University Examination -40 and Internal Assessment-10]

UNIT-I: Aquaculture Technology: (2 credits): 20+5 =25 Marks

1. **Fishing Technology:** Different types of fishing crafts and gears – classification, principles, importance. Floats and sinkers; Active and passive gears; Fishing crafts and gears used in inland fisheries of India. Maintenance and storage of gears and gear materials; Preservation of netting and other accessories.

2. **Importance of Fishes:** Nutritional value of fishes. Fish processing technology, byproducts and value added products of economic importance.

3. **Breeding & Genetic Manipulation:** Fish breeding, hybridization of fish and transgenic fishes.

UNIT-II: Fisheries Entrepreneurship Development: (2 credits):20+5 = 25 Marks

1. **Fisheries Extension & Employment:** Fisheries extension and education in India. Fishery as a tool for rural development and employment potentiality.

2. **Fisheries Development Activities:** Different fisheries development plant in India. Role of Government, NGOs and other agencies in fisheries sector. Different fishery related laws in India.

3. **Fisheries Project Formulation:** Planning and design of different projects related to aquaculture and their economic analysis.

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FSC-305

GENERAL PRACTICAL

(Core course - 4 credits: 50 Marks)

[University Examination - 40 and Internal Assessment-10]

[Based on FSC -301 (Unit – I & II) and FSC -302 (Unit – I & II)]

1. Identification of common bacterial, viral, protozoan and fungal diseases of finfishes & shellfishes.
2. Identification of common parasites & parasitic diseases of finfishes and shellfishes.
3. Studies of commonly used aquaculture medicines in West Bengal farms.
4. Estimation of DNA, RNA and protein and enzyme by standard method.
5. Protein profiling study of collected fish samples.
6. Study of the heamatological parameters of fish with special reference to fish immunity study.
7. Study of the principles & applications of modern instruments used in molecular biology.
8. Identification of traditional and modern fishing crafts and gears used in different aquatic system of India
9. Identification of fishing accessories (Floats/sinkers/synthetic & natural fibres/hooks/baits etc.).
10. Study of the different fish finding devices.
11. Identification of different fouling organisms.

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FSC-306
SPECIAL PAPER PRACTICAL (Aquaculture)
(Core course - 4 credits: 50 Marks)
[University Examination - 40 and Internal Assessment-10]

[Based on FSC -303 (Unit – I & II)]

1. Identification of common freshwater aquarium fishes (Indigenous and exotic).
2. Different aquarium plants and decorative materials identification.
3. Identification of weed fishes and predatory fishes.
4. Construction of home aquarium and decoration and management.
5. Culture of live fish food organisms.
6. Identification of eggs/fry/fingerlings of important finfishes & shellfishes.
7. Identification of common fish feed ingredients.
8. Proximate analysis of feed ingredients. Qualitative and quantitative analysis of carbohydrates, proteins, lipids and amino acids, vitamin, minerals.
9. Feed formulation in the laboratory.
10. Estimation of the energy from fish feed ingredients and prepared feed.
11. Analysis of the growth, FCR, PER
12. Visit to different aquaculture farm/hatchery.

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4th SEMESTER
(24 credits: 300 Marks)
Core course (Theory) - 150 Marks; Core course (Practical) - 150 Marks)

FSC-401
(Core course - 4 credits: 50 Marks)
[University Examination - 40 and Internal Assessment-10]

UNIT- I: Fish Processing Technology and Quality Assurance: (2 credits): 20+5 =25 Marks

1. **Fish Handling, Ice Storage and Biochemical Aspects of Fish:** Handling and transportation of fresh fish. Handling of fish on board and hygienic handling. Icing process of finfish and shellfishes. Freshness test by organoleptic method. Classification of ice, Storage and calculation of ice requirements. Methods of icing. Proximate composition of finfishes and shellfishes. Post mortem biochemical changes in fishes. Rigor mortis and freshness test. Spoilage of fishes. Spoilage indices.

2. **Fish Processing:** Principles and definition of fish freezing. Freezing curve. Individual Quick Freezing (IQF). Types of freezing, freezing process, namely - air blast freezing, plate freezing, immersion freezing and cryogenic freezing. Drip loss and Thawing of frozen fish. Concept of canning and outline of canning operation. Definition and concept of smoking. Significance of smoking. Concept of fish packaging.

3. **Food Safety of Fishery Products and Quality Assurance:** Concept of food safety in fishery products. Microbes and their role in food spoilage. Role of of Psychrophilic and Mesophilic microbes. Botulism and their impact on human health. Sanitary control of processing industry and standards of sanitation and hygiene. Principles of HACCP. Formation of HACCP team and their functioning.

UNIT- II: Fisheries Extension, Economics and Marketing: (2 credits): 20+5 =25 Marks

1. **Fisheries Extension:** Introduction to extension education and fisheries extension-concepts, objectives and principles. History and role of fisheries extension in fisheries development; Fisheries extension methods - individual, group and mass contact methods and their effectiveness; Role of NGO's and SHGs in fisheries. Adoption and diffusion of innovations. Extension programme planning and evaluation - steps and importance.

2. **Fisheries Economics and planning:** Definition, principle, concept and scope of economics. Law of demand and supply, Law of diminishing returns. Stages of production, cost concepts. Contribution of fisheries sector to National GDP. Financial

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Assistance available to fishery sector from Government, Commercial Banks, NABARD and other NGO's. Socio-Economic analysis, socio demographic profiles of fishermen and role of woman in fisheries development. Planning and strategies for aquaculture development. Role of FFDA, BFDA and other aquaculture related program. Aquaculture project, project cycle and appraisal of project. Entrepreneurship development.

3. **Marketing:** Concept of market, marketing channels, marketing functions, market structure and conduct. Types of Market, types of competition. Contract farming and direct marketing. Price determination. Problems of fish marketing in India. Exports and imports of fish and fishery products. Contribution of MPEDA and other associates in exports of fish and fishery products. Marketing system and environment market opportunity identification-customer analysis. Marketing policy and market assessment.

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FSC-402

(Core course - 4 credits: 50 Marks)

[University Examination - 40 and Internal Assessment-10]

UNIT- I: Fisheries Statistics and Research Methodology: (2 credits): 20+5 =25 Marks

1. **Concepts and Basics of Statistics:** Frequency distribution; Variance; Histogram; Pie-diagram; Bar-diagrams and Frequency curves. Concept of sample and population. Mean; Median; Mode; Standard Deviation (SD) and Standard Error of Mean (SEM). Normal and binomial distribution.

2. **Application of Fisheries Statistics:** Scope and objectives of fisheries statistics. Sample; Survey; Probability calculation; Chi-squire (X^2) test; Test of significance; ANOVA; Liner regression and correlation. Analysis of Variance. Fitting curves and index numbers. Statistical analysis of biological data.

3. **Research Methodologies:** Identification of problem, and formulation of objectives and hypothesis. Types of hypothesis. Testing of hypothesis. variables, data types: qualitative, quantitative; Experimental design. Application of statistical methods in Research. Methods of reporting. Use of tables, graphs, diagram, etc. in reports using computers.

UNIT- II: Fisheries Legislation, Computer and Bioinformatics: (2 credits): 20+5 =25 Marks

1. **Fisheries Legislation and Administration:** Fisheries administrative setup at Centre and States. Indian Fisheries Act, 1897; The MPEDA Act, 1972; The Maritime Zone of India (regulation of fishing by foreign vessels) Act 1981; Marine Fisheries Policy, 2004; The Coastal Aquaculture Authority Act, 2005; Marine fisheries legislation in the maritime states of India; Code of Conduct for Responsible Fishing; Inland Fisheries Act; Indian wildlife (protection) Act, 1972; The Merchant Shipping Act, 1958; The Coast Guard Act, 1978.

2. **Computer Application:** Basic components of computer. Types of software; Monitor program and operating system; Utility and application program; Computer languages. Problems solving and flow chart. MS Office (MS word, Power point, Excel); Internet browsing and communication, Statistical packages and their application in fisheries data analysis.

3. **Concept and Application of Bioinformatics:** Definition and basic principle of bioinformatics. Field of application and common biological database. Major bioinformatics resources; Knowledge of various database and bioinformatics tools. Genomics and proteomics.

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FSC-403

SPECIAL PAPER (Aquaculture)

(Core course - 4 credits: 50 Marks)

[University Examination - 40 and Internal Assessment - 10]

UNIT-I: Aquaculture Engineering & Environment Management: (2 credits): 20+5 =25 Marks

1. **Aquaculture and different Farming systems:** Trends in global and Indian aquaculture. Extensive, semi-intensive and intensive pisciculture; Pen and cage culture. Monoculture, polyculture, composite fish culture; Integrated Multitrophic Aquaculture; Aquaponics; Rotational aquaculture; Organic farming; Design, farming practices, constraints of integrated farming systems (fish with paddy, cattle, pig, poultry, duck, rabbit, etc).

2. **Aquafarm engineering:** Site selection, components and construction of different aquafarms. Design and layout of different aqua farms and aqua house. Construction and design of pond dyke, sluice gate, water supply and drainage system. Water treatment; design and fabrication of automatic feeder, aerator and bio-filter, instruments for measuring water quality.

3. **Soil and water quality management**: Physical and chemical properties of soil and water. Soil and water quality standards. Different kinds of fertilizers and manures and their application and their impact on environment. Biofertilizers. Ecological changes after fertilization. Aquatic microorganisms and their role in carbon, nitrogen, phosphorus and sulpher cycles. Primary production. Aquatic weed management.

UNIT-II: Fish Genetics and Biotechnology: (2 credits): 20+5 =25 Marks

1. **Cytogenetics and production of hybrids:** Chromosome structure; Current techniques of fish cytogenetics; Evolution of fish karyotypes; History and advancement of fish breeding, basic breeding methods and breeding programmes; Inbreeding and cross breeding; Hybridization; Chromosome manipulation.

2. **Fish Genetic Improvement:** Selecting breeding; Hybridization in fishes; Chromosomal manipulation: Androgenesis and Gynogenesis, Polyploidy. Genetic resources of India and conservation. Production of monosex population and super males.

3. **Fish Biotechnology:** Hormonal manipulation in advancing maturity and reproduction. Role of steroid in sex reversal. Bio-fertilization and bio-fermentation. Application of biotechnology in aquaculture and fisheries management. Recombinant DNA, protein of commercial importance; Transgenesis. Molecular markers used in fisheries and aquaculture. IPR issues related to fish biotechnology.

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FSC-404

GENERAL PRACTICAL

(Core course - 4 credits: 50 Marks)

[University Examination - 40 and Internal Assessment-10]

[Based on FSC -401 (Unit – I & II) and FSC -402 (Unit – I & II)]

1. Fish handling, icing, freezing of fin fish and shellfish. Calculation of ice requirement for freezing.

2. Preparation of fish fillets.

3. Study of proximate composition of fish.

4. Preparation of Value added product

5. Preparation of fish Byproducts.

6. Isolation and identification of fish spoilage causing microbes and their culture.

7. Collection of data and presentation of data. Testing of Goodness of fit; Chi squire (X^2) test and Student's t-test.

8. Operation of MS-Excel, tabulation of biological data, simple computation of different groups of data, making chart with MS-Excel, Bar-diagram, Line-diagram, Pie-diagram. Preparation of Power Point presentation on any topics on fisheries.

9. Database development through the survey, collection & analysis of data from fish market/ Fisheries Co-operative society / Fish farms/NGOs etc.

10. Visit to Fish processing centre / Fisheries Institutes

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FSC-405

SPECIAL PAPER PRACTICAL (Aquaculture)

(Core course - 4 credits: 50 Marks)

[University Examination - 40 and Internal Assessment - 10]

[Based on FSC -403 (Unit – I & II)]

1. Design and layout of different aquaculture system through computer.
2. Analysis of the Aquacultural project site - Water supply, Soil Type, Topography, Drainage system, Computations for water requirement, Seepage and evaporation. Types of ponds and their designs.
3. Identification and working of various equipments used in aquafarm and hatchery.
4. Preparation of project proposal through chart/ model for different fish production systems.
5. Lime and fertilizer requirement calculations in aquafarm.
6. Economic analysis of carp farming & shrimp farming.
7. Study of the fish chromosome.
8. Study of different transgenic and hybrid fish.

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FSC-406
Dissertation paper
(Core course - 4 credits: 50 Marks)

1. Dissertation work Report: 25 Marks:

Each student shall have to carry out a dissertation work (laboratory based or field based) under the guidance of a teacher for a period of minimum 3 months. Students shall have to prepare the dissertation report in a standard format and to submit the same in triplicate before the date of examination. (Date will be announced by the department).

2. Evaluation of dissertation work: 25 Marks:

The dissertation work will be evaluated on the basis of the seminar delivered by the student as well as *Viva Voce* on the dissertation work.

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